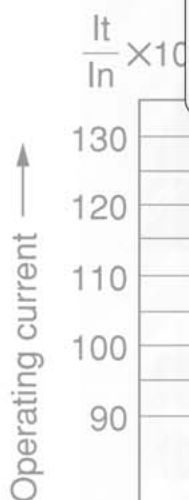
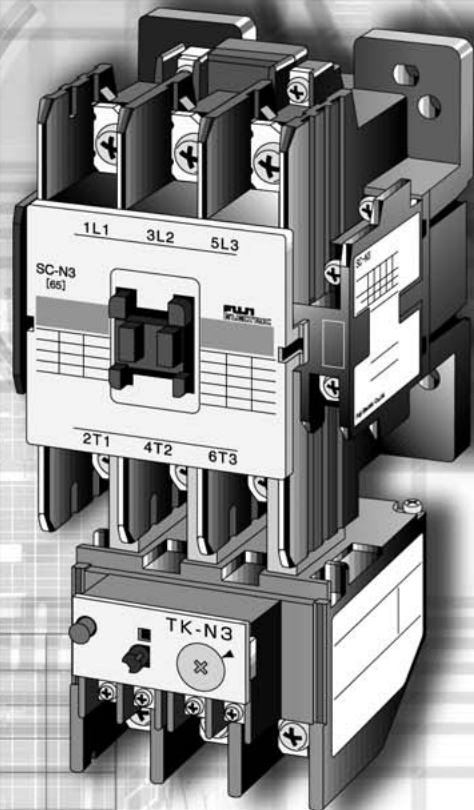
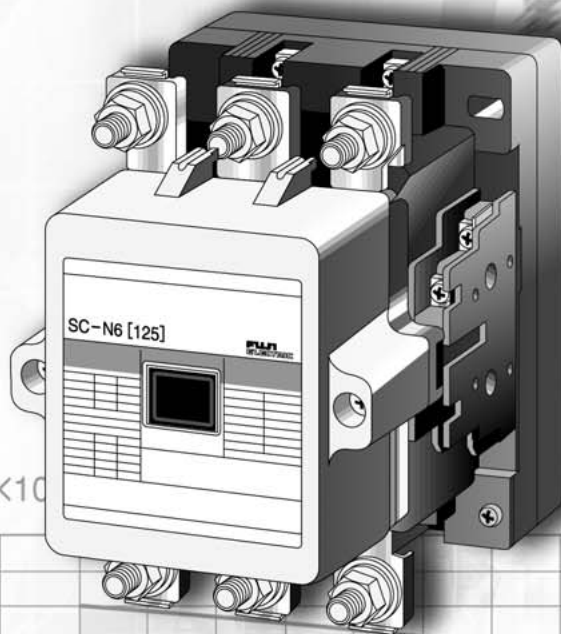
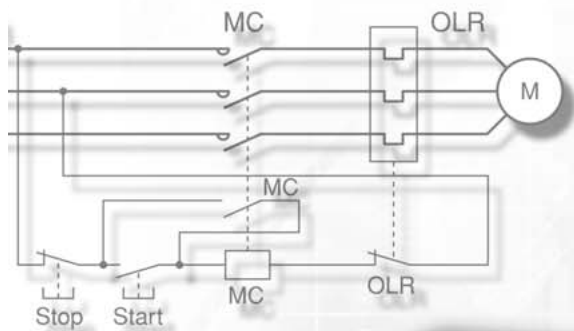


# FUJI Magnetic Contactors and Motor Starters

## Technical Information



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### Contactors and Starters

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# Chapter 1

## Contactors and Starters

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# 1 Contactors and Starters

## 1-1 International standards

### 1-1-1 Making and breaking capacities

| Utilization category | Typical application  | IEC 60947-4-1, EN 60947-4-1, VDE 0660, JIS C 8201-4-1 |       |             |        |      |             |      |
|----------------------|--|---|-------|-------------|--------|------|-------------|------|
|                      |  | Making and breaking                                   |       |             | Making |      |             |      |
|                      |  | Ic/Ie   | Ur/Ue | cosφ or L/R | I/Ie   | U/Ue | cosφ or L/R |      |
| AC-1                 | Non-inductive or slightly inductive loads, resistance furnaces             | 1.5   | 1.05  | 0.8         | 1.5    | 1.05 | 0.8         |      |
| AC-2                 | Slip-ring motors: Starting, switching off                                  | 4.0   | 1.05  | 0.65        | 4.0    | 1.05 | 0.65        |      |
| AC-3                 | Squirrel-cage motors:<br>Starting, switching off during running            | Ie ≤ 100A   | 8.0   | 1.05        | 0.45   | 10   | 1.05        | 0.45 |
|                      |  | Ie > 100A   | 8.0   | 1.05        | 0.35   | 10   | 1.05        | 0.35 |
| AC-4                 | Squirrel-cage motors:<br>Starting, plugging, inching                       | Ie ≤ 100A   | 10    | 1.05        | 0.45   | 12   | 1.05        | 0.45 |
|                      |  | Ie > 100A   | 10    | 1.05        | 0.35   | 12   | 1.05        | 0.35 |
| AC-5a                | Switching of electric discharge lamp controls                              | 3.0   | 1.05  | 0.45        | 3.0    | 1.05 | 0.45        |      |
| AC-5b                | Switching of incandescent lamps  | 1.5   | 1.05  | *           | 1.5    | 1.05 | *           |      |
| DC-1                 | Non-inductive, slightly inductive loads, resistance furnaces               | 1.5   | 1.0ms | –           | 1.5    | 1.05 | 1.0ms       |      |
| DC-3                 | Shunt-motors: Starting, plugging, inching<br>Dynamic braking of DC motors  | 4.0   | 2.5ms | –           | 4.0    | 1.05 | 2.5ms       |      |
| DC-5                 | Series-motors: Starting, plugging, inching<br>Dynamic braking of DC motors | 4.0   | 15ms  | –           | 4.0    | 1.05 | 15ms        |      |
| DC-6                 | Switching of incandescent lamps  | 1.5   | *     | –           | 1.5 *  | 1.05 | *           |      |

Note: \* Test to be carried out with an incandescent lamp load.

Ie: Rated operational current  
 Ue: Rated operational voltage  
 I: Current made  
 U: Voltage before make  
 Ur: Recovery voltage  
 Ic: Current broken

### 1-1-2 Intermittent duty

| IEC 60947-4-1, EN 60947-4-1, VDE 0660 |                     | JIS C 8201-4-1 |                     | Test duty: On-load factor * |                           |      |                           |
|---------------------------------------|---------------------|----------------|---------------------|-----------------------------|---------------------------|------|---------------------------|
| Classification                        | Operations per hour | Classification | Operations per hour | AC-1, 2, 3                  | AC-4                      | DC-1 | DC-3, 5                   |
| Not specified                         | 1,200               | 0              | 1,800               | 15%                         | Specified by manufacturer | 25%  | Specified by manufacturer |
|                                       | 300                 | 1              | 1,200               | 25%                         |                           | 40%  |                           |
|                                       | 120                 | 2              | 600                 | 40%                         |                           | 40%  |                           |
|                                       | 30                  | 3              | 300                 | 40%                         |                           | 40%  |                           |
|                                       | 12                  | 4              | 150                 | 60%                         |                           | 60%  |                           |
|                                       | 3                   | 5              | 30                  | 60%                         |                           | 60%  |                           |
|                                       | 1                   | 6              | 6                   | 60%                         |                           | 60%  |                           |

Note: \* Not specified in IEC, EN and VDE

### 1-1-3 Mechanical and electrical durability

#### (1) Make/break operations

| IEC 60947-4-1, EN60947-4-1, VDE 0660 |                                 |                                 | JIS C 8201-4-1 |                                 |                                 |
|--------------------------------------|---------------------------------|---------------------------------|----------------|---------------------------------|---------------------------------|
| Classification                       | Mechanical<br>( $\times 10^3$ ) | Electrical<br>( $\times 10^3$ ) | Classification | Mechanical<br>( $\times 10^3$ ) | Electrical<br>( $\times 10^3$ ) |
| Not specified                        | 10,000                          | Not specified                   | 0              | 10,000                          | 1,000                           |
|                                      | 3,000                           |                                 | 1              | 5,000                           | 500                             |
|                                      | 1,000                           |                                 | 2              | 2,500                           | 250                             |
|                                      | 300                             |                                 | 3              | 1,000                           | 100                             |
|                                      | 100                             |                                 | 4              | 250                             | 50                              |
|                                      | 10                              |                                 | 5              | 50                              | 10                              |
|                                      | 3                               |                                 | 6              | 5                               | 1                               |
|                                      | 1                               |                                 |                |                                 |                                 |

#### (2) Test duty

| Category | IEC 60947-4-1, EN 60947-4-1, VDE 0660, JIS C 8201-4-1 |      |                   |          |       |                   |
|----------|---|------|-------------------|----------|-------|-------------------|
|          | Making  |      |                   | Breaking |       |                   |
|          | I/le  | U/Ue | cos $\phi$ or L/R | Ic/le    | Ur/Ue | cos $\phi$ or L/R |
| AC-1     | 1   | 1    | 0.95              | 1        | 1     | 0.95              |
| AC-2     | 2.5   | 1    | 0.65              | 2.5      | 1     | 0.65              |
| AC-3     | le $\leq$ 17A   | 6    | 1                 | 0.65     | 1     | 0.17              |
|          | le > 17A  | 6    | 1                 | 0.35     | 1     | 0.17              |
| AC-4     | le $\leq$ 17A   | 6    | 1                 | 0.65     | 6     | 1                 |
|          | le > 17A  | 6    | 1                 | 0.35     | 6     | 1                 |
| DC-1     | 1   | 1    | 1ms               | 1        | 1     | 1ms               |
| DC-3     | 2.5   | 1    | 2ms               | 2.5      | 1     | 2ms               |
| DC-5     | 2.5   | 1    | 7.5ms             | 2.5      | 1     | 7.5ms             |

# 1 Contactors and Starters

## 1-1 International standards






### 1-1-4 Conformity of contactors and starters to international standards

#### (1) Frame size 03 to 5-1

| Version                |               | No. of TOR heat elements | Type      | IEC | VDE | EN | JIS | JEM | TÜV | CE mark | UL  | CSA | Standard for marine use |    |    |    |   |   |
|------------------------|---------------|--------------------------|-----------|-----|-----|----|-----|-----|-----|---------|-----|-----|-------------------------|----|----|----|---|---|
|                        |               |                          |           |     |     |    |     |     |     |         |     |     | LR                      | BV | KR | NK |   |   |
| Contactor Open         | Non-reversing | –                        | SC-□      | ○   | ○   | ○  | ○   | ○   | ○   | ○       | ○ L | ○   | ○                       | ○  | ○  | ○  | ○ |   |
|                        | Reversing     | –                        | SC-□RM    | ○   | ○   | ○  | ○   | ○   | ○   | ○       | ○ L | ○   | –                       | –  | –  | –  | – |   |
|                        | DC operated   | –                        | SC-□/G    | ○   | ○   | ○  | ○   | ○   | ○   | ○       | ○ L | ○   | –                       | ○  | –  | ○  | ○ |   |
| Starter Open           | Non-reversing | 2                        | SW-□      | –   | –   | –  | –   | ○   | –   | –       | –   | –   | –                       | –  | –  | –  | – |   |
|                        |               | 3                        | SW-□/3H   | ○   | ○   | ○  | ○   | ○   | ○   | ○       | ○ L | ○   | –                       | –  | –  | –  | – |   |
|                        |               | 3                        | SW-□/2E   | ○   | ○   | ○  | ○   | ○   | ○   | ○       | ○ L | ○   | –                       | –  | –  | –  | – |   |
|                        | Reversing     | 2                        | SW-□RM    | –   | –   | ○  | –   | ○   | –   | –       | –   | –   | –                       | –  | –  | –  | – | – |
|                        |               | 3                        | SW-□RM/3H | ○   | ○   | ○  | ○   | ○   | ○   | ○       | ○ L | ○   | –                       | –  | –  | –  | – | – |
|                        |               | 3                        | SW-□RM/2E | ○   | ○   | ○  | ○   | ○   | ○   | ○       | ○ L | ○   | –                       | –  | –  | –  | – | – |
| DC operated            | 2             | SW-□/G                   | –         | –   | ○   | –  | ○   | –   | –   | –       | –   | –   | –                       | –  | –  | –  | – |   |
|                        | 3             | SW-□/G3H                 | ○         | ○   | ○   | ○  | ○   | ○   | ○   | ○ L     | ○   | –   | –                       | –  | –  | –  | – |   |
| Starter Enclosed       | Non-reversing | 2                        | SW-□C     | –   | –   | –  | –   | ○   | –   | –       | –   | –   | –                       | –  | –  | –  | – |   |
|                        |               | 3                        | SW-□C/3H  | ○   | ○   | ○  | ○   | ○   | –   | –       | –   | –   | –                       | –  | –  | –  | – |   |
| Thermal overload relay | Standard      | 2                        | TR-□      | –   | –   | –  | –   | ○   | –   | –       | –   | –   | ○                       | ○  | –  | –  | – |   |
|                        |               | 3                        | TR-□/3    | ○   | ○   | ○  | ○   | ○   | ○   | ○       | ○ R | ○   | ○                       | ○  | –  | –  | – |   |
|                        | 2E type       | 3                        | TK-□      | ○   | ○   | ○  | ○   | ○   | ○   | ○       | ○ R | ○   | ○                       | ○  | –  | –  | – |   |
| Industrial relay       | Standard      | 2                        | SH-□      | ○   | ○   | ○  | ○   | ○   | ○   | ○       | ○ L | ○   | ○                       | ○  | –  | –  | – |   |
|                        | DC operated   | 3                        | SH-□/G    | ○   | ○   | ○  | ○   | ○   | ○   | ○       | ○ L | ○   | –                       | ○  | –  | –  | – |   |





Note: ○ Available, ○ L: UL Listed, ○ R: UL Recognized

**(2) Frame size N1 to N16**

| Version                |                   | No. of TOR heat elements | Type      | IEC      | VDE | EN | JIS | JEM | TÜV  | CE mark   | UL   | CSA   | Standard for marine use |    |    |    |   |   |
|------------------------|-------------------|--------------------------|-----------|----------|-----|----|-----|-----|--|---|--|---|-------------------------|----|----|----|---|---|
|                        |                   |                          |           |          |     |    |     |     |  |  | <br> |  | LR                      | BV | KR | NK |   |   |
| Contactor Open         | Non-reversing     | –                        | SC-□      | ○        | ○   | ○  | ○   | ○   | ○  | ○   | ○ L  | ○   | ○                       | ○  | ○  | –  | ○ |   |
|                        | Reversing         | –                        | SC-□RM    | ○        | ○   | ○  | ○   | ○   | ○  | ○   | ○ L  | ○   | –                       | –  | –  | –  | – |   |
|                        | DC operated       | –                        | SC-□/G    | ○        | ○   | ○  | ○   | ○   | ○  | ○   | ○ L  | ○   | ○                       | ○  | ○  | –  | ○ |   |
|                        | With SUPER MAGNET | –                        | SC-□/SE   | ○        | ○   | ○  | ○   | ○   | ○  | ○   | ○ L  | ○   | ○                       | ○  | ○  | –  | ○ |   |
| Starter Open           | Non-reversing     | 2                        | SW-□      | –        | –   | –  | –   | ○   | –  | –   | –  | –   | –                       | –  | –  | –  | – |   |
|                        |                   | 3                        | SW-□/3H   | ○        | ○   | ○  | ○   | ○   | ○  | ○   | ○ L  | ○   | –                       | –  | –  | –  | – |   |
|                        |                   | 3                        | SW-□/2E   | ○        | ○   | ○  | ○   | ○   | ○  | ○   | ○  | ○ L   | ○                       | –  | –  | –  | – |   |
|                        | Reversing         | 2                        | SW-□RM    | –        | –   | –  | –   | ○   | –  | –   | –  | –   | –                       | –  | –  | –  | – | – |
|                        |                   | 3                        | SW-□RM/3H | ○        | ○   | ○  | ○   | ○   | ○  | ○   | ○  | ○ L   | ○                       | –  | –  | –  | – | – |
|                        |                   | 3                        | SW-□RM/2E | ○        | ○   | ○  | ○   | ○   | ○  | ○   | ○  | ○ L   | ○                       | –  | –  | –  | – | – |
|                        | DC operated       | 2                        | SW-□/G    | –        | –   | –  | –   | ○   | –  | –   | –  | –   | –                       | –  | –  | –  | – | – |
|                        |                   | 3                        | SW-□/G3H  | ○        | ○   | ○  | ○   | ○   | ○  | ○   | ○  | ○ L   | ○                       | –  | –  | –  | – | – |
|                        | With SUPER MAGNET | 2                        | SW-□/SE   | –        | –   | –  | –   | ○   | –  | –   | –  | –   | –                       | –  | –  | –  | – | – |
|                        |                   | 3                        | SW-□/SE3H | ○        | ○   | ○  | ○   | ○   | ○  | ○   | ○  | ○ L   | ○                       | –  | –  | –  | – | – |
|                        | Starter Enclosed  | Non-reversing            | 2         | SW-□C    | –   | –  | –   | –   | ○  | –   | –  | –   | –                       | –  | –  | –  | – | – |
|                        |                   |                          | 3         | SW-□C/3H | ○   | ○  | ○   | ○   | ○  | –   | –  | –   | –                       | –  | –  | –  | – | – |
| Thermal overload relay | Standard          | 2                        | TR-□      | –        | –   | –  | –   | ○   | –  | –   | –  | –   | –                       | –  | –  | –  | – |   |
|                        |                   | 3                        | TR-□/3    | ○        | ○   | ○  | ○   | ○   | ○  | ○   | ○ L  | ○   | ○                       | ○  | ○  | –  | – |   |
|                        | 2E type           | 3                        | TK-□      | ○        | ○   | ○  | ○   | ○   | ○  | ○   | ○ L  | ○   | ○                       | ○  | ○  | ○  | – | – |

Note: ○ Available, ○ L: UL Listed, ○ R: UL Recognized

**(3) Optional unit**

| Version                              | Type   | IEC | VDE | EN | JIS | JEM | TÜV  | CE mark   | UL  | CSA   | Standard for marine use |    |    |    |   |   |
|--------------------------------------|--------|-----|-----|----|-----|-----|--|---|---|---|-------------------------|----|----|----|---|---|
|                                      |        |     |     |    |     |     |  |  |  |  | LR                      | BV | KR | NK |   |   |
| Auxiliary contact block              | SZ-A□  | ○   | ○   | ○  | ○   | ○   | ○  | ○   | ○ R   | ○   | ○                       | ○  | ○  | ○  | – | – |
| Operation counter unit               | SZ-J□  | ○   | ○   | ○  | ○   | ○   | –  | –   | ○ R *   | ○ *   | –                       | –  | –  | –  | – | – |
| Main circuit surge suppression unit  | SZ-ZM□ | ○   | ○   | ○  | ○   | ○   | –  | –   | ○ R   | ○   | –                       | –  | –  | –  | – | – |
| Interlock block                      | SZ-RM  | ○   | ○   | ○  | ○   | ○   | –  | –   | ○ R   | ○   | –                       | –  | –  | –  | – | – |
| Coil surge suppression unit          | SZ-Z□  | ○   | ○   | ○  | ○   | ○   | ○  | ○   | ○ R   | ○   | –                       | –  | –  | –  | – | – |
| Base unit for thermal overload relay | SZ-H□  | ○   | ○   | ○  | ○   | ○   | ○  | ○   | ○ R   | ○   | –                       | –  | –  | –  | – | – |
| Reset release button                 | SZ-R□  | ○   | ○   | ○  | ○   | ○   | –  | –   | ○ R   | ○   | –                       | –  | –  | –  | – | – |
| Dial cover                           | SZ-DA  | ○   | ○   | ○  | ○   | ○   | –  | –   | ○ R   | ○   | –                       | –  | –  | –  | – | – |
| Terminal cover                       | SZ-T□  | ○   | ○   | ○  | ○   | ○   | ○  | –   | ○ R   | ○   | –                       | –  | –  | –  | – | – |

Note: ○ Available, ○ L: UL Listed, ○ R: UL Recognized

\* Approval for use in combination with the contactor or starter.

# 1 Contactors and Starters

## 1-2 Ratings and specifications

### 1-2-1 Versions and ratings

| Frame size |                           |          | 03       | 0       | 05       | 4-0       | 4-1       | 5-1       | N1       |
|------------|---------------------------|----------|----------|---------|----------|-----------|-----------|-----------|----------|
| Type       | Contactor, non-reversing  | Open     | SC-03    | SC-0    | SC-05    | SC-4-0    | SC-4-1    | SC-5-1    | SC-N1    |
|            |                           | Enclosed | SC-03C   | SC-0C   | SC-05C   | SC-4-0C   | SC-4-1C   | SC-5-1C   | SC-N1C   |
|            | Starter, non-reversing *3 | Open     | SW-03    | SW-0    | SW-05    | SW-4-0    | SW-4-1    | SW-5-1    | SW-N1    |
|            |                           | Enclosed | SW-03C   | SW-0C   | SW-05C   | SW-4-0C   | SW-4-1C   | SW-5-1C   | SW-N1C   |
|            | Contactor, reversing      | Open     | SC-03RM  | SC-0RM  | SC-05RM  | SC-4-0RM  | SC-4-1RM  | SC-5-1RM  | SC-N1RM  |
|            | Starter, reversing *3     | Open     | SW-03RM  | SW-0RM  | SW-05RM  | SW-4-0RM  | SW-4-1RM  | SW-5-1RM  | SW-N1RM  |
|            |                           | Enclosed | SW-03RMC | SW-0RMC | SW-05RMC | SW-4-0RMC | SW-4-1RMC | SW-5-1RMC | SW-N1RMC |

| Rating                    |                          |          |     |     |     |     |     |     |     |
|---------------------------|--------------------------|----------|-----|-----|-----|-----|-----|-----|-----|
| Standard duty AC-3        | Max. motor capacity (kW) | 200–240V | 2.5 | 3.5 | 3.5 | 4.5 | 5.5 | 5.5 | 7.5 |
|                           |                          | 380–440V | 4   | 5.5 | 5.5 | 7.5 | 11  | 11  | 15  |
|                           |                          | 500–550V | 4   | 5.5 | 5.5 | 7.5 | 11  | 11  | 15  |
|                           |                          | 600–690V | 4   | 5.5 | 5.5 | 7.5 | 7.5 | 7.5 | 11  |
|                           | Operational current (A)  | 200–240V | 11  | 13  | 13  | 18  | 22  | 22  | 32  |
|                           |                          | 380–440V | 9   | 12  | 12  | 16  | 22  | 22  | 32  |
|                           |                          | 500–550V | 7   | 9   | 9   | 13  | 17  | 17  | 24  |
|                           |                          | 600–690V | 5   | 7   | 7   | 9   | 9   | 9   | 15  |
| Heavy duty AC-4, AC-2     | Max. motor capacity (kW) | 200–240V | 2   | 2.5 | 2.5 | 4.5 | 5   | 5   | 5.5 |
|                           |                          | 380–440V | 2.2 | 4   | 4   | 4   | 5.5 | 5.5 | 7.5 |
|                           |                          | 500–550V | 3.5 | 5.5 | 5.5 | 5.5 | 7.5 | 7.5 | 7.5 |
|                           | Operational current (A)  | 200–240V | 8   | 11  | 11  | 18  | 19  | 19  | 22  |
|                           |                          | 380–440V | 6   | 9   | 9   | 9   | 12  | 12  | 16  |
|                           |                          | 500–550V | 6   | 9   | 9   | 9   | 13  | 13  | 13  |
| Resistive load AC-1       | Operational current (A)  | 200–240V | 20  | 20  | 20  | 25  | 32  | 32  | 50  |
|                           |                          | 380–440V | 20  | 20  | 20  | 25  | 32  | 32  | 50  |
| Rated thermal current (A) |                          |          | 20  | 20  | 20  | 25  | 32  | 32  | 50  |

| Performance                                      |            |            |        |        |        |        |        |        |        |
|--|------------|------------|--------|--------|--------|--------|--------|--------|--------|
| Operating cycles per hour                        | AC-3, AC-1 |            | 1,800  | 1,800  | 1,800  | 1,800  | 1,800  | 1,800  | 1,200  |
|  | AC-4, AC-2 |            | 600    | 600    | 600    | 600    | 600    | 600    | 300    |
| Durability ON/OFF operations (×10 <sup>3</sup> ) | Mechanical |            | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 |
|  | Electrical | AC-3       | *1     | *1     | *1     | *1     | *1     | *1     | *1     |
|  |            | AC-4, AC-2 | 30     | 30     | 30     | 30     | 30     | 30     | 30     |
|  |            | AC-1       | 500    | 500    | 500    | 500    | 500    | 500    | 500    |

| Auxiliary contact arrangement (non-reversing) |  |            |            |                       |            |            |                                |         |
|---|--|------------|------------|-----------------------|------------|------------|--------------------------------|---------|
| Standard                                      |  | 1NO<br>1NC | 1NO<br>1NC | 1NO+1NC<br>2NO<br>2NC | 1NO<br>1NC | 1NO<br>1NC | 1NO+1NC<br>2NO, 2NC<br>2NO+2NC | 2NO+2NC |
| On request                                    |  | –          | –          | –                     | –          | –          | –                              | 4NO+4NC |

| Combined thermal overload relay |                           |                           |                           |                           |                                 |                                 |                                 |                           |
|---------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------|
| Standard type                   | 2-element *2<br>3-element | TR-0N<br>TR-0N/3<br>TK-0N | TR-0N<br>TR-0N/3<br>TK-0N | TR-0N<br>TR-0N/3<br>TK-0N | TR-5-1N<br>TR-5-1N/3<br>TK-5-1N | TR-5-1N<br>TR-5-1N/3<br>TK-5-1N | TR-5-1N<br>TR-5-1N/3<br>TK-5-1N | TR-N2<br>TR-N2/3<br>TK-N2 |
| Reset                           |                           | Manual/auto               | Manual/auto               | Manual/auto               | Manual/auto                     | Manual/auto                     | Manual/auto                     | Manual/auto               |

Notes: \*1 Refer to page 62.

\*2 Does not conform to IEC, UL/CSA and JIS standards.

\*3 2-element type: SW-□, 3-element type: SW-□/3H, SW-□/2E



# Contactors and Starters 1

## 1-2 Ratings and specifications

| Frame size            |                           |          | N2        | N2S      | N3       | N4       | N5       | N6       | N7     |
|-----------------------|---------------------------|----------|-----------|----------|----------|----------|----------|----------|--------|
| Type                  | Contactor, non-reversing  | Open     | SC-N2     | SC-N2S   | SC-N3    | SC-N4    | SC-N5    | SC-N6    | SC-N7  |
|                       |                           | Enclosed | SC-N2C    | SC-N2SC  | SC-N3C   | SC-N4C   | SC-N5C   | SC-N6C   | SC-N7C |
|                       | Starter, non-reversing *3 | Open     | SW-N2     | SW-N2S   | SW-N3    | SW-N4    | SW-N5    | SW-N6    | SW-N7  |
|                       |                           | Enclosed | SW-N2C    | SW-N2SC  | SW-N3C   | SW-N4C   | SW-N5C   | SW-N6C   | SW-N7C |
| Contactor, reversing  | Open                      | SC-N2RM  | SC-N2SRM  | SC-N3RM  | SC-N4RM  | SC-N5RM  | SC-N6RM  | SC-N7RM  |        |
|                       | Enclosed                  | SW-N2RM  | SW-N2SRM  | SW-N3RM  | SW-N4RM  | SW-N5RM  | SW-N6RM  | SW-N7RM  |        |
| Starter, reversing *3 | Open                      | SW-N2RMC | SW-N2SRMC | SW-N3RMC | SW-N4RMC | SW-N5RMC | SW-N6RMC | SW-N7RMC |        |
|                       | Enclosed                  | SW-N2RMC | SW-N2SRMC | SW-N3RMC | SW-N4RMC | SW-N5RMC | SW-N6RMC | SW-N7RMC |        |

### Rating

|                           |                          |          |      |    |      |      |     |     |     |
|---------------------------|--------------------------|----------|------|----|------|------|-----|-----|-----|
| Standard duty AC-3        | Max. motor capacity (kW) | 200–240V | 11   | 15 | 18.5 | 22   | 30  | 37  | 45  |
|                           |                          | 380–440V | 18.5 | 22 | 30   | 40   | 55  | 60  | 75  |
|                           |                          | 500–550V | 18.5 | 25 | 37   | 37   | 55  | 60  | 75  |
|                           |                          | 600–690V | 15   | 22 | 30   | 37   | 55  | 60  | 90  |
|                           | Operational current (A)  | 200–240V | 40   | 50 | 65   | 80   | 105 | 125 | 150 |
|                           |                          | 380–440V | 40   | 50 | 65   | 80   | 105 | 125 | 150 |
|                           |                          | 500–550V | 29   | 38 | 60   | 60   | 85  | 90  | 120 |
|                           |                          | 600–690V | 19   | 26 | 38   | 44   | 64  | 72  | 103 |
| Heavy duty AC-4, AC-2     | Max. motor capacity (kW) | 200–240V | 9    | 9  | 15   | 18.5 | 22  | 25  | 37  |
|                           |                          | 380–440V | 15   | 15 | 22   | 30   | 40  | 45  | 55  |
|                           |                          | 500–550V | 12.5 | 15 | 25   | 30   | 45  | 45  | 60  |
|                           | Operational current (A)  | 200–240V | 35   | 35 | 50   | 65   | 80  | 93  | 125 |
|                           |                          | 380–440V | 32   | 32 | 50   | 65   | 80  | 90  | 105 |
|                           |                          | 500–550V | 20   | 24 | 38   | 48   | 72  | 72  | 90  |
| Resistive load AC-1       | Operational current (A)  | 200–240V | 60   | 80 | 100  | 135  | 150 | 150 | 200 |
|                           |                          | 380–440V | 60   | 80 | 100  | 135  | 150 | 150 | 200 |
| Rated thermal current (A) |                          |          | 60   | 80 | 100  | 135  | 150 | 150 | 200 |

### Performance

|  |            |            |        |       |       |       |       |       |
|--|------------|------------|--------|-------|-------|-------|-------|-------|
| Operating cycles per hour                        | AC-3, AC-1 | 1,200      | 1,200  | 1,200 | 1,200 | 1,200 | 1,200 | 1,200 |
|  | AC-4, AC-2 | 300        | 300    | 300   | 300   | 300   | 300   | 300   |
| Durability ON/OFF operations (×10 <sup>3</sup> ) | Mechanical |            | 10,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 |
|  | Electrical | AC-3       | *1     | *1    | *1    | *1    | *1    | *1    |
|  |            | AC-4, AC-2 | 30     | 30    | 30    | 30    | 30    | 30    |
|  |            | AC-1       | 500    | 500   | 500   | 500   | 500   | 500   |

### Auxiliary contact arrangement (non-reversing)

|            |         |         |         |         |         |         |         |
|------------|---------|---------|---------|---------|---------|---------|---------|
| Standard   | 2NO+2NC | 2NO+2NC | 2NO+2NC | 2NO+2NC | 2NO+2NC | 2NO+2NC | 2NO+2NC |
| On request | 4NO+4NC | 4NO+4NC | 4NO+4NC | 4NO+4NC | 4NO+4NC | 4NO+4NC | 4NO+4NC |

### Combined thermal overload relay

|                            |              |             |             |             |             |             |             |             |
|----------------------------|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Standard type              | 2-element *2 | TR-N2       | TR-N3       | TR-N3       | TR-N5       | TR-N5       | TR-N6       | TR-N7       |
|                            | 3-element    | TR-N2/3     | TR-N3/3     | TR-N3/3     | TR-N5/3     | TR-N5/3     | TR-N6/3     | TR-N7/3     |
| Phase-loss protection type |              | TK-N2       | TK-N3       | TK-N3       | TK-N5       | TK-N5       | TK-N6       | TK-N7       |
| Reset                      |              | Manual/auto | Manual/auto | Manual/auto | Manual/auto | Manual/auto | Manual/auto | Manual/auto |

Notes: \*1 Refer to page 62 or 63.

\*2 Does not conform to IEC, UL/CSA and JIS standards.

\*3 2-element type: SW-□, 3-element type: SW-□/3H, SW-□/2E

# 1 Contactors and Starters

## 1-2 Ratings and specifications

| Frame size            |                           |          | N8        | N10      | N11      | N12      | N14     | N16    |
|-----------------------|---------------------------|----------|-----------|----------|----------|----------|---------|--------|
| Type                  | Contactor, non-reversing  | Open     | SC-N8     | SC-N10   | SC-N11   | SC-N12   | SC-N14  | SC-N16 |
|                       |                           | Enclosed | SC-N8C    | SC-N10C  | SC-N11C  | SC-N12C  | SC-N14C | –      |
|                       | Starter, non-reversing *3 | Open     | SW-N8     | SW-N10   | SW-N11   | SW-N12   | SW-N14  | –      |
|                       |                           | Enclosed | SW-N8C    | SW-N10C  | SW-N11C  | SW-N12C  | SW-N14C | –      |
| Contactor, reversing  | Open                      | SC-N8RM  | SC-N10RM  | SC-N11RM | SC-N12RM | SC-N14RM | –       |        |
|                       | Open                      | SW-N8RM  | SW-N10RM  | SW-N11RM | SW-N12RM | SW-N14RM | –       |        |
| Starter, reversing *3 | Open                      | SW-N8RM  | SW-N10RM  | SW-N11RM | SW-N12RM | SW-N14RM | –       |        |
|                       | Enclosed                  | SW-N8RMC | SW-N10RMC | –        | –        | –        | –       |        |

| Rating                    |                          |          |     |     |     |     |     |     |
|---------------------------|--------------------------|----------|-----|-----|-----|-----|-----|-----|
| Standard duty AC-3        | Max. motor capacity (kW) | 200–240V | 55  | 65  | 90  | 120 | 180 | 220 |
|                           |                          | 380–440V | 90  | 110 | 160 | 220 | 315 | 440 |
|                           |                          | 500–550V | 130 | 132 | 160 | 250 | 400 | 500 |
|                           |                          | 600–690V | 132 | 132 | 200 | 300 | 480 | 500 |
|                           | Operational current (A)  | 200–240V | 180 | 220 | 300 | 400 | 600 | 800 |
|                           |                          | 380–440V | 180 | 220 | 300 | 400 | 600 | 800 |
|                           |                          | 500–550V | 180 | 200 | 230 | 360 | 600 | 720 |
|                           |                          | 600–690V | 150 | 150 | 230 | 360 | 600 | 630 |
| Heavy duty AC-4, AC-2     | Max. motor capacity (kW) | 200–240V | 45  | 55  | 65  | 90  | 120 | 180 |
|                           |                          | 380–440V | 75  | 90  | 110 | 160 | 220 | 315 |
|                           |                          | 500–550V | 90  | 90  | 130 | 160 | 250 | –   |
|                           | Operational current (A)  | 200–240V | 150 | 180 | 220 | 300 | 400 | 600 |
|                           |                          | 380–440V | 150 | 180 | 220 | 300 | 400 | 600 |
|                           |                          | 500–550V | 145 | 145 | 180 | 230 | 360 | –   |
| Resistive load AC-1       | Operational current (A)  | 200–240V | 260 | 260 | 350 | 450 | 660 | 800 |
|                           |                          | 380–440V | 260 | 260 | 350 | 450 | 660 | 800 |
| Rated thermal current (A) |                          |          | 260 | 260 | 350 | 450 | 660 | 800 |

| Performance                                      |            |            |       |       |       |       |       |       |
|--|------------|------------|-------|-------|-------|-------|-------|-------|
| Operating cycles per hour                        | AC-3, AC-1 |            | 1,200 | 1,200 | 1,200 | 1,200 | 1,200 | 1,200 |
|  | AC-4, AC-2 |            | 300   | 300   | 300   | 300   | 300   | 300   |
| Durability ON/OFF operations (×10 <sup>3</sup> ) | Mechanical |            | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 2,500 |
|  | Electrical | AC-3       | *1    | *1    | *1    | *1    | *1    | *1    |
|  |            | AC-4, AC-2 | 30    | 30    | 30    | 30    | 30    | 15    |
|  |            | AC-1       | 500   | 500   | 500   | 500   | 500   | 250   |

| Auxiliary contact arrangement (non-reversing) |  |  |         |         |         |         |         |         |
|---|--|--|---------|---------|---------|---------|---------|---------|
| Standard                                      |  |  | 2NO+2NC | 2NO+2NC | 2NO+2NC | 2NO+2NC | 2NO+2NC | 2NO+2NC |
| On request                                    |  |  | 4NO+4NC | 4NO+4NC | 4NO+4NC | 4NO+4NC | 4NO+4NC | 4NO+4NC |

| Combined thermal overload relay |              |             |             |             |             |             |   |  |
|---------------------------------|--------------|-------------|-------------|-------------|-------------|-------------|---|--|
| Standard type                   | 2-element *2 | TR-N8       | TR-N10      | TR-N12      | TR-N12      | TR-N14      | – |  |
|                                 | 3-element    | TR-N8/3     | TR-N10/3    | TR-N12/3    | TR-N12/3    | TR-N14/3    | – |  |
| Phase-loss protection type      |              | TK-N8       | TK-N10      | TK-N12      | TK-N12      | TK-N14      | – |  |
| Reset                           |              | Manual/auto | Manual/auto | Manual/auto | Manual/auto | Manual/auto | – |  |

Notes: \*1 Refer to page 63.

\*2 Does not conform to IEC, UL/CSA and JIS standards.


\*3 2-element type: SW-□, 3-element type: SW-□/3H, SW-□/2E

**1-2-2 Main circuit ratings**

**(1) IEC 60947-4-1, EN 60947-4-1, VDE 0660**

| Type   | Max. motor capacity (kW) |      |      |      | Rated operational current (A) |      |      |      | Rated thermal current (A) |
|--------|--------------------------|------|------|------|-------------------------------|------|------|------|---------------------------|
|        | Three-phase motor        |      |      |      | Three-phase motor             |      |      |      |                           |
|        | Standard duty AC-3       |      |      |      | Standard duty AC-3            |      |      |      |                           |
|        | 200                      | 380  | 500  | 600  | 200                           | 380  | 500  | 600  |                           |
|        | 240V                     | 440V | 550V | 690V | 240V                          | 440V | 550V | 690V |                           |
| SC-03  | 2.5                      | 4    | 4    | 4    | 11                            | 9    | 7    | 5    | 20                        |
| SC-0   | 3.5                      | 5.5  | 5.5  | 5.5  | 13                            | 12   | 9    | 7    | 20                        |
| SC-05  | 3.5                      | 5.5  | 5.5  | 5.5  | 13                            | 12   | 9    | 7    | 20                        |
| SC-4-0 | 4.5                      | 7.5  | 7.5  | 7.5  | 18                            | 16   | 13   | 9    | 25                        |
| SC-4-1 | 5.5                      | 11   | 11   | 7.5  | 22                            | 22   | 17   | 9    | 32                        |
| SC-5-1 | 5.5                      | 11   | 11   | 7.5  | 22                            | 22   | 17   | 9    | 32                        |
| SC-N1  | 7.5                      | 15   | 15   | 11   | 32                            | 32   | 24   | 15   | 50                        |
| SC-N2  | 11                       | 18.5 | 18.5 | 15   | 40                            | 40   | 29   | 19   | 60                        |
| SC-N2S | 15                       | 22   | 25   | 22   | 50                            | 50   | 38   | 26   | 80                        |
| SC-N3  | 18.5                     | 30   | 37   | 30   | 65                            | 65   | 60   | 38   | 100                       |
| SC-N4  | 22                       | 40   | 37   | 37   | 80                            | 80   | 60   | 44   | 135                       |
| SC-N5  | 30                       | 55   | 55   | 55   | 105                           | 105  | 85   | 64   | 150                       |
| SC-N6  | 37                       | 60   | 60   | 60   | 125                           | 125  | 90   | 72   | 150                       |
| SC-N7  | 45                       | 75   | 75   | 90   | 150                           | 150  | 120  | 103  | 200                       |
| SC-N8  | 55                       | 90   | 130  | 132  | 180                           | 180  | 180  | 150  | 260                       |
| SC-N10 | 65                       | 110  | 132  | 132  | 220                           | 220  | 200  | 150  | 260                       |
| SC-N11 | 90                       | 160  | 160  | 200  | 300                           | 300  | 230  | 230  | 350                       |
| SC-N12 | 120                      | 220  | 250  | 300  | 400                           | 400  | 360  | 360  | 450                       |
| SC-N14 | 180                      | 315  | 400  | 480  | 600                           | 600  | 600  | 600  | 660                       |
| SC-N16 | 220                      | 440  | 500  | 500  | 800                           | 800  | 720  | 630  | 800                       |

**(2) UL 508, CSA C22.2**

| Type   | Max. motor capacity (HP) |      |       |       |                    |       | Rated operational current (A) |      |      |      |                    |     | Continuous current (A) | File No. Approval mark  |
|--------|--------------------------|------|-------|-------|--------------------|-------|-------------------------------|------|------|------|--------------------|-----|------------------------|---|
|        | Three-phase motor        |      |       |       | Single-phase motor |       | Three-phase motor             |      |      |      | Single-phase motor |     |                        |   |
|        | 200V                     | 220  | 440   | 550   | 100                | 220   | 200V                          | 220  | 440  | 550  | 100                | 220 |                        |   |
|        | 240V                     | 480V | 600V  | 120V  | 240V               | 240V  | 480V                          | 600V | 120V | 240V |                    |     |                        |   |
| SC-03  | 2                        | 2    | 5     | 5     | 1/3                | 1     | 7.8                           | 6.8  | 7.6  | 6.1  | 7.2                | 8   | 11                     | E42419<br> |
| SC-0   | 3                        | 3    | 5     | 5     | 1/3                | 1     | 11                            | 9.6  | 7.6  | 6.1  | 7.2                | 8   | 13                     |   |
| SC-05  | 3                        | 3    | 5     | 5     | 1/3                | 1     | 11                            | 9.6  | 7.6  | 6.1  | 7.2                | 8   | 13                     |   |
| SC-4-0 | 5                        | 5    | 7 1/2 | 7 1/2 | 1                  | 2     | 17.5                          | 15.2 | 11   | 9    | 16                 | 12  | 20                     |   |
| SC-4-1 | 5                        | 5    | 10    | 10    | 1                  | 2     | 17.5                          | 15.2 | 14   | 11   | 16                 | 12  | 20                     |   |
| SC-5-1 | 5                        | 5    | 10    | 10    | 1                  | 2     | 17.5                          | 15.2 | 14   | 11   | 16                 | 12  | 20                     |   |
| SC-N1  | 7 1/2                    | 10   | 25    | 25    | 2                  | 5     | 25.3                          | 28   | 34   | 27   | 24                 | 28  | 50                     |   |
| SC-N2  | 10                       | 15   | 30    | 30    | 3                  | 7 1/2 | 32.2                          | 42   | 40   | 32   | 34                 | 40  | 60                     |   |
| SC-N2S | 15                       | 20   | 40    | 40    | 3                  | 10    | 48.3                          | 54   | 52   | 41   | 34                 | 50  | 80                     |   |
| SC-N3  | 20                       | 25   | 50    | 50    | 5                  | 15    | 62.1                          | 68   | 65   | 52   | 56                 | 68  | 100                    |   |
| SC-N4  | 25                       | 30   | 60    | 60    | 7 1/2              | 15    | 78.2                          | 80   | 77   | 62   | 80                 | 68  | 135                    |   |
| SC-N5  | 30                       | 30   | 60    | 75    | 7 1/2              | 15    | 92                            | 80   | 77   | 77   | 80                 | 68  | 150                    |   |
| SC-N6  | 40                       | 40   | 75    | 100   | 10                 | 20    | 119.6                         | 104  | 96   | 99   | 100                | 88  | 150                    |   |
| SC-N7  | 50                       | 50   | 100   | 125   | 15                 | 25    | 149.5                         | 130  | 124  | 125  | 135                | 110 | 200                    |   |
| SC-N8  | 60                       | 60   | 150   | 150   | -                  | -     | 177.1                         | 154  | 180  | 144  | -                  | -   | 260                    |   |
| SC-N10 | 75                       | 75   | 150   | 200   | -                  | -     | 220.8                         | 192  | 180  | 192  | -                  | -   | 260                    |   |
| SC-N11 | 100                      | 100  | 200   | 250   | -                  | -     | 285.2                         | 248  | 240  | 242  | -                  | -   | 350                    |   |
| SC-N12 | 125                      | 150  | 300   | 350   | -                  | -     | 358.8                         | 360  | 361  | 336  | -                  | -   | 450                    |   |
| SC-N14 | 200                      | 200  | 500   | 600   | -                  | -     | 552                           | 480  | 590  | 578  | -                  | -   | 660                    |   |
| SC-N16 | 250                      | 300  | 600   | 700   | -                  | -     | 692.3                         | 720  | 722  | 672  | -                  | -   | 800                    |   |

# 1 Contactors and Starters

## 1-2 Ratings and specifications

### 1-2-3 Auxiliary contact ratings

#### (1) IEC, JIS

| Type         | Continuous current (A) | Make and break capacity at AC (A) | Rated operational current (A) |                 |                 |             |                 |                 | Minimum voltage and current |
|--------------|------------------------|-----------------------------------|-------------------------------|-----------------|-----------------|-------------|-----------------|-----------------|-----------------------------|
|              |                        |                                   | AC                            |                 |                 | DC          |                 |                 |                             |
|              |                        |                                   | Voltage (V)                   | AC-15 Ind. load | AC-12 Res. load | Voltage (V) | DC-13 Ind. load | DC-12 Res. load |                             |
| SC-03 to N12 | 10                     | 60                                | 100-120                       | 6               | 10              | 24          | 3               | 5               | 5V DC, 3mA                  |
|              |                        | 30                                | 200-240                       | 3               | 8               | 48          | 1.5             | 3               |                             |
|              |                        | 15                                | 380-440                       | 1.5             | 5               | 110         | 0.55            | 2.5             |                             |
|              |                        | 12                                | 500-600                       | 1.2             | 5               | 220         | 0.27            | 1               |                             |
| SC-N14, N16  | 10                     | 60                                | 100-120                       | 6               | 10              | 24          | 10              | 10              | 24V DC, 10mA                |
|              |                        | 60                                | 200-240                       | 6               | 10              | 48          | 3               | 5               |                             |
|              |                        | 40                                | 380-440                       | 4               | 10              | 110         | 1.5             | 2.5             |                             |
|              |                        | 25                                | 500-600                       | 2.5             | 10              | 220         | 0.5             | 1               |                             |

Note: In normal atmosphere (with no dust or corrosive gases), the failure rate is approximately  $10^{-7}$ .

#### (2) UL, CSA

| Type         | Continuous current (A) | Rated operational current (A) |        |          |                        |        |          |
|--------------|------------------------|-------------------------------|--------|----------|------------------------|--------|----------|
|              |                        | AC (Rating code: A600)        |        |          | DC (Rating code: Q300) |        |          |
|              |                        | Voltage (V)                   | Making | Breaking | Voltage (V)            | Making | Breaking |
| SC-03 to N16 | 10                     | 120                           | 60     | 6        | 125                    | 0.55   | 0.55     |
|              |                        | 240                           | 30     | 3        |                        |        |          |
|              |                        | 480                           | 15     | 1.5      | 250                    | 0.27   | 0.27     |
|              |                        | 600                           | 12     | 1.2      |                        |        |          |

Note: Rating codes are specified by UL508 and CSA C22.2 No. 14.

### 1-2-4 Operating coil voltage

#### (1) SC-03 to 5-1, SC-N1 to N4 (AC operated)

| Type   | Coil voltage and frequency  |
|--------|-----------------------------|
| SC-03  | 24V 50Hz/24-26V 60Hz        |
| SC-0   | 48V 50Hz/48-52V 60Hz        |
| SC-05  | 100V 50Hz/100-110V 60Hz     |
| SC-4-0 | 100-110V 50Hz/110-120V 60Hz |
| SC-4-1 | 110-120V 50Hz/120-130V 60Hz |
| SC-5-1 | 200V 50Hz/200-220V 60Hz     |
| SC-N1  | 200-220V 50Hz/220-240V 60Hz |
| SC-N2  | 220-240V 50Hz/240-260V 60Hz |
| SC-N2S | 346-380V 50Hz/380-420V 60Hz |
| SC-N3  | 380-400V 50Hz/400-440V 60Hz |
| SC-N4  | 415-440V 50Hz/440-480V 60Hz |
|        | 480-500V 50Hz/500-550V 60Hz |

#### (2) SC-N5 to N16, SC-N1/SE to N4/SE (AC/DC operated)

| Type               | Coil voltage and frequency |          |
|--------------------|----------------------------|----------|
|                    | AC                         | DC       |
| SC-N5, N6, N7, N8  | 24-25V 50/60Hz             | 24V      |
| SC-N10, N11, N12   | 48-50V 50/60Hz             | 48V      |
| SC-N14, N16, N1/SE | 100-127V 50/60Hz           | 100-120V |
| SC-N2/SE, N2S/SE   | 200-250V 50/60Hz           | 200-240V |
| SC-N3/SE, N4/SE    | 265-347V 50/60Hz           | -        |
|                    | 380-450V 50/60Hz           | -        |
|                    | 460-575V 50/60Hz           | -        |

Note: Other voltages are available on request.

N5 to N12: 24 to 575V (24 to 240V DC)  
 N14 and N16: 100 to 575V (100 to 240V DC)  
 N1/SE to N3/SE: 24 to 250V (24 to 240V DC)  
 N4/SE: 24 to 575V (24 to 240V DC)

#### (3) SC-03/G to 5-1/G, SC-N1G to N3/G (DC operated)

| Type     | Coil voltage                 |
|----------|------------------------------|
| SC-03/G  | 12V, 24V, 48V, 60V, 100V     |
| SC-0/G   | 110V, 120V, 200V, 210V, 220V |
| SC-05/G  |                              |
| SC-4-0/G |                              |
| SC-4-1/G |                              |
| SC-5-1/G |                              |
| SC-N1/G  |                              |
| SC-N2/G  |                              |
| SC-N2S/G |                              |
| SC-N3/G  |                              |

Note: Other voltages are available in the range of 12 to 250V on request.

1-3 Performance and characteristics

1-3-1 Making and breaking current capacity

| Type   | Test condition |                |             |                     |                     |       |                  |             |                |             |                     |                     | Test result * |         |      |
|--------|----------------|----------------|-------------|---------------------|---------------------|-------|------------------|-------------|----------------|-------------|---------------------|---------------------|---------------|---------|------|
|        | Voltage (V)    | Frequency (Hz) | Current (A) | Power factor (cosφ) | Breaking operations |       | Arcing time (ms) | Voltage (V) | Frequency (Hz) | Current (A) | Power factor (cosφ) | Breaking operations |               |         |      |
|        |                |                |             |                     | 0.85Us              | 1.1Us |                  |             |                |             |                     | 0.85Us              |               | 1.1Us   |      |
| SC-03  | 3φ, 231        | 50             | 110         | 0.44                | 25                  | 25    | 4-7              | 3φ, 462     | 50             | 90          | 0.44                | 25                  | 25            | 5-7.5   | Good |
| SC-0   | 3φ, 231        | 50             | 130         | 0.44                | 25                  | 25    | 4.5-6            | 3φ, 462     | 50             | 120         | 0.44                | 25                  | 25            | 4.5-7.5 |      |
| SC-05  | 3φ, 231        | 50             | 130         | 0.44                | 25                  | 25    | 4-5.5            | 3φ, 462     | 50             | 120         | 0.44                | 25                  | 25            | 4.5-7.5 |      |
| SC-4-0 | 3φ, 231        | 50             | 180         | 0.44                | 25                  | 25    | 4-7              | 3φ, 426     | 50             | 160         | 0.44                | 25                  | 25            | 4.5-7.5 |      |
| SC-4-1 | 3φ, 231        | 50             | 220         | 0.44                | 25                  | 25    | 4-7.5            | 3φ, 462     | 50             | 220         | 0.44                | 25                  | 25            | 4.5-8   |      |
| SC-5-1 | 3φ, 231        | 50             | 220         | 0.44                | 25                  | 25    | 4-7.5            | 3φ, 462     | 50             | 220         | 0.44                | 25                  | 25            | 4.5-8   |      |
| SC-N1  | 3φ, 231        | 50             | 320         | 0.45                | 25                  | 25    | 4-6              | 3φ, 462     | 50             | 320         | 0.45                | 25                  | 25            | 5-7     |      |
| SC-N2  | 3φ, 231        | 50             | 400         | 0.45                | 25                  | 25    | 4-6              | 3φ, 462     | 50             | 400         | 0.45                | 25                  | 25            | 5-7     |      |
| SC-N2S | 3φ, 231        | 50             | 500         | 0.45                | 25                  | 25    | 4-8              | 3φ, 462     | 50             | 500         | 0.45                | 25                  | 25            | 5-8     |      |
| SC-N3  | 3φ, 231        | 50             | 650         | 0.45                | 25                  | 25    | 4-8              | 3φ, 462     | 50             | 650         | 0.45                | 25                  | 25            | 5-8     |      |
| SC-N4  | 3φ, 231        | 50             | 800         | 0.44                | 25                  | 25    | 5-9              | 3φ, 462     | 50             | 800         | 0.44                | 25                  | 25            | 5-10    |      |
| SC-N5  | 3φ, 231        | 50             | 1,050       | 0.34                | 25                  | 25    | 4-9              | 3φ, 462     | 50             | 1,050       | 0.34                | 25                  | 25            | 4-10    |      |
| SC-N6  | 3φ, 231        | 50             | 1,250       | 0.36                | 25                  | 25    | 4-12             | 3φ, 462     | 50             | 1,250       | 0.36                | 25                  | 25            | 4-13    |      |
| SC-N7  | 3φ, 231        | 50             | 1,520       | 0.35                | 25                  | 25    | 3-12             | 3φ, 462     | 50             | 1,500       | 0.35                | 25                  | 25            | 3-13    |      |
| SC-N8  | 3φ, 231        | 50             | 1,800       | 0.37                | 25                  | 25    | 4-12             | 3φ, 462     | 50             | 1,800       | 0.37                | 25                  | 25            | 5-13    |      |
| SC-N10 | 3φ, 231        | 50             | 2,200       | 0.37                | 25                  | 25    | 4-13             | 3φ, 462     | 50             | 2,200       | 0.37                | 25                  | 25            | 6-14    |      |
| SC-N11 | 3φ, 231        | 50             | 3,000       | 0.32                | 25                  | 25    | 5-13             | 3φ, 462     | 50             | 3,000       | 0.32                | 25                  | 25            | 6-15    |      |
| SC-N12 | 3φ, 231        | 50             | 4,000       | 0.32                | 25                  | 25    | 5-13             | 3φ, 462     | 50             | 4,000       | 0.32                | 25                  | 25            | 6-15    |      |
| SC-N14 | 3φ, 231        | 50             | 6,000       | 0.32                | 25                  | 25    | 5-10             | 3φ, 462     | 50             | 6,000       | 0.32                | 25                  | 25            | 6-16    |      |
| SC-N16 | 3φ, 231        | 50             | 8,000       | 0.33                | 25                  | 25    | 5-13             | 3φ, 462     | 50             | 8,000       | 0.33                | 25                  | 25            | 6-19    |      |

1-3-2 Making current capacity

| Type   | Test condition |                |             |                     |             |                |             |                     | Duty              | Test result * |
|--------|----------------|----------------|-------------|---------------------|-------------|----------------|-------------|---------------------|-------------------|---------------|
|        | Voltage (V)    | Frequency (Hz) | Current (A) | Power factor (cosφ) | Voltage (V) | Frequency (Hz) | Current (A) | Power factor (cosφ) | Making operations |               |
| SC-03  | 3φ, 242        | 50             | 132         | 0.44                | 3φ, 484     | 50             | 108         | 0.44                | 50                | Good          |
| SC-0   | 3φ, 242        | 50             | 156         | 0.44                | 3φ, 484     | 50             | 144         | 0.44                | 50                |               |
| SC-05  | 3φ, 242        | 50             | 156         | 0.44                | 3φ, 484     | 50             | 144         | 0.44                | 50                |               |
| SC-4-0 | 3φ, 242        | 50             | 216         | 0.44                | 3φ, 484     | 50             | 192         | 0.44                | 50                |               |
| SC-4-1 | 3φ, 242        | 50             | 264         | 0.44                | 3φ, 484     | 50             | 264         | 0.44                | 50                |               |
| SC-5-1 | 3φ, 242        | 50             | 264         | 0.44                | 3φ, 484     | 50             | 264         | 0.44                | 50                |               |
| SC-N1  | 3φ, 242        | 50             | 384         | 0.45                | 3φ, 484     | 50             | 384         | 0.45                | 50                |               |
| SC-N2  | 3φ, 242        | 50             | 480         | 0.45                | 3φ, 484     | 50             | 480         | 0.45                | 50                |               |
| SC-N2S | 3φ, 242        | 50             | 600         | 0.45                | 3φ, 484     | 50             | 600         | 0.45                | 50                |               |
| SC-N3  | 3φ, 242        | 50             | 780         | 0.45                | 3φ, 484     | 50             | 780         | 0.45                | 50                |               |
| SC-N4  | 3φ, 242        | 50             | 960         | 0.44                | 3φ, 484     | 50             | 960         | 0.44                | 50                |               |
| SC-N5  | 3φ, 242        | 50             | 1,260       | 0.34                | 3φ, 484     | 50             | 1,260       | 0.34                | 50                |               |
| SC-N6  | 3φ, 242        | 50             | 1,500       | 0.36                | 3φ, 484     | 50             | 1,500       | 0.36                | 50                |               |
| SC-N7  | 3φ, 242        | 50             | 1,824       | 0.35                | 3φ, 484     | 50             | 1,800       | 0.35                | 50                |               |
| SC-N8  | 3φ, 242        | 50             | 2,160       | 0.37                | 3φ, 484     | 50             | 2,160       | 0.37                | 50                |               |
| SC-N10 | 3φ, 242        | 50             | 2,640       | 0.37                | 3φ, 484     | 50             | 2,640       | 0.37                | 50                |               |
| SC-N11 | 3φ, 242        | 50             | 3,600       | 0.32                | 3φ, 484     | 50             | 3,600       | 0.32                | 50                |               |
| SC-N12 | 3φ, 242        | 50             | 4,800       | 0.32                | 3φ, 484     | 50             | 4,800       | 0.32                | 50                |               |
| SC-N14 | 3φ, 242        | 50             | 7,200       | 0.32                | 3φ, 484     | 50             | 7,200       | 0.32                | 50                |               |
| SC-N16 | 3φ, 242        | 50             | 9,600       | 0.33                | 3φ, 484     | 50             | 9,600       | 0.33                | 50                |               |

Us: Coil rated voltage

\* Tested to confirm that there are no permanent arcing, no flash-over between poles, no blowing of the fusible element in the earth circuit and no welding of the contacts.

# 1 Contactors and Starters

## 1-3 Performance and characteristics

### 1-3-3 Mechanical durability

IEC Standards testing procedures require that the mechanical durability test be carried out without current flowing in the main circuit, with the rated voltage applied to the coil and for at least as many on-off operation cycles as specified for the corresponding intermittent duty class as shown in the table on page 5.

The mechanical life of the contactor is inversely proportional to the third or fourth power of the operating voltage.

Therefore, if the control circuit voltage is 10% higher than the coil's rated voltage, the mechanical durability will be reduced by half.

An increase in control circuit voltage will harm the operating mechanism, core and shading coil.

The results of the mechanical durability test for SC series contactors are given in the table below.

#### (1) Criteria

- (a) The contactors shall operate normally after completion of the mechanical durability test.
- (b) There shall be no loosening of conductor connection parts.

#### (2) Test results

| Type   | Test condition                        |                           | Test result                 |  |  |   |                              |  |  |   |
|--------|---------------------------------------|---------------------------|-----------------------------|--|--|---|------------------------------|--|--|---|
|        | Control circuit voltage (at 50Hz) (V) | Operating cycles per hour | Minimum pick-up voltage (V) |  |  |   | Maximum drop-out voltage (V) |  |  |   |
|        |                                       |                           | Before test                 | After 1,000 × 10 <sup>3</sup> operations | After 5,000 × 10 <sup>3</sup> operations | After 10,000 × 10 <sup>3</sup> operations | Before test                  | After 1,000 × 10 <sup>3</sup> operations | After 5,000 × 10 <sup>3</sup> operations | After 10,000 × 10 <sup>3</sup> operations |
| SC-03  | 210                                   | 12,000                    | 118                         | 116                                      | 119                                      | 120                                       | 82                           | 82                                       | 80                                       | 83  |
| SC-0   | 210                                   | 12,000                    | 116                         | 115                                      | 117                                      | 116                                       | 84                           | 87                                       | 85                                       | 84  |
| SC-05  | 210                                   | 12,000                    | 122                         | 122                                      | 120                                      | 121                                       | 79                           | 81                                       | 82                                       | 78  |
| SC-4-0 | 210                                   | 12,000                    | 126                         | 128                                      | 127                                      | 125                                       | 90                           | 90                                       | 86                                       | 88  |
| SC-4-1 | 210                                   | 12,000                    | 124                         | 126                                      | 126                                      | 124                                       | 88                           | 90                                       | 91                                       | 88  |
| SC-5-1 | 210                                   | 12,000                    | 126                         | 128                                      | 125                                      | 124                                       | 92                           | 94                                       | 92                                       | 90  |
| SC-N1  | 210                                   | 6,000                     | 111                         | 113                                      | 112                                      | 120                                       | 82                           | 83                                       | 86                                       | 88  |
| SC-N2  | 210                                   | 6,000                     | 112                         | 112                                      | 115                                      | 122                                       | 78                           | 78                                       | 80                                       | 84  |
| SC-N2S | 210                                   | 6,000                     | 130                         | 129                                      | 127                                      | –   | 109                          | 98                                       | 100                                      | –   |
| SC-N3  | 210                                   | 6,000                     | 130                         | 129                                      | 127                                      | –   | 109                          | 98                                       | 100                                      | –   |
| SC-N4  | 210                                   | 6,000                     | 126                         | 128                                      | 128                                      | –   | 86                           | 90                                       | 88                                       | –   |
| SC-N5  | 230                                   | 1,800                     | 144                         | 144                                      | 144                                      | –   | 86                           | 86                                       | 86                                       | –   |
| SC-N6  | 230                                   | 1,800                     | 148                         | 148                                      | 148                                      | –   | 87                           | 87                                       | 87                                       | –   |
| SC-N7  | 230                                   | 1,800                     | 148                         | 148                                      | 148                                      | –   | 87                           | 87                                       | 87                                       | –   |
| SC-N8  | 230                                   | 1,800                     | 145                         | 145                                      | 145                                      | –   | 86                           | 86                                       | 86                                       | –   |
| SC-N10 | 230                                   | 1,800                     | 145                         | 145                                      | 145                                      | –   | 86                           | 86                                       | 86                                       | –   |
| SC-N11 | 230                                   | 1,800                     | 147                         | 147                                      | 147                                      | –   | 88                           | 88                                       | 88                                       | –   |
| SC-N12 | 230                                   | 1,800                     | 147                         | 147                                      | 147                                      | –   | 88                           | 88                                       | 88                                       | –   |
| SC-N14 | 230                                   | 1,800                     | 148                         | 148                                      | 148                                      | –   | 88                           | 88                                       | 88                                       | –   |
| SC-N16 | 230                                   | 1,800                     | 148                         | 148                                      | 148 *                                    | –   | 88                           | 88                                       | 88 *                                     | –   |

Note: Coil rating: For frame size N4 or less 200V 50Hz/200–220V 60Hz  
For frame size N5 and above 200V–250V 50/60Hz, 200–240V AC

\* After 2,500 × 10<sup>3</sup> operations

### 1-3-4 Electrical durability

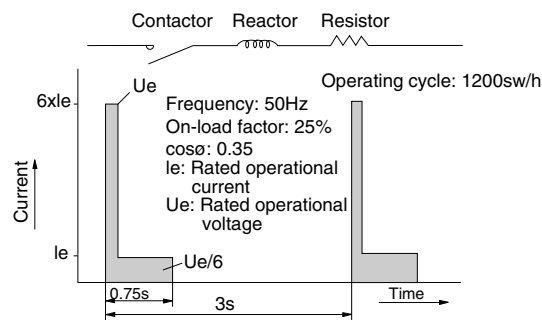
The electrical durability test must be carried out for the number of operation cycles specified for the corresponding intermittent duty class shown in the table on page 5, and under the circuit conditions of the corresponding utilization category as defined in the table on page 4.

Contact wear is caused by arcing that occurs between contacts when the current is interrupted. The amount of contact wear is directly proportional to approximately the second power of the interrupted current value.

Therefore, when a contactor is used for inching or plugging operations, the expected service life of the contacts will be much less than if used for normal operations.

### (1) Test condition - Category AC-3

The method of determining the durability and performance is prescribed by IEC as below.



Contactor makes a current equal to six times that of its rated operational current, immediately reduces the current to the rated operational current, and then breaks.

### (2) Criteria

The value of the overtravel shall exceed the permissible minimum overtravel value. The insulation resistance after testing shall be over 5MΩ. (500V DC megger)

### (3) Test results

| Type   | Test condition              |                   |                      |                     | Test result     |  |  |  |  |                                | Insulation resistance (MΩ) |
|--------|-----------------------------|-------------------|----------------------|---------------------|-----------------|--|--|--|--|--------------------------------|----------------------------|
|        | Voltage (at 50Hz)<br>Ee (V) | Current<br>Ie (A) | Power factor<br>cosφ | Operations per hour | Overtravel (mm) |  |  |  |  | Permissible minimum overtravel |                            |
|        |                             |                   |                      |                     | Before test     | After 500 × 10 <sup>3</sup> operations | After 1,000 × 10 <sup>3</sup> operations | After 1,500 × 10 <sup>3</sup> operations | After 2,000 × 10 <sup>3</sup> operations |                                |                            |
| SC-03  | 220                         | 11                | 0.34                 | 1,800               | 1.5             | 1.4                                    | 1.2                                      | 0.9                                      | 0.6                                      | 0.3                            | 100                        |
|        | 440                         | 9                 | 0.32                 | 1,800               | 1.5             | 1.2                                    | 0.9                                      | 0.6                                      | —  | 0.3                            |                            |
| SC-0   | 220                         | 13                | 0.32                 | 1,800               | 1.5             | 1.4                                    | 1.2                                      | 0.9                                      | 0.7                                      | 0.3                            | 100                        |
|        | 440                         | 12                | 0.33                 | 1,800               | 1.5             | 1.2                                    | 0.9                                      | 0.6                                      | —  | 0.3                            |                            |
| SC-05  | 220                         | 13                | 0.32                 | 1,800               | 1.5             | 1.3                                    | 1.1                                      | 0.9                                      | 0.6                                      | 0.3                            | 100                        |
|        | 440                         | 12                | 0.33                 | 1,800               | 1.5             | 1.2                                    | 0.9                                      | 0.6                                      | —  | 0.3                            |                            |
| SC-4-0 | 220                         | 18                | 0.35                 | 1,800               | 1.7             | 1.4                                    | 1.1                                      | 0.7                                      | —  | 0.3                            | 100                        |
|        | 440                         | 16                | 0.31                 | 1,800               | 1.7             | 1.3                                    | 0.9                                      | —  | —  | 0.3                            |                            |
| SC-4-1 | 220                         | 22                | 0.34                 | 1,800               | 1.7             | 1.3                                    | 0.8                                      | —  | —  | 0.3                            | 100                        |
|        | 440                         | 22                | 0.32                 | 1,800               | 1.7             | 1.2                                    | 0.7                                      | —  | —  | 0.3                            |                            |
| SC-5-1 | 220                         | 22                | 0.34                 | 1,800               | 1.7             | 1.3                                    | 0.8                                      | —  | —  | 0.3                            | 100                        |
|        | 440                         | 22                | 0.32                 | 1,800               | 1.7             | 1.2                                    | 0.7                                      | —  | —  | 0.3                            |                            |
| SC-N1  | 220                         | 32                | 0.35                 | 1,200               | 1.8             | 1.5                                    | 1.3                                      | 1.1                                      | —  | 1.0                            | 100                        |
|        | 440                         | 32                | 0.36                 | 1,200               | 1.8             | 1.5                                    | 1.2                                      | —  | —  | 1.0                            |                            |
| SC-N2  | 220                         | 40                | 0.35                 | 1,200               | 1.8             | 1.6                                    | 1.3                                      | 1.2                                      | —  | 1.0                            | 100                        |
|        | 440                         | 40                | 0.34                 | 1,200               | 1.8             | 1.6                                    | 1.3                                      | —  | —  | 1.0                            |                            |
| SC-N2S | 220                         | 50                | 0.35                 | 1,200               | 2.0             | 1.7                                    | 1.4                                      | —  | —  | 1.0                            | 100                        |
|        | 440                         | 50                | 0.34                 | 1,200               | 2.0             | 1.7                                    | 1.4                                      | —  | —  | 1.0                            |                            |
| SC-N3  | 220                         | 65                | 0.35                 | 1,200               | 2.0             | 1.7                                    | 1.4                                      | —  | —  | 1.0                            | 100                        |
|        | 440                         | 65                | 0.35                 | 1,200               | 2.0             | 1.7                                    | 1.4                                      | —  | —  | 1.0                            |                            |
| SC-N4  | 220                         | 80                | 0.37                 | 1,200               | 2.1             | 2.0                                    | 1.9                                      | —  | —  | 1.0                            | 100                        |
|        | 440                         | 80                | 0.35                 | 1,200               | 2.1             | 1.9                                    | 1.7                                      | —  | —  | 1.0                            |                            |
| SC-N5  | 220                         | 105               | 0.35                 | 1,200               | 2.7             | 1.9                                    | —  | —  | —  | 1.0                            | 100                        |
|        | 440                         | 105               | 0.35                 | 1,200               | 2.7             | 1.6                                    | —  | —  | —  | 1.0                            |                            |
| SC-N6  | 220                         | 125               | 0.35                 | 1,200               | 3.0             | 2.7                                    | 2.4                                      | —  | —  | 1.0                            | 100                        |
|        | 440                         | 125               | 0.34                 | 1,200               | 3.0             | 2.1                                    | —  | —  | —  | 1.0                            |                            |
| SC-N7  | 220                         | 150               | 0.35                 | 1,200               | 3.0             | 2.7                                    | 2.4                                      | —  | —  | 1.0                            | 100                        |
|        | 440                         | 150               | 0.36                 | 1,200               | 3.0             | 2.5                                    | 2.0                                      | —  | —  | 1.0                            |                            |
| SC-N8  | 220                         | 180               | 0.33                 | 1,200               | 4.1             | 3.6                                    | 3.1                                      | —  | —  | 1.5                            | 100                        |
|        | 440                         | 180               | 0.35                 | 1,200               | 4.1             | 3.5                                    | 2.8                                      | —  | —  | 1.5                            |                            |
| SC-N10 | 220                         | 220               | 0.35                 | 1,200               | 4.1             | 3.6                                    | 3.1                                      | —  | —  | 1.5                            | 100                        |
|        | 440                         | 220               | 0.35                 | 1,200               | 4.1             | 3.4                                    | 2.7                                      | —  | —  | 1.5                            |                            |
| SC-N11 | 220                         | 300               | 0.34                 | 1,200               | 5.3             | 4.7                                    | 4.0                                      | —  | —  | 2.0                            | 100                        |
|        | 440                         | 300               | 0.35                 | 1,200               | 5.3             | 4.5                                    | 3.8                                      | —  | —  | 2.0                            |                            |
| SC-N12 | 220                         | 400               | 0.36                 | 1,200               | 5.3             | 4.7                                    | —  | —  | —  | 2.0                            | 100                        |
|        | 440                         | 400               | 0.35                 | 1,200               | 5.3             | 4.5                                    | —  | —  | —  | 2.0                            |                            |
| SC-N14 | 220                         | 600               | 0.36                 | 1,200               | 4.5             | 3.8                                    | —  | —  | —  | 2.0                            | 100                        |
|        | 440                         | 600               | 0.34                 | 1,200               | 4.5             | 3.7                                    | —  | —  | —  | 2.0                            |                            |
| SC-N16 | 220                         | 800               | 0.36                 | 1,200               | 4.5             | 3.2 *                                  | —  | —  | —  | 2.0                            | 100                        |
|        | 440                         | 800               | 0.35                 | 1,200               | 4.5             | 3.0 *                                  | —  | —  | —  | 2.0                            |                            |

\* After 250 × 10<sup>3</sup> operations

# 1 Contactors and Starters

## 1-3 Performance and characteristics

### 1-3-5 Overcurrent withstand value

The overcurrent withstand value is maximum value of current which can be allowed to flow in contactors for a specified period of time which is expressed by “time-current (root-mean-square) value”.

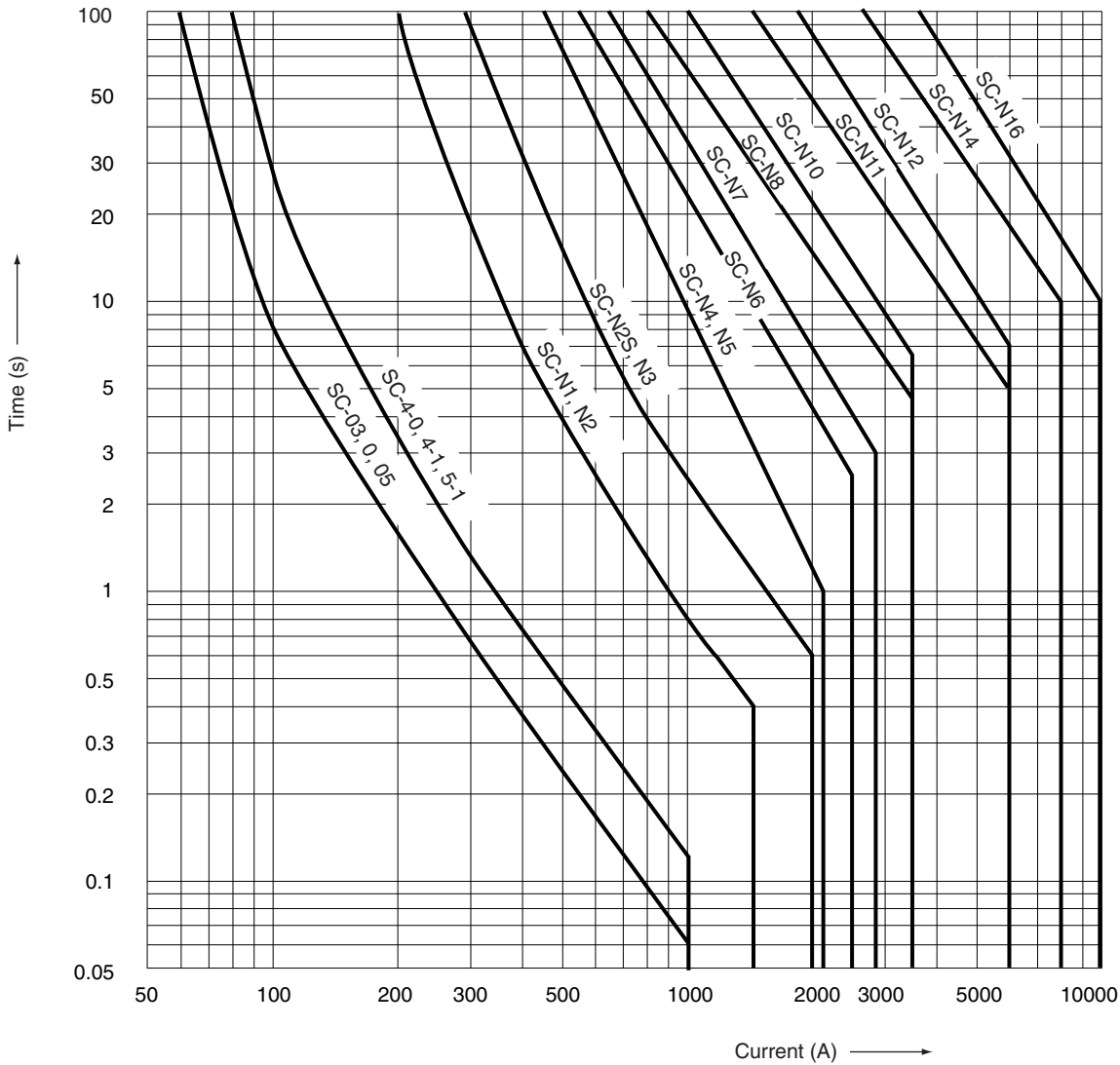
The starting current of squirrel-cage motor is 5 to 6 times the full load current. The starting time of special purpose motors for blower, winder, fan and centrifugal separator having a large

rotational inertia is 7 to 8 seconds, which is a longer period than that of standard motor with driven machine.

Thus larger current than the rated operational current will be allowed to flow through the contactors for a longer time than usual under these conditions.

The graph below indicates the overcurrent withstand values for SC series contactors.

Fig. 1 Contactor overcurrent withstand value





**1-3-6 Short-circuit current withstand value**

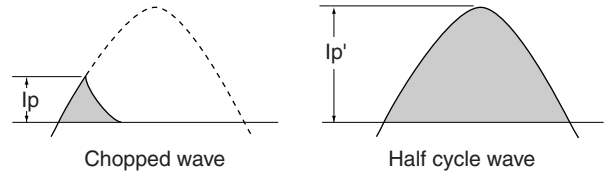
When a short-circuit fault occurs on the load side of the contactor, the short-circuit current is interrupted by an MCCB or a fuse.

However, the contact is influenced by a repulsion force generated by the large current that flows before the interruption occurs. This causes the contact pressure to decrease and the temperature of the contacting portion to rise with the possibility of the contact welding.

If the magnetic repulsion force is greater than the contact pressure, the contact will open and the arc energy generated between the contacts may also cause them to be welded. The magnitude of this repulsion force is directly proportional to the second power of the peak value of the current passing through the unit.

The maximum withstand values of SC series contactors against the chopped wave or half cycle wave are as shown below.

**Fig. 2 Wave form of current interrupted**



| Type   | Chopped wave |       | Half cycle wave |        |
|--------|--------------|-------|-----------------|--------|
|        | Ip (A)       | Ip/Ie | Ip' (A)         | Ip'/Ie |
| SC-03  | 6,700        | 609   | 1,400           | 127    |
| SC-0   | 6,700        | 515   | 1,400           | 107    |
| SC-05  | 6,700        | 515   | 1,400           | 107    |
| SC-4-0 | 7,500        | 416   | 1,600           | 88     |
| SC-4-1 | 7,500        | 394   | 1,600           | 84     |
| SC-5-1 | 7,500        | 394   | 1,600           | 84     |
| SC-N1  | 10,000       | 384   | 2,400           | 92     |
| SC-N2  | 10,000       | 285   | 2,400           | 68     |
| SC-N2S | 13,000       | 260   | 2,800           | 56     |
| SC-N3  | 13,000       | 200   | 2,800           | 43     |
| SC-N4  | 16,000       | 200   | 3,500           | 44     |
| SC-N5  | 16,000       | 172   | 3,500           | 38     |
| SC-N6  | 17,000       | 136   | 3,700           | 29     |
| SC-N7  | 19,000       | 126   | 4,400           | 29     |
| SC-N8  | 25,000       | 138   | 5,600           | 31     |
| SC-N10 | 25,000       | 113   | 5,600           | 25     |
| SC-N11 | 38,000       | 126   | 8,000           | 27     |
| SC-N12 | 40,000       | 100   | 8,500           | 21     |
| SC-N14 | 62,000       | 103   | 13,000          | 21     |
| SC-N16 | 69,000       | 86    | 14,600          | 18     |

Notes: Ie: Rated operational current (A)  
 Ip, Ip': Peak current (A)  
 Ip/Ie, Ip'/Ie: Multiple of rated operational current (at 220V AC)

# 1 Contactors and Starters

## 1-3 Performance and characteristics

### 1-3-7 Operating characteristics

#### (1) Pick-up and drop-out voltage

The contactor shall operate correctly at 85% of the coil's rated voltage when the temperature has reached a constant value following the temperature rise test.

• **Test condition**

Ambient temperature: 20°C

On-Off operation: 20 operations

Coil ratings

- SC-03 to 5-1, SC-N1 to N4  
200V AC (200V, 50Hz/200–220V 60Hz)
- SC-03/G to N3/G  
200V DC
- SC-N5 to N16  
200V (200–250V AC, 50/60Hz, 200–240V DC)

| Type     | Frequency (Hz) | Pick-up voltage (V) | Drop-out voltage (V) | Exciting current (mA) | Watt loss (W) | Remarks                 |         |
|----------|----------------|---------------------|----------------------|-----------------------|---------------|-------------------------|---------|
| SC-03    | 50             | 105–125             | 70–98                | 40–52                 | 2.3–3.3       | 50Hz/60Hz<br>common use |         |
|          | 60             | 116–136             | 80–110               | 35–47                 | 2.3–3.3       |                         |         |
| SC-0     | 50             | 105–125             | 70–98                | 40–52                 | 2.3–3.3       |                         |         |
|          | 60             | 116–136             | 80–110               | 35–47                 | 2.3–3.3       |                         |         |
| SC-05    | 50             | 105–125             | 7–98                 | 40–52                 | 2.3–3.3       |                         |         |
|          | 60             | 116–136             | 80–110               | 35–47                 | 2.3–3.3       |                         |         |
| SC-4-0   | 50             | 118–136             | 75–106               | 42–53                 | 2.3–3.3       |                         |         |
|          | 60             | 130–146             | 88–120               | 37–48                 | 2.3–3.3       |                         |         |
| SC-4-1   | 50             | 118–136             | 75–106               | 42–53                 | 2.3–3.3       |                         |         |
|          | 60             | 130–146             | 88–120               | 37–48                 | 2.3–3.3       |                         |         |
| SC-5-1   | 50             | 118–136             | 75–106               | 42–53                 | 2.3–3.3       |                         |         |
|          | 60             | 130–146             | 88–120               | 37–48                 | 2.3–3.3       |                         |         |
| SC-03/G  | DC             | 88–124              | 24–52                | 35                    | 7             |                         | DC coil |
| SC-0/G   | DC             | 88–124              | 24–52                | 35                    | 7             |                         |         |
| SC-05/G  | DC             | 86–122              | 28–56                | 35                    | 7             |                         |         |
| SC-4-0/G | DC             | 92–128              | 28–56                | 35                    | 7             |                         |         |
| SC-4-1/G | DC             | 92–128              | 28–56                | 35                    | 7             |                         |         |
| SC-5-1/G | DC             | 92–130              | 30–60                | 35                    | 7             |                         |         |
| SC-N1/G  | DC             | 80–120              | 30–70                | 45                    | 9             |                         |         |
| SC-N2/G  | DC             | 80–120              | 30–70                | 45                    | 9             |                         |         |
| SC-N2S/G | DC             | 80–120              | 24–60                | 60                    | 12            |                         |         |
| SC-N3/G  | DC             | 80–120              | 24–60                | 60                    | 12            |                         |         |
| SC-N1    | 50             | 110–130             | 75–105               | 56–69                 | 2.7–4.5       | 50Hz/60Hz<br>common use |         |
|          | 60             | 120–140             | 85–115               | 49–61                 | 2.7–4.5       |                         |         |
| SC-N2    | 50             | 110–130             | 75–105               | 56–69                 | 2.7–4.5       |                         |         |
|          | 60             | 120–140             | 85–115               | 49–61                 | 2.7–4.5       |                         |         |
| SC-N2S   | 50             | 115–135             | 85–110               | 60–75                 | 3.6–6         |                         |         |
|          | 60             | 130–150             | 100–125              | 61–76                 | 3.6–6         |                         |         |
| SC-N3    | 50             | 115–135             | 85–110               | 60–75                 | 3.6–6         |                         |         |
|          | 60             | 130–150             | 100–125              | 61–76                 | 3.6–6         |                         |         |
| SC-N4    | 50             | 120–140             | 70–95                | 65–80                 | 3.8–6.3       |                         |         |
|          | 60             | 135–155             | 95–120               | 66–81                 | 3.8–6.3       |                         |         |

Note: The exciting current and watt loss are those when sealed with applied voltage of 200V AC (for 50Hz), 220V AC (for 60Hz).

| Type             | Frequency (Hz) | Pick-up voltage (V) | Drop-out voltage (V) | Exciting current (mA) | Watt loss (W)      | Remarks                                       |
|------------------|----------------|---------------------|----------------------|-----------------------|--------------------|---|
| <b>SC-N5</b>     | 50-60<br>DC    | 140–150<br>140–160  | 60–100<br>40–100     | 18–23<br>12–15        | 2.6–4.3<br>2.5–3.5 | With SUPER<br>MAGNET<br>(AC/DC common<br>use) |
| <b>SC-N6</b>     | 50-60<br>DC    | 140–150<br>140–160  | 60–100<br>40–100     | 22–28<br>14–18        | 2.7–4.4<br>2.8–4.2 |   |
| <b>SC-N7</b>     | 50-60<br>DC    | 140–150<br>140–160  | 60–100<br>40–100     | 22–28<br>14–18        | 2.7–4.4<br>2.8–4.2 |   |
| <b>SC-N8</b>     | 50-60<br>DC    | 140–150<br>140–160  | 60–100<br>40–100     | 25–33<br>19–23        | 3.8–6.0<br>3.7–5.5 |   |
| <b>SC-N10</b>    | 50-60<br>DC    | 140–150<br>140–160  | 60–100<br>40–100     | 25–33<br>19–23        | 3.8–6.0<br>3.7–5.5 |   |
| <b>SC-N11</b>    | 50-60<br>DC    | 140–150<br>140–160  | 60–100<br>40–100     | 27–34<br>20–24        | 4.5–6.9<br>3.9–5.8 |   |
| <b>SC-N12</b>    | 50-60<br>DC    | 140–150<br>140–160  | 60–100<br>40–100     | 27–34<br>21–24        | 4.5–6.9<br>3.9–5.8 |   |
| <b>SC-N14</b>    | 50-60<br>DC    | 140–160<br>140–160  | 60–100<br>40–100     | 41–52<br>35–43        | 6.2–9.5<br>6.8–9.5 |   |
| <b>SC-N16</b>    | 50-60<br>DC    | 140–160<br>140–160  | 60–100<br>40–100     | 41–52<br>35–43        | 6.2–9.5<br>6.8–9.5 |   |
| <b>SC-N1/SE</b>  | 50-60<br>DC    | 140–150<br>140–160  | 60–100<br>40–100     | 18–19<br>12.5         | 2.8–3.2<br>1       |   |
| <b>SC-N2/SE</b>  | 50-60<br>DC    | 140–150<br>140–160  | 60–100<br>40–100     | 18–19<br>12.5         | 2.8–3.2<br>1       |   |
| <b>SC-N2S/SE</b> | 50-60<br>DC    | 140–150<br>140–160  | 60–100<br>40–100     | 18–19<br>12.5         | 2.9–3.3<br>1       |   |
| <b>SC-N3/SE</b>  | 50-60<br>DC    | 140–150<br>140–160  | 60–100<br>40–100     | 18–19<br>12.5         | 2.9–3.3<br>1       |   |
| <b>SC-N4/SE</b>  | 50-60<br>DC    | 140–150<br>140–160  | 60–100<br>40–100     | 20–21<br>14           | 3.2–3.6<br>1       |   |

Notes: • The exciting current and watt loss are those when sealed with applied voltage of 200V AC (for 50Hz), 220V AC (for 60Hz), or 220V DC (models N5 to N16).  
 • A three-phase full-wave rectified DC power supply is used for models N5 to N16.

## (2) Abrupt voltage drop characteristics

Standard type contactors are designed to operate correctly at 85% of their coil's rated voltage.

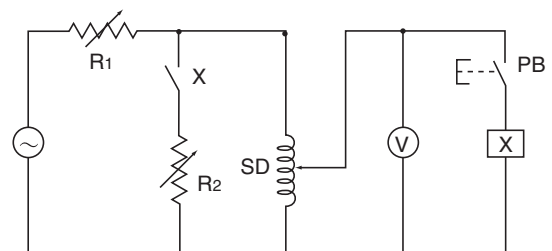
If there is no margin in power source capacity, the operating voltage will abruptly drop due to inrush current at the moment the contacts close.

If the operating voltage drops below the sealed voltage of the contactor, the contacts will not close completely. Since the contactor makes and breaks the inrush current in an extremely short period of time, contact welding is likely under these conditions.

### (a) Test Condition

Confirm that the contactor operates normally with no contact weld when the rated voltage is applied to the tested contactor (X) and the applied voltage suddenly drops to 75% (65% for N5 models or higher) of the coil's rated voltage when the main contacts close.

**Fig. 3 Test circuit (for AC)**



R1, R2: Variable resistor      X: Tested contactor  
 SD: Auto transformer      PB: Pushbutton switch  
 V: Voltmeter

# 1 Contactors and Starters

## 1-3 Performance and characteristics

### (b) Test result

| Type           |             | Test condition   |   | Test result     |
|----------------|-------------|--|---|-----------------|
|                |             | Coil applied voltage before contactor close (V) (60Hz) | Coil applied voltage immediately after contactor close (V) (60Hz) |                 |
| AC operated    | SC-03       | 200  | 150   | No contact weld |
|                | SC-0        | 200  | 150   |                 |
|                | SC-05       | 200  | 150   |                 |
|                | SC-4-0      | 200  | 150   |                 |
|                | SC-4-1      | 200  | 150   |                 |
|                | SC-5-1      | 200  | 150   |                 |
| DC operated    | SC-03/G     | 200 (DC)   | 150 (DC)  | No contact weld |
|                | SC-0/G      | 200 (DC)   | 150 (DC)  |                 |
|                | SC-05/G     | 200 (DC)   | 150 (DC)  |                 |
|                | SC-4-0/G    | 200 (DC)   | 150 (DC)  |                 |
|                | SC-4-1/G    | 200 (DC)   | 150 (DC)  |                 |
|                | SC-5-1/G    | 200 (DC)   | 150 (DC)  |                 |
| AC operated    | SC-N1       | 200  | 150   | No contact weld |
|                | SC-N2       | 200  | 150   |                 |
|                | SC-N2S      | 200  | 150   |                 |
|                | SC-N3       | 200  | 150   |                 |
|                | SC-N4       | 200  | 150   |                 |
| AC/DC operated | SC-N5       | 200  | 130   | No contact weld |
|                | SC-N6       | 200  | 130   |                 |
|                | SC-N7       | 200  | 130   |                 |
|                | SC-N8       | 200  | 130   |                 |
|                | SC-N10      | 200  | 130   |                 |
|                | SC-N11      | 200  | 130   |                 |
|                | SC-N12      | 200  | 130   |                 |
|                | SC-N14      | 200  | 130   |                 |
|                | SC-N16      | 200  | 130   |                 |
|                | DC operated | SC-N1/G  | 200 (DC)  |                 |
| SC-N2/G        |             | 200 (DC)   | 150 (DC)  |                 |
| SC-N2S/G       |             | 200 (DC)   | 150 (DC)  |                 |
| SC-N3/G        |             | 200 (DC)   | 150 (DC)  |                 |
| AC/DC operated | SC-N1/SE    | 200  | 130   | No contact weld |
|                | SC-N2/SE    | 200  | 130   |                 |
|                | SC-N2S/SE   | 200  | 130   |                 |
|                | SC-N3/SE    | 200  | 130   |                 |
|                | SC-N4/SE    | 200  | 130   |                 |

Note: Coil ratings:

- SC-03 to 5-1, SC-N1 to N4  
200V AC (200V 50Hz/200–220V 60Hz)
- SC-N5 to N16  
200V (200–250V AC 50/60Hz, 200–240V DC)
- SC-03/G to 5-1/G, SC-N1/G to N3/G  
200V DC
- SC-N1/SE to N4/SE  
200V (200–250V AC 50/60Hz, 200–240V DC)

**(3) Operating time**

**(a) Coil ratings: 100V**

| Type      | Voltage (V) | Frequency (Hz) | Pick-up time (ms) |                        |                        | Drop-out time (ms) |                        |                        | Auxiliary contact arrangement  |
|-----------|-------------|----------------|-------------------|------------------------|------------------------|--------------------|------------------------|------------------------|--------------------------------|
|           |             |                | Main contact      | Auxiliary NO contact * | Auxiliary NC contact * | Main contact       | Auxiliary NO contact * | Auxiliary NC contact * |                                |
| SC-03     | 100         | 50             | 9-20              | 9-20                   | 5-14                   | 5-16               | 5-16                   | 8-19                   | 1NO, 1NC                       |
|           | 110         | 60             | 8-18              | 8-18                   | 5-14                   | 5-16               | 5-16                   | 8-19                   |                                |
| SC-0      | 100         | 50             | 9-20              | 9-20                   | 5-14                   | 5-16               | 5-16                   | 8-19                   | 1NO, 1NC                       |
|           | 110         | 60             | 8-18              | 8-18                   | 5-14                   | 5-16               | 5-16                   | 8-19                   |                                |
| SC-05     | 100         | 50             | 9-20              | 9-20                   | 5-14                   | 5-16               | 5-16                   | 8-19                   | 1NO+1NC                        |
|           | 110         | 60             | 8-18              | 8-18                   | 5-14                   | 5-16               | 5-16                   | 8-19                   |                                |
| SC-4-0    | 100         | 50             | 9-20              | 9-20                   | 5-14                   | 5-16               | 5-16                   | 8-19                   | 1NO, 1NC                       |
|           | 110         | 60             | 8-18              | 8-18                   | 5-14                   | 5-16               | 5-16                   | 8-19                   |                                |
| SC-4-1    | 100         | 50             | 9-20              | 9-20                   | 5-14                   | 5-16               | 5-16                   | 8-19                   | 1NO, 1NC                       |
|           | 110         | 60             | 8-18              | 8-18                   | 5-14                   | 5-16               | 5-16                   | 8-19                   |                                |
| SC-5-1    | 100         | 50             | 9-20              | 9-20                   | 5-14                   | 5-16               | 5-16                   | 8-19                   | 1NO+1NC                        |
|           | 110         | 60             | 8-18              | 8-18                   | 5-14                   | 5-16               | 5-16                   | 8-19                   |                                |
| SC-N1     | 100         | 50             | 10-17             | 10-17                  | 6-14                   | 6-16               | 4-15                   | 9-17                   | 2NO+2NC                        |
|           | 110         | 60             | 11-18             | 11-18                  | 7-17                   | 7-17               | 4-16                   | 9-19                   |                                |
| SC-N2     | 100         | 50             | 10-17             | 10-17                  | 6-14                   | 6-16               | 4-15                   | 9-17                   | 2NO+2NC                        |
|           | 110         | 60             | 11-18             | 11-18                  | 7-17                   | 7-17               | 4-16                   | 9-19                   |                                |
| SC-N2S    | 100         | 50             | 10-18             | 11-19                  | 8-15                   | 8-18               | 5-13                   | 8-20                   | 2NO+2NC                        |
|           | 110         | 60             | 12-21             | 13-22                  | 9-15                   | 5-14               | 5-13                   | 8-20                   |                                |
| SC-N3     | 100         | 50             | 10-18             | 11-19                  | 8-15                   | 8-18               | 5-13                   | 8-20                   | 2NO+2NC                        |
|           | 110         | 60             | 12-21             | 13-22                  | 9-15                   | 5-14               | 5-13                   | 8-20                   |                                |
| SC-N4     | 100         | 50             | 16-23             | 14-23                  | 11-19                  | 7-17               | 7-17                   | 9-20                   | 2NO+2NC                        |
|           | 110         | 60             | 18-27             | 16-25                  | 13-22                  | 6-16               | 7-17                   | 9-20                   |                                |
| SC-N5     | 100         | AC-DC          | 39-45             | 40-46                  | 37-43                  | 27-33              | 27-33                  | 30-36                  | 2NO+2NC                        |
| SC-N6     | 100         | AC-DC          | 31-37             | 30-36                  | 28-34                  | 30-36              | 31-37                  | 34-41                  | 2NO+2NC                        |
| SC-N7     | 100         | AC-DC          | 31-37             | 30-36                  | 28-34                  | 30-36              | 31-37                  | 34-41                  | 2NO+2NC                        |
| SC-N8     | 100         | AC-DC          | 38-44             | 35-41                  | 32-38                  | 31-37              | 33-39                  | 34-44                  | 2NO+2NC                        |
| SC-N10    | 100         | AC-DC          | 38-44             | 35-41                  | 32-38                  | 31-37              | 33-39                  | 34-44                  | 2NO+2NC                        |
| SC-N11    | 100         | AC-DC          | 43-49             | 40-46                  | 37-43                  | 41-47              | 42-49                  | 44-54                  | 2NO+2NC                        |
| SC-N12    | 100         | AC-DC          | 43-49             | 40-46                  | 37-43                  | 41-47              | 42-49                  | 44-54                  | 2NO+2NC                        |
| SC-N14    | 100         | AC-DC          | 69-75             | 68-75                  | 55-70                  | 56-62              | 56-63                  | 61-68                  | 2NO+2NC                        |
| SC-N16    | 100         | AC-DC          | 69-75             | 68-75                  | 55-70                  | 56-62              | 56-63                  | 61-68                  | 2NO+2NC                        |
| SC-N1/SE  | 100         | AC-DC          | 21-27             | 22-27                  | 18-27                  | 18-24              | 17-24                  | 21-26                  | 2NO+2NC                        |
| SC-N2/SE  | 100         | AC-DC          | 21-27             | 22-27                  | 18-27                  | 18-24              | 17-24                  | 21-26                  | 2NO+2NC                        |
| SC-N2S/SE | 100         | AC-DC          | 24-30             | 25-32                  | 20-28                  | 24-32              | 24-31                  | 27-34                  | 2NO+2NC                        |
| SC-N3/SE  | 100         | AC-DC          | 24-30             | 25-32                  | 20-28                  | 24-32              | 24-31                  | 27-34                  | 2NO+2NC                        |
| SC-N4/SE  | 100         | AC-DC          | 39-45             | 40-46                  | 37-43                  | 27-33              | 27-33                  | 30-36                  | 2NO+2NC                        |
| SC-03/G   | 100         | DC             | 43-47             | 43-47                  | 35-39                  | 10-24              | 21-23                  | 28-30                  | 1NO, 1NC                       |
| SC-0/G    | 100         | DC             | 43-47             | 43-47                  | 35-39                  | 10-24              | 21-23                  | 28-30                  | 1NO, 1NC                       |
| SC-05/G   | 100         | DC             | 43-47             | 43-48                  | 35-40                  | 10-24              | 21-23                  | 28-30                  | 2NO, 2NC<br>1NO+1NC            |
| SC-4-0/G  | 100         | DC             | 44-48             | 45-50                  | 37-43                  | 10-25              | 21-23                  | 25-29                  | 1NO, 1NC                       |
| SC-4-1/G  | 100         | DC             | 44-48             | 45-50                  | 37-43                  | 10-25              | 21-23                  | 25-29                  | 1NO, 1NC                       |
| SC-5-1/G  | 100         | DC             | 45-49             | 46-51                  | 38-43                  | 10-26              | 21-24                  | 25-30                  | 2NO, 2NC<br>1NO+1NC<br>2NO+2NC |
| SC-N1/G   | 100         | DC             | 40-50             | 42-52                  | 35-45                  | 8-17               | 6-15                   | 12-21                  | 2NO+2NC                        |
| SC-N2/G   | 100         | DC             | 40-50             | 42-52                  | 35-45                  | 8-17               | 6-15                   | 12-21                  | 2NO+2NC                        |
| SC-N2S/G  | 100         | DC             | 60-70             | 61-71                  | 52-62                  | 14-21              | 12-20                  | 17-24                  | 2NO+2NC                        |
| SC-N3/G   | 100         | DC             | 60-70             | 61-71                  | 52-62                  | 14-21              | 12-20                  | 17-24                  | 2NO+2NC                        |

Notes: • Coil ratings:  
 SC-03 to 5-1, SC-N1 to N4 100V AC (100V AC 50Hz/100-110V 60Hz)  
 SC-N5 to N16 100V (100-127V AC 50/60Hz, 100-120V DC)  
 • A three-phase full-wave rectified DC power supply is used for models N5 to N16.

\* NO: Normally open  
 NC: Normally closed

# 1 Contactors and Starters

## 1-3 Performance and characteristics

### (b) Coil ratings: 200V

| Type             | Voltage (V) | Frequency (Hz) | Pick-up time (ms) |                        |                        | Drop-out time (ms) |                        |                        | Auxiliary contact arrangement  |
|------------------|-------------|----------------|-------------------|------------------------|------------------------|--------------------|------------------------|------------------------|--------------------------------|
|                  |             |                | Main contact      | Auxiliary NO contact * | Auxiliary NC contact * | Main contact       | Auxiliary NO contact * | Auxiliary NC contact * |                                |
| <b>SC-03</b>     | 200<br>220  | 50<br>60       | 9-20<br>8-18      | 9-20<br>8-18           | 5-14<br>5-14           | 5-16<br>5-16       | 5-16<br>5-16           | 8-19<br>8-19           | 1NO, 1NC                       |
| <b>SC-0</b>      | 200<br>220  | 50<br>60       | 9-20<br>8-18      | 9-20<br>8-18           | 5-14<br>5-14           | 5-16<br>5-16       | 5-16<br>5-16           | 8-19<br>8-19           | 1NO, 1NC                       |
| <b>SC-05</b>     | 200<br>220  | 50<br>60       | 9-20<br>8-18      | 9-20<br>8-18           | 5-14<br>5-14           | 5-16<br>5-16       | 5-16<br>5-16           | 8-19<br>8-19           | 1NO+1NC                        |
| <b>SC-4-0</b>    | 200<br>220  | 50<br>60       | 9-20<br>8-18      | 9-20<br>8-18           | 5-14<br>5-14           | 5-16<br>5-16       | 5-16<br>5-16           | 8-19<br>8-19           | 1NO, 1NC                       |
| <b>SC-4-1</b>    | 200<br>220  | 50<br>60       | 9-20<br>8-18      | 9-20<br>8-18           | 5-14<br>5-14           | 5-16<br>5-16       | 5-16<br>5-16           | 8-19<br>8-19           | 1NO, 1NC                       |
| <b>SC-5-1</b>    | 200<br>220  | 50<br>60       | 9-20<br>8-18      | 9-20<br>8-18           | 5-14<br>5-14           | 5-16<br>5-16       | 5-16<br>5-16           | 8-19<br>8-19           | 1NO+1NC                        |
| <b>SC-N1</b>     | 200<br>220  | 50<br>60       | 10-17<br>11-18    | 10-17<br>11-18         | 6-14<br>7-17           | 6-13<br>7-17       | 4-12<br>4-12           | 9-17<br>9-19           | 2NO+2NC                        |
| <b>SC-N2</b>     | 200<br>220  | 50<br>60       | 10-17<br>11-18    | 10-17<br>11-18         | 6-14<br>7-17           | 6-13<br>7-17       | 4-12<br>4-12           | 9-17<br>9-19           | 2NO+2NC                        |
| <b>SC-N2S</b>    | 200<br>220  | 50<br>60       | 10-18<br>12-21    | 11-19<br>13-22         | 8-15<br>9-15           | 8-18<br>5-14       | 5-13<br>5-13           | 8-20<br>8-20           | 2NO+2NC                        |
| <b>SC-N3</b>     | 200<br>220  | 50<br>60       | 10-18<br>12-21    | 11-19<br>13-22         | 8-15<br>9-15           | 8-18<br>5-14       | 5-13<br>5-13           | 8-20<br>8-20           | 2NO+2NC                        |
| <b>SC-N4</b>     | 200<br>220  | 50<br>60       | 16-23<br>18-27    | 14-23<br>16-25         | 11-19<br>13-22         | 7-17<br>6-16       | 7-17<br>7-17           | 9-20<br>9-20           | 2NO+2NC                        |
| <b>SC-N5</b>     | 200         | AC-DC          | 39-45             | 40-46                  | 37-43                  | 27-33              | 27-33                  | 30-36                  | 2NO+2NC                        |
| <b>SC-N6</b>     | 200         | AC-DC          | 31-37             | 30-36                  | 28-34                  | 30-36              | 31-37                  | 34-41                  | 2NO+2NC                        |
| <b>SC-N7</b>     | 200         | AC-DC          | 31-37             | 30-36                  | 28-34                  | 30-36              | 31-37                  | 34-41                  | 2NO+2NC                        |
| <b>SC-N8</b>     | 200         | AC-DC          | 38-44             | 35-41                  | 32-38                  | 31-37              | 33-39                  | 34-44                  | 2NO+2NC                        |
| <b>SC-N10</b>    | 200         | AC-DC          | 38-44             | 35-41                  | 32-38                  | 31-37              | 33-39                  | 34-44                  | 2NO+2NC                        |
| <b>SC-N11</b>    | 200         | AC-DC          | 43-49             | 40-46                  | 37-43                  | 41-47              | 42-49                  | 44-54                  | 2NO+2NC                        |
| <b>SC-N12</b>    | 200         | AC-DC          | 43-49             | 40-46                  | 37-43                  | 41-47              | 42-49                  | 44-54                  | 2NO+2NC                        |
| <b>SC-N14</b>    | 200         | AC-DC          | 69-75             | 68-75                  | 55-70                  | 56-62              | 56-63                  | 61-68                  | 2NO+2NC                        |
| <b>SC-N16</b>    | 200         | AC-DC          | 69-75             | 68-75                  | 55-70                  | 56-62              | 56-63                  | 61-68                  | 2NO+2NC                        |
| <b>SC-N1/SE</b>  | 200         | AC-DC          | 21-27             | 22-27                  | 18-27                  | 18-24              | 17-24                  | 21-26                  | 2NO+2NC                        |
| <b>SC-N2/SE</b>  | 200         | AC-DC          | 21-27             | 22-27                  | 18-27                  | 18-24              | 17-24                  | 21-26                  | 2NO+2NC                        |
| <b>SC-N2S/SE</b> | 200         | AC-DC          | 24-30             | 25-32                  | 20-28                  | 24-32              | 24-31                  | 27-34                  | 2NO+2NC                        |
| <b>SC-N3/SE</b>  | 200         | AC-DC          | 24-30             | 25-32                  | 20-28                  | 24-32              | 24-31                  | 27-34                  | 2NO+2NC                        |
| <b>SC-N4/SE</b>  | 200         | AC-DC          | 39-45             | 40-46                  | 37-43                  | 27-33              | 27-33                  | 30-36                  | 2NO+2NC                        |
| <b>SC-03/G</b>   | 200         | DC             | 43-47             | 43-47                  | 35-39                  | 10-24              | 21-23                  | 28-30                  | 1NO, 1NC                       |
| <b>SC-0/G</b>    | 200         | DC             | 43-47             | 43-47                  | 35-39                  | 10-24              | 21-23                  | 28-30                  | 1NO, 1NC                       |
| <b>SC-05/G</b>   | 200         | DC             | 43-47             | 43-48                  | 35-40                  | 10-24              | 21-23                  | 28-30                  | 2NO, 2NC<br>1NO+1NC            |
| <b>SC-4-0/G</b>  | 200         | DC             | 44-48             | 45-50                  | 37-43                  | 10-25              | 21-23                  | 25-29                  | 1NO, 1NC                       |
| <b>SC-4-1/G</b>  | 200         | DC             | 44-48             | 45-50                  | 37-43                  | 10-25              | 21-23                  | 25-29                  | 1NO, 1NC                       |
| <b>SC-5-1/G</b>  | 200         | DC             | 45-49             | 46-51                  | 38-43                  | 10-26              | 21-24                  | 25-30                  | 2NO, 2NC<br>1NO+1NC<br>2NC+2NC |
| <b>SC-N1/G</b>   | 200         | DC             | 40-50             | 42-52                  | 35-45                  | 8-17               | 6-15                   | 12-21                  | 2NO+2NC                        |
| <b>SC-N2/G</b>   | 200         | DC             | 40-50             | 42-52                  | 35-45                  | 8-17               | 6-15                   | 12-21                  | 2NO+2NC                        |
| <b>SC-N2S/G</b>  | 200         | DC             | 60-70             | 61-71                  | 52-62                  | 14-21              | 12-20                  | 17-24                  | 2NO+2NC                        |
| <b>SC-N3/G</b>   | 200         | DC             | 60-70             | 61-71                  | 52-62                  | 14-21              | 12-20                  | 17-24                  | 2NO+2NC                        |

Notes: • Coil ratings:  
 SC-03 to 5-1, SC-N1 to N4 200V AC (200V AC 50Hz/200-220V 60Hz)  
 SC-N5 to N16 200V (200-250V AC 50/60Hz, 200-240V DC)  
 • A three-phase full-wave rectified DC power supply is used for models N5 to N16.

\* NO: Normally open  
 NC: Normally closed

### 1-3-8 Coil characteristics

#### (1) AC operated

##### (a) Coil ratings: 100V

| Type      | Voltage (V) | Frequency (Hz) | Power consumption (VA) |        | Exciting current (mA) | Watt loss (W) | Power factor (cos $\phi$ ) |
|-----------|-------------|----------------|------------------------|--------|-----------------------|---------------|----------------------------|
|           |             |                | Inrush                 | Sealed | Sealed                | Sealed        | Sealed                     |
| SC-03     | 100         | 50             | 90                     | 9      | 90                    | 2.7           | 0.32                       |
|           | 110         | 60             | 95                     | 9      | 80                    | 2.8           |                            |
| SC-0      | 100         | 50             | 90                     | 9      | 90                    | 2.7           | 0.32                       |
|           | 110         | 60             | 95                     | 9      | 80                    | 2.8           |                            |
| SC-05     | 100         | 50             | 90                     | 9      | 90                    | 2.7           | 0.32                       |
|           | 110         | 60             | 95                     | 9      | 80                    | 2.8           |                            |
| SC-4-0    | 100         | 50             | 90                     | 9      | 90                    | 2.7           | 0.32                       |
|           | 110         | 60             | 95                     | 9      | 80                    | 2.8           |                            |
| SC-4-1    | 100         | 50             | 90                     | 9      | 90                    | 2.7           | 0.32                       |
|           | 110         | 60             | 95                     | 9      | 80                    | 2.8           |                            |
| SC-5-1    | 100         | 50             | 90                     | 9      | 90                    | 2.7           | 0.32                       |
|           | 110         | 60             | 95                     | 9      | 80                    | 2.8           |                            |
| SC-N1     | 100         | 50             | 120                    | 12.7   | 127                   | 3.6           | 0.29                       |
|           | 110         | 60             | 135                    | 12.4   | 113                   | 3.8           |                            |
| SC-N2     | 100         | 50             | 120                    | 12.7   | 127                   | 3.6           | 0.29                       |
|           | 110         | 60             | 135                    | 12.4   | 113                   | 3.8           |                            |
| SC-N2S    | 100         | 50             | 180                    | 13.3   | 133                   | 4.5           | 0.34                       |
|           | 110         | 60             | 190                    | 13.4   | 122                   | 5             |                            |
| SC-N3     | 100         | 50             | 180                    | 13.3   | 133                   | 4.5           | 0.34                       |
|           | 110         | 60             | 190                    | 13.4   | 122                   | 5             |                            |
| SC-N4     | 100         | 50             | 200                    | 14.3   | 143                   | 4.8           | 0.34                       |
|           | 110         | 60             | 210                    | 14.4   | 131                   | 5.3           |                            |
| SC-N5     | 100         | 50             | 85                     | 2.8    | 28                    | 2.2           | 0.8                        |
|           | 110         | 60             | 100                    | 3.2    | 29                    | 2.3           |                            |
| SC-N6     | 100         | 50             | 175                    | 3.1    | 31                    | 2.6           | 0.84                       |
|           | 110         | 60             | 220                    | 3.6    | 33                    | 2.8           |                            |
| SC-N7     | 100         | 50             | 175                    | 3.1    | 31                    | 2.6           | 0.84                       |
|           | 110         | 60             | 220                    | 3.6    | 33                    | 2.8           |                            |
| SC-N8     | 100         | 50             | 205                    | 3.9    | 39                    | 3.3           | 0.84                       |
|           | 110         | 60             | 260                    | 4.4    | 41                    | 3.6           |                            |
| SC-N10    | 100         | 50             | 205                    | 3.9    | 39                    | 3.3           | 0.84                       |
|           | 110         | 60             | 260                    | 4.4    | 41                    | 3.6           |                            |
| SC-N11    | 100         | 50             | 200                    | 3.6    | 36                    | 3.1           | 0.88                       |
|           | 110         | 60             | 255                    | 4.2    | 38                    | 3.4           |                            |
| SC-N12    | 100         | 50             | 200                    | 3.6    | 36                    | 3.1           | 0.88                       |
|           | 110         | 60             | 255                    | 4.2    | 38                    | 3.4           |                            |
| SC-N14    | 100         | 50             | 410                    | 5.2    | 52                    | 4.7           | 0.9                        |
|           | 110         | 60             | 470                    | 5.3    | 53                    | 5             |                            |
| SC-N16    | 100         | 50             | 410                    | 5.2    | 52                    | 4.7           | 0.9                        |
|           | 110         | 60             | 470                    | 5.3    | 53                    | 5             |                            |
| SC-N1/SE  | 100         | 50             | 120                    | 2.8    | 28                    | 2.1           | 0.75                       |
|           | 110         | 60             | 145                    | 3.2    | 29                    | 2.3           |                            |
| SC-N2/SE  | 100         | 50             | 120                    | 2.8    | 28                    | 2.1           | 0.75                       |
|           | 110         | 60             | 145                    | 3.2    | 29                    | 2.3           |                            |
| SC-N2S/SE | 100         | 50             | 145                    | 2.7    | 27                    | 2             | 0.74                       |
|           | 110         | 60             | 180                    | 3.1    | 28.5                  | 2.3           |                            |
| SC-N3/SE  | 100         | 50             | 145                    | 2.7    | 27                    | 2             | 0.74                       |
|           | 110         | 60             | 180                    | 3.1    | 28.5                  | 2.3           |                            |
| SC-N4/SE  | 100         | 50             | 85                     | 2.8    | 28                    | 2.2           | 0.8                        |
|           | 110         | 60             | 100                    | 3.2    | 29                    | 2.3           |                            |

Note: Coil ratings:

- SC-03 to 5-1, SC-N1 to N4 100V AC (100V 50Hz/100–110V 60Hz)
- SC-N5 to N16, SC-N1/SE to N4/SE 100V (100–127V AC 50/60Hz, 100–120V DC)

# 1 Contactors and Starters

## 1-3 Performance and characteristics

### (b) Coil ratings: 200V

| Type      | Voltage (V) | Frequency (Hz) | Power consumption (VA) |        | Exciting current (mA) | Watt loss (W) | Power factor (cos $\phi$ ) |
|-----------|-------------|----------------|------------------------|--------|-----------------------|---------------|----------------------------|
|           |             |                | Inrush                 | Sealed | Sealed                | Sealed        | Sealed                     |
| SC-03     | 200         | 50             | 90                     | 9      | 45                    | 2.7           | 0.32                       |
|           | 220         | 60             | 95                     | 9      | 40                    | 2.8           |                            |
| SC-0      | 200         | 50             | 90                     | 9      | 45                    | 2.7           | 0.32                       |
|           | 220         | 60             | 95                     | 9      | 40                    | 2.8           |                            |
| SC-05     | 200         | 50             | 90                     | 9      | 45                    | 2.7           | 0.32                       |
|           | 220         | 60             | 95                     | 9      | 40                    | 2.8           |                            |
| SC-4-0    | 200         | 50             | 90                     | 9      | 45                    | 2.7           | 0.32                       |
|           | 220         | 60             | 95                     | 9      | 40                    | 2.8           |                            |
| SC-4-1    | 200         | 50             | 90                     | 9      | 45                    | 2.7           | 0.32                       |
|           | 220         | 60             | 95                     | 9      | 40                    | 2.8           |                            |
| SC-5-1    | 200         | 50             | 90                     | 9      | 45                    | 2.7           | 0.32                       |
|           | 220         | 60             | 95                     | 9      | 40                    | 2.8           |                            |
| SC-N1     | 200         | 50             | 120                    | 12.7   | 63.5                  | 3.6           | 0.29                       |
|           | 220         | 60             | 135                    | 12.4   | 56.3                  | 3.8           |                            |
| SC-N2     | 200         | 50             | 120                    | 12.7   | 63.5                  | 3.6           | 0.29                       |
|           | 220         | 60             | 135                    | 12.4   | 56.3                  | 3.8           |                            |
| SC-N2S    | 200         | 50             | 180                    | 13.3   | 66.5                  | 4.5           | 0.34                       |
|           | 220         | 60             | 190                    | 13.4   | 67                    | 5             |                            |
| SC-N3     | 200         | 50             | 180                    | 13.3   | 66.5                  | 4.5           | 0.34                       |
|           | 220         | 60             | 190                    | 13.4   | 67                    | 5             |                            |
| SC-N4     | 200         | 50             | 200                    | 14.3   | 71.5                  | 4.8           | 0.34                       |
|           | 220         | 60             | 210                    | 14.4   | 72                    | 5.3           |                            |
| SC-N5     | 200         | 50             | 85                     | 4      | 20                    | 3.2           | 0.8                        |
|           | 220         | 60             | 95                     | 4.6    | 21                    | 3.6           |                            |
| SC-N6     | 200         | 50             | 190                    | 4.9    | 25                    | 3.4           | 0.7                        |
|           | 220         | 60             | 230                    | 5.8    | 26                    | 3.7           |                            |
| SC-N7     | 200         | 50             | 190                    | 4.9    | 25                    | 3.4           | 0.7                        |
|           | 220         | 60             | 230                    | 5.8    | 26                    | 3.7           |                            |
| SC-N8     | 200         | 50             | 200                    | 5.4    | 28                    | 4.7           | 0.84                       |
|           | 220         | 60             | 255                    | 6.2    | 30                    | 5.2           |                            |
| SC-N10    | 200         | 50             | 200                    | 5.4    | 28                    | 4.7           | 0.84                       |
|           | 220         | 60             | 255                    | 6.2    | 30                    | 5.2           |                            |
| SC-N11    | 200         | 50             | 240                    | 5.7    | 30                    | 5.6           | 0.93                       |
|           | 220         | 60             | 320                    | 6.5    | 31                    | 6             |                            |
| SC-N12    | 200         | 50             | 240                    | 5.7    | 30                    | 5.6           | 0.93                       |
|           | 220         | 60             | 320                    | 6.5    | 31                    | 6             |                            |
| SC-N14    | 200         | 50             | 400                    | 9.3    | 46                    | 7.8           | 0.85                       |
|           | 220         | 60             | 460                    | 11     | 47                    | 8.6           |                            |
| SC-N16    | 200         | 50             | 400                    | 9.3    | 46                    | 7.8           | 0.85                       |
|           | 220         | 60             | 460                    | 11     | 47                    | 8.6           |                            |
| SC-N1/SE  | 200         | 50             | 105                    | 3.5    | 18                    | 2.8           | 0.77                       |
|           | 220         | 60             | 130                    | 4.2    | 19                    | 3.2           |                            |
| SC-N2/SE  | 200         | 50             | 105                    | 3.5    | 18                    | 2.8           | 0.77                       |
|           | 220         | 60             | 130                    | 4.2    | 19                    | 3.2           |                            |
| SC-N2S/SE | 200         | 50             | 130                    | 3.6    | 18                    | 2.9           | 0.75                       |
|           | 220         | 60             | 160                    | 4.3    | 19                    | 3.3           |                            |
| SC-N3/SE  | 200         | 50             | 130                    | 3.6    | 18                    | 2.9           | 0.75                       |
|           | 220         | 60             | 160                    | 4.3    | 19                    | 3.3           |                            |
| SC-N4/SE  | 200         | 50             | 80                     | 4      | 20                    | 3.2           | 0.8                        |
|           | 220         | 60             | 95                     | 4.6    | 21                    | 3.6           |                            |

Note: Coil ratings:

- SC-03 to 5-1, SC-N1 to N4 200V AC (200V 50Hz/200–220V 60Hz)
- SC-N5 to N16, SC-N1/SE to N4/SE 200V (200–250V AC 50/60Hz, 200–240V DC)



**(2) DC operated**

**(a) Coil ratings: 100V**

| Type      | Voltage (V) | Power consumption (W) |            | Exciting current (mA) | Time constant (ms) |
|-----------|-------------|-----------------------|------------|-----------------------|--------------------|
|           |             | Inrush                | Sealed     | Sealed                | Sealed             |
| SC-03/G   | 100         | 7                     | 7          | 70                    | 50                 |
| SC-0/G    | 100         | 7                     | 7          | 70                    | 50                 |
| SC-05/G   | 100         | 7                     | 7          | 70                    | 50                 |
| SC-4-0/G  | 100         | 7                     | 7          | 70                    | 50                 |
| SC-4-1/G  | 100         | 7                     | 7          | 70                    | 50                 |
| SC-5-1/G  | 100         | 7                     | 7          | 70                    | 50                 |
| SC-N1/G   | 100         | 9                     | 9          | 90                    | 60                 |
| SC-N2/G   | 100         | 9                     | 9          | 90                    | 60                 |
| SC-N2S/G  | 100         | 12                    | 12         | 120                   | 70                 |
| SC-N3/G   | 100         | 12                    | 12         | 120                   | 70                 |
| SC-N5     | 100<br>110  | 95<br>115             | 2.0<br>2.1 | 20<br>21              | 1                  |
| SC-N6     | 100<br>110  | 210<br>260            | 2.4<br>2.5 | 24<br>25              | 1                  |
| SC-N7     | 100<br>110  | 210<br>260            | 2.4<br>2.5 | 24<br>25              | 1                  |
| SC-N8     | 100<br>110  | 245<br>300            | 3.2<br>3.4 | 32<br>34              | 1                  |
| SC-N10    | 100<br>110  | 245<br>300            | 3.2<br>3.4 | 32<br>34              | 1                  |
| SC-N11    | 100<br>110  | 264<br>340            | 2.9<br>3.1 | 29<br>31              | 1                  |
| SC-N12    | 100<br>110  | 264<br>340            | 2.9<br>3.1 | 29<br>31              | 1                  |
| SC-N14    | 100<br>110  | 425<br>490            | 4.7<br>5.2 | 47<br>52              | 1                  |
| SC-N16    | 100<br>110  | 425<br>490            | 4.7<br>5.2 | 47<br>52              | 1                  |
| SC-N1/SE  | 100<br>110  | 135<br>160            | 2.0<br>2.1 | 20<br>21              | 1                  |
| SC-N2/SE  | 100<br>110  | 135<br>160            | 2.0<br>2.1 | 20<br>21              | 1                  |
| SC-N2S/SE | 100<br>110  | 165<br>205            | 1.9<br>2.1 | 19<br>21              | 1                  |
| SC-N3/SE  | 100<br>110  | 165<br>205            | 1.9<br>2.1 | 19<br>21              | 1                  |
| SC-N4/SE  | 100<br>110  | 95<br>115             | 2.0<br>2.1 | 20<br>21              | 1                  |

Note: Coil ratings:

- SC-03/G to N3/G 100V DC
- SC-N5 to N16 100V (100–120V DC, 100–127V AC 50/60Hz)
- SC-N1/SE to N4/SE 100V (100–120V DC, 100–127V AC 50/60Hz)

# 1 Contactors and Starters

## 1-3 Performance and characteristics

### (3) Coil resistance at 20°C (Average)

#### (a) AC coil

| Type   | Resistance (Ω)                          |   |   |
|--------|---|---|---|
|        | 100V AC<br>(100V 50Hz<br>100–110V 60Hz) | 200V AC<br>(200V 50Hz<br>200–220V 60Hz) | 400V AC<br>(380–400V 50Hz<br>400–440V 60Hz) |
| SC-03  | 81                                      | 321                                     | 1,228                                       |
| SC-0   | 81                                      | 321                                     | 1,228                                       |
| SC-05  | 81                                      | 321                                     | 1,228                                       |
| SC-4-0 | 81                                      | 321                                     | 1,228                                       |
| SC-4-1 | 81                                      | 321                                     | 1,228                                       |
| SC-5-1 | 81                                      | 321                                     | 1,228                                       |
| SC-N1  | 56                                      | 223                                     | 913   |
| SC-N2  | 56                                      | 223                                     | 913   |
| SC-N2S | 25                                      | 105                                     | 422   |
| SC-N3  | 25                                      | 105                                     | 422   |
| SC-N4  | 24                                      | 101                                     | 449   |
| SC-N5  | 95                                      | 417                                     | 1,489                                       |
| SC-N6  | 41                                      | 162                                     | 614   |
| SC-N7  | 41                                      | 162                                     | 614   |
| SC-N8  | 35                                      | 149                                     | 610   |
| SC-N10 | 35                                      | 149                                     | 610   |
| SC-N11 | 28                                      | 105                                     | 405   |
| SC-N12 | 28                                      | 105                                     | 405   |
| SC-N14 | 12                                      | 55                                      | 222   |
| SC-N16 | 12                                      | 55                                      | 222   |

Note: Resistance value of electronic circuit is not included.

#### (b) AC/DC coil

| Type      | Resistance (Ω)                               |  |
|-----------|--|--|
|           | 100V (100–127V AC<br>50/60Hz<br>100–120V DC) | 200V (200–250V AC<br>50/60Hz<br>200–240V DC) |
| SC-N1/SE  | 70   | 306  |
| SC-N2/SE  | 70   | 306  |
| SC-N2S/SE | 54   | 241  |
| SC-N3/SE  | 54   | 241  |
| SC-N4/SE  | 95   | 417  |

Note: Resistance value of electronic circuit is not included.

#### (c) DC coil

| Type     | Resistance (Ω) |         |         |
|----------|----------------|---------|---------|
|          | 24V DC         | 100V DC | 200V DC |
| SC-03/G  | 90             | 1,526   | 5,585   |
| SC-0/G   | 90             | 1,526   | 5,585   |
| SC-05/G  | 90             | 1,526   | 5,585   |
| SC-4-0/G | 90             | 1,526   | 5,585   |
| SC-4-1/G | 90             | 1,526   | 5,585   |
| SC-5-1/G | 90             | 1,526   | 5,585   |
| SC-N1/G  | 64             | 1,108   | 4,451   |
| SC-N2/G  | 64             | 1,108   | 4,451   |
| SC-N2S/G | 50             | 873     | 3,426   |
| SC-N3/G  | 50             | 873     | 3,426   |

### 1-3-9 Temperature rise test

The temperature rise test is carried out with the rated voltage applied to the coil, and rated current (shown in table below) flowing through the main circuit.

Under these conditions, temperature rise of contacts, terminals and coil shall not exceed the value specified by the standard after the temperature reaches a constant value.

#### (1) Test results – Contactors

| Type             | Test conditions           |                     |                              | Test result (K) |               |      |                          |
|------------------|---------------------------|---------------------|------------------------------|-----------------|---------------|------|--------------------------|
|                  | Current (A)               | Coil voltage (V/Hz) | Wire size (mm <sup>2</sup> ) | Contact         | Terminal Line | Load | Coil (Resistance method) |
| SC-03            | 20                        | 220/60              | 2.5                          | 55              | 42            | 40   | 46                       |
| SC-0             | 20                        | 220/60              | 2.5                          | 53              | 40            | 38   | 46                       |
| SC-05            | 20                        | 220/60              | 2.5                          | 50              | 39            | 38   | 45                       |
| SC-4-0           | 25                        | 220/60              | 4.0                          | 58              | 43            | 41   | 48                       |
| SC-4-1           | 32                        | 220/60              | 6.0                          | 70              | 48            | 47   | 50                       |
| SC-5-1           | 32                        | 220/60              | 6.0                          | 72              | 48            | 48   | 50                       |
| SC-N1            | 50                        | 220/60              | 10                           | 63              | 46            | 43   | 60                       |
| SC-N2            | 60                        | 220/60              | 16                           | 59              | 44            | 43   | 61                       |
| SC-N2S           | 80                        | 220/60              | 25                           | 62              | 41            | 40   | 63                       |
| SC-N3            | 100                       | 220/60              | 35                           | 77              | 48            | 47   | 62                       |
| SC-N4            | 135                       | 220/60              | 50                           | 87              | 49            | 46   | 72                       |
| SC-N5            | 150                       | 250/60              | 50                           | 68              | 47            | 40   | 36                       |
| SC-N6            | 150                       | 250/60              | 50                           | 56              | 41            | 37   | 31                       |
| SC-N7            | 200                       | 250/60              | 95                           | 72              | 46            | 43   | 32                       |
| SC-N8            | 260                       | 250/60              | 150                          | 59              | 33            | 34   | 42                       |
| SC-N10           | 260                       | 250/60              | 150                          | 58              | 33            | 34   | 42                       |
| SC-N11           | 350                       | 250/60              | 185                          | 69              | 42            | 41   | 35                       |
| SC-N12           | 450                       | 250/60              | 150x2                        | 83              | 45            | 46   | 42                       |
| SC-N14           | 660                       | 250/60              | 240x2                        | 72              | 36            | 34   | 16                       |
| SC-N16           | 800                       | 250/60              | 240x2                        | 55              | 36            | 33   | 17                       |
| Temp. rise limit | Ambient temperature: 55°C |                     |                              | *               | 50            | 50   | 85 (E class)             |

Note: \* Temperature rise is limited without damage to adjacent parts.

# 1 Contactors and Starters

## 1-3 Performance and characteristics

### (2) Test results – Starters

| Type             | Test conditions           |                     |                              | Test result (K) |               |      | Coil (Resistance method) |
|------------------|---------------------------|---------------------|------------------------------|-----------------|---------------|------|--------------------------|
|                  | Current (A)               | Coil voltage (V/Hz) | Wire size (mm <sup>2</sup> ) | Contact         | Terminal Line | Load |                          |
| <b>SW-03</b>     | 11                        | 220/60              | 1.5                          | 56              | 29            | 40   | 53                       |
| <b>SW-0</b>      | 13                        | 220/60              | 2.5                          | 68              | 31            | 48   | 57                       |
| <b>SW-05</b>     | 13                        | 220/60              | 2.5                          | 65              | 29            | 48   | 56                       |
| <b>SW-4-0</b>    | 18                        | 220/60              | 2.5                          | 55              | 36            | 49   | 55                       |
| <b>SW-4-1</b>    | 22                        | 220/60              | 4.0                          | 46              | 30            | 46   | 55                       |
| <b>SW-5-1</b>    | 22                        | 220/60              | 4.0                          | 49              | 31            | 47   | 56                       |
| <b>SW-N1</b>     | 32                        | 220/60              | 6.0                          | 51              | 37            | 44   | 62                       |
| <b>SW-N2</b>     | 40                        | 220/60              | 10                           | 47              | 35            | 34   | 61                       |
| <b>SW-N2S</b>    | 50                        | 220/60              | 10                           | 55              | 42            | 44   | 65                       |
| <b>SW-N3</b>     | 65                        | 220/60              | 16                           | 67              | 48            | 49   | 64                       |
| <b>SW-N4</b>     | 80                        | 220/60              | 25                           | 68              | 47            | 49   | 63                       |
| <b>SW-N5</b>     | 105                       | 250/60              | 35                           | 64              | 45            | 44   | 40                       |
| <b>SW-N6</b>     | 125                       | 250/60              | 50                           | 72              | 48            | 48   | 37                       |
| <b>SW-N7</b>     | 150                       | 250/60              | 50                           | 76              | 48            | 48   | 43                       |
| <b>SW-N8</b>     | 180                       | 250/60              | 95                           | 66              | 40            | 39   | 41                       |
| <b>SW-N10</b>    | 220                       | 250/60              | 95                           | 71              | 42            | 44   | 42                       |
| <b>SW-N11</b>    | 300                       | 250/60              | 185                          | 46              | 42            | 42   | 29                       |
| <b>SW-N12</b>    | 400                       | 250/60              | 240                          | 78              | 44            | 34   | 39                       |
| <b>SW-N14</b>    | 600                       | 250/60              | 185x2                        | 73              | 38            | 36   | 20                       |
| Temp. rise limit | Ambient temperature: 55°C |                     |                              | *               | 50            | 50   | 85 (E class)             |

Note: \* Temperature rise is limited without damage to adjacent insulated parts.

### 1-3-10 Rated impulse withstand voltage

| Frame size                          | Contactor    |                               | Starter      |                               |
|-------------------------------------|--------------|-------------------------------|--------------|-------------------------------|
|                                     | Main circuit | Auxiliary and control circuit | Main circuit | Auxiliary and control circuit |
| 03, 0, 05, 4-0, 4-1, 5-1            | 6kV          | 6kV                           | 6kV          | 6kV                           |
| N1, N2, N2S, N3, N4, N5, N6, N7, N8 | 8kV          | 6kV                           | 6kV          | 6kV                           |
| N10, N11, N12, N14, (N16)           | 8kV          | 6kV                           | 8kV          | 6kV                           |

( ): Contactor only

### 1-3-11 Insulation resistance and dielectric property

| Frame size                          | Contactor | Starter |
|-------------------------------------|-----------|---------|
| 03, 0, 05, 4-0, 4-1, 5-1            | Table a   | Table a |
| N1, N2, N2S, N3, N4, N5, N6, N7, N8 | Table b   | Table a |
| N10, N11, N12, N14, (N16)           | Table b   | Table b |

( ): Contactor only

#### (1) Table a

| Measuring point       |                      | Between live parts and earth<br>(Contact: Open/closed) | Between control circuit and earth<br>(Contact: Open/closed) | Between main circuits and control circuits<br>(Contact: Open/closed) | Between main poles<br>(Contact: Open) | Between line and load sides<br>(Contact: Open) |
|-----------------------|----------------------|--|---|--|---------------------------------------|--|
| Insulation resistance | Standard requirement | 5MΩ or over  | 5MΩ or over   | 5MΩ or over  | 5MΩ or over                           | 5MΩ or over                                    |
|                       | Test result          | 100MΩ or over  | 100MΩ or over   | 100MΩ or over  | 100MΩ or over                         | 100MΩ or over                                  |
| Dielectric property   | Standard requirement | 2,500V 50Hz 1 min.                                     | 2,500V 50Hz 1 min.  | 2,500V 50Hz 1 min.   | 2,500V 50Hz 1 min.                    | 2,500V 50Hz 1 min.                             |
|                       | Test result          | 2,500V 50Hz 1 min.                                     | 2,500V 50Hz 1 min.  | 2,500V 50Hz 1 min.   | 2,500V 50Hz 1 min.                    | 2,500V 50Hz 1 min.                             |

#### (2) Table b

| Measuring point       |                      | Between live parts and earth<br>(Contact: Open/closed) | Between control circuit and earth<br>(Contact: Open/closed) | Between main circuits and control circuits<br>(Contact: Open/closed) | Between main poles<br>(Contact: Open) | Between line and load sides<br>(Contact: Open) |
|-----------------------|----------------------|--|---|--|---------------------------------------|--|
| Insulation resistance | Standard requirement | 5MΩ or over  | 5MΩ or over   | 5MΩ or over  | 5MΩ or over                           | 5MΩ or over                                    |
|                       | Test result          | 100MΩ or over  | 100MΩ or over   | 100MΩ or over  | 100MΩ or over                         | 100MΩ or over                                  |
| Dielectric property   | Standard requirement | 3,500V 50Hz 1 min.                                     | 2,500V 50Hz 1 min.  | 3,500V 50Hz 1 min.   | 3,500V 50Hz 1 min.                    | 3,500V 50Hz 1 min.                             |
|                       | Test result          | 3,500V 50Hz 1 min.                                     | 2,500V 50Hz 1 min.  | 3,500V 50Hz 1 min.   | 3,500V 50Hz 1 min.                    | 3,500V 50Hz 1 min.                             |

# 1 Contactors and Starters

## 1-3 Performance and characteristics

### 1-3-12 Noise characteristics

The noise generated by the contactors operating and while they are in the closed position is minimal due to the specially designed “free floating magnetic mechanism” and “shading coils.”

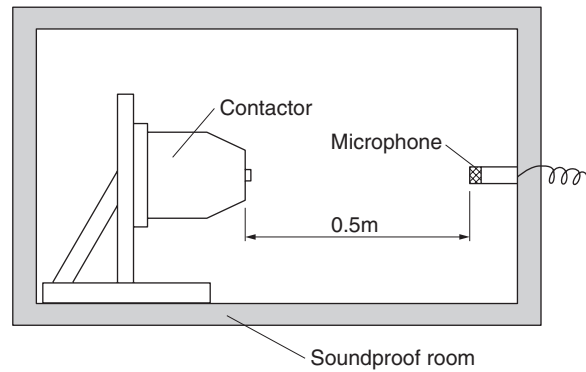
#### (1) Test condition

|                                  |   |                                 |
|----------------------------------|---|---------------------------------|
| Type                             | SC-03 to SC-N4                            | SC-N5 to SC-N14                 |
| Coil rated voltage               | 200V 50Hz/<br>200–220V 60Hz               | 200–250V 50/60Hz<br>200–220V DC |
| Coil applied voltage             | 200V AC 50Hz                              |                                 |
| Soundproof room background noise | 30dB (A-weighted sound pressure level)    |                                 |
| Measuring device                 | Precision noise meter<br>CRT oscillograph |                                 |

#### (2) Test results

| Type   | Maximum noise level (dB) |          |        |
|--------|--------------------------|----------|--------|
|        | Pick-up                  | Drop-out | Sealed |
| SC-03  | 100                      | 100      | 30     |
| SC-0   | 100                      | 100      | 30     |
| SC-05  | 101                      | 101      | 30     |
| SC-4-0 | 102                      | 100      | 30     |
| SC-4-1 | 102                      | 100      | 30     |
| SC-5-1 | 102                      | 101      | 30     |
| SC-N1  | 90                       | 87       | 30     |
| SC-N2  | 90                       | 87       | 30     |
| SC-N2S | 87                       | 87       | 30     |
| SC-N3  | 87                       | 87       | 30     |
| SC-N4  | 84                       | 84       | 30     |
| SC-N5  | 87                       | 84       | 30     |
| SC-N6  | 85                       | 85       | 30     |
| SC-N7  | 86                       | 85       | 30     |
| SC-N8  | 86                       | 80       | 30     |
| SC-N10 | 86                       | 80       | 30     |
| SC-N11 | 88                       | 84       | 30     |
| SC-N12 | 88                       | 84       | 30     |
| SC-N14 | 117                      | 112      | 30     |
| SC-N16 | 117                      | 112      | 30     |

Fig. 7 Noise level testing equipment



### 1-3-13 Reversing change-over time

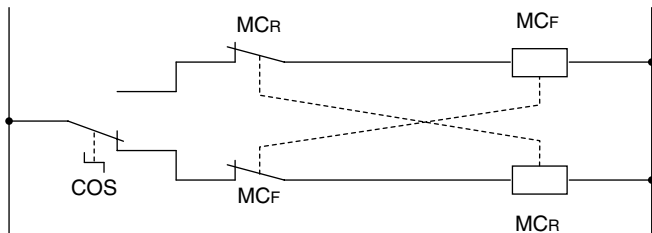
When automatic reversing is triggered by a change-over switch with a short time snap action as shown in Fig. 8, the contactor will quickly change from MCF to MCR or MCR to MCF.

Fig. 9 illustrates the timing of such an abrupt reversing operation. Because small-sized contactors have a rapid action, their change-over time ( $t$ ) is even shorter. If the change-over time ( $t$ ) is shorter than the arcing time of the main circuit, an arc short will occur between the main contacts and cause abnormal wear or welding.

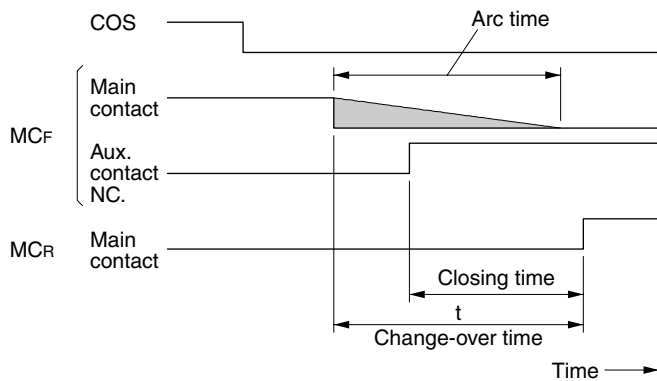
Change-over times are given in the table on the right.

When using the SC-03RM to SC-N3RM types, installation of a control relay (see Fig. 10) is recommended. Doing so will extend the change-over time and so reduce the possibility of arcing.

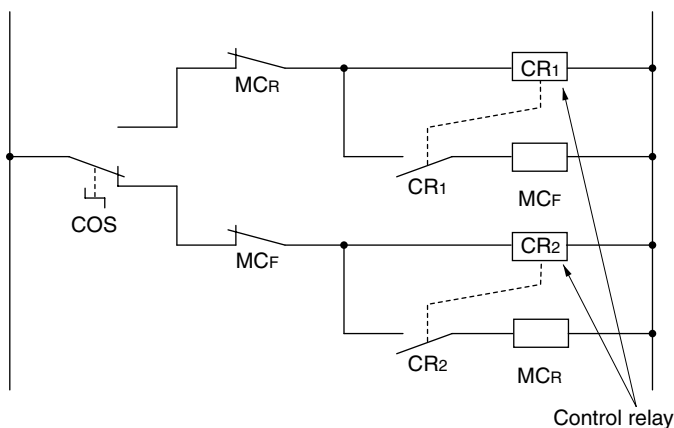
**Fig. 8 Reversing by change-over switch**



**Fig. 9 Timing diagram**



**Fig. 10 Reversing of using control relay (CR)**



| Type     | Arc time (ms) at $10 \times I_e$ (A) breaking |         | Change-over time (ms) With mechanical interlock device |
|----------|---|---------|--|
|          | 220V  | 440V    |  |
| SC-03RM  | 4-7   | 5-7.5   | 15-21  |
| SC-0RM   | 4.5-6   | 4.5-7.5 | 15-21  |
| SC-05RM  | 4-5.5   | 4.5-7.5 | 15-21  |
| SC-4-0RM | 4-7   | 4.5-7.5 | 14-19  |
| SC-4-1RM | 4-7.5   | 4.5-8   | 14-19  |
| SC-5-1RM | 4-7.5   | 4.5-8   | 14-19  |
| SC-N1RM  | 4-6   | 5-7     | 11-28  |
| SC-N2RM  | 4-6   | 5-7     | 11-28  |
| SC-N2SRM | 4-8   | 5-8     | 14-32  |
| SC-N3RM  | 4-8   | 5-8     | 14-32  |
| SC-N4RM  | 5-9   | 5-10    | 19-30  |
| SC-N5RM  | 4-9   | 4-10    | 32-77  |
| SC-N6RM  | 4-12  | 4-13    | 27-63  |
| SC-N7RM  | 3-12  | 3-13    | 27-63  |
| SC-N8RM  | 4-12  | 5-13    | 35-44  |
| SC-N10RM | 4-13  | 6-14    | 35-44  |
| SC-N11RM | 5-13  | 6-15    | 50-60  |
| SC-N12RM | 5-13  | 6-15    | 50-60  |
| SC-N14RM | 5-10  | 6-16    | 70-110   |

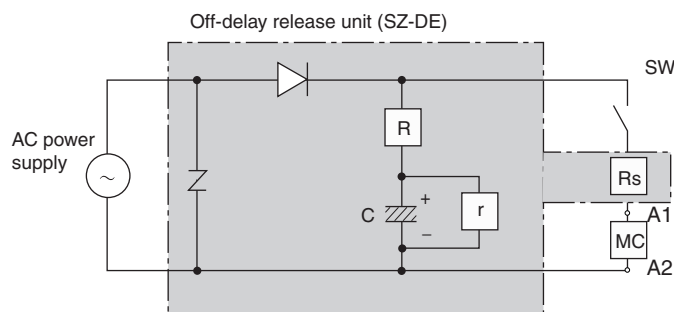
# 1 Contactors and Starters

## 1-3 Performance and characteristics

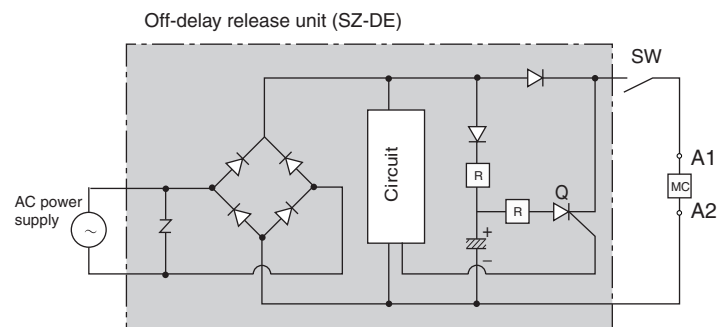
### 1-3-14 Off-delay release contactors

This is a combination of DC-operated magnetic contactor and off-delay release unit. It prevents circuit opening due to instantaneous voltage drops.

**Fig. 11** SC-03/G to 5-1/G+SZ-DE□  
SC-N1/G to N3/G+SZ-DE□



**Fig. 12** SC-N4/SE to N14+SZ-DE□



#### (1) Delay time measurement data

If a problem occurs in power lines due, for example, to lightning, there will be a short power interruption and a reduction in the voltage that will remain until the problem is removed. Instantaneous power interruptions and voltage drops are, to a certain extent, unavoidable and they may continue for up to 0.3s. An interval of 1s must be allowed to ensure safety.

With contactors, if a voltage drop of 50% or more continues for between 0.005 and 0.02s, the contactors are released. In order to avoid stoppages in installations when instantaneous power interruptions and voltage drops occur, an Off-delay release contactor (a combination of a DC-operated magnetic contactor

and off-delay release unit) that delays the release of the contactors for between 1 and 5s is used. The delay time for SC-03 to SC-N3 models is 1 to 5s, and the delay time for SC-N4 to SC-N14 models is 1 to 4s.

Disparities in the delay time may be caused by allowable error in the capacitances of the units and differences in the holding force of the contactors.

For more details on the disparities in the delay times for different models and different operational voltages, refer to the table below.

#### (a) Test condition

Control circuit voltage: Decreased from 100%V to 0V  
Coil: Cold state  
Ambient temperature: Normal temperature

#### (b) Off-delay time (Example)

| Contactor       |              |                               | Off-delay time (s) |                    |                    |                    |
|-----------------|--------------|-------------------------------|--------------------|--------------------|--------------------|--------------------|
| Type            | Aux. contact | Additional aux. contact block | SZ-DE100 (100V AC) | SZ-DE110 (110V AC) | SZ-DE200 (200V AC) | SZ-DE220 (220V AC) |
| SC-03/G, 0/G    | 1NO          | —                             | 2.0–2.7            | 1.9–2.6            | 2.0–2.7            | 1.8–2.5            |
| SC-05/G         | 2NO          | —                             | 1.9–2.6            | 1.8–2.5            | 1.9–2.7            | 1.7–2.3            |
| SC-05/G         | 2NO          | SZ-A40 (4NO)                  | 1.6–2.2            | 1.5–2.2            | 1.6–2.3            | 1.4–2.2            |
| SC-4-0/G, 4-1/G | 1NO          | —                             | 2.0–2.6            | 1.8–2.5            | 2.0–2.7            | 1.8–2.4            |
| SC-5-1/G        | 2NO          | —                             | 1.8–2.5            | 1.7–2.4            | 1.7–2.5            | 1.6–2.3            |
| SC-5-1/G        | 2NO          | SZ-A40 (4NO)                  | 1.6–2.3            | 1.4–2.2            | 1.6–2.3            | 1.4–2.3            |
| SC-N1/G, N2/G   | —            | —                             | 1.7–2.5            | 2.0–3.0            | 1.8–2.7            | 2.2–3.3            |
|                 |              | SZ-A40 (4NO)                  | 1.5–2.3            | 1.8–2.8            | 1.6–2.4            | 2.0–3.0            |
| SC-N2S/G, N3/G  | —            | —                             | 1.6–2.5            | 2.0–3.0            | 1.6–2.4            | 2.0–3.1            |
|                 |              | SZ-A40 (4NO)                  | 1.5–2.3            | 1.8–2.8            | 1.5–2.3            | 1.9–2.8            |
| SC-N4/SE, N5    | —            | —                             | 1.6–2.4            | 1.9–2.9            | 1.7–2.5            | 2.1–3.2            |
| SC-N6, N7       | —            | —                             | 1.5–2.2            | 1.7–2.7            | 1.6–2.4            | 2.0–3.0            |
| SC-N8, N10      | —            | —                             | 1.6–2.4            | 1.9–2.9            | 1.5–2.2            | 1.8–2.8            |
| SC-N11, N12     | —            | —                             | 1.4–2.1            | 1.6–2.6            | 2.0–3.0            | 2.5–3.8            |
| SC-N14          | —            | —                             | 1.3–2.5            | 1.5–2.8            | 1.5–2.7            | 1.7–2.9            |

Note: The values given in the above table are representative samples.



**(2) Durability of capacitors**

The capacitors in Off-delay release units must have a large capacity and be compact. For this reason, aluminum catalytic capacitors are used. It is well known that this type of capacitor is a wear-out failure type. Basically, degradation and consumption of the electrolyte leads to deterioration in the characteristics and eventually the capacity is reduced, signalling the end of the service life. Although the time taken to reach the end of the service life is influenced to some extent by ripple current and the number of charges and discharges, it is significantly influenced by temperature, with the service life halved for every increase of 10°C.

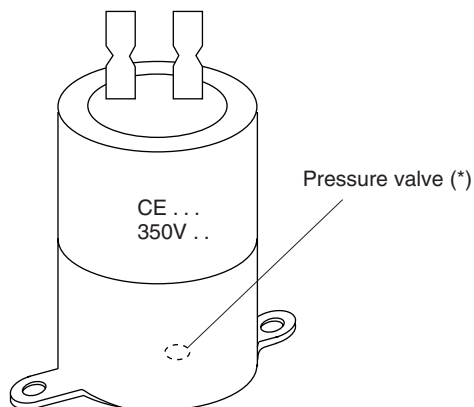
The life expectancies for the capacitors used in Off-delay release units are as follows.

**Life expectancies of capacitors**

- Cumulative charged life:  
 The cumulative time for which the Off-delay release unit is used with the rated voltage applied  
 Cumulative charged life of capacitor at 55°C: 100,000 hours
- Discharge time life:  
 The number of Off-delay release operations due, for example, to power interruptions  
 Discharge time life of capacitor at 55°C: 100,000 operations

As described above, capacitors have a finite service life and so inspection is required if they are used for several years. There is a pressure valve (\*) attached to the bottom of the capacitor and when the capacitor reaches the end of its service life, the valve opens and electrolyte starts to leak out. This can be used as a rough guide to determine when the service life has expired.

**Fig. 13 Schematic diagram of pressure valve**



**(3) Precautions regarding the operation command contact and connection position**

Ensure that the operation command contact (switch) is connected to the DC side. If it is connected to the AC input side, the following problems will occur.

- Off-delay release operation will occur even if the operation command contact is turned OFF.
- Chattering will occur in the contactor.

(In combinations of models SC-03/G to N3/G and model SZ-□DE, this is because when the switch closes, initially only single-phase half-wave current is supplied.)

# 1 Contactors and Starters

## 1-3 Performance and characteristics

### 1-3-15 Mechanical latch contactors

Mechanical latch contactors are used where operating sequence continuity must be maintained regardless of any outside interruptions, such as voltage failure or instantaneous voltage drop. Typical applications are for electric furnaces, machine tool circuits, standby power supply and normal power changeover circuits in hospitals, schools and office buildings.

These contactors are provided with two coils. One is CC (Closing Coil) and the other is TC (Tripping Coil).

An interlocking circuit is provided between the CC coil and the TC coil. Since a coil voltage is not applied during operation it is extremely quiet. Power consumption can also be saved.

(1) Ratings Same as standard types.

### (2) Performance

| Type                    |                     | Making and breaking current (A) |             | Operating cycles per hour | Durability operation (×10 <sup>3</sup> ) |            | Utilization category |     |      |
|-------------------------|---------------------|---------------------------------|-------------|---------------------------|--|------------|----------------------|-----|------|
| Non reversing contactor | Reversing contactor | Making                          | Breaking    |                           | Mechanical                               | Electrical |                      |     |      |
| AC-operated             | DC-operated         | AC-operated                     | DC-operated |                           |  |            |                      |     |      |
| SC-03/V                 | SC-03/VG            | SC-03RM/V                       | SC-03RM/VG  | 10×Ie                     | 8×Ie                                     | 1,200      | 1,000                | 500 | AC-3 |
| SC-0/V                  | SC-0/VG             | SC-0RM/V                        | SC-0RM/VG   | 10×Ie                     | 8×Ie                                     | 1,200      | 1,000                | 500 | AC-3 |
| SC-05/V                 | SC-05/VG            | SC-05RM/V                       | SC-05RM/VG  | 10×Ie                     | 8×Ie                                     | 1,200      | 1,000                | 500 | AC-3 |
| SC-4-0/V                | SC-4-0/VG           | SC-4-0RM/V                      | SC-4-0RM/VG | 10×Ie                     | 8×Ie                                     | 1,200      | 1,000                | 500 | AC-3 |
| SC-4-1/V                | SC-4-1/VG           | SC-4-1RM/V                      | SC-4-1RM/VG | 10×Ie                     | 8×Ie                                     | 1,200      | 1,000                | 500 | AC-3 |
| SC-5-1/V                | SC-5-1/VG           | SC-5-1RM/V                      | SC-5-1RM/VG | 10×Ie                     | 8×Ie                                     | 1,200      | 1,000                | 500 | AC-3 |
| SC-N1/VS, N2/VS         |                     | SC-N1RM/VS, N2RM/VS             |             | 10×Ie                     | 8×Ie                                     | 600        | 500                  | 500 | AC-3 |
| SC-N2S/VS, N3/VS        |                     | SC-N2SRM/VS, N3RM/VS            |             |                           |  |            |                      |     |      |
| SC-N4/VS, N5/VS, N6/VS  |                     | SC-N4RM/VS, N5RM/VS             |             | 10×Ie                     | 8×Ie                                     | 600        | 250                  | 250 | AC-3 |
| SC-N7/VS, N8/VS, N10/VS |                     | SC-N6RM/VS, N7RM/VS             |             |                           |  |            |                      |     |      |
| SC-N11/VS, N12/VS       |                     | SC-N8RM/VS, N10RM/VS            |             |                           |  |            |                      |     |      |
|                         |                     | SC-N11RM/VS, N12RM/VS           |             |                           |  |            |                      |     |      |
| SC-N14/VS               |                     | SC-N14RM/VS                     |             | 10×Ie                     | 8×Ie                                     | 600        | 100                  | 100 | AC-3 |

Ie: Rated operational current.

### (3) Coil characteristics

#### (a) AC operated

| Type      | Power consumption (VA) |          | Coil voltage *   | Min. closing and tripping signal time (s) |
|-----------|------------------------|----------|--|---|
|           | Closing                | Tripping |  |   |
| SC-03/V   | 95                     | 150      | 100V AC<br>(100V 50Hz<br>100–110V 60Hz)  | 0.3                                       |
| SC-0/V    | 95                     | 150      |  |   |
| SC-05/V   | 95                     | 150      |  |   |
| SC-4-0/V  | 95                     | 150      |  |   |
| SC-4-1/V  | 95                     | 150      |  |   |
| SC-5-1/V  | 95                     | 150      |  |   |
| SC-N1/VS  | 100                    | 140      | 100V<br>(100–110V<br>50/60Hz<br>100–110V DC)<br>200V<br>(200–220V<br>50/60Hz<br>200–220V DC) | 0.3                                       |
| SC-N2/VS  | 100                    | 140      |  |   |
| SC-N2S/VS | 115                    | 140      |  |   |
| SC-N3/VS  | 115                    | 140      |  |   |
| SC-N4/VS  | 161                    | 266      |  |   |
| SC-N5/VS  | 161                    | 266      |  |   |
| SC-N6/VS  | 229                    | 266      |  |   |
| SC-N7/VS  | 229                    | 266      |  |   |
| SC-N8/VS  | 273                    | 385      |  |   |
| SC-N10/VS | 273                    | 385      |  |   |
| SC-N11/VS | 490                    | 385      |  |   |
| SC-N12/VS | 490                    | 385      |  |   |
| SC-N14/VS | 500                    | 660      |  |   |

Notes: • The above figures are given as examples. They are subject to the following conditions.  
Coil temperature: 20°C  
Coil ratings: 200–220V, 50/60Hz  
Applied voltage: 200V AC, 60Hz

\* Following voltage ranges are also available.  
SC-03/V to 5-1/V: 24 to 220V AC 50/60Hz  
SC-N1/VS to N12/VS: 24 to 220V AC 50/60Hz  
SC-N14/VS: 100 to 220V AC 50/60Hz

#### (b) DC operated

| Type      | Power consumption (W) |          | Coil voltage *   | Min. closing and tripping signal time (s) |
|-----------|-----------------------|----------|--|---|
|           | Closing               | Tripping |  |   |
| SC-03/VG  | 7                     | 150      | 100, 110V DC<br>200, 220V DC   | 0.3                                       |
| SC-0/VG   | 7                     | 150      |  |   |
| SC-05/VG  | 7                     | 150      |  |   |
| SC-4-0/VG | 7                     | 150      |  |   |
| SC-4-1/VG | 7                     | 150      |  |   |
| SC-5-1/VG | 7                     | 150      |  |   |
| SC-N1/VS  | 95                    | 150      | 100V<br>(100–110V DC<br>100–110V AC<br>50/60Hz)<br>200V<br>(200–220V DC<br>200–220V AC<br>50/60Hz) | 0.3                                       |
| SC-N2/VS  | 95                    | 150      |  |   |
| SC-N2S/VS | 110                   | 150      |  |   |
| SC-N3/VS  | 110                   | 150      |  |   |
| SC-N4/VS  | 153                   | 198      |  |   |
| SC-N5/VS  | 153                   | 198      |  |   |
| SC-N6/VS  | 216                   | 198      |  |   |
| SC-N7/VS  | 216                   | 198      |  |   |
| SC-N8/VS  | 260                   | 294      |  |   |
| SC-N10/VS | 260                   | 294      |  |   |
| SC-N11/VS | 515                   | 294      |  |   |
| SC-N12/VS | 515                   | 294      |  |   |
| SC-N14/VS | 500                   | 660      |  |   |

Notes: • The above figures are given as examples. They are subject to the following conditions.  
Coil temperature: 20°C  
Coil ratings: 200–220V, 50/60Hz  
Applied voltage: 200V DC

\* Other voltage with a voltage range of 24 to 220V DC (100 to 220V DC for N14/VS type) are also available.

**(4) Operating characteristics and operating time**

**(a) AC operated**

| Type      | Pick-up voltage (V) |         |               |         | Operating time (ms) |                 |                 |              |                 |                 |
|-----------|---------------------|---------|---------------|---------|---------------------|-----------------|-----------------|--------------|-----------------|-----------------|
|           | Closing coil        |         | Tripping coil |         | Pick-up             |                 |                 | Drop-out     |                 |                 |
|           | 50Hz                | 60Hz    | 50Hz          | 60Hz    | Main contact        | Aux. NO contact | Aux. NC contact | Main contact | Aux. NO contact | Aux. NC contact |
| SC-03/V   | 109-129             | 120-141 | 46-66         | 50-72   | 9-20                | -               | -               | 4-11         | -               | -               |
| SC-0/V    | 109-129             | 120-141 | 46-66         | 50-72   | 9-20                | -               | -               | 4-11         | -               | -               |
| SC-05/V   | 112-132             | 123-144 | 46-68         | 50-72   | 10-22               | 10-22           | 6-17            | 4-11         | 4-11            | 10-18           |
| SC-4-0/V  | 113-136             | 123-144 | 46-68         | 50-72   | 9-21                | -               | -               | 5-13         | -               | -               |
| SC-4-1/V  | 113-136             | 123-144 | 46-68         | 50-72   | 9-21                | -               | -               | 5-13         | -               | -               |
| SC-5-1/V  | 115-139             | 125-146 | 46-68         | 50-72   | 9-21                | 9-21            | 6-19            | 5-13         | 5-13            | 9-20            |
| SC-N1/VS  | 120-132             | 130-135 | 90-110        | 100-122 | 14-18               | 14-19           | 8-16            | 8-15         | 6-14            | 10-19           |
| SC-N2/VS  | 120-132             | 130-135 | 90-110        | 100-122 | 14-18               | 14-19           | 8-16            | 8-15         | 6-14            | 10-19           |
| SC-N2S/VS | 120-132             | 130-135 | 90-110        | 100-122 | 18-22               | 18-23           | 10-18           | 8-15         | 5-13            | 8-20            |
| SC-N3/VS  | 120-132             | 130-135 | 90-110        | 100-122 | 18-22               | 18-23           | 10-18           | 8-15         | 5-13            | 8-20            |
| SC-N4/VS  | 140-150             | 140-150 | 90-120        | 100-130 | 39-45               | 40-46           | 37-43           | 11-17        | 11-17           | 14-21           |
| SC-N5/VS  | 140-150             | 140-150 | 90-120        | 100-130 | 39-45               | 40-46           | 37-43           | 11-17        | 11-17           | 14-21           |
| SC-N6/VS  | 140-150             | 140-150 | 90-120        | 100-130 | 38-43               | 37-42           | 35-40           | 11-17        | 10-17           | 15-22           |
| SC-N7/VS  | 140-150             | 140-150 | 90-120        | 100-130 | 38-43               | 37-42           | 35-40           | 11-17        | 10-17           | 15-22           |
| SC-N8/VS  | 140-150             | 140-150 | 90-120        | 100-130 | 43-47               | 40-44           | 37-41           | 13-20        | 15-22           | 16-27           |
| SC-N10/VS | 140-150             | 140-150 | 90-120        | 100-130 | 43-47               | 40-44           | 37-41           | 13-20        | 15-22           | 16-27           |
| SC-N11/VS | 140-150             | 140-150 | 90-120        | 100-130 | 42-45               | 39-42           | 36-40           | 13-20        | 14-22           | 16-27           |
| SC-N12/VS | 140-150             | 140-150 | 90-120        | 100-130 | 42-45               | 39-42           | 36-40           | 13-20        | 14-22           | 16-27           |
| SC-N14/VS | 140-160             | 140-160 | 90-140        | 90-140  | 69-75               | 68-75           | 55-70           | 16-30        | 16-30           | 16-30           |

Notes: • Coil ratings: 03/V to 5-1/V: 200V AC (200V, 50Hz/200 to 220V 60Hz)  
N1/VS to N14/VS: 200V (200 to 220V AC, 50/60Hz, 200 to 220V DC)

• Operating time: 03/V to 5-1/V: For 200V AC, 50Hz.  
N1/VS to N14/VS: For 200V AC, 50Hz.

**(b) DC operated**

| Type      | Pick-up voltage (V) |               | Operating time (ms) |                 |                 |              |                 |                 |
|-----------|---------------------|---------------|---------------------|-----------------|-----------------|--------------|-----------------|-----------------|
|           | Closing coil        | Tripping coil | Pick-up             |                 |                 | Drop-out     |                 |                 |
|           |                     |               | Main contact        | Aux. NO contact | Aux. NC contact | Main contact | Aux. NO contact | Aux. NC contact |
| SC-03/VG  | 46-63               | 23-42         | 42-51               | -               | -               | 23-28        | -               | -               |
| SC-0/VG   | 42-63               | 23-42         | 42-51               | -               | -               | 23-28        | -               | -               |
| SC-05/VG  | 45-62               | 24-43         | 43-52               | 43-52           | 36-42           | 23-28        | 20-25           | 27-32           |
| SC-4-0/VG | 48-65               | 24-43         | 43-52               | -               | -               | 23-28        | -               | -               |
| SC-4-1/VG | 48-65               | 24-43         | 43-52               | -               | -               | 23-28        | -               | -               |
| SC-5-1/VG | 48-65               | 24-43         | 45-54               | 45-54           | 39-44           | 23-28        | 20-25           | 26-31           |
| SC-N1/VS  | 115-125             | 100-125       | 14-16               | 14-18           | 8-16            | 13-15        | 11-15           | 15-19           |
| SC-N2/VS  | 115-125             | 100-125       | 14-16               | 14-18           | 8-16            | 13-15        | 11-15           | 15-19           |
| SC-N2S/VS | 115-125             | 100-125       | 18-20               | 18-22           | 10-18           | 9-11         | 6-10            | 9-20            |
| SC-N3/VS  | 115-125             | 100-125       | 18-20               | 18-22           | 10-18           | 9-11         | 6-10            | 9-20            |
| SC-N4/VS  | 140-160             | 100-125       | 35-41               | 34-41           | 31-39           | 18-26        | 18-26           | 21-30           |
| SC-N5/VS  | 140-160             | 85-105        | 35-41               | 34-41           | 31-39           | 18-26        | 18-26           | 21-30           |
| SC-N6/VS  | 140-160             | 85-105        | 35-41               | 34-42           | 33-39           | 18-26        | 17-26           | 21-31           |
| SC-N7/VS  | 140-160             | 85-105        | 35-41               | 34-42           | 33-39           | 18-26        | 17-26           | 21-31           |
| SC-N8/VS  | 140-160             | 85-105        | 38-44               | 35-42           | 32-39           | 20-28        | 22-30           | 23-35           |
| SC-N10/VS | 140-160             | 85-105        | 38-44               | 35-42           | 32-39           | 20-28        | 22-30           | 23-35           |
| SC-N11/VS | 140-160             | 85-105        | 38-44               | 35-42           | 32-38           | 20-28        | 21-30           | 23-35           |
| SC-N12/VS | 140-160             | 85-105        | 38-44               | 35-42           | 32-38           | 20-28        | 21-30           | 23-35           |
| SC-N14/VS | 140-160             | 80-120        | 64-70               | 63-70           | 50-65           | 33-41        | 33-41           | 33-46           |

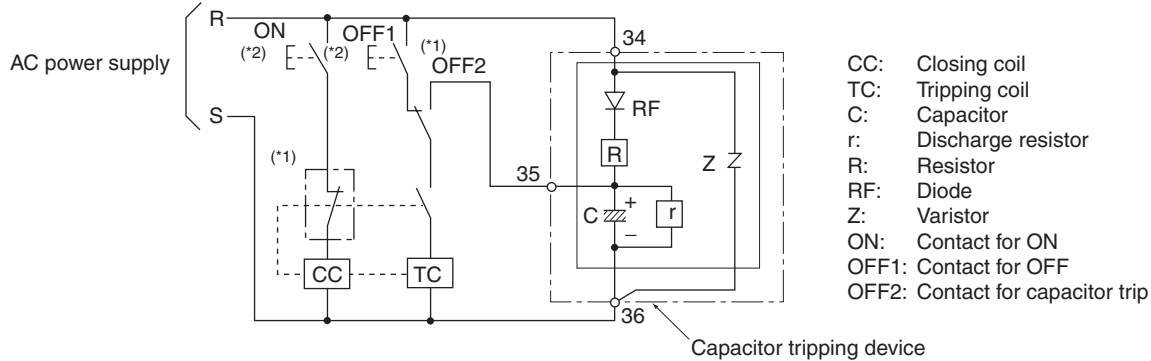
Notes: • Coil ratings: 03/VG to 5-1/VG: 200V DC  
N1/VS to N14/VS: 200V (200 to 220V DC, 200 to 220V AC, 50/60Hz)

• Operating time: For 200V DC.

# 1 Contactors and Starters

## 1-3 Performance and characteristics

Fig. 14 Capacitor tripping circuit example



Notes: NC contact for ON:

\*<sub>1</sub> With SC-N4/VS to N14/VS models, because they have an electronic NC contact function (i.e., an electronic circuit for controlling the closing coil), the contactor's own auxiliary NC contact is not connected. With SC-03/V to 5-1/V models and SC-N1/VS to N3/VS models, the latch unit's built-in NC contact (terminals 55–56) is connected in series.

\*<sub>2</sub> Use a non-overlapping circuit configuration for the ON command (ON) and trip commands (OFF1 and OFF2). Overlapping may result in contact chattering or burning of the coil.

### (5) Resistance to vibration and shock

#### (a) Resistance to vibration

The test checks that the self-hold contact of the SH-4 industrial relay connected in series with the tested contact does not open, and the bounce time is between 0.1 and 1ms. No vibration is applied to the SH-4.

#### (b) Resistance to shock

The test investigates contact malfunctions and contact durability when drop impact is applied in the normally mounted state using a pneumatic drop tester. Malfunctions are detected in the same way as for the vibration resistance test.

#### (c) Test result

The contactor operates normally and the parts are not damaged within the figures shown in table below.

| Type      | Resistance to vibration<br>(double amplitude 2mm)<br>Acceleration (m/s <sup>2</sup> ) | Resistance to shock (m/s <sup>2</sup> ) |  |
|-----------|---|---|--|
|           |   | Malfunction durability                  | Mechanical durability<br>Screw mounted    Rail mounted |
| SC-03/VG  | 30  | 100                                     | 500    400   |
| SC-0/VG   | 30  | 100                                     | 500    400   |
| SC-05/VG  | 30  | 100                                     | 500    400   |
| SC-4-0/VG | 30  | 100                                     | 500    400   |
| SC-4-1/VG | 30  | 100                                     | 500    400   |
| SC-5-1/VG | 30  | 100                                     | 500    400   |
| SC-N1/VS  | 30  | 100                                     | 500    350   |
| SC-N2/VS  | 30  | 100                                     | 500    350   |
| SC-N2S/VS | 30  | 100                                     | 500    350   |
| SC-N3/VS  | 30  | 100                                     | 500    350   |
| SC-N4/VS  | 30  | 100                                     | 500    –   |
| SC-N5/VS  | 30  | 100                                     | 500    –   |
| SC-N6/VS  | 30  | 100                                     | 500    –   |
| SC-N7/VS  | 30  | 100                                     | 500    –   |
| SC-N8/VS  | 30  | 100                                     | 500    –   |
| SC-N10/VS | 30  | 100                                     | 500    –   |
| SC-N11/VS | 30  | 100                                     | 500    –   |
| SC-N12/VS | 30  | 100                                     | 500    –   |
| SC-N14/VS | 30  | 100                                     | 500    –   |

# Chapter 2

## Thermal Overload Relays

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## 2 Thermal Overload Relays

### 2-1 Ratings and specifications

#### 2-1-1 Standard type

| On-contactor mounting    | 3-element<br>2-element * <sub>2</sub> | TR-0N/3<br>TR-0N   |               | TR-5-1N/3<br>TR-5-1N   |                  | TR-N2/3<br>TR-N2   |       | TR-N3/3<br>TR-N3   |                       |
|--------------------------|---------------------------------------|--------------------|---------------|------------------------|------------------|--------------------|-------|--------------------|-----------------------|
| Separate mounting        | 3-element<br>2-element * <sub>2</sub> | TR-0NH/3<br>TR-0NH |               | TR-5-1NH/3<br>TR-5-1NH |                  | TR-N2H/3<br>TR-N2H |       | TR-N3H/3<br>TR-N3H |                       |
| Contactor to be combined |                                       | SC-03              | SC-0<br>SC-05 | SC-4-0                 | SC-4-1<br>SC-5-1 | SC-N1              | SC-N2 | SC-N2S             | SC-N3                 |
| Ampere setting range (A) |                                       | 0.1–0.15           | 0.1–0.15      | 0.1–0.15               | 0.1–0.15         |                    |       |                    |                       |
|                          |                                       | 0.13–0.2           | 0.13–0.2      | 0.13–0.2               | 0.13–0.2         |                    |       |                    |                       |
|                          |                                       | 0.15–0.24          | 0.15–0.24     | 0.15–0.24              | 0.15–0.24        |                    |       |                    |                       |
|                          |                                       | 0.2–0.3            | 0.2–0.3       | 0.2–0.3                | 0.2–0.3          |                    |       |                    |                       |
|                          |                                       | 0.24–0.36          | 0.24–0.36     | 0.24–0.36              | 0.24–0.36        |                    |       |                    |                       |
|                          |                                       | 0.3–0.45           | 0.3–0.45      | 0.3–0.45               | 0.3–0.45         |                    |       |                    |                       |
|                          |                                       | 0.36–0.54          | 0.36–0.54     | 0.36–0.54              | 0.36–0.54        |                    |       |                    |                       |
|                          |                                       | 0.48–0.72          | 0.48–0.72     | 0.48–0.72              | 0.48–0.72        |                    |       |                    |                       |
|                          |                                       | 0.64–0.96          | 0.64–0.96     | 0.64–0.96              | 0.64–0.96        |                    |       |                    |                       |
|                          |                                       | 0.8–1.2            | 0.8–1.2       | 0.8–1.2                | 0.8–1.2          |                    |       |                    |                       |
|                          |                                       | 0.95–1.45          | 0.95–1.45     | 0.95–1.45              | 0.95–1.45        |                    |       |                    |                       |
|                          |                                       | 1.4–2.2            | 1.4–2.2       | 1.4–2.2                | 1.4–2.2          |                    |       |                    |                       |
|                          |                                       | 1.7–2.6            | 1.7–2.6       | 1.7–2.6                | 1.7–2.6          |                    |       |                    |                       |
|                          |                                       | 2.2–3.4            | 2.2–3.4       | 2.2–3.4                | 2.2–3.4          |                    |       |                    |                       |
|                          |                                       | 2.8–4.2            | 2.8–4.2       | 2.8–4.2                | 2.8–4.2          |                    |       |                    |                       |
|                          |                                       | 4–6                | 4–6           | 4–6                    | 4–6              | 4–6                | 4–6   |                    |                       |
|                          |                                       | 5–8                | 5–8           | 5–8                    | 5–8              | 5–8                | 5–8   |                    |                       |
|                          |                                       | 6–9                | 6–9           | 6–9                    | 6–9              | 6–9                | 6–9   |                    |                       |
|                          |                                       | 7–11               | 7–11          | 7–11                   | 7–11             | 7–11               | 7–11  | 7–11               | 7–11                  |
|                          |                                       |                    | 9–13          | 9–13                   | 9–13             | 9–13               | 9–13  | 9–13               | 9–13                  |
|                          |                                       |                    |               | 12–18                  | 12–18            | 12–18              | 12–18 | 12–18              | 12–18                 |
|                          |                                       |                    |               |                        | 16–22            |                    |       |                    |                       |
|                          |                                       |                    |               |                        |                  | 18–26              | 18–26 | 18–26              | 18–26                 |
|                          |                                       |                    |               |                        |                  | 24–36              | 24–36 | 24–36              | 24–36                 |
|                          |                                       |                    |               |                        |                  |                    | 32–42 | 28–40              | 28–40                 |
|                          |                                       |                    |               |                        |                  |                    |       | 34–50              | 34–50                 |
|                          |                                       |                    |               |                        |                  |                    |       | 45–65              | 45–65                 |
|                          |                                       |                    |               |                        |                  |                    |       |                    | 48–68                 |
|                          |                                       |                    |               |                        |                  |                    |       |                    | 53–80 * <sub>1</sub>  |
|                          |                                       |                    |               |                        |                  |                    |       |                    | 63–95 * <sub>1</sub>  |
|                          |                                       |                    |               |                        |                  |                    |       |                    | 85–105 * <sub>1</sub> |

| On-contactor mounting    | 3-element<br>2-element * <sub>2</sub> | TR-N5/3<br>TR-N5 |        | TR-N6/3<br>TR-N6       | TR-N7/3<br>TR-N7 | TR-N8/3<br>TR-N8 | TR-N10/3<br>TR-N10   | TR-N12/3<br>TR-N12   | TR-N14/3<br>TR-N14   |
|--------------------------|---------------------------------------|------------------|--------|------------------------|------------------|------------------|----------------------|----------------------|----------------------|
| Separate mounting        | 3-element<br>2-element * <sub>2</sub> | –                |        | TR-N6H/3<br>TR-N6H     | –                | –                | TR-N10H/3<br>TR-N10H | TR-N12H/3<br>TR-N12H | TR-N14H/3<br>TR-N14H |
| Contactor to be combined |                                       | SC-N4            | SC-N5  | SC-N6                  | SC-N7            | SC-N8            | SC-N10               | SC-N11               | SC-N12               |
| Ampere setting range (A) |                                       | 18–26            | 18–26  |                        |                  |                  |                      |                      |                      |
|                          |                                       | 24–36            | 24–36  |                        |                  |                  |                      |                      |                      |
|                          |                                       | 28–40            | 28–40  |                        |                  |                  |                      |                      |                      |
|                          |                                       | 34–50            | 34–50  |                        |                  |                  |                      |                      |                      |
|                          |                                       | 45–65            | 45–65  | 45–65                  | 45–65            |                  |                      |                      |                      |
|                          |                                       | 53–80            | 53–80  | 53–80                  | 53–80            |                  |                      |                      |                      |
|                          |                                       |                  | 65–95  | 65–95                  | 65–95            | 65–95            |                      |                      |                      |
|                          |                                       |                  | 85–105 |                        |                  |                  |                      |                      |                      |
|                          |                                       |                  |        | 85–125                 | 85–125           | 85–125           | 85–125               |                      |                      |
|                          |                                       |                  |        | 110–160 * <sub>1</sub> | 110–160          | 110–160          | 110–160              | 110–160              |                      |
|                          |                                       |                  |        |                        |                  | 125–185          | 125–185              | 125–185              |                      |
|                          |                                       |                  |        |                        |                  | 160–240          | 160–240              | 160–240              |                      |
|                          |                                       |                  |        |                        |                  |                  | 200–300              | 200–300              |                      |
|                          |                                       |                  |        |                        |                  |                  |                      | 240–360              | 240–360              |
|                          |                                       |                  |        |                        |                  |                  |                      | 300–450              | 300–450              |
|                          |                                       |                  |        |                        |                  |                  |                      |                      | 400–600              |

Notes: • TR-N10/3 and TR-N10 to N14/3 and TR-N14 types are provided with CTs.

• Setting range of SW-03 and 03/H for 380–440V AC: Max. 6–9A

• When ordering the thermal overload relays for starter use, select the appropriate setting range.

\*<sub>1</sub> Separate mounting only

\*<sub>2</sub> Does not conform to IEC, UL/CSA and JIS standards.

### 2-1-2 Long-time operating type

|                          |                           |                      |                          |                      |                      |                    |        |         |
|--------------------------|---------------------------|----------------------|--------------------------|----------------------|----------------------|--------------------|--------|---------|
| On-contactor mounting    | 3-element<br>2-element *2 | –                    | –                        | –                    | TR-N2L/3<br>TR-N2L   | TR-N3L/3<br>TR-N3L |        |         |
| Separate mounting        | 3-element<br>2-element *2 | TR-0NLH/3<br>TR-0NLH | TR-5-1NLH/3<br>TR-5-1NLH | TR-N2LH/3<br>TR-N2LH | TR-N3LH/3<br>TR-N3LH |                    |        |         |
| Contactor to be combined | SC-03                     | SC-0<br>SC-05        | SC-4-0                   | SC-4-1<br>SC-5-1     | SC-N1                | SC-N2              | SC-N2S | SC-N3   |
| Ampere setting range (A) | 0.95–1.45                 | 0.95–1.45            | 0.95–1.45                | 0.95–1.45            |                      |                    |        |         |
|                          | 1.4–2.2                   | 1.4–2.2              | 1.4–2.2                  | 1.4–2.2              |                      |                    |        |         |
|                          | 1.7–2.6                   | 1.7–2.6              | 1.7–2.6                  | 1.7–2.6              |                      |                    |        |         |
|                          | 2.2–3.4                   | 2.2–3.4              | 2.2–3.4                  | 2.2–3.4              |                      |                    |        |         |
|                          | 2.8–4.2                   | 2.8–4.2              | 2.8–4.2                  | 2.8–4.2              |                      |                    |        |         |
|                          | 4–6                       | 4–6                  | 4–6                      | 4–6                  | 4–6                  | 4–6                |        |         |
|                          | 5–8                       | 5–8                  | 5–8                      | 5–8                  | 5–8                  | 5–8                |        |         |
|                          | 6–9                       | 6–9                  | 6–9                      | 6–9                  | 6–9                  | 6–9                |        |         |
|                          | 7–11                      | 7–11                 | 7–11                     | 7–11                 | 7–11                 | 7–11               | 7–11   | 7–11    |
|                          |                           | 9–13                 | 9–13                     | 9–13                 | 9–13                 | 9–13               | 9–13   | 9–13    |
|                          |                           |                      | 12–18                    | 12–18                | 12–18                | 12–18              | 12–18  | 12–18   |
|                          |                           |                      |                          |                      | 18–26                | 18–26              | 18–26  | 18–26   |
|                          |                           |                      |                          |                      |                      | 24–36              | 24–36  | 24–36   |
|                          |                           |                      |                          |                      |                      |                    | 28–40  | 28–40   |
|                          |                           |                      |                          |                      |                      |                    | 34–50  | 34–50   |
|                          |                           |                      |                          |                      |                      |                    |        | 45–65   |
|                          |                           |                      |                          |                      |                      |                    |        | 53–80 * |
|                          |                           |                      |                          |                      |                      |                    |        | 65–95 * |

|                          |                           |                    |                      |                    |                        |                        |                        |         |         |
|--------------------------|---------------------------|--------------------|----------------------|--------------------|------------------------|------------------------|------------------------|---------|---------|
| On-contactor mounting    | 3-element<br>2-element *2 | TR-N5L/3<br>TR-N5L | TR-N6L/3<br>TR-N6L   | TR-N7L/3<br>TR-N7L | TR-N10L/3<br>TR-N10L   | TR-N12L/3<br>TR-N12L   | TR-N14L/3<br>TR-N14L   |         |         |
| Separate mounting        | 3-element<br>2-element *2 | –                  | TR-N6LH/3<br>TR-N6LH | –                  | TR-N10LH/3<br>TR-N10LH | TR-N12LH/3<br>TR-N12LH | TR-N14LH/3<br>TR-N14LH |         |         |
| Contactor to be combined | SC-N4                     | SC-N5              | SC-N6                | SC-N7              | SC-N8                  | SC-N10                 | SC-N11                 | SC-N12  | SC-N14  |
| Ampere setting range (A) | 18–26                     | 18–26              |                      |                    |                        |                        |                        |         |         |
|                          | 24–36                     | 24–36              |                      |                    |                        |                        |                        |         |         |
|                          | 28–40                     | 28–40              |                      |                    |                        |                        |                        |         |         |
|                          | 34–50                     | 34–50              |                      |                    |                        |                        |                        |         |         |
|                          | 45–65                     | 45–65              | 45–65                | 45–65              |                        |                        |                        |         |         |
|                          | 53–80                     | 53–80              | 53–80                | 53–80              |                        |                        |                        |         |         |
|                          |                           | 65–95              | 65–95                | 65–95              |                        |                        |                        |         |         |
|                          |                           |                    | 85–125               | 85–125             | 85–125                 | 85–125                 |                        |         |         |
|                          |                           |                    | 110–160 *            | 110–160            | 110–160                | 110–160                | 110–160                |         |         |
|                          |                           |                    |                      |                    | 125–185                | 125–185                | 125–185                |         |         |
|                          |                           |                    |                      |                    |                        | 160–240                | 160–240                | 160–240 |         |
|                          |                           |                    |                      |                    |                        |                        | 200–300                | 200–300 |         |
|                          |                           |                    |                      |                    |                        |                        |                        | 240–360 | 240–360 |
|                          |                           |                    |                      |                    |                        |                        |                        | 300–450 | 300–450 |
|                          |                           |                    |                      |                    |                        |                        |                        |         | 400–600 |

Notes: Setting range of SW-03/2L and 3L for 380–440V AC: Max. 6–9A  
Select the appropriate setting range when ordering the thermal overload relays for starter use.

\*1 Separate mounting only

\*2 Does not conform to IEC, UL/CSA and JIS standards.

## 2 Thermal Overload Relays

### 2-1 Ratings and specifications

#### 2-1-3 Quick operating type

| On-contactor mounting         | 3-element            | TR-0NQ  |               | TR-5-1NQ  |                  | TR-N2Q *1  |          |
|-------------------------------|----------------------|---------|---------------|-----------|------------------|------------|----------|
| Separate mounting             | 3-element            | TR-0NQH |               | TR-5-1NQH |                  | TR-N2QH *1 |          |
| Contactor to be combined      |                      | SC-03   | SC-0<br>SC-05 | SC-4-0    | SC-4-1<br>SC-5-1 | SC-N1      | SC-N2    |
| Rated operational current (A) | 200–240V<br>380–440V | 11<br>9 | 13<br>12      | 18<br>16  | 22<br>22         | 27<br>30   | 39<br>37 |
| Ampere setting range (A)      |                      | 1.4–2.2 | 1.4–2.2       | 1.4–2.2   | 1.4–2.2          |            |          |
|                               |                      | 1.7–2.6 | 1.7–2.6       | 1.7–2.6   | 1.7–2.6          |            |          |
|                               |                      | 2.2–3.4 | 2.2–3.4       | 2.2–3.4   | 2.2–3.4          |            |          |
|                               |                      | 2.8–4.2 | 2.8–4.2       | 2.8–4.2   | 2.8–4.2          |            |          |
|                               |                      | 4–6     | 4–6           | 4–6       | 4–6              |            |          |
|                               |                      | 5–8     | 5–8           | 5–8       | 5–8              |            |          |
|                               |                      | 6–9     | 6–9           | 6–9       | 6–9              |            |          |
|                               |                      | 7–11 *1 | 7–11 *1       | 7–11 *1   | 7–11 *1          |            |          |
|                               |                      |         | 9–13 *1       | 9–13 *1   | 9–13 *1          |            |          |
|                               |                      |         |               | 12–18 *1  | 12–18 *1         | 12–18      | 12–18    |
|                               |                      |         |               |           | 18–26            | 18–26      |          |
|                               |                      |         |               |           |                  | 24–36      |          |

| On-contactor mounting         | 3-element            | TR-N3Q *1 |          | TR-N5Q *1 |            |
|-------------------------------|----------------------|-----------|----------|-----------|------------|
| Separate mounting             | 3-element            | TR-N3Q *1 |          | –         |            |
| Contactor to be combined      |                      | SC-N2S    | SC-N3    | SC-N4     | SC-N5      |
| Rated operational current (A) | 200–240V<br>380–440V | 52<br>48  | 65<br>65 | 80<br>80  | 105<br>105 |
| Ampere setting range (A)      |                      | 18–26     | 18–26    | 18–26     | 18–26      |
|                               |                      | 24–36     | 24–36    | 24–36     | 24–36      |
|                               |                      | 28–40     | 28–40    | 28–40     | 28–40      |
|                               |                      | 34–50     | 34–50    | 34–50     | 34–50      |
|                               |                      |           | 45–65    | 45–65     | 45–65      |
|                               |                      |           | 53–80 *2 | 53–80     | 53–80      |
|                               |                      |           | 65–95 *2 |           | 65–95      |

Notes: • Setting range of SW-3/3Q for 380–440V AC: Max. 6–9A

\*1 Thermal overload relay with phase-loss protection is available with setting ranges of TR-0NQ, TR-5-1NQ and all setting ranges of TR-N2Q to N5Q.

Type numbers are TK-0NQ, TK-5-1NQ, TK-N2Q to N5Q. The setting ranges of these TK-□Q type relays are as same as those of the above setting ranges.

\*2 Separate mounting only.



**2-1-4 2E type (with phase-loss protection)**

| On-contactor mounting    | 3-element | TK-0N   |   | TK-5-1N  |   | TK-N2  |   | TK-N3  |   |
|--------------------------|-----------|---|---|--|---|--|---|--|---|
| Separate mounting        | 3-element | TK-0NH  |   | TK-5-1NH   |   | TK-N2H   |   | TK-N3H   |   |
| Contactor to be combined |           | SC-03   | SC-0<br>SC-05   | SC-4-0   | SC-4-1<br>SC-5-1  | SC-N1  | SC-N2   | SC-N2S   | SC-N3   |
| Ampere setting range (A) |           | 0.1–0.15<br>0.13–0.2<br>0.15–0.24<br>0.2–0.3<br>0.24–0.36<br>0.3–0.45<br>0.36–0.54<br>0.48–0.72<br>0.64–0.96<br>0.8–1.2<br>0.95–1.45<br>1.4–2.2<br>1.7–2.6<br>2.2–3.4<br>2.8–4.2<br>4–6<br>5–8<br>6–9<br>7–11 | 0.1–0.15<br>0.13–0.2<br>0.15–0.24<br>0.2–0.3<br>0.24–0.36<br>0.3–0.45<br>0.36–0.54<br>0.48–0.72<br>0.64–0.96<br>0.8–1.2<br>0.95–1.45<br>1.4–2.2<br>1.7–2.6<br>2.2–3.4<br>2.8–4.2<br>4–6<br>5–8<br>6–9<br>7–11<br>9–13 | 0.1–0.15<br>0.13–0.2<br>0.15–0.24<br>0.2–0.3<br>0.24–0.36<br>0.3–0.45<br>0.36–0.54<br>0.48–0.72<br>0.64–0.96<br>0.8–1.2<br>0.95–1.45<br>1.4–2.2<br>1.7–2.6<br>2.2–3.4<br>2.8–4.2<br>4–6<br>5–8<br>6–9<br>7–11<br>9–13<br>12–18 | 0.1–0.15<br>0.13–0.2<br>0.15–0.24<br>0.2–0.3<br>0.24–0.36<br>0.3–0.45<br>0.36–0.54<br>0.48–0.72<br>0.64–0.96<br>0.8–1.2<br>0.95–1.45<br>1.4–2.2<br>1.7–2.6<br>2.2–3.4<br>2.8–4.2<br>4–6<br>5–8<br>6–9<br>7–11<br>9–13<br>12–18<br>16–22 |  |   |  |   |
|                          |           |   |   |  |   | 4–6<br>5–8<br>6–9<br>7–11<br>9–13<br>12–18<br>18–26<br>24–36 | 4–6<br>5–8<br>6–9<br>7–11<br>9–13<br>12–18<br>18–26<br>24–36<br>32–42 | 7–11<br>9–13<br>12–18<br>18–26<br>24–36<br>28–40<br>34–50<br>45–65 | 7–11<br>9–13<br>12–18<br>18–26<br>24–36<br>28–40<br>34–50<br>45–65<br>48–68<br>53–80 *<br>63–95 *<br>85–105 * |

| On-contactor mounting    | 3-element | TK-N5   |   | TK-N6  | TK-N7  | TK-N8                        | TK-N10                                  | TK-N12                                   |  | TK-N14                        |
|--------------------------|-----------|---|---|--|--|------------------------------|---|--|--|-------------------------------|
| Separate mounting        | 3-element | –   |   | TK-N6H   | –  | –                            | TK-N10H                                 | TK-N12H                                  |  | TK-N14H                       |
| Contactor to be combined |           | SC-N4   | SC-N5   | SC-N6  | SC-N7  | SC-N8                        | SC-N10                                  | SC-N11                                   | SC-N12   | SC-N14                        |
| Ampere setting range (A) |           | 18–26<br>24–36<br>28–40<br>34–50<br>45–65<br>53–80<br>65–95<br>85–105 | 18–26<br>24–36<br>28–40<br>34–50<br>45–65<br>53–80<br>65–95<br>85–105 | 45–65<br>53–80<br>65–95<br>85–125<br>110–160 * | 45–65<br>53–80<br>65–95<br>85–125<br>110–160 | 85–125<br>110–160<br>125–185 | 85–125<br>110–160<br>125–185<br>160–240 | 110–160<br>125–185<br>160–240<br>200–300 | 110–160<br>125–185<br>160–240<br>200–300<br>240–360<br>300–450 | 240–360<br>300–450<br>400–600 |

Notes: • Setting range of SW-03/2E for 380–440V AC: Max. 6–9A  
 • When ordering the thermal overload relays for starter use, select the appropriate setting range.  
 \* Separate mounting only

## 2 Thermal Overload Relays

### 2-2 Performance and characteristics

#### 2-2-1 Operating characteristics

The operating characteristics of a thermal overload relays represents its tripping time and response current starting from cold or hot state.

##### Cold starting characteristics

In cold starting, tripping time is measured from the time when the temperature of the thermal overload relay is equal to the ambient temperature.

##### Hot starting characteristics

In hot starting, tripping time is measured from the time when the thermal overload relay reaches the steady state after non-tripping current flows two hours.

| Standard       | When all poles are equally energized |                                  |                      |                                   | When all poles are not equally energized |  |              | Ambient temp.                   |  |      |
|----------------|--------------------------------------|----------------------------------|----------------------|-----------------------------------|--|--|--------------|---------------------------------|--|------|
|                | Operating limit                      |                                  | Overload (hot start) | Locked rotor (cold start)         | Phase-loss protection                    | Operating limit                        |              |                                 |  |      |
|                | Non-tripping                         | Tripping                         |                      |                                   |  |  |              | Non-tripping                    | Tripping   |      |
| IEC 60947-4-1  | 105% I <sub>e</sub>                  | 120% I <sub>e</sub><br>(2h max.) | class 10A            | 150% I <sub>e</sub><br>2min max.  | class 10A                                | 720% I <sub>e</sub><br>2 to 10s max.   | Not provided | 3-phase:<br>105% I <sub>e</sub> | 2-phase:<br>132% I <sub>e</sub><br>1-phase: 0<br>(2h max.) | 20°C |
|                |                                      |                                  | class 10             | 150% I <sub>e</sub><br>4min max.  | class 10                                 | 720% I <sub>e</sub><br>4 to 10s max.   |              |                                 |  |      |
|                |                                      |                                  | class 20             | 150% I <sub>e</sub><br>8min max.  | class 20                                 | 720% I <sub>e</sub><br>6 to 20s max.   | Provided     | 2-phase:<br>100% I <sub>e</sub> | 2-phase:<br>115% I <sub>e</sub>                            |      |
|                |                                      |                                  | class 30             | 150% I <sub>e</sub><br>12min max. | class 30                                 | 720% I <sub>e</sub><br>9 to 30s max. * |              | 1-phase:<br>90% I <sub>e</sub>  | 1-phase: 0<br>(2h max.)                                    |      |
| JIS C 8201-4-1 | 105% I <sub>e</sub>                  | 120% I <sub>e</sub><br>(2h max.) | class 5              | 150% I <sub>e</sub><br>2min max.  | class 5                                  | 720% I <sub>e</sub><br>5s max.         | Not provided | 3-phase:<br>105% I <sub>e</sub> | 2-phase:<br>132% I <sub>e</sub><br>1-phase: 0<br>(2h max.) | 20°C |
|                |                                      |                                  | class 10A            | 150% I <sub>e</sub><br>2min max.  | class 10A                                | 720% I <sub>e</sub><br>2 to 10s max.   |              |                                 |  |      |
|                |                                      |                                  | class 10             | 150% I <sub>e</sub><br>4min max.  | class 10                                 | 720% I <sub>e</sub><br>4 to 10s max.   |              |                                 |  |      |
|                |                                      |                                  | class 20             | 150% I <sub>e</sub><br>8min max.  | class 20                                 | 720% I <sub>e</sub><br>6 to 20s max.   | Provided     | 2-phase:<br>100% I <sub>e</sub> | 2-phase:<br>115% I <sub>e</sub>                            |      |
|                |                                      |                                  | class 30             | 150% I <sub>e</sub><br>12min max. | class 30                                 | 720% I <sub>e</sub><br>9 to 30s max. * |              | 1-phase:<br>90% I <sub>e</sub>  | 1-phase: 0<br>(2h max.)                                    |      |

- Notes:
- I<sub>e</sub>: Set current
  - The standard values given are for thermal overload relays with an ambient temperature compensator.
  - \* The maximum operating time is used for items exceeding 30s.

#### 2-2-2 Auxiliary contact ratings

##### (1) Conforming to IEC and JIS

| Type  | Conventional free air thermal current (A) | Rated operational current (A) |            |            |
|---|---|-------------------------------|------------|------------|
|   |   | Rated voltage (V)             | AC-15      | DC-13      |
| TR-0N/3, 0NQ<br>TR-5-1N/3, 5-1NQ<br>TK-0N, 5-1N<br>TR-0NLH/3, TR-5-1NLH/3 | 5   | 24                            | 3 (0.3)*   | 1.1 (0.3)* |
|   |   | 100-120                       | 2.5 (0.3)* | 0.28       |
|   |   | 200-240                       | 2 (0.3)*   | 0.14       |
|   |   | 380-440                       | 1 (0.3)*   | —          |
|   |   | 500-600                       | 0.6 (0.3)* | —          |
| TR-N2/3 to N14/3<br>TR-N2L/3 to N14L/3<br>TR-N2Q to N5Q<br>TK-N2 to N14   | 5   | 24                            | 3 (0.5)*   | 1.1 (0.5)* |
|   |   | 100-120                       | 2.5 (0.5)* | 0.28       |
|   |   | 200-240                       | 2 (0.5)*   | 0.14       |
|   |   | 380-440                       | 1 (0.5)*   | —          |
|   |   | 500-600                       | 0.6 (0.5)* | —          |

- Notes: Conforming to IEC 60947-4-1.  
(\*) NO contact of auto reset type.

### (2) Conforming to UL and CSA

| Type                             | Continuous current (A) | Rated operational current (A) |      |       |               |      |       | Rating code  |
|----------------------------------|------------------------|-------------------------------|------|-------|---------------|------|-------|--------------|
|                                  |                        | AC                            |      |       | DC            |      |       |              |
|                                  |                        | Rated voltage                 | Make | Break | Rated voltage | Make | Break |              |
| TR-0N/3, 5-1N/3<br>TK-0N, 5-1N   | 2.5                    | 120V                          | 15   | 1.5   | 125V          | 0.22 | 0.22  | C600<br>R300 |
|                                  |                        | 240V                          | 7.5  | 0.75  |               |      |       |              |
|                                  |                        | 480V                          | 3.75 | 0.375 | 250V          | 0.11 | 0.11  |              |
|                                  |                        | 600V                          | 3    | 0.3   |               |      |       |              |
| TR-N2/3 to N14/3<br>TK-N2 to N14 | 5                      | 120V                          | 30   | 3     | 125V          | 0.22 | 0.22  | B600<br>R300 |
|                                  |                        | 240V                          | 15   | 1.5   |               |      |       |              |
|                                  |                        | 480V                          | 7.5  | 0.75  | 250V          | 0.11 | 0.11  |              |
|                                  |                        | 600V                          | 6    | 0.6   |               |      |       |              |

### 2-2-3 Making and breaking capacity

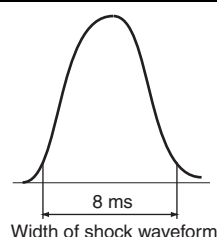
| Type                             | Operational current (A) | Test current (A) |      |       | No. of operations | Power factor cosφ | Operating duty        | Test result     |
|----------------------------------|-------------------------|------------------|------|-------|-------------------|-------------------|-----------------------|-----------------|
|                                  |                         | Test voltage     | Make | Break |                   |                   |                       |                 |
| TR-0N/3, 5-1N/3<br>TK-0N, 5-1N   | 2                       | 264V AC          | 20   | 2     | 50                | 0.3               | at 10-second interval | No contact weld |
|                                  |                         | 240V AC          | 20   | 2     | 6,000             |                   |                       |                 |
| TR-N2/3 to N14/3<br>TK-N2 to N14 | 2                       | 264V AC          | 20   | 2     | 50                | 0.3               | at 10-second interval | No contact weld |
|                                  |                         | 240V AC          | 20   | 2     | 6,000             |                   |                       |                 |

### 2-2-4 Resistance to vibration and shock

The relays are tested to confirm that the items specified by JEM 1356 are satisfied.

| Test item               |                            | Test condition and method  | Judgement conditions  | Test result   |
|-------------------------|----------------------------|--|---|---|
| Resistance to vibration | Mechanical endurance test  | <ul style="list-style-type: none"> <li>Frequency: 10 to 25Hz</li> <li>Double amplitude: 2mm</li> <li>Direction: All 3 axes</li> <li>Time: 2 hours in each direction</li> <li>Main circuit: No current</li> </ul>   | <ul style="list-style-type: none"> <li>The relay can be used without damage to any part.</li> <li>(There is no significant difference during the 200% I<sub>e</sub> operating time before and after vibration is applied.)</li> </ul> | <ul style="list-style-type: none"> <li>No loose screws and no damage to any part.</li> <li>(The rate of change during the 200% I<sub>e</sub> operating time was within ±5%, indicating no problems in practice.)</li> </ul> |
|                         | Malfunction endurance test | <ul style="list-style-type: none"> <li>Setting current value: Minimum of current value in adjustment setting range</li> <li>Main circuit current: Set current</li> <li>Frequency: 10 to 55Hz (changed continuous and uniformly over one minute)</li> <li>Double amplitude: 0.3mm</li> <li>Direction: All 3 axes</li> <li>Time: 10 minutes in each direction</li> </ul> | <ul style="list-style-type: none"> <li>The NC contact's drop-out time is less than 1ms.</li> </ul>  | <ul style="list-style-type: none"> <li>No NC contact malfunction.</li> </ul>  |
| Resistance to shock     | Mechanical endurance test  | <ul style="list-style-type: none"> <li>Shock value: 500m/s<sup>2</sup> (drop test)</li> <li>Direction: All 3 axes</li> <li>Number of times: 3 times in each direction</li> <li>Main circuit current: No current</li> </ul>   | <ul style="list-style-type: none"> <li>The relay can be used without damage to any part.</li> <li>(There is no significant difference during the 200% I<sub>e</sub> operating time before and after shock is applied.)</li> </ul>     | <ul style="list-style-type: none"> <li>No loose screws and no damage to any part.</li> <li>(The rate of change during the 200% I<sub>e</sub> operating time was within ±5%, indicating no problems in practice.)</li> </ul> |
|                         | Malfunction endurance test | <ul style="list-style-type: none"> <li>Setting current value: Minimum of current value in adjustment setting range</li> <li>Main circuit current: Set current</li> <li>Shock acceleration: 50m/s<sup>2</sup></li> <li>Direction: All 3 axes</li> <li>Number of times: 3 times in each direction</li> </ul>   | <ul style="list-style-type: none"> <li>The NC contact's drop-out time is less than 1ms.</li> </ul>  | <ul style="list-style-type: none"> <li>No NC contact malfunction.</li> </ul>  |

- Notes:
- The judgement conditions indicated in parentheses are items not specified by JEM 1356. (FUJI's own judgement conditions)
  - Shock waves of width 8ms were used in the test for shock resistance. Refer to the diagram.
  - The test for malfunctions was performed after temperature saturation.



## 2 Thermal Overload Relays

### 2-2 Performance and characteristics

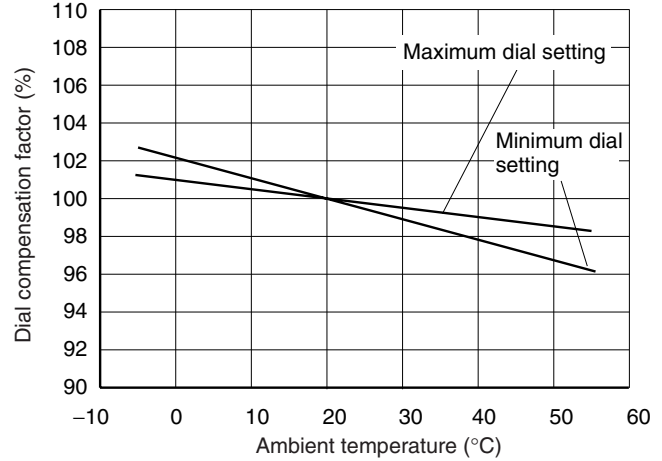
#### 2-2-5 Operating temperature compensation

The current for the thermal overload relay is adjusted using an ambient temperature of 20°C as a standard. An ambient temperature compensator is provided to minimize the affect of fluctuations in the ambient temperature on the operating characteristics.

If the ambient temperature of the thermal overload relay is greatly lower than 20°C, the relay may fail to operate. If the temperature is greatly higher than 20°C, the relay may mistrip. In either case, the set current value must be used as a compensation as shown in the figure at the right.

Example: Calculating the set current value at an ambient temperature of 55°C

$$\frac{\text{Dial setting at } 20^{\circ}\text{C}}{\text{Compensation factor at } 55^{\circ}\text{C}} = \text{Dial setting for } 55^{\circ}\text{C}$$



#### 2-2-6 Thermal time constants

With thermal relays used to protect motors that perform fluctuating load operation or intermittent operation based on separate programs, in order to prevent a mistrip, it is necessary to obtain the equivalent continuous current for each of the fluctuating currents and set the current to the maximum of these values. If, however, the motor's thermal capacity is small relative to the set values, or if the operation is completely irregular, a FUJI motor guard that directly measures the winding temperature must be used.

| Type             | Current setting range | Thermal time constant Tc (sec) |
|------------------|-----------------------|--------------------------------|
| TR-0N, TK-0N     | 6 to 9A or less       | 120                            |
| TR-5-1N, TK-5-1N | 7 to 11A or over      | 90                             |
| TR-N2, TK-N2     | —                     | 160                            |
| TR-N3, TK-N3     |                       |                                |
| TR-N5, TK-N5     |                       |                                |
| TR-N6, TK-N6     | —                     | 200                            |
| TR-N7, TK-N7     |                       |                                |
| TR-N8, TK-N8     |                       |                                |
| TR-N10 to N14    | —                     | 350                            |
| TK-N10 to N14    |                       |                                |

**2-3-1 Standard type/220V**

| Motor rating *<br>220V 50Hz 3-phase |      | Heater element setting range (A) |               |                      |                  |                  |       |                  |       |
|-------------------------------------|------|----------------------------------|---------------|----------------------|------------------|------------------|-------|------------------|-------|
|                                     |      | TR-0N/3<br>TK-0N                 |               | TR-5-1N/3<br>TK-5-1N |                  | TR-N2/3<br>TK-N2 |       | TR-N3/3<br>TK-N3 |       |
|                                     |      | Contactor to be combined         |               |                      |                  |                  |       |                  |       |
| (kW)                                | (A)  | SC-03                            | SC-0<br>SC-05 | SC-4-0               | SC-4-1<br>SC-5-1 | SC-N1            | SC-N2 | SC-N2S           | SC-N3 |
| 0.06                                | 0.39 | 0.36-0.54                        | 0.36-0.54     | 0.36-0.54            | 0.36-0.54        |                  |       |                  |       |
| 0.09                                | 0.58 | 0.48-0.72                        | 0.48-0.72     | 0.48-0.72            | 0.48-0.72        |                  |       |                  |       |
| 0.12                                | 0.68 | 0.48-0.72                        | 0.48-0.72     | 0.48-0.72            | 0.48-0.72        |                  |       |                  |       |
| 0.18                                | 1.1  | 0.8-1.2                          | 0.8-1.2       | 0.8-1.2              | 0.8-1.2          |                  |       |                  |       |
| 0.25                                | 1.3  | 0.95-1.45                        | 0.95-1.45     | 0.95-1.45            | 0.95-1.45        |                  |       |                  |       |
| 0.37                                | 1.9  | 1.4-2.2                          | 1.4-2.2       | 1.4-2.2              | 1.4-2.2          |                  |       |                  |       |
| 0.55                                | 2.3  | 1.7-2.6                          | 1.7-2.6       | 1.7-2.6              | 1.7-2.6          |                  |       |                  |       |
| 0.75                                | 3.3  | 2.8-4.2                          | 2.8-4.2       | 2.8-4.2              | 2.8-4.2          |                  |       |                  |       |
| 1.1                                 | 4.2  | 4-6                              | 4-6           | 4-6                  | 4-6              | 4-6              | 4-6   |                  |       |
| 1.5                                 | 5.5  | 4-6                              | 4-6           | 4-6                  | 4-6              | 4-6              | 4-6   |                  |       |
| 2.2                                 | 8.4  | 6-9                              | 6-9           | 6-9                  | 6-9              | 6-9              | 6-9   | 7-11             | 7-11  |
| 3                                   | 11   | 7-11                             | 9-13          | 9-13                 | 9-13             | 9-13             | 9-13  | 9-13             | 9-13  |
| 3.7                                 | 13.5 |                                  |               | 12-18                | 12-18            | 12-18            | 12-18 | 12-18            | 12-18 |
| 4                                   | 14.5 |                                  |               | 12-18                | 12-18            | 12-18            | 12-18 | 12-18            | 12-18 |
| 5.5                                 | 20   |                                  |               |                      | 16-22            | 18-26            | 18-26 | 18-26            | 18-26 |
| 7.5                                 | 26.5 |                                  |               |                      |                  | 24-36            | 24-36 | 24-36            | 24-36 |
| 11                                  | 39   |                                  |               |                      |                  |                  | 32-42 | 28-40            | 28-40 |
| 15                                  | 50   |                                  |               |                      |                  |                  |       | 34-50            | 34-50 |
| 18.5                                | 61   |                                  |               |                      |                  |                  |       |                  | 45-65 |

| Motor rating *<br>220V 50Hz 3-phase |      | Heater element setting range (A) |        |                  |                  |                  |                    |                    |                    |         |
|-------------------------------------|------|----------------------------------|--------|------------------|------------------|------------------|--------------------|--------------------|--------------------|---------|
|                                     |      | TR-N5/3<br>TK-N5                 |        | TR-N6/3<br>TK-N6 | TR-N7/3<br>TK-N7 | TR-N8/3<br>TK-N8 | TR-N10/3<br>TK-N10 | TR-N12/3<br>TK-N12 | TR-N14/3<br>TK-N14 |         |
|                                     |      | Contactor to be combined         |        |                  |                  |                  |                    |                    |                    |         |
| (kW)                                | (A)  | SC-N4                            | SC-N5  | SC-N6            | SC-N7            | SC-N8            | SC-N10             | SC-N11             | SC-N12             | SC-N14  |
| 5.5                                 | 20   | 18-26                            | 18-26  |                  |                  |                  |                    |                    |                    |         |
| 7.5                                 | 26.5 | 24-36                            | 24-36  |                  |                  |                  |                    |                    |                    |         |
| 11                                  | 39   | 34-50                            | 34-50  |                  |                  |                  |                    |                    |                    |         |
| 15                                  | 50   | 45-65                            | 45-65  | 45-65            | 45-65            |                  |                    |                    |                    |         |
| 18.5                                | 61   | 53-80                            | 53-80  | 53-80            | 53-80            |                  |                    |                    |                    |         |
| 22                                  | 72   | 65-95                            | 65-95  | 65-95            | 65-95            | 65-95            |                    |                    |                    |         |
| 30                                  | 98   |                                  | 85-105 | 85-125           | 85-125           | 85-125           | 85-125             |                    |                    |         |
| 37                                  | 118  |                                  |        | 85-125           | 85-125           | 85-125           | 85-125             |                    |                    |         |
| 45                                  | 143  |                                  |        |                  | 110-160          | 110-160          | 110-160            | 110-160            |                    |         |
| 55                                  | 177  |                                  |        |                  |                  | 125-185          | 125-185            | 125-185            |                    |         |
| 75                                  | 240  |                                  |        |                  |                  |                  |                    | 200-300            | 200-300            |         |
| 90                                  | 285  |                                  |        |                  |                  |                  |                    | 200-300            | 200-300            |         |
| 110                                 | 340  |                                  |        |                  |                  |                  |                    |                    | 240-360            | 240-360 |
| 132                                 | 405  |                                  |        |                  |                  |                  |                    |                    |                    | 300-450 |
| 160                                 | 495  |                                  |        |                  |                  |                  |                    |                    |                    | 400-600 |

Note: \* The motor full load currents are typical examples.  
 TR: Standard type  
 TK: With phase-loss protection device

For 2-element type (TR-□): Same heater element setting range

## 2 Thermal Overload Relays

### 2-3 Selection of thermal overload relays

#### 2-3-2 Standard type/380V

| Motor rating *<br>380V 50Hz 3-phase |      | Heater element setting range (A) |               |                      |                  |                  |       |                  |       |
|-------------------------------------|------|----------------------------------|---------------|----------------------|------------------|------------------|-------|------------------|-------|
|                                     |      | TR-0N/3<br>TK-0N                 |               | TR-5-1N/3<br>TK-5-1N |                  | TR-N2/3<br>TK-N2 |       | TR-N3/3<br>TK-N3 |       |
|                                     |      | Contactor to be combined         |               |                      |                  |                  |       |                  |       |
| (kW)                                | (A)  | SC-03                            | SC-0<br>SC-05 | SC-4-0               | SC-4-1<br>SC-5-1 | SC-N1            | SC-N2 | SC-N2S           | SC-N3 |
| 0.06                                | 0.23 | 0.15–0.24                        | 0.15–0.24     | 0.15–0.24            | 0.15–0.24        |                  |       |                  |       |
| 0.09                                | 0.34 | 0.24–0.36                        | 0.24–0.36     | 0.24–0.36            | 0.24–0.36        |                  |       |                  |       |
| 0.12                                | 0.39 | 0.36–0.54                        | 0.36–0.54     | 0.36–0.54            | 0.36–0.54        |                  |       |                  |       |
| 0.18                                | 0.63 | 0.48–0.72                        | 0.48–0.72     | 0.48–0.72            | 0.48–0.72        |                  |       |                  |       |
| 0.25                                | 0.74 | 0.64–0.96                        | 0.64–0.96     | 0.64–0.96            | 0.64–0.96        |                  |       |                  |       |
| 0.37                                | 1.1  | 0.8–1.2                          | 0.8–1.2       | 0.8–1.2              | 0.8–1.2          |                  |       |                  |       |
| 0.55                                | 1.3  | 0.95–1.45                        | 0.95–1.45     | 0.95–1.45            | 0.95–1.45        |                  |       |                  |       |
| 0.75                                | 1.8  | 1.4–2.2                          | 1.4–2.2       | 1.4–2.2              | 1.4–2.2          |                  |       |                  |       |
| 1.1                                 | 2.4  | 1.7–2.6                          | 1.7–2.6       | 1.7–2.6              | 1.7–2.6          |                  |       |                  |       |
| 1.5                                 | 3.2  | 2.2–3.4                          | 2.2–3.4       | 2.2–3.4              | 2.2–3.4          |                  |       |                  |       |
| 2.2                                 | 4.7  | 4–6                              | 4–6           | 4–6                  | 4–6              | 4–6              | 4–6   |                  |       |
| 3                                   | 6.4  | 5–8                              | 5–8           | 5–8                  | 5–8              | 5–8              | 5–8   |                  |       |
| 3.7                                 | 7.7  | 5–8                              | 5–8           | 5–8                  | 5–8              | 5–8              | 5–8   |                  |       |
| 4                                   | 8.4  | 6–9                              | 6–9           | 6–9                  | 6–9              | 6–9              | 6–9   |                  |       |
| 5.5                                 | 11.5 |                                  | 9–13          | 9–13                 | 9–13             | 9–13             | 9–13  | 9–13             | 9–13  |
| 7.5                                 | 15   |                                  |               | 12–18                | 12–18            | 12–18            | 12–18 | 12–18            | 12–18 |
| 11                                  | 21.5 |                                  |               |                      | 16–22            | 18–26            | 18–26 | 18–26            | 18–26 |
| 15                                  | 28.5 |                                  |               |                      |                  | 24–36            | 24–36 | 24–36            | 24–36 |
| 18.5                                | 35   |                                  |               |                      |                  |                  | 24–36 | 28–40            | 28–40 |
| 22                                  | 41   |                                  |               |                      |                  |                  |       | 34–50            | 34–50 |
| 30                                  | 56   |                                  |               |                      |                  |                  |       |                  | 45–65 |

| Motor rating *<br>380V 50Hz 3-phase |      | Heater element setting range (A) |        |                  |                  |                  |                    |                    |                    |         |
|-------------------------------------|------|----------------------------------|--------|------------------|------------------|------------------|--------------------|--------------------|--------------------|---------|
|                                     |      | TR-N5/3<br>TK-N5                 |        | TR-N6/3<br>TK-N6 | TR-N7/3<br>TK-N7 | TR-N8/3<br>TK-N8 | TR-N10/3<br>TK-N10 | TR-N12/3<br>TK-N12 | TR-N14/3<br>TK-N14 |         |
|                                     |      | Contactor to be combined         |        |                  |                  |                  |                    |                    |                    |         |
| (kW)                                | (A)  | SC-N4                            | SC-N5  | SC-N6            | SC-N7            | SC-N8            | SC-N10             | SC-N11             | SC-N12             | SC-N14  |
| 11                                  | 21.5 | 18–26                            | 18–26  |                  |                  |                  |                    |                    |                    |         |
| 15                                  | 28.5 | 24–36                            | 24–36  |                  |                  |                  |                    |                    |                    |         |
| 18.5                                | 35   | 28–40                            | 28–40  |                  |                  |                  |                    |                    |                    |         |
| 22                                  | 41   | 34–50                            | 34–50  |                  |                  |                  |                    |                    |                    |         |
| 30                                  | 56   | 45–65                            | 45–65  | 45–65            | 45–65            |                  |                    |                    |                    |         |
| 37                                  | 68   | 53–80                            | 53–80  | 53–80            | 53–80            |                  |                    |                    |                    |         |
| 45                                  | 83   |                                  | 65–95  | 65–95            | 65–95            | 65–95            |                    |                    |                    |         |
| 55                                  | 103  |                                  | 85–125 | 85–125           | 85–125           | 85–125           | 85–125             |                    |                    |         |
| 75                                  | 139  |                                  |        |                  | 110–160          | 110–160          | 110–160            | 110–160            | 110–160            |         |
| 90                                  | 165  |                                  |        |                  |                  | 125–185          | 125–185            | 125–185            | 125–185            |         |
| 110                                 | 197  |                                  |        |                  |                  |                  | 160–240            | 160–240            | 160–240            |         |
| 132                                 | 235  |                                  |        |                  |                  |                  |                    | 200–300            | 200–300            |         |
| 160                                 | 290  |                                  |        |                  |                  |                  |                    | 200–300            | 200–300            |         |
| 200                                 | 355  |                                  |        |                  |                  |                  |                    |                    | 240–360            | 240–360 |
| 250                                 | 440  |                                  |        |                  |                  |                  |                    |                    |                    | 300–450 |
| 315                                 | 570  |                                  |        |                  |                  |                  |                    |                    |                    | 400–600 |

Note: \* The motor full load currents are typical examples.

TR: Standard type

TK: With phase-loss protection device

For 2-element type (TR-□): Same heater element setting range

### 2-3-3 Long-time operating type/220V

| Motor rating *<br>220V 50Hz 3-phase |      | Heater element setting range (A) |               |                          |                  |                    |       |                    |       |
|-------------------------------------|------|----------------------------------|---------------|--------------------------|------------------|--------------------|-------|--------------------|-------|
|                                     |      | TR-0NLH/3<br>TK-0NLH             |               | TR-5-1NLH/3<br>TK-5-1NLH |                  | TR-N2L/3<br>TK-N2L |       | TR-N3L/3<br>TK-N3L |       |
|                                     |      | Contactor to be combined         |               |                          |                  |                    |       |                    |       |
| (kW)                                | (A)  | SC-03                            | SC-0<br>SC-05 | SC-4-0                   | SC-4-1<br>SC-5-1 | SC-N1              | SC-N2 | SC-N2S             | SC-N3 |
| 0.18                                | 1.1  | 0.8-1.2                          | 0.8-1.2       | 0.8-1.2                  | 0.8-1.2          |                    |       |                    |       |
| 0.25                                | 1.3  | 0.95-1.45                        | 0.95-1.45     | 0.95-1.45                | 0.95-1.45        |                    |       |                    |       |
| 0.37                                | 1.9  | 1.4-2.2                          | 1.4-2.2       | 1.4-2.2                  | 1.4-2.2          |                    |       |                    |       |
| 0.55                                | 2.3  | 1.7-2.6                          | 1.7-2.6       | 1.7-2.6                  | 1.7-2.6          |                    |       |                    |       |
| 0.75                                | 3.3  | 2.8-4.2                          | 2.8-4.2       | 2.8-4.2                  | 2.8-4.2          |                    |       |                    |       |
| 1.1                                 | 4.2  | 4-6                              | 4-6           | 4-6                      | 4-6              | 4-6                | 4-6   |                    |       |
| 1.5                                 | 5.5  | 4-6                              | 4-6           | 4-6                      | 4-6              | 4-6                | 4-6   |                    |       |
| 2.2                                 | 8.4  | 6-9                              | 6-9           | 6-9                      | 6-9              | 6-9                | 6-9   | 7-11               | 7-11  |
| 3                                   | 11   | 7-11                             | 9-13          | 9-13                     | 9-13             | 9-13               | 9-13  | 9-13               | 9-13  |
| 3.7                                 | 13.5 |                                  |               | 12-18                    | 12-18            | 12-18              | 12-18 | 12-18              | 12-18 |
| 4                                   | 14.5 |                                  |               | 12-18                    | 12-18            | 12-18              | 12-18 | 12-18              | 12-18 |
| 5.5                                 | 20   |                                  |               |                          | 16-22            | 18-26              | 18-26 | 18-26              | 18-26 |
| 7.5                                 | 26.5 |                                  |               |                          |                  | 24-36              | 24-36 | 24-36              | 24-36 |
| 11                                  | 39   |                                  |               |                          |                  |                    | 32-42 | 28-40              | 28-40 |
| 15                                  | 50   |                                  |               |                          |                  |                    |       | 34-50              | 34-50 |
| 18.5                                | 61   |                                  |               |                          |                  |                    |       |                    | 45-65 |

| Motor rating *<br>220V 50Hz 3-phase |      | Heater element setting range (A) |        |                    |                    |                      |         |                      |                      |         |
|-------------------------------------|------|----------------------------------|--------|--------------------|--------------------|----------------------|---------|----------------------|----------------------|---------|
|                                     |      | TR-N5L/3<br>TK-N5L               |        | TR-N6L/3<br>TK-N6L | TR-N7L/3<br>TK-N7L | TR-N10L/3<br>TK-N10L |         | TR-N12L/3<br>TK-N12L | TR-N14L/3<br>TK-N14L |         |
|                                     |      | Contactor to be combined         |        |                    |                    |                      |         |                      |                      |         |
| (kW)                                | (A)  | SC-N4                            | SC-N5  | SC-N6              | SC-N7              | SC-N8                | SC-N10  | SC-N11               | SC-N12               | SC-N14  |
| 5.5                                 | 20   | 18-26                            | 18-26  |                    |                    |                      |         |                      |                      |         |
| 7.5                                 | 26.5 | 24-36                            | 24-36  |                    |                    |                      |         |                      |                      |         |
| 11                                  | 39   | 34-50                            | 34-50  |                    |                    |                      |         |                      |                      |         |
| 15                                  | 50   | 45-65                            | 45-65  | 45-65              | 45-65              |                      |         |                      |                      |         |
| 18.5                                | 61   | 53-80                            | 53-80  | 53-80              | 53-80              |                      |         |                      |                      |         |
| 22                                  | 72   | 65-95                            | 65-95  | 65-95              | 65-95              | 65-95                |         |                      |                      |         |
| 30                                  | 98   |                                  | 85-105 | 85-125             | 85-125             | 85-125               | 85-125  |                      |                      |         |
| 37                                  | 118  |                                  |        | 85-125             | 85-125             | 85-125               | 85-125  |                      |                      |         |
| 45                                  | 143  |                                  |        |                    | 110-160            | 110-160              | 110-160 | 110-160              |                      |         |
| 55                                  | 177  |                                  |        |                    |                    | 125-185              | 125-185 | 125-185              |                      |         |
| 75                                  | 240  |                                  |        |                    |                    |                      |         | 200-300              | 200-300              |         |
| 90                                  | 285  |                                  |        |                    |                    |                      |         | 200-300              | 200-300              |         |
| 110                                 | 340  |                                  |        |                    |                    |                      |         |                      | 240-360              | 240-360 |
| 132                                 | 405  |                                  |        |                    |                    |                      |         |                      |                      | 300-450 |
| 160                                 | 495  |                                  |        |                    |                    |                      |         |                      |                      | 400-600 |

Note: \* The motor full load currents are typical examples.  
 TR: Standard type  
 TK: With phase-loss protection device

For 2-element type (TR-□): Same heater element setting range

## 2 Thermal Overload Relays

### 2-3 Selection of thermal overload relays

#### 2-3-4 Long-time operating type/380V

| Motor rating *<br>380V 50Hz 3-phase |      | Heater element setting range (A) |               |                          |                  |                    |       |                    |       |
|-------------------------------------|------|----------------------------------|---------------|--------------------------|------------------|--------------------|-------|--------------------|-------|
|                                     |      | TR-0NLH/3<br>TK-0NLH             |               | TR-5-1NLH/3<br>TK-5-1NLH |                  | TR-N2L/3<br>TK-N2L |       | TR-N3L/3<br>TK-N3L |       |
|                                     |      | Contactor to be combined         |               |                          |                  |                    |       |                    |       |
| (kW)                                | (A)  | SC-03                            | SC-0<br>SC-05 | SC-4-0                   | SC-4-1<br>SC-5-1 | SC-N1              | SC-N2 | SC-N2S             | SC-N3 |
| 0.18                                | 0.63 | 0.48-0.72                        | 0.48-0.72     | 0.48-0.72                | 0.48-0.72        |                    |       |                    |       |
| 0.25                                | 0.74 | 0.46-0.96                        | 0.46-0.96     | 0.46-0.96                | 0.46-0.96        |                    |       |                    |       |
| 0.37                                | 1.1  | 0.8-1.2                          | 0.8-1.2       | 0.8-1.2                  | 0.8-1.2          |                    |       |                    |       |
| 0.55                                | 1.3  | 0.95-1.45                        | 0.95-1.45     | 0.95-1.45                | 0.95-1.45        |                    |       |                    |       |
| 0.75                                | 1.8  | 1.4-2.2                          | 1.4-2.2       | 1.4-2.2                  | 1.4-2.2          |                    |       |                    |       |
| 1.1                                 | 2.4  | 1.7-2.6                          | 1.7-2.6       | 1.7-2.6                  | 1.7-2.6          |                    |       |                    |       |
| 1.5                                 | 3.2  | 2.2-3.4                          | 2.2-3.4       | 2.2-3.4                  | 2.2-3.4          |                    |       |                    |       |
| 2.2                                 | 4.7  | 4-6                              | 4-6           | 4-6                      | 4-6              | 4-6                | 4-6   |                    |       |
| 3                                   | 6.4  | 5-8                              | 5-8           | 5-8                      | 5-8              | 5-8                | 5-8   |                    |       |
| 3.7                                 | 7.7  | 5-8                              | 5-8           | 5-8                      | 5-8              | 5-8                | 5-8   |                    |       |
| 4                                   | 8.4  | 6-9                              | 6-9           | 6-9                      | 6-9              | 6-9                | 6-9   |                    |       |
| 5.5                                 | 11.5 |                                  | 9-13          | 9-13                     | 9-13             | 9-13               | 9-13  | 9-13               | 9-13  |
| 7.5                                 | 15   |                                  |               | 12-18                    | 12-18            | 12-18              | 12-18 | 12-18              | 12-18 |
| 11                                  | 21.5 |                                  |               |                          | 16-22            | 18-26              | 18-26 | 18-26              | 18-26 |
| 15                                  | 28.5 |                                  |               |                          |                  | 24-36              | 24-36 | 24-36              | 24-36 |
| 18.5                                | 35   |                                  |               |                          |                  |                    | 24-36 | 28-40              | 28-40 |
| 22                                  | 41   |                                  |               |                          |                  |                    |       | 34-50              | 34-50 |
| 30                                  | 56   |                                  |               |                          |                  |                    |       |                    | 45-65 |

| Motor rating *<br>380V 50Hz 3-phase |      | Heater element setting range (A) |        |                    |                    |                      |                      |                      |         |         |
|-------------------------------------|------|----------------------------------|--------|--------------------|--------------------|----------------------|----------------------|----------------------|---------|---------|
|                                     |      | TR-N5L/3<br>TK-N5L               |        | TR-N6L/3<br>TK-N6L | TR-N7L/3<br>TK-N7L | TR-N10L/3<br>TK-N10L | TR-N12L/3<br>TK-N12L | TR-N14L/3<br>TK-N14L |         |         |
|                                     |      | Contactor to be combined         |        |                    |                    |                      |                      |                      |         |         |
| (kW)                                | (A)  | SC-N4                            | SC-N5  | SC-N6              | SC-N7              | SC-N8                | SC-N10               | SC-N11               | SC-N12  | SC-N14  |
| 11                                  | 21.5 | 18-26                            | 18-26  |                    |                    |                      |                      |                      |         |         |
| 15                                  | 28.5 | 24-36                            | 24-36  |                    |                    |                      |                      |                      |         |         |
| 18.5                                | 35   | 28-40                            | 28-40  |                    |                    |                      |                      |                      |         |         |
| 22                                  | 41   | 34-50                            | 34-50  |                    |                    |                      |                      |                      |         |         |
| 30                                  | 56   | 45-65                            | 45-65  | 45-65              | 45-65              |                      |                      |                      |         |         |
| 37                                  | 68   | 53-80                            | 53-80  | 53-80              | 53-80              |                      |                      |                      |         |         |
| 45                                  | 83   |                                  | 65-95  | 65-95              | 65-95              | 65-95                |                      |                      |         |         |
| 55                                  | 103  |                                  | 85-125 | 85-125             | 85-125             | 85-125               | 85-125               |                      |         |         |
| 75                                  | 139  |                                  |        |                    | 110-160            | 110-160              | 110-160              | 110-160              | 110-160 |         |
| 90                                  | 165  |                                  |        |                    |                    | 125-185              | 125-185              | 125-185              | 125-185 |         |
| 110                                 | 197  |                                  |        |                    |                    |                      | 160-240              | 160-240              | 160-240 |         |
| 132                                 | 235  |                                  |        |                    |                    |                      |                      | 200-300              | 200-300 |         |
| 160                                 | 290  |                                  |        |                    |                    |                      |                      | 200-300              | 200-300 |         |
| 200                                 | 355  |                                  |        |                    |                    |                      |                      |                      | 240-360 | 240-360 |
| 250                                 | 440  |                                  |        |                    |                    |                      |                      |                      |         | 300-450 |
| 315                                 | 570  |                                  |        |                    |                    |                      |                      |                      |         | 400-600 |

Note: \* The motor full load currents are typical examples.

TR: Standard type

TK: With phase-loss protection device

For 2-element type (TR-□): Same heater element setting range



# Chapter 3

## Operating Conditions

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## **3** Operating Conditions

### **3-1 Standard operating conditions**

Performance characteristics for contactors and starters are assured by testing under the following conditions.

- Ambient temperature range:  $-5$  to  $+40^{\circ}\text{C}$   
(The temperature must not exceed  $40^{\circ}\text{C}$  at any time; the average temperature over a 24-hour period must not exceed  $35^{\circ}\text{C}$ ; and the average temperature over a year must not exceed  $20^{\circ}\text{C}$ .)
- Temperature range inside panel box:  $-5$  to  $+55^{\circ}\text{C}$
- Relative humidity: 45 to 85%
- Altitude: 2,000m max.
- Atmosphere: No excessive dust, smoke, flammable gases, corrosive gases, steam, or salt.  
No sudden temperature changes resulting in condensation or icing.

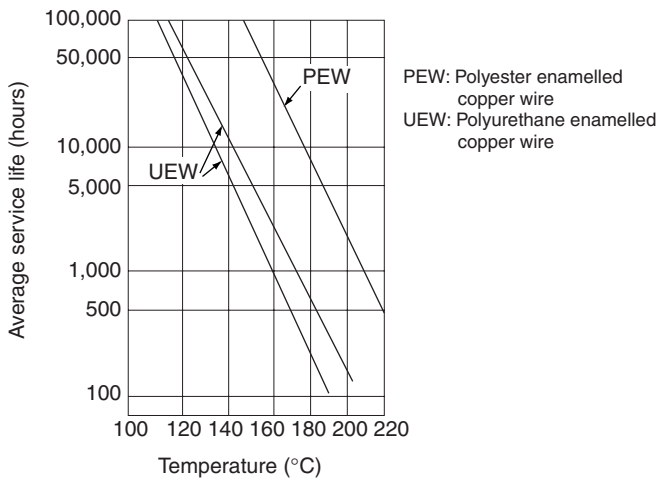
### 3-2 Conditions for special environments

#### 3-2-1 Durability at high temperatures

The durability of a contactor at high temperatures is mainly determined by the aging of molded parts and the coil's winding insulation material. The latter is a particularly significant factor. SC series contactors are designed to operate for long periods even if the temperature inside the control panel is 55°C.

The coil's continuous service life can be estimated the sum of the ambient operating temperature and the coil's temperature rise (refer to page 27). As shown by the graph, the durability can be improved by lowering the ambient temperature.

Fig. 1 Temperature vs service life characteristics of magnet wire



#### 3-2-2 Tropical, humid, or extremely cold locations

Contactors and starters are sometimes exported to or used in tropical, humid, or extremely cold locations, either as standalone products or built into panels or other structures. In such cases, standard products can be used as long as they satisfy the conditions detailed in the following table. In applications that go beyond the scope of these conditions, however, models can be produced that satisfy special specifications.

| Ambient conditions |   | Standard products | Special products for tropical, humid, or extremely cold locations |
|--------------------|---|-------------------|---|
| Temperature        | Operating condition Without enclosure <sup>*3</sup> | -5 to +55°C       | -50 to +55°C <sup>*1</sup><br>(-25 to +55°C)                      |
|                    | Operating condition With enclosure                  | -5 to +40°C       | -50 to +40°C <sup>*1</sup><br>(-25 to +40°C)                      |
|                    | Transport Storage                                   | -40 to +65°C      | -60 to +65°C <sup>*2</sup><br>(-40 to +65°C)                      |
| Relative humidity  |   | 85% max.          | 95% max.  |

Notes: • These conditions are based on the assumption that there is no icing or condensation due to sudden changes in temperature.

• The figures in parentheses apply to models SC-N1/SE to SC-N4/SE and model SC-N5 and over.

\*1: The lower limit is -10°C for thermal overload relays.

\*2: The lower limit is -40°C for thermal overload relays.

\*3: The temperature inside the panel is given.

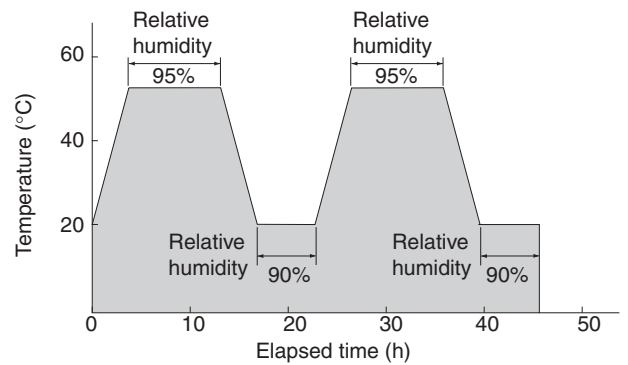
#### 3-2-3 High temperature and humidity test

Although it is desirable for contactors and starters to be used under normal operating conditions, in practice there are situations where it is difficult to maintain these conditions. For this reason, tests are performed under the following conditions.

##### (1) Temperature and humidity test

Testing is performed under the conditions shown in the following graph. It is confirmed that there are no problems caused by rust, deterioration in insulation, or deformation of molded items, and that there is no adverse effect on performance.

Fig. 2 Temperature and humidity test conditions



##### (2) Salt spray test

The salt spray test is often used as a method of evaluating the environment-resistance of a contactor. Testing is performed under the conditions given in the following table. It is confirmed that there are no changes in operation before and after the salt spray test.

##### Salt spray test conditions (JIS Z 2371)

|  |                               |
|--|-------------------------------|
| Water  | Distilled water               |
| Salt   | Sodium chloride               |
| Temperature  | 35°C                          |
| pH value at 35°C   | 6.5 to 7.2                    |
| Volume of salt water sprayed over 1h across an area of 80cm <sup>2</sup> | 1 to 2ml                      |
| Spraying time  | 48h                           |
| Cleaning method for tested item  | Washing (at room temperature) |

# 3 Operating Conditions

## 3-2 Conditions for special environments

### 3-2-4 Protective structure for special environments

#### (1) Dust

When using contactors and starters at locations subject to particularly large amounts of dust, such as cement factories, spinning factories, or construction sites, either use a control panel of a dust-proof construction or use a contactor or starter with an enclosure that has dust-proof specifications (SC-□LG or SW-□LG models). If dust adheres to the contacts, the contact resistance will increase, and there will be an abnormal temperature rise in contactor parts, resulting in the deterioration of insulation and a reduction in electrical durability. In addition, dust may accumulate at insulated parts, resulting in decreased insulation and possibly leading to a short-circuit. Also, if dust builds up between the contacting surfaces of an AC-operated magnetic armature, it may result in incomplete magnetic attraction and lead to problems in operation.

#### (2) Corrosive gases

When using contactors or starters at locations subject to particularly large amounts of corrosive gas, such as chemical factories, refineries, or sewage plants, it is generally desirable to consider protection together with a protective structure for the panel. Protection against mild corrosive gases can be provided by using plating with a high resistance to corrosive gases at weak points. There is no effective method, however, for protecting the silver contact material and there is a limit to the degree of protection possible when the product is used by itself. Furthermore, contactors and starters that can be used in environments subject to mild corrosive gases can be made on request. Select a product suitable for the application environment. The lower the humidity and temperature are, the slower the rate of metal corrosion will be, even in environments subject to corrosive gases, and so raising the pressure inside the panel and feeding in clean air (i.e., air purging) is effective in preventing corrosion.

The relationship between humidity/temperature and the rate of metal corrosion is shown in the following graphs.

#### Examples of environments with corrosive gases

| Gas type                                | Concentration (ppm) |           | Environment example   | Type of metal affected and nature of effect   |
|---|---------------------|-----------|---|---|
|   | Normal              | Abnormal  |   |   |
| Hydrogen sulfide gas (H <sub>2</sub> S) | 0.02 max.           | 0.07 min. | Thermal regions<br>Near iron/copper blast furnaces<br>Sewage plants<br>Paper, pulp, and rayon factories | Ag: Blackening<br>Cu: Blackening, corrosion   |
| Sulfurous acid gas (SO <sub>2</sub> )   | 0.04 max.           | 0.07 min. | Near iron/copper blast furnaces<br>Chemical factories   | Ni: Blackening<br>Fe: Red rust, corrosion<br>Zn: White rust, corrosion<br>Cu: Blackening<br>Corrosion is unlikely to occur, however, if the relative humidity is less than 65%. |
| Chlorine gas (Cl <sub>2</sub> )         | 0.02 max.           | 0.05 min. | Water purification plants<br>Swimming-pool sterilization rooms<br>Chemical factories                    | Sn: Blackening, corrosion<br>Cr: Blackening, corrosion  |
| Nitrous acid gas (NO <sub>2</sub> )     | 0.04 max.           | 0.5 min.  | Urban areas<br>Chemical factories   | Fe: Red rust, corrosion<br>Zn: White rust, corrosion<br>Corrosion is unlikely to occur, however, if the relative humidity is less than 65%.                                     |
| Ammonia gas (NH <sub>3</sub> )          | 0.01 max.           | 5 min.    | Chemical factories  | Brass: Stress corrosion cracking  |

Fig. 3 Relationship between humidity and the occurrence of rust

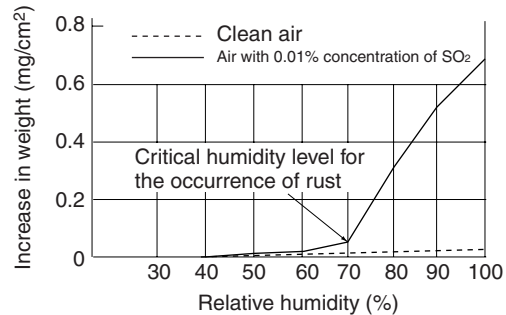
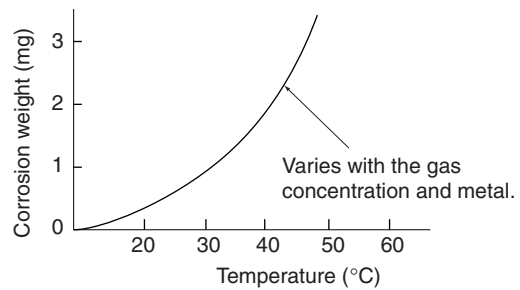


Fig. 4 Relationship between temperature and the occurrence of rust



### Resistance of metals to corrosive gases

| Material    | H <sub>2</sub> S | SO <sub>2</sub> | Cl <sub>2</sub> | NO <sub>2</sub> | NH <sub>3</sub> |
|-------------|------------------|-----------------|-----------------|-----------------|-----------------|
| Silver      | Poor             | Average         | Average         | Average         | Good            |
| Copper      | Poor             | Average         | Poor            | Average         | Good            |
| Nickel      | Average          | Poor            | Poor            | Average         | Good            |
| Chrome      | Average          | Average         | Average         | Average         | Good            |
| Tin         | Good             | Good            | Good            | Good            | Good            |
| SUS304      | Excellent        | Good            | Poor            | Excellent       | Excellent       |
| Brass       | Poor             | Average         | Poor            | Average         | Poor            |
| White metal | Average          | Good            | Poor            | Poor            | Good            |

### (3) Products for other types of special environment

Products for the following types of special environment can be made on request.

#### (a) Products using zinc-plated cores

These products are suitable for locations with humidity levels approaching 100% (plastic greenhouses, kitchens, and outdoor panels) and locations where chlorine gas is present, such as electrical installations at water purification plants.

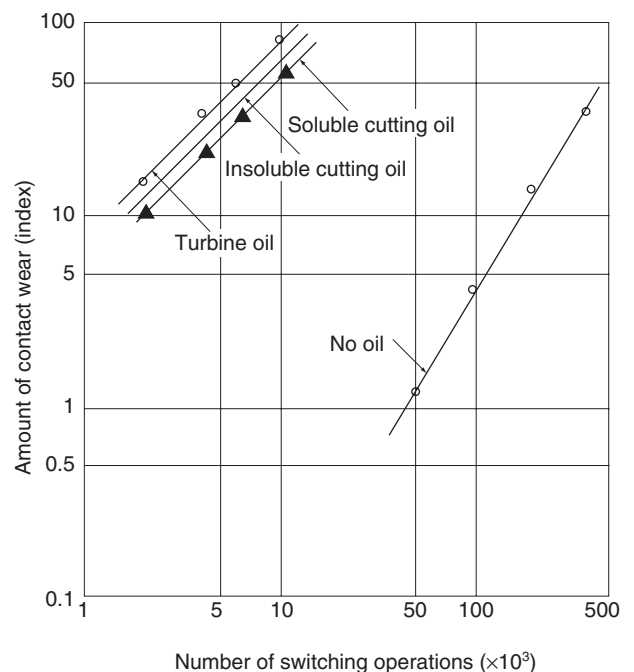
#### (b) Ammonia-free products

These products are suitable for environments with a high-degree of sealing and a relatively high temperature and humidity level (e.g., control panels for car-washing equipment and explosion-proof boards for coal mines).

### 3-2-5 Oil mist

When using machine tools, for example, there are occasions when cutting oil forms an oil mist and adheres to the contacting surfaces in contactors and starters in the control panel. Although contact failure is unlikely in environments subject to oil mist, oil decomposition due to switching arcs can lead to the release of large amounts of hydrogen gas, which will accelerate wear and tear in the contacts. The amount of wear in contacts with oil present is approximately 10 to 100 times that of contacts without oil present. Therefore, it is desirable to provide a protective structure to prevent oil mist entering the panel interior.

**Fig. 5 Comparison of the amount of wear in contacts with and without oil present**



- Tested product: SC-5-1  
Product without oil  
Product with oil: Before the test and with 1,000 switching operations, 1.5μl of oil is applied to all contacts.
- Test conditions: 3φ, 200V, 3.7kW  
AC-3 load  
1,200 operations per hour
- Amount of contact wear: Total amount of wear for 3 phases

# 3 Operating Conditions

## 3-2 Conditions for special environments

### 3-2-6 High altitudes

When using contactors and starters at high altitudes, the dielectric strength and cooling coefficient are reduced because of the lower air density and so it is necessary to correct the ratings in the way shown below.

#### (1) Criteria for using at high altitudes

The values for the rated insulation voltage and the rated continuous current of contactors and starters used at high altitudes are reduced by the correction coefficients (shown below) specified by ANSI, IEC, BS, and EN standards.

#### Rating correction coefficients for altitudes exceeding 1,000m

| Altitude (m) | ANSI C37.30-1971         |                          |                     | IEC 60282-1, BS, EN60282-1          |                           |                           |                           |
|--------------|--------------------------|--------------------------|---------------------|-------------------------------------|---------------------------|---------------------------|---------------------------|
|              | Rated insulation voltage | Rated continuous current | Ambient temperature | Voltage of dielectric strength test | Rated insulation voltage  | Rated continuous current  | Temperature rise          |
| 1000         | 1.00                     | 1.00                     | 1.00                | 1.0                                 | 1.0                       | 1.0                       | 1.0                       |
| 1200         | 0.98                     | 0.995                    | 0.992               | 1.0 to 1.05 proportional            | 1.0 to 0.95 proportional  | 1.0 to 0.99 proportional  | 1.0 to 0.98 proportional  |
| 1500         | 0.95                     | 0.99                     | 0.980               | 1.05                                | 0.95                      | 0.99                      | 0.98                      |
| 1800         | 0.92                     | 0.985                    | 0.968               | 1.05 to 1.25 proportional           | 0.95 to 0.8, proportional | 0.99 to 0.96 proportional | 0.98 to 0.92 proportional |
| 2100         | 0.89                     | 0.98                     | 0.956               |                                     |                           |                           |                           |
| 2400         | 0.86                     | 0.97                     | 0.944               |                                     |                           |                           |                           |
| 2700         | 0.83                     | 0.965                    | 0.932               |                                     |                           |                           |                           |
| 3000         | 0.80                     | 0.96                     | 0.920               | 1.25                                | 0.8                       | 0.96                      | 0.92                      |
| 3600         | 0.75                     | 0.95                     | 0.896               | –                                   | –                         | –                         | –                         |
| 4200         | 0.70                     | 0.935                    | 0.872               | –                                   | –                         | –                         | –                         |
| 4800         | 0.65                     | 0.925                    | 0.848               | –                                   | –                         | –                         | –                         |
| 5400         | 0.61                     | 0.91                     | 0.824               | –                                   | –                         | –                         | –                         |
| 6000         | 0.56                     | 0.90                     | 0.800               | –                                   | –                         | –                         | –                         |

- Notes:
- Because the normal operating conditions for starters apply at 2,000m, use the above correction coefficients to correct the ratings for starters used above 2,000m.
  - It is sufficient to reduce either the rated continuous current or the ambient temperature (i.e., not both).
  - ANSI C37.30: American National Standard Definitions and Requirements for High-voltage Air Switches, Insulators, and Bus Supports
  - BS, EN 60282-1: High voltage fuses Part 1. Current-limiting fuses
  - IEC 60282-1: High voltage fuses Part 1. Current-limiting fuses

#### (2) Countermeasures for decreased ambient temperature

In general, temperatures are lower at higher altitude, so use products with specifications for extremely cold locations as appropriate.

# Chapter 4

## Application and Selection

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## **4** Application and Selection

### **4-1 Applications to motors**

Magnetic motor starters and contactors are basically designed for use in making and breaking motor loads. It is necessary to understand the performance characteristics of contactors, power supplies and loads in order to select the most suitable contactor for the load. Selection considerations are described in the following.

#### **4-1-1 Starting of squirrel-cage motors**

The typical starting method for squirrel-cage motors is full voltage starting, i.e., direct-on-line starting. However, a starting current having a magnitude 5 to 6 times the motor full load current may flow in the circuit at the time of starting.

If the power supply has insufficient capacity, or if the power cable is installed over a long distance and/or has a small cross-sectional area, there will be a large voltage drop due to the starting current, which may cause contactors or other equipment on the same power system to erroneously operate. As a rule, it is recommended to employ the star-delta or reduced voltage starting method for motors having a rating of 5.5kW and above, in order to avoid a large starting current. Typical starting methods for 3-phase squirrel-cage motors are as follows:

1. Full voltage starting ..... Direct-on-line starting
2. Reduced voltage starting ..... Star-delta starting  
Reactor starting  
Autotransformer starting

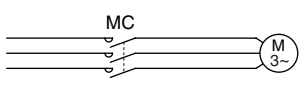
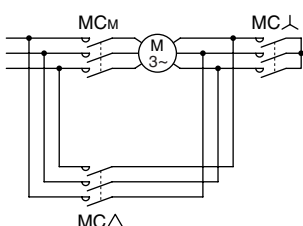
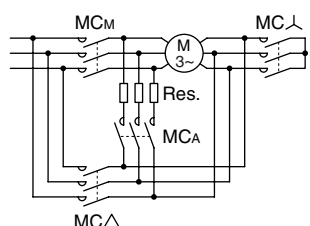
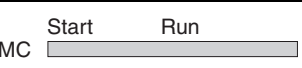
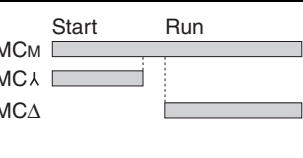
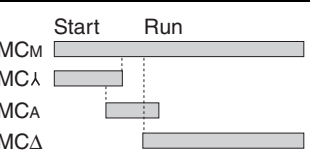


### (1) Comparison of different starting methods

Two systems are available for the starting of low voltage squirrel-cage motors: full voltage starting and reduced voltage starting.

Reduced voltage starting is further divided into star-delta starting, reactor starting and autotransformer starting. Each method of starting has both advantages and disadvantages.

When selecting a starting method, care must be given to establishing a suitable relation between the power supply capacity, permissible starting current, load torque and starting torque, accelerating torque and starting time. The major differences between these starting methods are shown in the table below.

| Type of starting                                  | Full voltage starting  | Reduced voltage starting   |  |
|---|--|--|--|
|   |  | Star-delta starting  | Star-delta starting (Closed transitional system)   |
| Circuit   |   |    |   |
| Operational timing diagram                        |   |   |    |
| Arrangement                                       | The full voltage is applied to the motor at the time of starting. This is the most popular starting method.  | The motor is started in star connection, then switched over to delta connection for running. The starting current and starting torque are reduced to 1/3 (33.3%) those of full voltage starting.   | The motor remains connected to the power supply even at the time of change-over from star to delta connection.   |
| Advantage   | <ul style="list-style-type: none"> <li>• Since starting torque is large, can be carried out under full load conditions.</li> <li>• Accelerating torque is large.</li> <li>• Starting time duration is short.</li> <li>• The most economical among all starting methods.</li> </ul> | <ul style="list-style-type: none"> <li>• The voltage drop at the time of starting is reduced.</li> <li>• The most economical method of reduced voltage starting.</li> </ul>  | <ul style="list-style-type: none"> <li>• Starting current can be lowered.</li> <li>• As transient inrush current can be restricted to a minimum at the time of change-over from star to delta connection, both mistrip of MCCB's and related troubles such as contact welding can be prevented.</li> </ul> |
| Disadvantage                                      | <ul style="list-style-type: none"> <li>• Since the starting current is large, high voltage drop is to be expected.</li> <li>• As the starting current and starting torque are large at the time of starting, the power supply or load will be subject to shocks.</li> </ul>        | <ul style="list-style-type: none"> <li>• The starting torque and accelerating torque are small.</li> <li>• Since the motor is open-circuited when changing over from star connection to delta connection, a large shock can be expected to be given to the power supply or load.</li> <li>• Both the starting current and the starting torque cannot be adjusted.</li> </ul> | <ul style="list-style-type: none"> <li>• Price is higher than those of standard type star-delta starters.</li> <li>• The starting torque is small.</li> </ul>  |
| Starting performance as a percent of full voltage |  |  |  |
| Voltage at motor terminal                         | 100%   | 57.7%  | 57.7%  |
| Starting current                                  | 100%   | 33.3%  | 33.3%  |
| Starting torque                                   | 100%   | 33.3%  | 33.3%  |
| Application                                       | When the capacity of the power supply is large enough to permit full load starting, this is the most economical method of starting.  | <ul style="list-style-type: none"> <li>• Motors with a rating of over 5.5kW which start under no-load or light load conditions.</li> <li>• Machinery and loading-unloading equipment with a clutch.</li> </ul>   | <ul style="list-style-type: none"> <li>• Motors having a rating of over 5.5kW which start under no-load or light load conditions.</li> <li>• Where it is desired to restrict inrush current to a minimum at the time of change-over from star to delta connection.</li> </ul>                              |

# 4 Application and Selection

## 4-1 Applications to motors

|   |  |   |
|---|--|---|
| Type of starting                                  | Reduced voltage starting   |   |
|   | Reactor starting   | Autotransformer starting  |
| Circuit   |  |   |
| Operational timing diagram                        |  |   |
| Arrangement                                       | The motor starts with the voltage reduced by the insertion of reactors on the primary side.  | The full voltage is applied to the motor after acceleration following starting under autotransformer-reduced voltage.   |
| Advantage   | <ul style="list-style-type: none"> <li>• The starting current and the starting torque can be adjusted by selecting a suitable tap.</li> <li>• The accelerating torque increases rapidly, providing smooth acceleration.</li> <li>• Since this is a closed circuit transition starting method, the change-over from starting to running occurs smoothly.</li> </ul> | <ul style="list-style-type: none"> <li>• Starting current is the least among all reduced voltage starting methods.</li> <li>• Inrush current at the time of change-over is small.</li> <li>• The accelerating torque increase slightly together with the speed. The maximum torque is less than that with the reactor starting method.</li> </ul> |
| Disadvantage                                      | <ul style="list-style-type: none"> <li>• More expensive than star-delta starting.</li> <li>• Increase in torque is comparatively small.</li> <li>• The starting torque is small.</li> </ul>  | <ul style="list-style-type: none"> <li>• Ratio of the reduction of starting current is larger than that of the reduction of starting torque.</li> </ul>   |
| Starting performance as a percent of full voltage |  |   |
| Voltage at motor terminal                         | 50–65–80% (taps 50–65–80%)   | 50–65–80% (taps 50–65–80%)  |
| Starting current                                  | 50–65–80% (taps 50–65–80%)   | 25–42.2–64% (taps 50–65–80%)  |
| Starting torque                                   | 25–42.2–64% (taps 50–65–80%)   | 25–42.2–64% (taps 50–65–80%)  |
| Application                                       | Loads requiring a large starting torque.   | <ul style="list-style-type: none"> <li>• Where starting current must be reduced.</li> <li>• Where high starting efficiency is required.</li> </ul>  |

## (2) Basic criteria for selection

### (a) Starting contactor selection points

In order to select the most cost-efficient contactors for your purposes, the following points should be taken into consideration:

- **Making and breaking current capacity**

The relationship between the motor full load current and the starting current will vary with the starting method chosen. Starting current when using a reduced voltage starting method is less than that with a full voltage method. For example, star-delta starting results in only one-third the starting current generated by full voltage starting. Thus it is possible to use contactors of the AC-3 category that provide a higher motor rating.

- **Operation cycles and temperature rise**

General purpose contactors are designed to operate up to 1200 to 1800 times per hour. In practice, such a high frequency of on-off operation is unlikely to be carried out. Moreover, in the case of reduced voltage starting, current flows through the starting contactors for only a short period of time, provided the motor starts normally. Therefore, if it is to be used infrequently, a contactor having a lower rating than one for continuous use may be selected.

- **Mechanical and electrical durability**

Where contactors operate under normal conditions, and are not used for inching or plugging operations, it is unlikely that they will exceed a million operations during their service lifetime. Inching and plugging are not often performed when the application warrants reduced voltage starting. On the other hand, hoist and crane motors are often involved in inching and plugging, so contactors used for these kinds of applications require a durability greater than a million operations. Therefore, operating conditions and expected frequency of operation must be taken into consideration when selecting contactors.

### (b) Precautions to be taken when selecting contactors for motor running

Torque is proportional to the second power of the voltage. In the case of reduced voltage starting, the starting torque is less than that of full voltage starting. The full voltage is applied to the motor only after it has accelerated to close to its final running speed; at starting time the motor must be under little or no load. If starting torque is inadequate—for example if a voltage drop reduces the voltage too low, or if the motor is erroneously started under full load—the motor will not start, or will start but fail to reach normal running speed during the acceleration phase. If the motor does not begin to move (locked-rotor condition) a current of the same magnitude as the starting current will continue to flow through it. If it starts but does not accelerate to full speed, a current of almost the same magnitude as the starting current will continue to flow through it.

Even if the motor has failed to start or to reach full speed, it will still be changed over to full load mode after the pre-set time elapses, allowing full voltage to be applied.

Therefore, even when a reduced voltage starting method is used, the motor running contactor may make a current having the same magnitude as the starting current under full voltage starting.

If the motor is under locked-rotor condition, after the full voltage has been applied, the overload relay will operate, causing the contactor to break the locked-rotor current. For these reasons, contactors for motor running circuits should have AC-3 category making and breaking capacities.

### (c) Making and breaking capacities of contactors for motor starting

Category AC-3 contactors have a making capacity of 10 times and breaking capacity of 8 times the rated operational current. Since the starting current of a squirrel-cage motor is, as a rule, 5 to 6 times the full load current, such a contactor will have a safety factor of 1.67 times ( $10 \div 6 = 1.67$ ) the starting current in its making capacity. Therefore, even in the case of reduced voltage starting, it is necessary for motor starting contactors to have a making capacity of 1.67 times the starting current under reduced voltage starting conditions.

### (d) Breaking capacity of motor starting contactors in normal running

When a reduced voltage starting method is applied, the current interrupted by the contactors when changing over from starting to full voltage is assumed to be as follows:

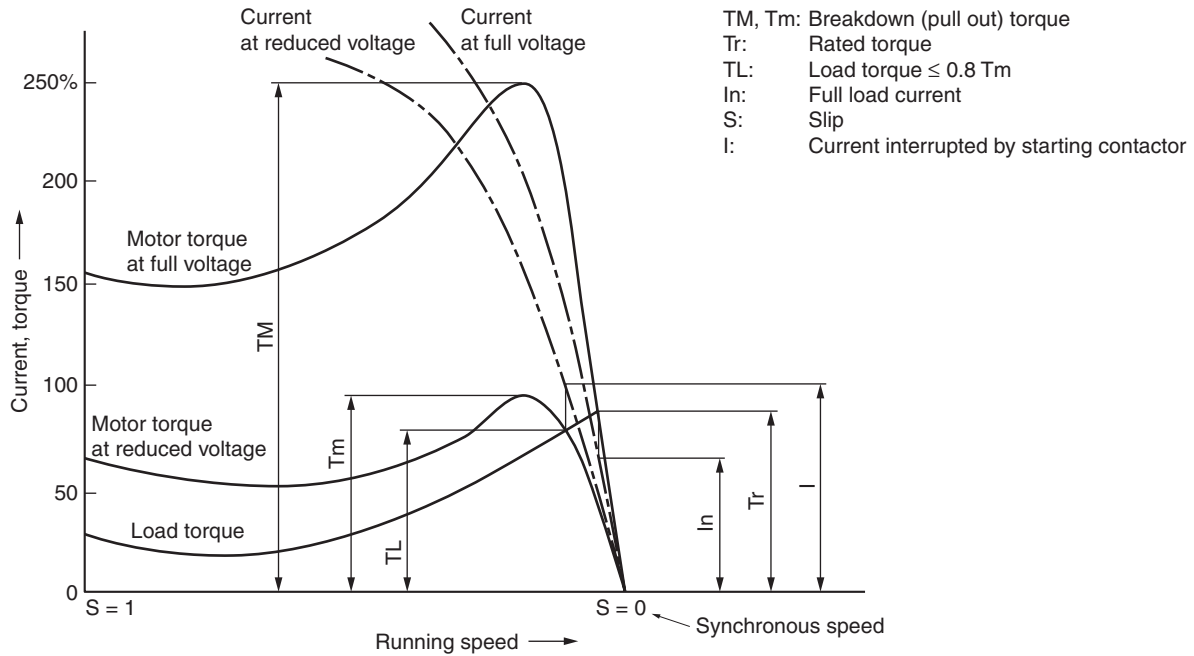
- 1) A current corresponding to a load torque equal to 80% of the maximum motor torque at reduced voltage, or
- 2) If load torque is greater than motor rated torque, a current corresponding to the motor rated torque at reduced voltage. (Refer to "Motor current and torque characteristics" on page 60.)

Contactors can be selected with reference to the following table (page 60) of making and breaking current values.

# 4 Application and Selection

## 4-1 Applications to motors

Fig. 1 Motor current and torque characteristics



| Starting method and contactor |              | Taps (a%) | Contactor rated operational current (Multiple of motor full load current) | Contactor making current (Multiple of motor full load current) | Contactor breaking current (Multiple of motor full load current) | Contactor continuous current        |            |
|-------------------------------|--------------|-----------|---|--|--|-------------------------------------|------------|
|                               |              |           |   |  |  | Multiple of motor full load current | Time       |
| Direct-on-line starting       | MC           | —         | 1In   | 6In  | 1In  | 1In                                 | Continuous |
| Star-delta starting           | MC $\lambda$ | —         | 0.35In  | 2In  | 0.7In  | 2In                                 | Short time |
|                               | MCA          | —         | 0.6In   | 1.2In  | 0.6In  | 0.6In                               | Continuous |
|                               | MCA          | —         | *   | *  | *  | *                                   | Short time |
|                               | MCM          | —         | 0.6In   | 1.2In  | 0.6In  | 0.6In                               | Continuous |
| Autotransformer starting      | MCS          | a=50      | 0.6In   | 1.5In  | —  | 1.5In                               | Short time |
|                               | MCS          | a=65      | 0.6In   | 2.6In  | —  | 2.6In                               | Short time |
|                               | MCS          | a=80      | 0.6In   | 3.9In  | —  | 3.9In                               | Short time |
|                               | MCN          | a=50      | 0.25In  | —  | 0.5In  | 1.5In                               | Short time |
|                               | MCN          | a=65      | 0.25In  | —  | 0.46In   | 1.4In                               | Short time |
|                               | MCN          | a=80      | 0.25In  | —  | 0.25In   | 0.95In                              | Short time |
|                               | MCRN         | a=50      | 1In   | 2.4In  | 1In  | 1In                                 | Continuous |
|                               | MCRN         | a=65      | 1In   | 2.4In  | 1In  | 1In                                 | Continuous |
|                               | MCRN         | a=80      | 1In   | 1.6In  | 1In  | 1In                                 | Continuous |
| Reactor starting              | MCS          | a=50      | 0.8In   | 3In  | —  | 3In                                 | Short time |
|                               | MCS          | a=65      | 0.8In   | 3.9In  | —  | 3.9In                               | Short time |
|                               | MCS          | a=80      | 0.8In   | 4.8In  | —  | 4.8In                               | Short time |
|                               | MCRN         | a=50      | 1In   | 1In  | 1In  | 1In                                 | Continuous |
|                               | MCRN         | a=65      | 1In   | 1.4In  | 1In  | 1In                                 | Continuous |
|                               | MCRN         | a=80      | 1In   | 1.25In   | 1In  | 1In                                 | Continuous |

Note: \* Contactor ratings depend on resistor capacity and current carrying time.

**(3) Selecting a starting system by taking voltage variation into consideration**

In order to reduce adverse load influence on the power system, a starting system should be selected that restricts voltage variation within the allowable limits. Fig. 3 below, illustrating the voltage variation curves of various starting methods, can be used to help select an appropriate system.

When using these curves, please note the following assumptions.

- a) The main circuit should be as shown in Fig. 2, i.e., the motor is loaded on a transformer.
- b) For percent impedance, only reactance is taken into consideration.
- c) Starting power factor is 0 ( $\cos\phi_s=0$ ).
- d) The motor starting current is 6 times the full load current. As for the power factor ( $\cos\phi_s$ ) and efficiency ( $\eta$ ) at rated operation,  $\cos\phi_s \times \eta = 0.7$ .
- e) Main circuit cable impedance is ignored.

**Example of use**

Suppose the following conditions hold for the main circuit:

- a) Motor output capacity ( $P_m$ ) = 45kW
- b) Transformer capacity ( $P_t$ ) = 150kVA
- c) Transformer percent impedance ( $\%X_T$ ) = 4%
- d) Allowable voltage variation factor ( $\Delta V$ )  $\leq 5\%$

**Method**

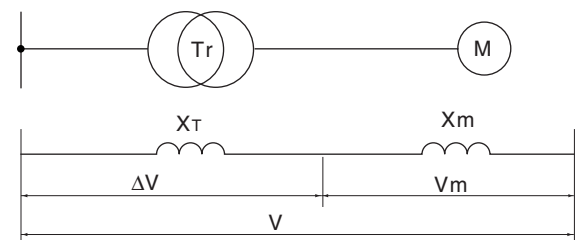
- a) The ratio ( $K_t$ ) of  $P_t$  to  $P_m$  is  $K_t = P_t/P_m = 3.3$
- b) Select the point on the x axis corresponding to the allowable voltage variation factor (5% in this case). Since the percent impedance is 4%, select the point on the y axis corresponding to  $K_t$  (3.3) on the 4% impedance scale. Draw lines through the selected points, perpendicular to the axes, so that they intersect at point A.

- c) When a vertical line is dropped from point A to the x axis, it passes through the curves of all the applicable starting methods. In this example, star-delta starting, reactor starting (50 tap) and autotransformer starting (50, 65% taps) can be used.

- d) The required interrupting capacity of the circuit breaker can be obtained as follows.

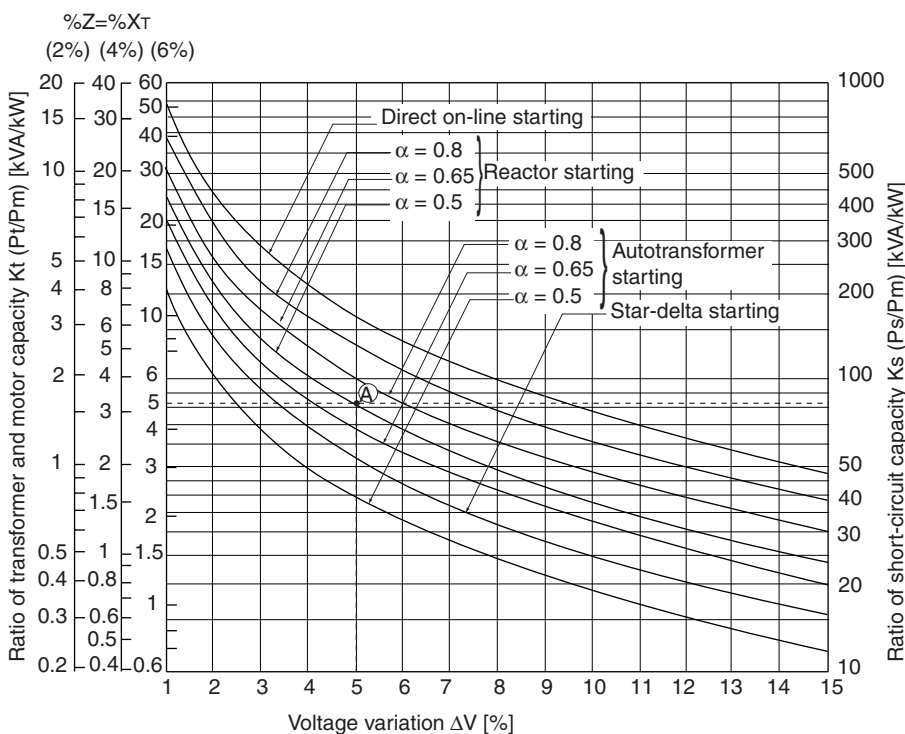
$$\begin{aligned} \text{Interrupting capacity} &= K_s \text{ (point of intersection with the scale at right)} \times P_m \\ &= 83 \times P_m \text{ (kW)} \end{aligned}$$

**Fig. 2 Main circuit and its equivalent circuit**



- Pt: Transformer capacity
- Vm: Transformer secondary voltage
- $\%Z = \%X_T$  (Percent impedance)
- Ps: Short-circuit capacity at secondary side
- Pm: Motor output capacity
- V: Rated voltage
- In: Full load current
- $n \cdot I_n$  = Starting current
- Starting impedance = Starting reactance =  $X_m$
- Starting power factor  $\cos\phi_s = 0$

**Fig. 3 Voltage variation and short-circuit capacity of various starting methods**



# 4 Application and Selection

## 4-1 Applications to motors

### 4-1-2 Breaking current and electrical durability

#### (1) Breaking current and electrical durability curves/AC-3 duty

Fig. 4 SC-03 to 5-1

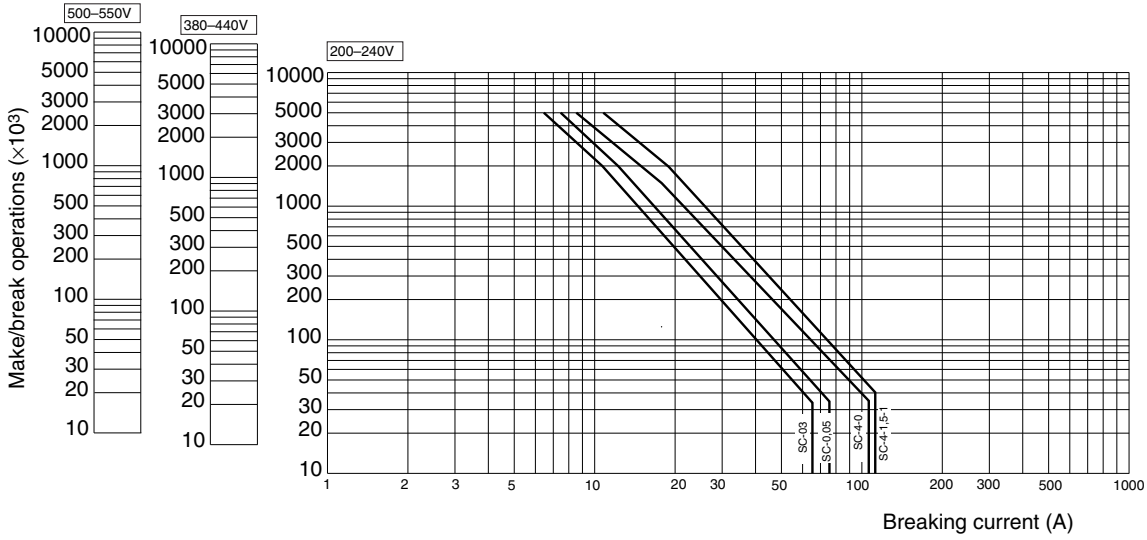
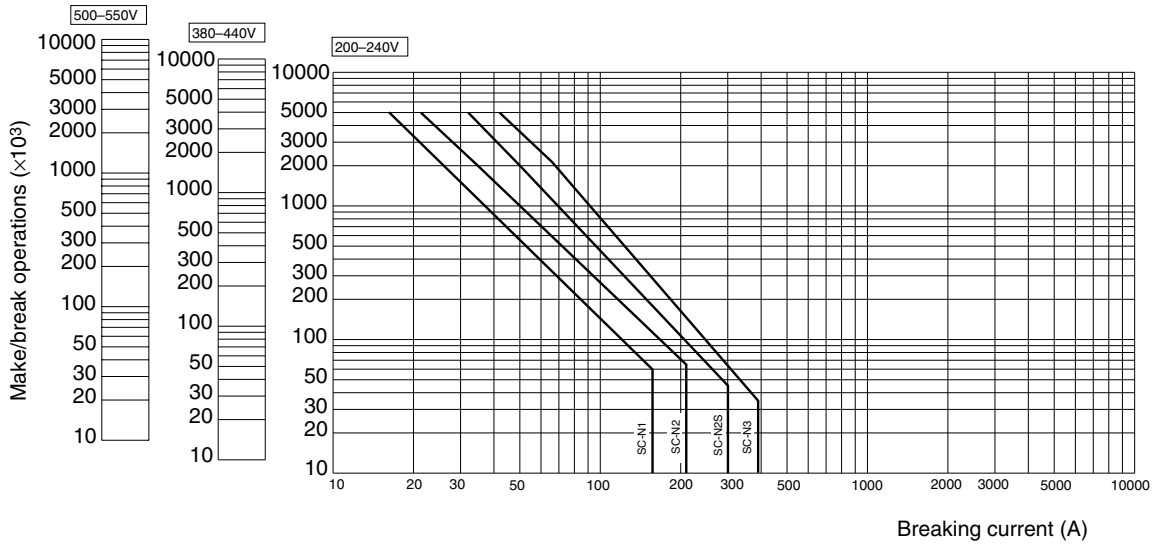
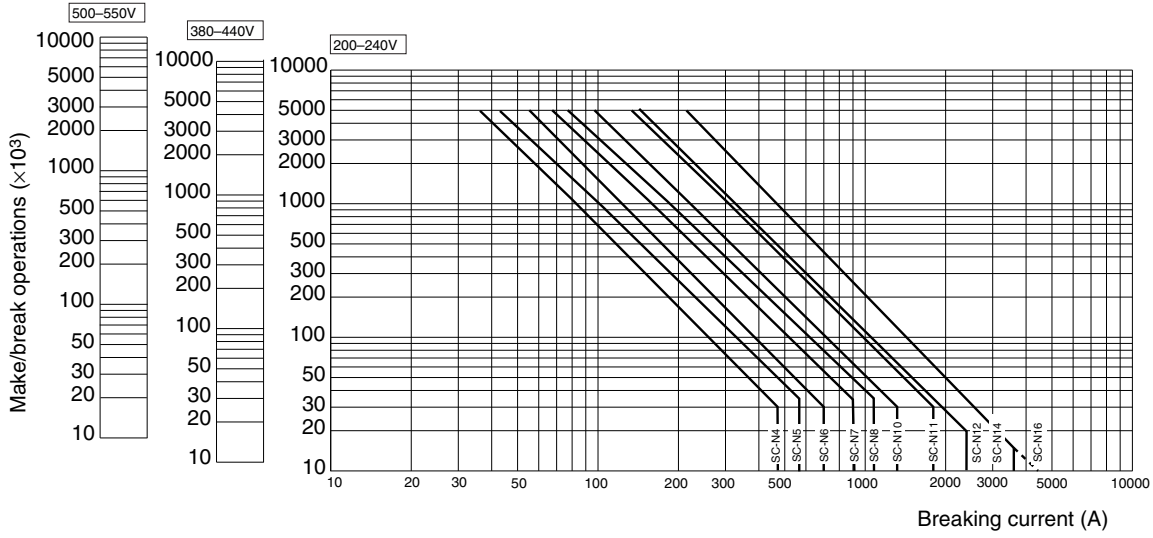


Fig. 5 SC-N1 to N3



Note: Currents above the rated operating current are for inching and plugging applications.

Fig. 6 SC-N4 to N16



Note: Currents above the rated operating current are for inching and plugging applications.

# 4 Application and Selection

## 4-1 Applications to motors

### (2) Inching operations and electrical durability

Contact life is approximately inversely proportional to the magnitude of breaking current.

Therefore, where inching operations are carried out, contact life will be greatly reduced.

When normal and inching operations are combined, contact life, X can be calculated by the following formula.

$$X = \frac{A}{1 + \frac{C}{100} \left( \frac{A}{B} - 1 \right)}$$

Where,

A: Contact life when normal operations are carried out

B: Contact life when only inching operations are carried out

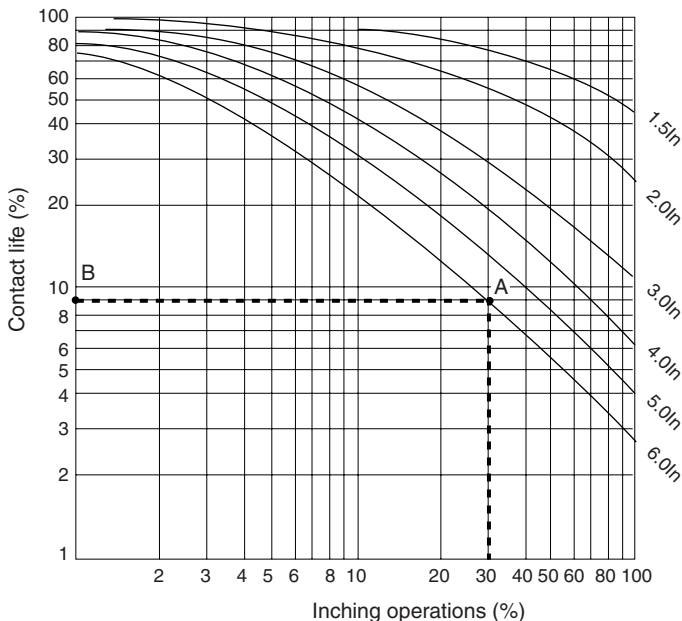
C: Inching ratio (%)

$$= \frac{\text{No. of inching operations}}{\text{Total No. of switching operations}} \times 100\%$$

Fig. 7 shows contact life curves calculated by this formula. Contact life can easily be determined by referring to the graph below. For example, when an SC-0 contactor is used for a motor whose full load current is 10A, the starting current is six times the full load current, and 30% of all on/off operations are inching operations, then contact life is calculated as follows: From Fig. 4 the electrical durability of an SC-0 contactor is approximately 3 million operations ( $3 \times 10^6$ ) when breaking the full load current of 10A at 220VAC.

In Fig. 7 draw a vertical line from the point on the x axis corresponding to the 30% inching ratio so that it intersects the 6.0In curve at point A. Then draw a line through A, parallel to the x axis, intersecting the y axis at point B. The y axis scale has been established assuming contact life is 100% when the inching ratio is 0%. Therefore, in this example, an inching operation ratio of 30% reduces contact life to 9% of what it would be under normal operational use. The electrical durability of the SC-0 contactor would be only  $(3 \times 10^6) \times 0.09 = 0.27 \times 10^6$  on/off operations.

Fig. 7



### 4-1-3 Direct-on-line starting

#### (1) Description

In the direct-on-line starting method, the full voltage is applied directly to the motor as soon as the switch is engaged. Since this type of starter is inexpensive to install and easy to operate, this starting method is frequently used for squirrel-cage motors with small ratings.

Category AC-3 contactors are suitable for this purpose.

However, since a high current flows on starting, it is necessary that special attention be paid to prevent abrupt voltage drop due to insufficient power supply capacity and excessively long main circuit wiring.

In addition, during inching and plugging operations, the contactor opens and closes with currents  $I_p$  and  $I_s$  as shown in Fig. 9, which will reduce the electrical durability.

Fig. 8 Wiring diagram of direct-on-line starting

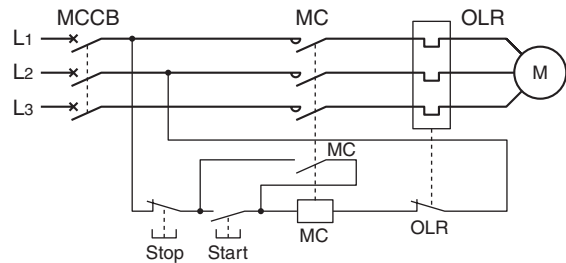
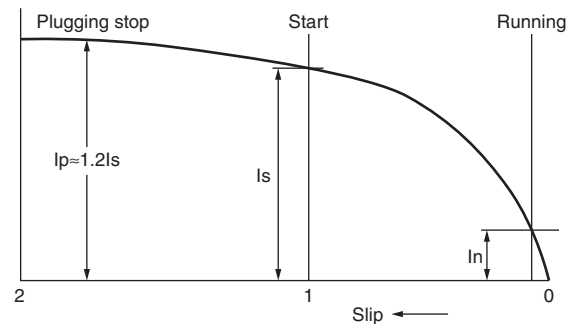


Fig. 9 A current when inching and plugging operations are carried out





**(2) Contactors for direct-on-line starting (AC-3)**

**(a) Applications where the electrical durability is taken into consideration**

| Main circuit voltage | Motor rating |                            | Electrical durability            |                                  |                                  |                                  |                                  |
|----------------------|--------------|----------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
|                      | Output (kW)  | Max. full load current (A) | 1,000×10 <sup>3</sup> operations | 2,000×10 <sup>3</sup> operations | 3,000×10 <sup>3</sup> operations | 4,000×10 <sup>3</sup> operations | 5,000×10 <sup>3</sup> operations |
| 200–240V             | 1.5          | 6.6                        | SC-03                            | SC-03                            | SC-03                            | SC-03                            | SC-03                            |
|                      | 2.5          | 11                         | SC-03                            | SC-03                            | SC-4-0                           | SC-4-1, 5-1                      | SC-4-1, 5-1                      |
|                      | 3.5          | 13                         | SC-03                            | SC-0, 05                         | SC-4-1, 5-1                      | SC-4-1, 5-1                      | SC-N1                            |
|                      | 4.5          | 18                         | SC-4-0                           | SC-4-1, 5-1                      | SC-N1                            | SC-N1                            | SC-N2                            |
|                      | 5.5          | 22                         | SC-4-0                           | SC-N1                            | SC-N2                            | SC-N2                            | SC-N2                            |
|                      | 7.5          | 32                         | SC-N1                            | SC-N2                            | SC-N2S                           | SC-N2S                           | SC-N2S                           |
|                      | 11           | 40                         | SC-N2                            | SC-N2S                           | SC-N2S                           | SC-N3                            | SC-N5                            |
|                      | 15           | 50                         | SC-N2                            | SC-N2S                           | SC-N5                            | SC-N6                            | SC-N6                            |
|                      | 18.5         | 65                         | SC-N2S                           | SC-N3                            | SC-N6                            | SC-N7                            | SC-N7                            |
|                      | 22           | 80                         | SC-N4                            | SC-N6                            | SC-N7                            | SC-N8                            | SC-N10                           |
|                      | 30           | 105                        | SC-N6                            | SC-N7                            | SC-N8                            | SC-N10                           | SC-N11                           |
|                      | 37           | 125                        | SC-N6                            | SC-N8                            | SC-N10                           | SC-N11                           | SC-N11                           |
|                      | 45           | 150                        | SC-N7                            | SC-N10                           | SC-N11                           | SC-N11                           | SC-N14                           |
|                      | 55           | 180                        | SC-N8                            | SC-N11                           | SC-N12                           | SC-N14                           | SC-N14                           |
|                      | 65           | 220                        | SC-N10                           | SC-N11                           | SC-N14                           | SC-N14                           | SC-N14                           |
|                      | 90           | 300                        | SC-N11                           | SC-N14                           | –                                | –                                | –                                |
| 120                  | 400          | SC-N14                     | –                                | –                                | –                                | –                                |                                  |
| 380–440V             | 4            | 9                          | SC-03                            | SC-0, 05                         | SC-4-1, 5-1                      | SC-4-1, 5-1                      | SC-N1                            |
|                      | 5.5          | 12                         | SC-03                            | SC-4-0                           | SC-4-1, 5-1                      | SC-N1                            | SC-N1                            |
|                      | 7.5          | 16                         | SC-4-0                           | SC-N1                            | SC-N1                            | SC-N1                            | SC-N1                            |
|                      | 11           | 22                         | SC-4-1, 5-1                      | SC-N1                            | SC-N2                            | SC-N2                            | SC-N2S                           |
|                      | 15           | 32                         | SC-N1                            | SC-N2                            | SC-N2S                           | SC-N2S                           | SC-N3                            |
|                      | 18.5         | 40                         | SC-N2                            | SC-N2S                           | SC-N4                            | SC-N5                            | SC-N5                            |
|                      | 22           | 50                         | SC-N2S                           | SC-N3                            | SC-N5                            | SC-N6                            | SC-N6                            |
|                      | 30           | 65                         | SC-N3                            | SC-N6                            | SC-N6                            | SC-N7                            | SC-N7                            |
|                      | 40           | 80                         | SC-N4                            | SC-N6                            | SC-N7                            | SC-N8                            | SC-N10                           |
|                      | 55           | 105                        | SC-N6                            | SC-N7                            | SC-N10                           | SC-N10                           | SC-N11                           |
|                      | 60           | 125                        | SC-N6                            | SC-N8                            | SC-N10                           | SC-N11                           | SC-N11                           |
|                      | 75           | 150                        | SC-N7                            | SC-N10                           | SC-N11                           | SC-N12                           | SC-N14                           |
|                      | 90           | 180                        | SC-N8                            | SC-N11                           | SC-N12                           | SC-N14                           | SC-N14                           |
|                      | 110          | 220                        | SC-N10                           | SC-N14                           | SC-N14                           | SC-N14                           | SC-N14                           |
|                      | 160          | 300                        | SC-N11                           | SC-N14                           | –                                | –                                | –                                |
|                      | 220          | 400                        | SC-N14                           | –                                | –                                | –                                | –                                |

# 4 Application and Selection

## 4-1 Applications to motors

### (b) Applications where inching and plugging operations are carried out

| Main circuit voltage | Motor rating |                            | Inching and plugging for 10% operation |                                | Inching and plugging for 50% operation |                                | Inching and plugging for 100% operation |                                |
|----------------------|--------------|----------------------------|--|--------------------------------|--|--------------------------------|---|--------------------------------|
|                      | Output (kW)  | Max. full load current (A) | Electrical durability                  |                                |  |                                |   |                                |
|                      |              |                            | 100×10 <sup>3</sup> operations         | 500×10 <sup>3</sup> operations | 100×10 <sup>3</sup> operations         | 500×10 <sup>3</sup> operations | 100×10 <sup>3</sup> operations          | 500×10 <sup>3</sup> operations |
| 200–240V             | 0.4          | 1.8                        | SC-03                                  | SC-03                          | SC-03                                  | SC-03                          | SC-03                                   | SC-03                          |
|                      | 0.75         | 3.3                        | SC-03                                  | SC-03                          | SC-03                                  | SC-03                          | SC-03                                   | SC-03                          |
|                      | 1.5          | 6.6                        | SC-03                                  | SC-03                          | SC-03                                  | SC-4-0                         | SC-03                                   | SC-N1                          |
|                      | 2.5          | 11                         | SC-03                                  | SC-4-0                         | SC-4-0                                 | SC-N1                          | SC-4-1, 5-1                             | SC-N2                          |
|                      | 3.5          | 13                         | SC-4-0                                 | SC-4-0                         | SC-4-0                                 | SC-N2                          | SC-N1                                   | SC-N2S                         |
|                      | 4.5          | 18                         | SC-4-0                                 | SC-N1                          | SC-N1                                  | SC-N2S                         | SC-N1                                   | SC-N3                          |
|                      | 5.5          | 22                         | SC-4-1, 5-1                            | SC-N1                          | SC-N1                                  | SC-N2S                         | SC-N1                                   | SC-N5                          |
|                      | 7.5          | 32                         | SC-N1                                  | SC-N2                          | SC-N2                                  | SC-N5                          | SC-N2S                                  | SC-N7                          |
|                      | 11           | 40                         | SC-N2                                  | SC-N2S                         | SC-N2S                                 | SC-N7                          | SC-N4                                   | SC-N7                          |
|                      | 15           | 50                         | SC-N2S                                 | SC-N3                          | SC-N3                                  | SC-N7                          | SC-N5                                   | SC-N10                         |
|                      | 18.5         | 65                         | SC-N3                                  | SC-N5                          | SC-N6                                  | SC-N8                          | SC-N6                                   | SC-N11                         |
|                      | 22           | 80                         | SC-N4                                  | SC-N6                          | SC-N6                                  | SC-N11                         | SC-N7                                   | SC-N14                         |
|                      | 30           | 105                        | SC-N5                                  | SC-N7                          | SC-N7                                  | SC-N12                         | SC-N8                                   | SC-N14                         |
|                      | 37           | 125                        | SC-N6                                  | SC-N8                          | SC-N8                                  | SC-N14                         | SC-N10                                  | –                              |
|                      | 45           | 150                        | SC-N7                                  | SC-N10                         | SC-N10                                 | –                              | SC-N11                                  | –                              |
|                      | 55           | 180                        | SC-N8                                  | SC-N11                         | SC-N11                                 | –                              | SC-N12                                  | –                              |
|                      | 65           | 220                        | SC-N10                                 | SC-N12                         | SC-N11                                 | –                              | SC-N14                                  | –                              |
|                      | 90           | 300                        | SC-N11                                 | –                              | SC-N14                                 | –                              | –                                       | –                              |
|                      | 120          | 400                        | SC-N12                                 | –                              | –                                      | –                              | –                                       | –                              |
|                      | 380–440V     | 0.75                       | 1.7                                    | SC-03                          | SC-03                                  | SC-03                          | SC-03                                   | SC-03                          |
| 1.5                  |              | 3.4                        | SC-03                                  | SC-03                          | SC-03                                  | SC-03                          | SC-03                                   | SC-4-0                         |
| 2.5                  |              | 5.6                        | SC-03                                  | SC-03                          | SC-03                                  | SC-4-1, 5-1                    | SC-0, 05                                | SC-4-1, 5-1                    |
| 3.5                  |              | 7.8                        | SC-03                                  | SC-0, 05                       | SC-0, 05                               | SC-4-1, 5-1                    | SC-4-0                                  | SC-N1                          |
| 4                    |              | 9                          | SC-03                                  | SC-4-0                         | SC-4-0                                 | SC-N1                          | SC-4-1, 5-1                             | SC-N2                          |
| 5.5                  |              | 12                         | SC-03                                  | SC-4-1, 5-1                    | SC-4-1, 5-1                            | SC-N2                          | SC-4-1, 5-1                             | SC-N2S                         |
| 7.5                  |              | 16                         | SC-4-0                                 | SC-4-1, 5-1                    | SC-4-1, 5-1                            | SC-N2S                         | SC-N1                                   | SC-N3                          |
| 11                   |              | 22                         | SC-N1                                  | SC-N1                          | SC-N1                                  | SC-N2S                         | SC-N2                                   | SC-N6                          |
| 15                   |              | 32                         | SC-N1                                  | SC-N2S                         | SC-N2                                  | SC-N6                          | SC-N3                                   | SC-N7                          |
| 18.5                 |              | 40                         | SC-N2                                  | SC-N4                          | SC-N2S                                 | SC-N6                          | SC-N4                                   | SC-N8                          |
| 22                   |              | 50                         | SC-N2S                                 | SC-N5                          | SC-N4                                  | SC-N8                          | SC-N6                                   | SC-N11                         |
| 30                   |              | 65                         | SC-N3                                  | SC-N6                          | SC-N6                                  | SC-N10                         | SC-N7                                   | SC-N11                         |
| 40                   |              | 80                         | SC-N4                                  | SC-N7                          | SC-N6                                  | SC-N11                         | SC-N7                                   | SC-N14                         |
| 55                   |              | 105                        | SC-N5                                  | SC-N8                          | SC-N7                                  | SC-N14                         | SC-N10                                  | SC-N14                         |
| 60                   |              | 125                        | SC-N6                                  | SC-N10                         | SC-N8                                  | SC-N14                         | SC-N11                                  | –                              |
| 75                   |              | 150                        | SC-N7                                  | SC-N11                         | SC-N10                                 | –                              | SC-N11                                  | –                              |
| 90                   |              | 180                        | SC-N8                                  | SC-N11                         | SC-N11                                 | –                              | SC-N14                                  | –                              |
| 110                  |              | 220                        | SC-N10                                 | SC-N12                         | SC-N11                                 | –                              | SC-N14                                  | –                              |
| 160                  |              | 300                        | SC-N11                                 | –                              | SC-N14                                 | –                              | –                                       | –                              |
| 220                  |              | 400                        | SC-N12                                 | –                              | –                                      | –                              | –                                       | –                              |
| 315                  | 600          | SC-N14                     | –                                      | –                              | –                                      | –                              | –                                       |                                |

Note: • The inching ratio (%) =  $\frac{\text{Number of inching operations}}{\text{Total number of switching operations}} \times 100$

### 4-1-4 Star-delta starting

#### (1) Description

The star-delta starting method is a typical reduced voltage starting method.

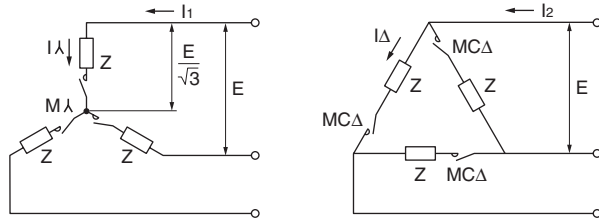
A star-delta motor has six leads so that the winding can be switched to either the star or delta connection. The motor is star connected at the time of starting, and when the motor has reached normal speed, the winding is changed over to delta connection.

- At the time of starting with the motor winding connected in star mode, a voltage of  $1/\sqrt{3}$  of the line voltage is applied to the motor winding.

When motor winding impedance =  $Z$ , line voltage =  $E$ , phase current =  $I_\lambda$  and line current =  $I_1$ ,

$$I_\lambda = \frac{1}{\sqrt{3}} \frac{E}{Z} = \frac{E}{\sqrt{3} Z} I_1$$

Fig. 10



- Changing over from star to delta mode after the motor is running. The full voltage  $E$  is applied to the motor. Since the impedance of the motor winding is  $Z$ ,

$$I_\Delta = \frac{E}{Z}$$

However, the line current  $I_2$  is

$$I_2 = \sqrt{3} I_\Delta = \frac{\sqrt{3} E}{Z}$$

- Therefore, the ratio of  $I_1$  (the line current in the case of star connection) to  $I_2$  (the line current in the case of delta connection) is

$$\frac{I_2}{I_1} = \frac{\frac{\sqrt{3} E}{Z}}{\frac{E}{\sqrt{3} Z}} = \frac{1}{3}$$

Namely the motor draws only one-third of the starting current in star connection that it does in full voltage delta starting.

- When the starting current of a motor is  $6 \times I_n$  ( $I_n$  = full load current of the motor), the starting current in the case of star connection is

$$\frac{1}{3} \times 6 \times I_n = 2I_n.$$

In this case, more than 200% of full load current is not exceeded.

Since the torque is directly proportional to the square of the voltage,

$$\frac{T_\lambda}{T_\Delta} = \frac{(E/\sqrt{3})^2}{(E)^2} = \frac{1}{3}$$

Accordingly the starting torque and starting current will be 1/3 those of full voltage starting.

#### (2) Wiring diagrams for automatic star-delta starting

Automatic star-delta starting methods using contactors can be classified as open transition systems and closed transition systems.

##### (a) Open transition system

This is a popular connecting method since the circuit is simple and economical.

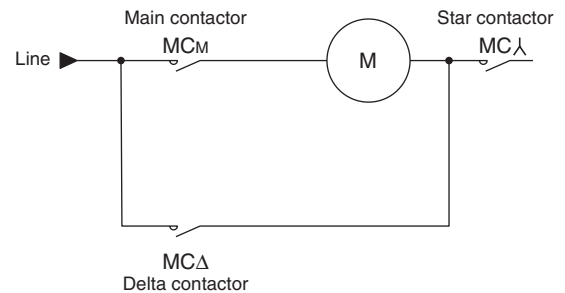
However, the motor is temporarily disconnected from the power supply when connection is changed over from star to delta, so that a residual voltage is generated within the motor stator winding.

This voltage overlaps the power supply voltage which can be expected to produce a transient inrush current larger than the starting current.

This kind of large inrush current is likely to cause trouble, such as an abnormal voltage drop in an emergency power supply unit, or erroneous tripping of MCCBs protecting against short circuits.

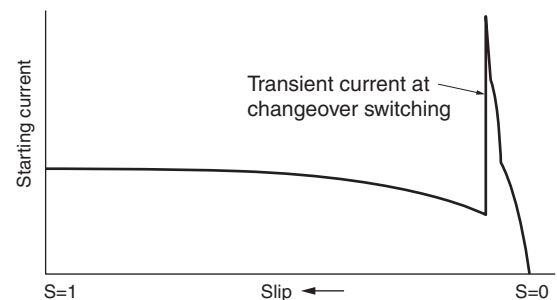
Fig. 11 Open transition system

- 3-contactor type



| Contactor | Start | Transition | Run |
|-----------|-------|------------|-----|
| MCM       | On    | Off        | Off |
| MCλ       | Off   | On         | Off |
| MCΔ       | Off   | Off        | On  |

- Speed-current characteristic



# 4 Application and Selection

## 4-1 Applications to motors

### (b) Closed transition system

In this system, resistors and a resistor circuit closing contactor are added to the star-delta starter used in the open transition system.

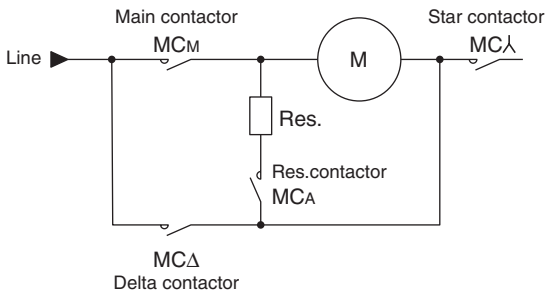
At the time of change-over, the motor will not be disconnected from the power supply, so restricting any large transient inrush current.

Thus this system prevents erroneous tripping of MCCBs due to transient inrush current.

Moreover since the necessary generator capacity of emergency generating equipment is determined according to the motor's starting kVA, the size and the price of such equipment can obviously be reduced.

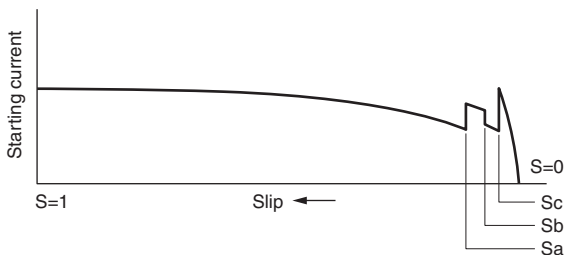
**Fig. 12 Closed transition system**

- One-line diagram



| Contactors | Start | Transition |    |    | Run |
|------------|-------|------------|----|----|-----|
|            |       | Sa         | Sb | Sc |     |
| MCM        | █     | █          | █  | █  | █   |
| MCλ        | █     | █          | █  | █  | █   |
| MCA        |       | █          | █  | █  | █   |
| MCΔ        |       |            |    | █  | █   |

- Speed-current characteristic



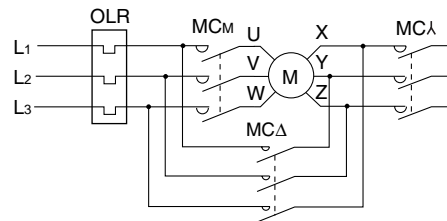
### (3) Thermal overload relay

When installing the thermal overload relays, there are two alternative methods, which differ by the location where relays are installed. The choice is between line current detection and phase current detection systems as shown in the diagram below.

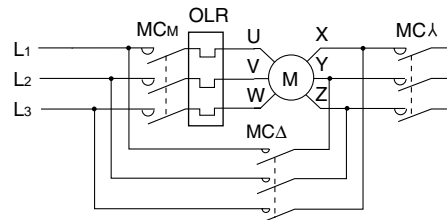
In the line current detection system, the heater element of the thermal overload relay is selected to agree with motor full load current, and in the phase current detection system the element is selected to conform with a current having a magnitude of  $1/\sqrt{3}$  of the full load current.

The phase current detection system allows use of smaller thermal overload relays than those required by the line current detection system. However, since the wire sizes of the motor circuit are the same in both cases, it is necessary to check if the wires can be connected or not before smaller frame size relays are used.

**Fig. 13 Installation of thermal overload relay**



**(a) Line current detection**



**(b) Phase current detection**

**(4) Selection of contactors**

**(a) Contactors for star starting use**

- The starting current of the motor is twice its full load current.
- A contactor is satisfactory if it can make and break the starting current. The making and breaking capacity of a contactor is

$$10I_n \times \frac{1}{3} = 3.5I_n, \text{ where } I_n = \text{motor full load current.}$$

- An AC-3 class contactor is suitable for star starting use. Since the making capacity of this contactor is 10 times the rated operational current, the rated operational current ( $I_e$ ) of the contactor for star connection use is

$$I_e = 3.5I_n/10 = 0.35I_n.$$

- Moreover, when a contactor is used for star starting a short time rating will suffice since it is only required when the motor is started.

The starting time ( $t_s$ ) of the motor is given by the following formula.

$$t_s = 4 + 2\sqrt{p} \text{ (sec), where } p = \text{motor (kW)}$$

However, if the contactor is used repeatedly during the starting time of the motor, it must have an overcurrent capacity of  $3 \times t_s$  (sec) when  $p \leq 37\text{kW}$ , or  $2 \times t_s$  (sec) when  $p > 37\text{kW}$ .

- When changeover from star connection to delta connection occurs, the contactor for star starting breaks the following current.

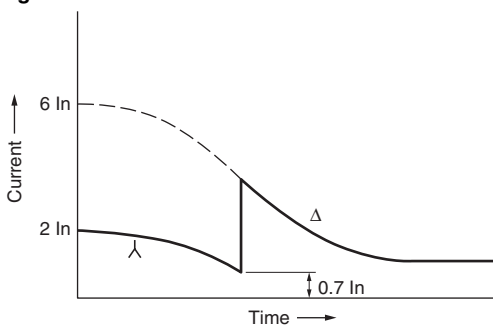
$$0.7 \times I_n = 0.7 \times \frac{1}{0.3} I_e = 2.5I_e$$

( $I_n$  = motor full load current,  $I_e$  = contactor rated operational current.)

Namely, it breaks a current of 2.5 times the rated operational current.

The electrical durability of the contactor is calculated using this as the breaking current.

**Fig. 14**



**(b) Contactor for delta running use**

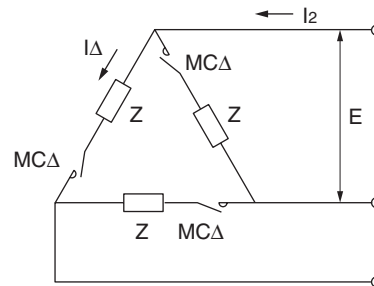
The contactor connects each phase of the delta connection.

The phase current is

$$I_{\Delta} = \frac{1}{\sqrt{3}} I_n = 0.6I_n.$$

The contactor for delta running use should be of AC-3 class and its rated operational current should be 0.6 times the full load current of the motor.

**Fig. 15**



# 4 Application and Selection

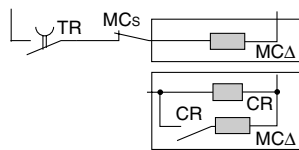
## 4-1 Applications to motors

### (5) Contactors for star-delta starting

#### (a) Open transition system

| Main circuit voltage | Motor rating |                            | Contactor                      |                                |   | Permissible starting time for starting contactor (sec) | Permissible number of repeat starting operations |
|----------------------|--------------|----------------------------|--------------------------------|--------------------------------|---|--|--|
|                      | Output (kW)  | Max. full load current (A) | For star (MC λ) connection     |                                | For main (MC <sub>M</sub> ) and delta (MC <sub>Δ</sub> ) connection |  |  |
|                      |              |                            | Electrical durability          |                                |   |  |  |
|                      |              |                            | 500×10 <sup>3</sup> operations | 100×10 <sup>3</sup> operations |   |  |  |
| 200–240V             | 5.5          | 22                         | SC-03, 0, 05                   | SC-03, 0, 05                   | SC-4-0, 4-1, 5-1  | 8.7  | 3  |
|                      | 7.5          | 32                         | SC-0, 05                       | SC-0, 05                       | SC-4-0, 4-1, 5-1  | 9.5  | 3  |
|                      | 11           | 40                         | SC-4-0, 4-1, 5-1               | SC-4-0, 4-1, 5-1               | SC-N1   | 10.6   | 3  |
|                      | 15           | 50                         | SC-N1                          | SC-N1                          | SC-N1   | 11.7   | 3  |
|                      | 18.5         | 65                         | SC-N1                          | SC-N1                          | SC-N2   | 12.6   | 3  |
|                      | 22           | 80                         | SC-N1                          | SC-N1                          | SC-N2S  | 13.4   | 3  |
|                      | 30           | 105                        | SC-N2S                         | SC-N2                          | SC-N3   | 15.0   | 3  |
|                      | 37           | 130                        | SC-N2S                         | SC-N2S                         | SC-N4   | 16.2   | 3  |
|                      | 40           | 135                        | SC-N2S                         | SC-N2S                         | SC-N4   | 16.6   | 3  |
|                      | 45           | 152                        | SC-N3                          | SC-N3                          | SC-N5   | 17.4   | 2  |
|                      | 55           | 180                        | SC-N3                          | SC-N3                          | SC-N6   | 18.8   | 2  |
|                      | 60           | 196                        | SC-N5                          | SC-N4                          | SC-N6   | 19.5   | 2  |
|                      | 65           | 212                        | SC-N6                          | SC-N4                          | SC-N7   | 20.1   | 2  |
|                      | 75           | 254                        | SC-N7                          | SC-N5                          | SC-N8   | 21.3   | 2  |
|                      | 90           | 300                        | SC-N7                          | SC-N6                          | SC-N8   | 23.0   | 2  |
|                      | 110          | 367                        | SC-N7                          | SC-N7                          | SC-N10  | 25.0   | 2  |
|                      | 120          | 400                        | SC-N10                         | SC-N8                          | SC-N11  | 25.9   | 2  |
|                      | 160          | 533                        | SC-N11                         | SC-N10                         | SC-N12  | 29.3   | 2  |
|                      | 180          | 600                        | SC-N11                         | SC-N10                         | SC-N12  | 30.8   | 2  |
|                      | 220          | 800                        | SC-N14                         | SC-N11                         | SC-N14  | 33.7   | 2  |
| 380–440V             | 5.5          | 12                         | SC-03, 0, 05                   | SC-03, 0, 05                   | SC-03, 0, 05  | 8.7  | 3  |
|                      | 7.5          | 16                         | SC-03, 0, 05                   | SC-03, 0, 05                   | SC-4-0, 4-1, 5-1  | 9.5  | 3  |
|                      | 11           | 22                         | SC-03, 0, 05                   | SC-03, 0, 05                   | SC-4-0, 4-1, 5-1  | 10.6   | 3  |
|                      | 15           | 32                         | SC-4-0, 4-1, 5-1               | SC-4-0, 4-1, 5-1               | SC-4-1, 5-1   | 11.7   | 3  |
|                      | 18.5         | 40                         | SC-4-0, 4-1, 5-1               | SC-4-0, 4-1, 5-1               | SC-N1   | 12.6   | 3  |
|                      | 22           | 50                         | SC-N1                          | SC-N1                          | SC-N1   | 13.4   | 3  |
|                      | 30           | 65                         | SC-N1                          | SC-N1                          | SC-N2   | 15.0   | 3  |
|                      | 40           | 80                         | SC-N2                          | SC-N1                          | SC-N2S  | 16.6   | 3  |
|                      | 55           | 105                        | SC-N2S                         | SC-N2                          | SC-N3   | 18.8   | 2  |
|                      | 60           | 125                        | SC-N2S                         | SC-N2S                         | SC-N4   | 19.5   | 2  |
|                      | 75           | 150                        | SC-N3                          | SC-N3                          | SC-N5   | 21.3   | 2  |
|                      | 90           | 180                        | SC-N5                          | SC-N4                          | SC-N6   | 23.0   | 2  |
|                      | 110          | 220                        | SC-N6                          | SC-N4                          | SC-N7   | 25.0   | 2  |
|                      | 160          | 300                        | SC-N7                          | SC-N7                          | SC-N8   | 29.3   | 2  |
|                      | 220          | 400                        | SC-N10                         | SC-N8                          | SC-N11  | 33.7   | 2  |
|                      | 315          | 600                        | SC-N12                         | SC-N11                         | SC-N12  | 39.5   | 2  |
|                      | 440          | 800                        | SC-N14                         | SC-N11                         | SC-N14  | 46.0   | 2  |

Note: • When applying models SC-03, 0, 05, 4-0, 4-1, 5-1, N1, N2, N2S, and N3 to an MC<sub>Δ</sub>, use a circuit equipped with a time delay relay.



With time delay relay

### (b) Closed transition system

| Main circuit voltage | Motor rating |                            | Contactor                           |  |                            | Permissible starting time for starting contactor (sec) | Permissible number of repeat starting operations | Starting resistor (per phase)                             |
|----------------------|--------------|----------------------------|-------------------------------------|--|----------------------------|--|--|---|
|                      | Output (kW)  | Max. full load current (A) | For star (MC $\lambda$ ) connection | For main (MCM) and delta (MC $\Delta$ ) connection | For resistor closing (MCA) |  |  |   |
| 200–240V             | 5.5          | 26                         | SC-03, 0, 05                        | SC-4-0, 4-1, 5-1                                   | SC-03, 0, 05               | 8.7  | 3  | 120W 3.6 $\Omega$   |
|                      | 7.5          | 34                         | SC-03, 0, 05                        | SC-4-0, 4-1, 5-1                                   | SC-03, 0, 05               | 9.5  | 3  | 120W 2.7 $\Omega$   |
|                      | 11           | 48                         | SC-4-0, 4-1, 5-1                    | SC-N1  | SC-03, 0, 05               | 11   | 3  | 120W 2.0 $\Omega$   |
|                      | 15           | 65                         | SC-N1                               | SC-N2  | SC-03, 0, 05               | 12   | 3  | 180W 1.5 $\Omega$   |
|                      | 18.5         | 79                         | SC-N1                               | SC-N2S   | SC-4-0, 4-1, 5-1           | 13   | 3  | 225W 1.2 $\Omega$   |
|                      | 22           | 93                         | SC-N1                               | SC-N3  | SC-4-0, 4-1, 5-1           | 13   | 3  | 225W 1.0 $\Omega$   |
|                      | 30           | 124                        | SC-N2S                              | SC-N4  | SC-4-0, 4-1, 5-1           | 15   | 3  | 300W 0.75 $\Omega$  |
|                      | 37           | 152                        | SC-N2S                              | SC-N5  | SC-N1                      | 16   | 3  | 450W 0.6 $\Omega$   |
|                      | 45           | 180                        | SC-N4                               | SC-N6  | SC-N2                      | 17   | 2  | 450W 0.5 $\Omega$   |
|                      | 55           | 220                        | SC-N5                               | SC-N7  | SC-N2                      | 19   | 2  | 600W 0.4 $\Omega$   |
|                      | 75           | 300                        | SC-N6                               | SC-N8  | SC-N2S                     | 21   | 2  | 2 $\times$ 600W 0.6 $\Omega$<br>(2 connected in parallel) |
|                      | 90           | 360                        | SC-N7                               | SC-N10   | SC-N3                      | 23   | 2  | 0.26 $\Omega$ 250A<br>4s rating                           |
|                      | 110          | 440                        | SC-N8                               | SC-N11   | SC-N3                      | 25   | 2  | 0.21 $\Omega$ 310A<br>5s rating                           |
|                      | 132          | 528                        | SC-N8                               | SC-N12   | SC-N4                      | 27   | 2  | 0.18 $\Omega$ 360A<br>4s rating                           |
|                      | 160          | 640                        | SC-N10                              | SC-N12   | SC-N5                      | 29   | 2  | 0.16 $\Omega$ 430A<br>5s rating                           |
|                      | 380–440V     | 5.5                        | 13                                  | SC-03, 0, 05                                       | SC-03, 0, 05               | SC-03, 0, 05   | 8.7  | 3   |
| 7.5                  |              | 17                         | SC-03, 0, 05                        | SC-4-0, 4-1, 5-1                                   | SC-03, 0, 05               | 9.5  | 3  | 80W 10 $\Omega$   |
| 11                   |              | 24                         | SC-03, 0, 05                        | SC-4-0, 4-1, 5-1                                   | SC-03, 0, 05               | 11   | 3  | 80W 8 $\Omega$  |
| 15                   |              | 32.5                       | SC-4-0, 4-1, 5-1                    | SC-4-1, 5-1  | SC-03, 0, 05               | 12   | 3  | 180W 6 $\Omega$   |
| 18.5                 |              | 39.5                       | SC-4-0, 4-1, 5-1                    | SC-N1  | SC-03, 0, 05               | 13   | 3  | 225W 4.7 $\Omega$   |
| 22                   |              | 46.5                       | SC-4-0, 4-1, 5-1                    | SC-N1  | SC-4-0, 4-1, 5-1           | 13   | 3  | 225W 4 $\Omega$   |
| 30                   |              | 62                         | SC-N1                               | SC-N2S   | SC-4-0, 4-1, 5-1           | 15   | 3  | 300W 3 $\Omega$   |
| 37                   |              | 76                         | SC-N1                               | SC-N2S   | SC-4-0, 4-1, 5-1           | 16   | 3  | 450W 2.4 $\Omega$   |
| 45                   |              | 90                         | SC-N1                               | SC-N3  | SC-N1                      | 17   | 2  | 450W 2 $\Omega$   |
| 55                   |              | 110                        | SC-N2                               | SC-N3  | SC-N1                      | 19   | 2  | 600W 1.6 $\Omega$   |
| 75                   |              | 150                        | SC-N2S                              | SC-N5  | SC-N1                      | 21   | 2  | 2 $\times$ 600W 2.4 $\Omega$<br>(2 connected in parallel) |
| 90                   |              | 180                        | SC-N4                               | SC-N6  | SC-N1                      | 23   | 2  | 2 $\times$ 600W 2.0 $\Omega$<br>(2 connected in parallel) |
| 110                  |              | 220                        | SC-N5                               | SC-N7  | SC-N2                      | 25   | 2  | 0.84 $\Omega$ 150A<br>5s rating                           |
| 132                  |              | 264                        | SC-N5                               | SC-N8  | SC-N2S                     | 27   | 2  | 0.72 $\Omega$ 180A<br>4s rating                           |
| 160                  |              | 320                        | SC-N7                               | SC-N10   | SC-N2S                     | 29   | 2  | 0.6 $\Omega$ 210A<br>5s rating                            |

Notes: • When applying models SC-03, 0, 05, 4-0, 4-1, 5-1, N1, N2, N2S, and N3 to an MC $\Delta$ , use a circuit equipped with a time delay relay.  
• The values for the motor output are based on the values specified in JIS C8201-4-1 and JEM 1038-1990.

#### • Selection conditions

- (1) Motor load: For light load starting (e.g., fans and pumps)
- (2) Electrical durability: 100,000 operations min.
- (3) If the number of repeat starting operations exceeds the figure given in the above table, provide an OFF time of at least 15 minutes.
- (4) Selection of the switching current for each starting process was based on a symmetric AC base and 120% max. of the motor star starting current. The following conditions, however, apply to the motor: The motor is a FUJI general-purpose motor or equivalent product and the motor must accelerate to more than 2 times the rated slip after completion of star starting.

# 4 Application and Selection

## 4-1 Applications to motors

### 4-1-5 Reactor starting

#### (1) Description

In this method of starting, a reactor is connected in each motor line to produce a voltage drop in the motor starting current. A time delay relay shorts out these reactors after the motor has gained normal speed. Thus the motor starts on a reduced voltage and operates at full voltage.

#### (2) Selection of contactors

Starting reactors normally have taps of 50–65–80% standard voltage. The voltage applied to motor starting, starting current and starting torque for each tap are as shown in the table on the right. Contactors are selected on the basis of the 80% tap, which results in the largest current, so that they can be applied irrespective of which tap they are connected to. Assuming that the full motor load current is  $I_n$  and the starting current at the time of full voltage starting is  $6I_n$ , then the starting current will be  $4.8I_n$  ( $0.8 \times 6I_n$ ) when 80% tap is used.

Since the making and breaking capacity required for MCs starting contactors is

$$\frac{10}{6} \times 4.8I_n = 8I_n,$$

those MCs starting contactors having a rated operational current of  $0.8I_n$  within the AC-3 category will be suitable. It is unnecessary to take the electrical durability of these MCs contactors into consideration, since hardly any current flows through the MCs contactor when the MCRN contactor is closed. The making and breaking capacity required for MCRN running contactors must be within the AC-3 category when starting failure is taken into consideration, and the continuous current capacity must be equal to or exceed the motor full load current. The overcurrent withstand values for MCs contactors must permit the passing of a current of  $4.8I_n$  during starting.

Starting characteristics

|                  | Taps |       |     |
|------------------|------|-------|-----|
|                  | 50%  | 65%   | 80% |
| Voltage at motor | 50%  | 65%   | 80% |
| Starting current | 50%  | 65%   | 80% |
| Starting torque  | 25%  | 42.2% | 64% |

Fig. 16 Circuit diagram (for explanation)

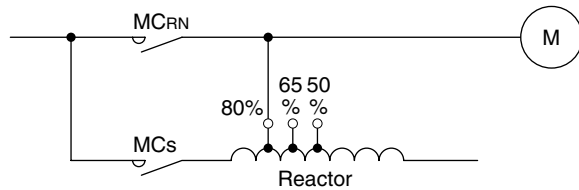
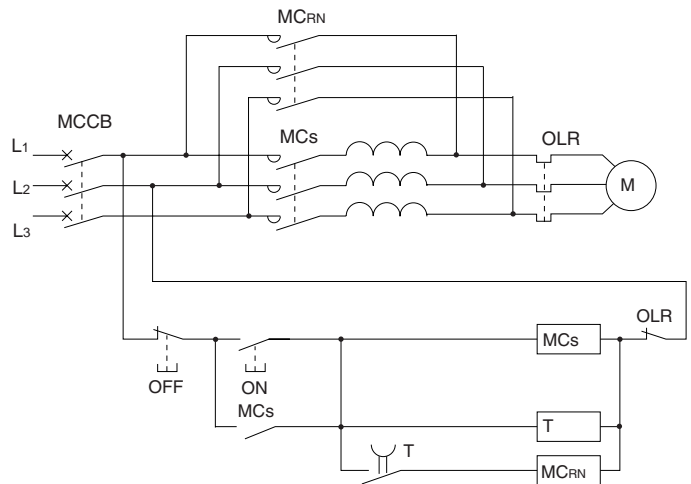


Fig. 17 Wiring diagram





**(3) Contactors for reactor starting**

| Main circuit voltage | Motor rating |                            | Contactor          |                    | Permissible starting time for starting contactor ts (s) | Permissible number of repeat starting operations |
|----------------------|--------------|----------------------------|--------------------|--------------------|---|--|
|                      | Output (kW)  | Max. full load current (A) | For running (MCRN) | For starting (MCs) |   |  |
| 200–240V             | 2.5          | 11                         | SC-0, 05           | SC-03              | 7.2   | 3  |
|                      | 3.5          | 13                         | SC-0, 05           | SC-03              | 7.7   | 3  |
|                      | 4.5          | 18                         | SC-4-0             | SC-4-0             | 8.2   | 3  |
|                      | 5.5          | 22                         | SC-4-1, 5-1        | SC-4-1, 5-1        | 8.7   | 3  |
|                      | 7.5          | 32                         | SC-N1              | SC-N1              | 9.5   | 3  |
|                      | 11           | 40                         | SC-N2              | SC-N1              | 10.6  | 3  |
|                      | 15           | 50                         | SC-N2S             | SC-N2              | 11.7  | 3  |
|                      | 18.5         | 65                         | SC-N3              | SC-N3              | 12.6  | 3  |
|                      | 22           | 80                         | SC-N4              | SC-N4              | 13.4  | 3  |
|                      | 30           | 105                        | SC-N5              | SC-N5              | 15.0  | 3  |
|                      | 37           | 125                        | SC-N6              | SC-N6              | 16.2  | 3  |
|                      | 45           | 150                        | SC-N7              | SC-N6              | 17.4  | 2  |
|                      | 55           | 180                        | SC-N8              | SC-N7              | 18.8  | 2  |
|                      | 65           | 220                        | SC-N10             | SC-N8              | 20.1  | 2  |
|                      | 90           | 300                        | SC-N11             | SC-N11             | 23.0  | 2  |
|                      | 120          | 400                        | SC-N12             | SC-N12             | 25.9  | 2  |
|                      | 180          | 600                        | SC-N14             | SC-N14             | 30.8  | 2  |
| 220                  | 800          | SC-N16                     | SC-N16             | 33.7               | 2   |  |
| 380–440V             | 2.5          | 5.6                        | SC-03              | SC-03              | 7.2   | 3  |
|                      | 3.5          | 7.8                        | SC-03              | SC-03              | 7.7   | 3  |
|                      | 4            | 9                          | SC-03              | SC-03              | 8.0   | 3  |
|                      | 5.5          | 12                         | SC-0, 05           | SC-0, 05           | 8.7   | 3  |
|                      | 7.5          | 16                         | SC-4-0             | SC-4-0             | 9.5   | 3  |
|                      | 11           | 22                         | SC-4-1, 5-1        | SC-N1              | 10.6  | 3  |
|                      | 15           | 32                         | SC-N1              | SC-N1              | 11.7  | 3  |
|                      | 18.5         | 40                         | SC-N2              | SC-N1              | 12.6  | 3  |
|                      | 22           | 50                         | SC-N2S             | SC-N2              | 13.4  | 3  |
|                      | 30           | 65                         | SC-N3              | SC-N3              | 15.0  | 3  |
|                      | 40           | 80                         | SC-N4              | SC-N4              | 16.6  | 3  |
|                      | 55           | 105                        | SC-N6              | SC-N5              | 18.8  | 2  |
|                      | 60           | 125                        | SC-N6              | SC-N6              | 19.5  | 2  |
|                      | 75           | 150                        | SC-N7              | SC-N6              | 21.3  | 2  |
|                      | 90           | 180                        | SC-N8              | SC-N7              | 23.0  | 2  |
|                      | 110          | 220                        | SC-N10             | SC-N8              | 25.0  | 2  |
|                      | 160          | 300                        | SC-N11             | SC-N11             | 29.3  | 2  |
| 220                  | 400          | SC-N12                     | SC-N12             | 33.7               | 2   |  |
| 315                  | 600          | SC-N14                     | SC-N14             | 39.5               | 2   |  |
| 440                  | 800          | SC-N16                     | SC-N16             | 46.0               | 2   |  |

# 4 Application and Selection

## 4-1 Applications to motors

### 4-1-6 Autotransformer starting

#### (1) Description

An autotransformer starter provides reduced voltage at the motor terminals for starting through the use of a tapped, 3-phase autotransformer. The motor is started with MCN and MCs contactors closed. After it accelerates, a time delay relay causes transfer from reduced voltage start to full voltage operation connection without disconnecting the motor from the power supply.

#### (2) Selection of contactors

Assuming that the transformer tap is a (%) and the motor full load current is  $I_n$ , the transformer primary current ( $I$ ) can be expressed as follows:

$$I = a^2 I_n$$

When the transformer tap values are 50–65–80% the motor terminal voltage, starting current and starting torque are as shown in the table below.

Therefore, the primary current of the transformer at the time of motor starting is maximal with the 80% tap and approximately 3.8 $I_n$  if the motor starting current is 6 $I_n$ .

The making and breaking capacity required for MCs contactor is

$$\frac{10}{6} \times 3.8 I_n = 6.3 I_n$$

Therefore AC-3 category contactors with a rated operational current of 0.63 $I_n$  are appropriate for selection. The maximal current of 1.5 $I_n$  flows through the MCN contactor when the 50% tap is used.

Consequently the making and breaking capacity is

$$\frac{10}{6} \times 1.5 I_n = 2.5 I_n$$

Accordingly, MCN contactors are selected from among those having a rated operational current of 0.25 $I_n$  within the AC-3 category.

It is unnecessary to take the electrical durability of MCs contactors into consideration because they do not interrupt current.

However, it is necessary in the case of the MCN contactor if it interrupts current in excess of 0.5 $I_n$ .

For overcurrent withstand values, it is assumed that MCN and MCs contactors allow current of 1.5 $I_n$  and 3.8 $I_n$  respectively to flow during starting.

#### Starting characteristics

|                  | Taps |       |     |
|------------------|------|-------|-----|
|                  | 50%  | 65%   | 80% |
| Voltage at motor | 50%  | 65%   | 80% |
| Starting current | 25%  | 42.2% | 64% |
| Starting torque  | 25%  | 42.2% | 64% |

Fig. 18 Voltage and current for autotransformer starting (single-phase equivalent circuit)

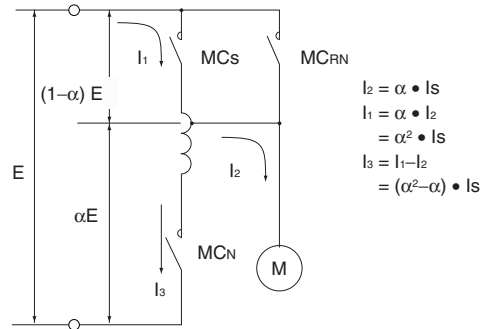
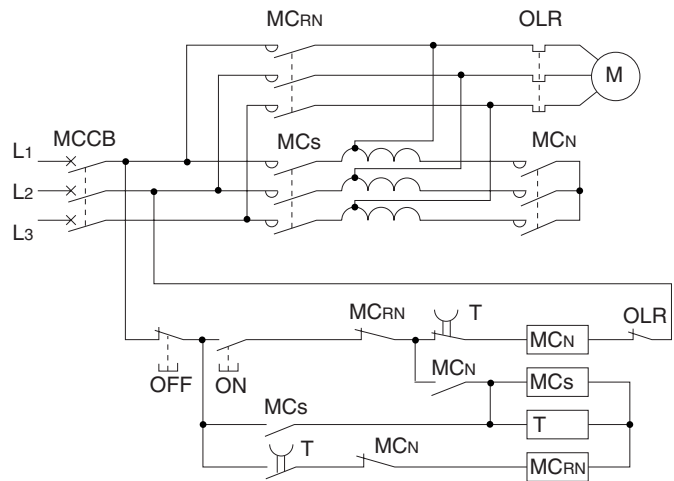


Fig. 19 Wiring diagram



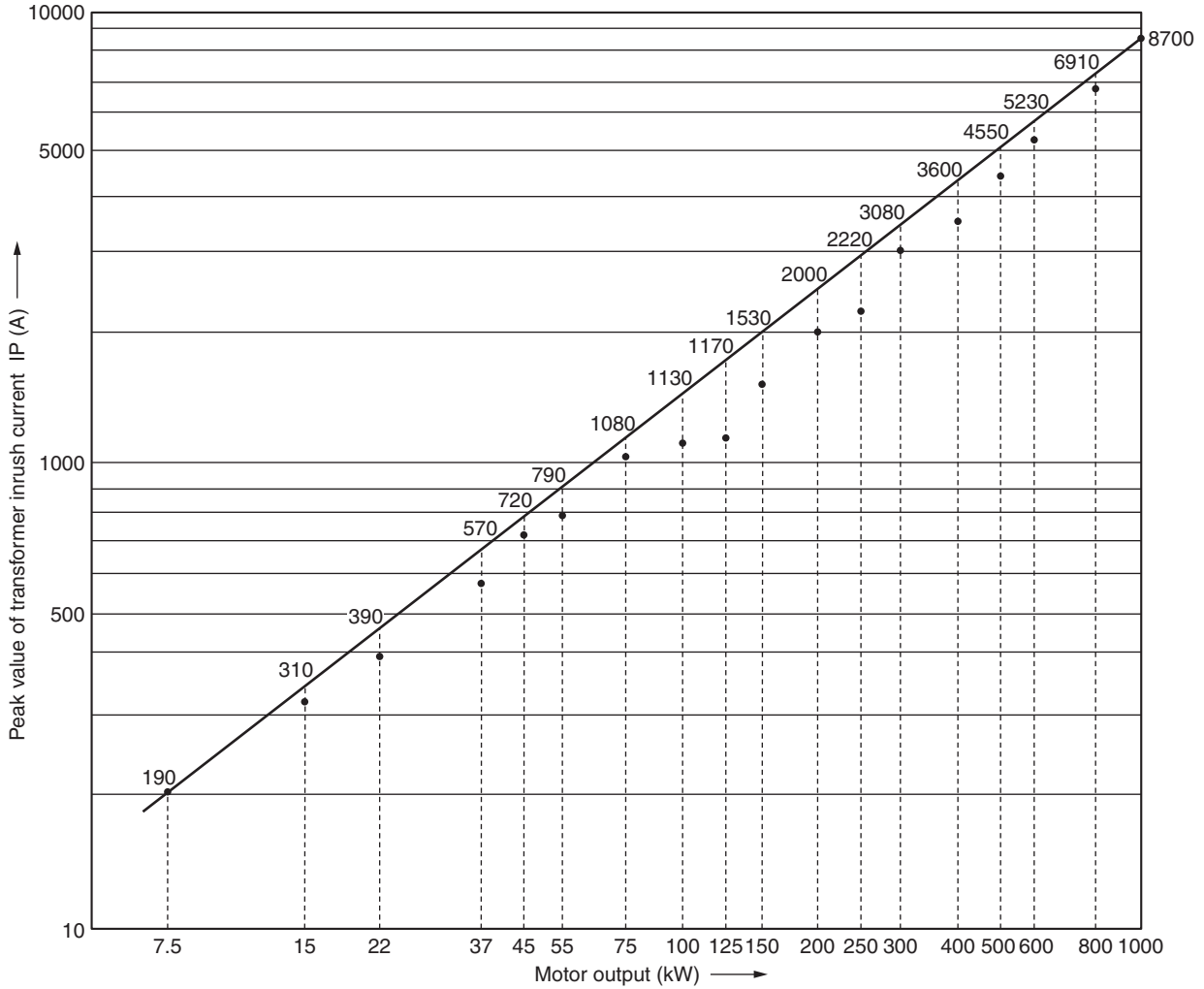
**(3) Contactors for autotransformer starting**

| Main circuit voltage | Motor rating |                            | Contactor          |                    |                           | Permissible starting time for starting contactors (s) | Permissible number of repeat starting operations |
|----------------------|--------------|----------------------------|--------------------|--------------------|---------------------------|---|--|
|                      | Output (kW)  | Max. full load current (A) | For running (MCRN) | For starting (MCs) | For neutral circuit (MCN) |   |  |
| 200–240V             | 11           | 40                         | SC-N2              | SC-N2              | SC-0, 05                  | 10.6  | 3  |
|                      | 15           | 50                         | SC-N2S             | SC-N2S             | SC-4-0                    | 11.7  | 3  |
|                      | 18.5         | 65                         | SC-N3              | SC-N2S             | SC-4-1, 5-1               | 12.6  | 3  |
|                      | 22           | 80                         | SC-N4              | SC-N3              | SC-N1                     | 13.4  | 3  |
|                      | 30           | 105                        | SC-N5              | SC-N4              | SC-N1                     | 15.0  | 3  |
|                      | 37           | 125                        | SC-N6              | SC-N5              | SC-N2                     | 16.2  | 3  |
|                      | 45           | 150                        | SC-N7              | SC-N5              | SC-N2S                    | 17.4  | 2  |
|                      | 55           | 180                        | SC-N8              | SC-N6              | SC-N3                     | 18.8  | 2  |
|                      | 65           | 220                        | SC-N10             | SC-N8              | SC-N4                     | 20.1  | 2  |
|                      | 90           | 300                        | SC-N11             | SC-N10             | SC-N5                     | 23.0  | 2  |
|                      | 120          | 400                        | SC-N12             | SC-N11             | SC-N6                     | 25.9  | 2  |
|                      | 180          | 600                        | SC-N14             | SC-N14             | SC-N8                     | 30.8  | 2  |
|                      | 220          | 800                        | SC-N16             | SC-N14             | SC-N11                    | 33.7  | 2  |
|                      | 380–440V     | 11                         | 22                 | SC-4-1, 5-1        | SC-4-1, 5-1               | SC-03   | 10.6   |
| 15                   |              | 32                         | SC-N1              | SC-N1              | SC-0, 05                  | 11.7  | 3  |
| 18.5                 |              | 40                         | SC-N2              | SC-N1              | SC-0, 05                  | 12.6  | 3  |
| 22                   |              | 50                         | SC-N2S             | SC-N2              | SC-4-0                    | 13.4  | 3  |
| 30                   |              | 65                         | SC-N3              | SC-N2S             | SC-4-1, 5-1               | 15.0  | 3  |
| 40                   |              | 80                         | SC-N4              | SC-N3              | SC-N1                     | 16.6  | 3  |
| 55                   |              | 105                        | SC-N5              | SC-N4              | SC-N2                     | 18.8  | 2  |
| 60                   |              | 125                        | SC-N6              | SC-N5              | SC-N2                     | 19.5  | 2  |
| 75                   |              | 150                        | SC-N7              | SC-N5              | SC-N2S                    | 21.3  | 2  |
| 90                   |              | 180                        | SC-N8              | SC-N7              | SC-N3                     | 23.0  | 2  |
| 110                  |              | 220                        | SC-N10             | SC-N8              | SC-N4                     | 25.0  | 2  |
| 160                  |              | 300                        | SC-N11             | SC-N10             | SC-N6                     | 29.3  | 2  |
| 220                  |              | 400                        | SC-N12             | SC-N11             | SC-N6                     | 33.7  | 2  |
| 315                  |              | 600                        | SC-N14             | SC-N14             | SC-N8                     | 39.5  | 2  |
| 440                  |              | 800                        | SC-N16             | SC-N16             | SC-N11                    | 46.0  | 2  |

# 4 Application and Selection

## 4-1 Applications to motors

**Fig. 20 Reference example: Inrush current for commercially available autotransformer (for autotransformer starting)**  
 Rating: 440V, time: 1min



- Notes:
- $I_p$  for 220V circuits will be approximately twice the value shown in the above graph.
  - The  $I_p$  values shown in the graph are calculated based on the worst conditions and represent the peak values for the first half-wave.

### 4-2-1 Transformer load applications

#### (1) Transformer primary switching

When a transformer is connected to its power supply, transient inrush current exceeding 10 times its rated full load current can be expected. This transient inrush current results from the iron core being momentarily saturated by the flux of the DC component transiently generated at the moment the transformer is energized. Thus the contactor selected for switching the transformer circuit must have the capability of handling the expected transient inrush current, otherwise contact welding will occur.

The ratings given in the table below are suitable for contactors being used to switch transformers having inrush current not exceeding 20 times their rated current, irrespective of the nature of their secondary loads.

| Contactor type | Single-phase transformer |                   |                     |                   | Three-phase transformer |                   |                     |                   |
|----------------|--------------------------|-------------------|---------------------|-------------------|-------------------------|-------------------|---------------------|-------------------|
|                | 220V Capacity (kVA)      | Rated current (A) | 440V Capacity (kVA) | Rated current (A) | 220V Capacity (kVA)     | Rated current (A) | 440V Capacity (kVA) | Rated current (A) |
| SC-03          | 1                        | 5                 | 1.5                 | 3                 | 2                       | 5                 | 2.5                 | 3                 |
| SC-0           | 1.5                      | 7.5               | 2                   | 5                 | 3                       | 7.5               | 4                   | 5                 |
| SC-05          | 1.5                      | 7.5               | 2                   | 5                 | 3                       | 7.5               | 4                   | 5                 |
| SC-4-0         | 2                        | 9                 | 3                   | 7                 | 3.5                     | 9                 | 5                   | 7                 |
| SC-4-1         | 2.5                      | 10                | 4                   | 9.5               | 4                       | 10                | 7.5                 | 9.5               |
| SC-5-1         | 2.5                      | 10                | 4                   | 9.5               | 4                       | 10                | 7.5                 | 9.5               |
| SC-N1          | 3                        | 13                | 5                   | 12                | 5                       | 13                | 10                  | 12                |
| SC-N2          | 4                        | 17                | 7.5                 | 16                | 6.5                     | 17                | 12                  | 16                |
| SC-N2S         | 5                        | 25                | 10                  | 24                | 10                      | 25                | 18                  | 24                |
| SC-N3          | 7                        | 32                | 15                  | 32                | 12                      | 32                | 25                  | 32                |
| SC-N4          | 9                        | 40                | 18                  | 40                | 15                      | 40                | 30                  | 40                |
| SC-N5          | 10                       | 46                | 20                  | 45                | 18                      | 46                | 35                  | 45                |
| SC-N6          | 15                       | 62                | 25                  | 55                | 25                      | 62                | 42                  | 55                |
| SC-N7          | 17                       | 75                | 33                  | 75                | 30                      | 75                | 60                  | 75                |
| SC-N8          | 20                       | 90                | 40                  | 90                | 35                      | 90                | 70                  | 90                |
| SC-N10         | 25                       | 110               | 50                  | 110               | 42                      | 110               | 85                  | 110               |
| SC-N11         | 33                       | 150               | 57                  | 130               | 57                      | 150               | 100                 | 130               |
| SC-N12         | 44                       | 200               | 90                  | 200               | 75                      | 200               | 150                 | 200               |
| SC-N14         | 65                       | 300               | 130                 | 300               | 110                     | 300               | 250                 | 300               |
| SC-N16         | 90                       | 400               | 175                 | 400               | 150                     | 400               | 300                 | 400               |

# 4 Application and Selection

## 4-2 Load applications

### 4-2-2 Resistive load applications

#### (1) Resistive load switching

Contactors conforming to IEC standards for use in switching resistive loads are listed in the table below. The table gives the ratings of SC series contactors when used to switch resistive loads. Current carrying capacity can be increased by connecting contacts in parallel.

| Contactor type | Single-phase   |                   |               |                   | Three-phase    |                   |               |                   |
|----------------|----------------|-------------------|---------------|-------------------|----------------|-------------------|---------------|-------------------|
|                | 110V           |                   | 220V          |                   | 220V           |                   | 440V          |                   |
|                | Resistive load |                   |               |                   | Resistive load |                   |               |                   |
|                | Capacity (kW)  | Rated current (A) | Capacity (kW) | Rated current (A) | Capacity (kW)  | Rated current (A) | Capacity (kW) | Rated current (A) |
| SC-03          | 2.2            | 20                | 4.4           | 20                | 7.6            | 20                | 15            | 20                |
| SC-0, 05       | 2.2            | 20                | 4.4           | 20                | 7.6            | 20                | 15            | 20                |
| SC-4-0         | 2.7            | 25                | 5.5           | 25                | 9.5            | 25                | 19            | 25                |
| SC-4-1, 5-1    | 3.5            | 32                | 7             | 32                | 12             | 32                | 24            | 32                |
| SC-N1          | 5.5            | 50                | 11            | 50                | 19             | 50                | 38            | 50                |
| SC-N2          | 6.6            | 60                | 13            | 60                | 23             | 60                | 46            | 60                |
| SC-N2S         | 8.8            | 80                | 17            | 80                | 30             | 80                | 61            | 80                |
| SC-N3          | 11             | 100               | 22            | 100               | 38             | 100               | 76            | 100               |
| SC-N4          | 14             | 135               | 29            | 135               | 51             | 135               | 102           | 135               |
| SC-N5          | 16             | 150               | 33            | 150               | 57             | 150               | 114           | 150               |
| SC-N6          | 16             | 150               | 33            | 150               | 57             | 150               | 114           | 150               |
| SC-N7          | 22             | 200               | 44            | 200               | 76             | 200               | 152           | 200               |
| SC-N8          | 28             | 260               | 57            | 260               | 99             | 260               | 198           | 260               |
| SC-N10         | 28             | 260               | 57            | 260               | 99             | 260               | 198           | 260               |
| SC-N11         | 38             | 350               | 77            | 350               | 133            | 350               | 266           | 350               |
| SC-N12         | 50             | 450               | 99            | 450               | 171            | 450               | 343           | 450               |
| SC-N14         | 72             | 660               | 145           | 660               | 251            | 660               | 503           | 660               |
| SC-N16         | 88             | 800               | 176           | 800               | 304            | 800               | 609           | 800               |

#### (2) Parallel connection switching

AC magnetic contactors are designed primarily for the switching of three-phase motors. When these contactors are used for switching single phase resistive loads, it is possible to increase their current carrying capacity by connecting the main contacts of the 3 poles in parallel. When used in this manner it is necessary to take the following matters into consideration.

##### (a) Current carrying capacity

Assuming the number of contacts connected in parallel to be "n", the current carrying capacity can be expressed by the following formula:

$$2\sqrt{n-1} \times I_{th} \text{ (Ith: Rated thermal current of contactor).}$$

Hence, if n = 2 or 3

the current carrying capacities are

$$2\sqrt{2-1} \times I_{th} = 2I_{th} \text{ and}$$

$$2\sqrt{3-1} \times I_{th} = 2.8I_{th} \text{ respectively.}$$

##### (b) Making and breaking capacity

The opening times for three main contacts vary slightly with each other. Therefore, when switching single phase loads only the last opening contact interrupts the current and only the first closing contact makes the current. Therefore, the switching capacity is similar to when handling three phase loads.

##### (c) Intermittent duty (the No. of switching cycles per hour)

The reduction ratio of switching frequency is normally directly proportional to the square of the interrupting current. If the interrupting current is twice as much as the rated operating current, the switching frequency is reduced to a quarter of the maximum switching frequency when interrupting the rated operating current.

So supposing that the switching frequency is 1200 cycles per hour when the rated operating current is  $I_e$ , the switching frequency can be expressed by the following formula when switching a  $2 \times I_e$  current:

$$1200 \left( \frac{I_e}{2I_e} \right)^2 = 1200 \times \frac{1}{4} = 300 \text{ switches per hour.}$$

**(d) Electrical durability**

When 2 or 3 poles connected in parallel are applied to single phase circuits, only the contact which opens last interrupts the current in the early stages of operation and this contact alone takes the wear.

Thus in course of time this contact can be expected to fail at which time a second contact will take its place; it will fail and the third contact will take over.

Therefore, supposing the number of contacts connected in parallel to be “n”, the electrical durability is “n” times longer than when a single contact is used for interrupting the current, since “n” contacts connected in parallel relieve one another.

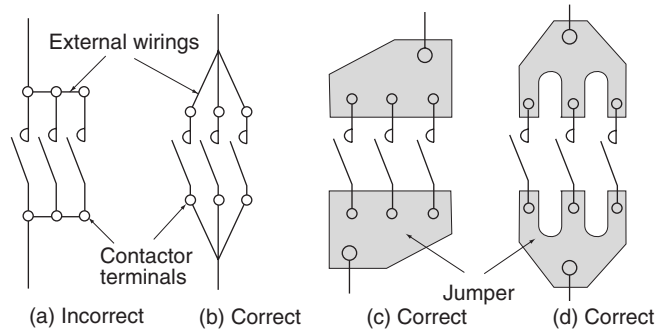
However, since the current carrying capacity is  $2\sqrt{n-1}$  times the rated operating current the electrical life is

$$\frac{n}{(2\sqrt{n-1})^2} = n/4 (n-1) \text{ times}$$

**(e) Parallel connection of poles**

When connecting poles in parallel the resistance value of the connectors used on each pole must be similar.

**Fig. 21 Parallel connecting poles**



# 4 Application and Selection

## 4-2 Load applications

### 4-2-3 Capacitor load applications

#### (1) Capacitor switching

When using a magnetic contactor for a capacitor circuit, the inrush current when the circuit is made and the recovery voltage when the circuit is broken require particular consideration. The inrush current when the circuit is made is determined by the impedance of the circuit. If the impedance is extremely small, a large inrush current with higher harmonic current will flow. This current may, particularly if capacitors are connected in parallel, combine with the discharge current from capacitors already closed, resulting in a larger inrush current, and significantly increasing the risk of contact welding. For this reason, in handling capacitor loads, it is desirable to have a series reactor to suppress the inrush current when the circuit is made and also to suppress distortion in the voltage or current

due to harmonics. (In general, a reactor of approx. 6% the capacity of the capacitor is recommended.) With low-voltage circuits, however, a reactor is often not used, e.g., for cost reasons, or there is a transformer at upstream in the circuit that suppress the inrush current. Also, because a large recovery voltage will occur between contacts when the circuit is broken, sufficient insulation recovery characteristics are required in the contactor.

The following table of SC-series contactors allows logical and economical selection based on considering the transient phenomena in capacitor circuit switching and contactor operation.

#### (a) Contactors for capacitor circuits

| Contactor type | Single-phase capacitor |                   |                 |                   | Three-phase capacitor |                   |                 |                   |                 |                   |
|----------------|------------------------|-------------------|-----------------|-------------------|-----------------------|-------------------|-----------------|-------------------|-----------------|-------------------|
|                | 200–220V               |                   | 400–440V        |                   | 200–220V              |                   | 400–440V        |                   | 500–550V        |                   |
|                | Capacity (kvar)        | Rated current (A) | Capacity (kvar) | Rated current (A) | Capacity (kvar)       | Rated current (A) | Capacity (kvar) | Rated current (A) | Capacity (kvar) | Rated current (A) |
| SC-03          | 1.2                    | 6                 | 1.7             | 4.3               | 2                     | 6                 | 3               | 4.3               | 3               | 3.5               |
| SC-0           | 1.8                    | 9                 | 3.2             | 8                 | 3                     | 9                 | 5               | 8                 | 5               | 6                 |
| SC-05          | 1.8                    | 9                 | 3.2             | 8                 | 3                     | 9                 | 5               | 8                 | 5               | 6                 |
| SC-4-0         | 3                      | 15                | 6               | 15                | 5                     | 15                | 10              | 15                | 10              | 12                |
| SC-4-1         | 4                      | 20                | 8               | 20                | 7                     | 20                | 14              | 20                | 14              | 16                |
| SC-5-1         | 4                      | 20                | 8               | 20                | 7                     | 20                | 14              | 20                | 14              | 16                |
| SC-N1          | 6                      | 30                | 12              | 30                | 10                    | 30                | 20              | 30                | 20              | 25                |
| SC-N2          | 7.5                    | 38                | 15              | 38                | 13                    | 38                | 26              | 38                | 25              | 30                |
| SC-N2S         | 11                     | 53                | 21              | 53                | 18                    | 53                | 36              | 53                | 35              | 41                |
| SC-N3          | 13                     | 65                | 26              | 65                | 22                    | 65                | 45              | 65                | 40              | 50                |
| SC-N4          | 15                     | 75                | 30              | 75                | 26                    | 75                | 52              | 75                | 50              | 55                |
| SC-N5          | 16                     | 80                | 32              | 80                | 28                    | 80                | 55              | 80                | 60              | 70                |
| SC-N6          | 20                     | 100               | 40              | 100               | 35                    | 100               | 69              | 100               | 75              | 87                |
| SC-N7          | 26                     | 130               | 52              | 130               | 45                    | 130               | 90              | 130               | 90              | 105               |
| SC-N8          | 35                     | 175               | 70              | 175               | 60                    | 175               | 120             | 175               | 150             | 170               |
| SC-N10         | 35                     | 175               | 70              | 175               | 60                    | 175               | 120             | 175               | 150             | 170               |
| SC-N11         | 47                     | 235               | 94              | 235               | 80                    | 235               | 160             | 235               | 200             | 230               |
| SC-N12         | 60                     | 300               | 120             | 300               | 104                   | 300               | 208             | 300               | 250             | 290               |
| SC-N14         | 88                     | 440               | 176             | 440               | 152                   | 440               | 300             | 440               | 375             | 435               |
| SC-N16         | 107                    | 535               | 214             | 535               | 185                   | 535               | 370             | 535               | 430             | 497               |

#### Notes:

- The inrush current peak value must be less than 20 times the capacitor's rated current.
- Selection is based on a contactor current carrying capacity that allows for 1.3×1.15 times the capacitor's overcurrent.
- The above table is applicable when a series reactor that is 0.5% or more of the capacitor's capacity is inserted.
- Electrical durability: 100,000 operations min.
- Use the following formula to convert kvar to μF:

$$C = \frac{\text{kvar}}{2\pi f E^2} \times 10^9 \text{ (}\mu\text{F)}$$

E: Rated voltage  
f: Frequency



**(b) Contactors for parallel capacitor banks (three-phase capacitor circuits)**

| Circuit voltage | Capacitor (C <sub>2</sub> ) |                   | Contactor type with serial reactor * |             | Contactor type without serial reactor |
|-----------------|-----------------------------|-------------------|--------------------------------------|-------------|---------------------------------------|
|                 | Capacity (kvar)             | Rated current (A) | K = 0.06                             | K ≥ 0.005   |                                       |
| 200–220V        | 5                           | 14.5              | SC-4-0                               | SC-4-0      | SC-N2                                 |
|                 | 7.5                         | 21.6              | SC-4-1, 5-1                          | SC-4-1, 5-1 | SC-N3                                 |
|                 | 10                          | 28.9              | SC-N1                                | SC-N1       | SC-N4                                 |
|                 | 15                          | 43.4              | SC-N2S                               | SC-N2S      | SC-N6                                 |
|                 | 20                          | 57.8              | SC-N3                                | SC-N3       | SC-N8                                 |
|                 | 25                          | 72.3              | SC-N4                                | SC-N4       | SC-N8                                 |
|                 | 30                          | 86.7              | SC-N4                                | SC-N5       | SC-N10                                |
|                 | 40                          | 115.6             | SC-N7                                | SC-N7       | SC-N11                                |
|                 | 50                          | 144.5             | SC-N8                                | SC-N8       | SC-N12                                |
|                 | 60                          | 173.4             | SC-N8                                | SC-N8       | SC-N14                                |
|                 | 75                          | 216.8             | SC-N11                               | SC-N11      | SC-N14                                |
|                 | 100                         | 289               | SC-N12                               | SC-N12      | –                                     |
|                 | 125                         | 361               | SC-N14                               | SC-N14      | –                                     |
|                 | 150                         | 434               | SC-N14                               | SC-N14      | –                                     |
|                 | 185                         | 535               | SC-N16                               | SC-N16      | –                                     |
|                 | 400–440V                    | 5                 | 7.3                                  | SC-03       | SC-0, 05                              |
| 7.5             |                             | 10.8              | SC-03                                | SC-4-0      | SC-N2                                 |
| 10              |                             | 14.5              | SC-4-0                               | SC-4-0      | SC-N2                                 |
| 15              |                             | 21.6              | SC-4-1, 5-1                          | SC-N1       | SC-N3                                 |
| 20              |                             | 28.9              | SC-N1                                | SC-N1       | SC-N5                                 |
| 25              |                             | 36.1              | SC-N2                                | SC-N2       | SC-N6                                 |
| 30              |                             | 43.4              | SC-N2S                               | SC-N2S      | SC-N7                                 |
| 40              |                             | 57.8              | SC-N3                                | SC-N3       | SC-N8                                 |
| 50              |                             | 72.3              | SC-N4                                | SC-N4       | SC-N10                                |
| 60              |                             | 86.7              | SC-N4                                | SC-N5       | SC-N11                                |
| 75              |                             | 108.4             | SC-N7                                | SC-N7       | SC-N11                                |
| 100             |                             | 145               | SC-N8                                | SC-N8       | SC-N12                                |
| 125             |                             | 181               | SC-N8                                | SC-N10      | SC-N14                                |
| 150             |                             | 217               | SC-N11                               | SC-N11      | –                                     |
| 200             |                             | 289               | SC-N12                               | SC-N12      | –                                     |
| 250             |                             | 361               | SC-N14                               | SC-N14      | –                                     |
| 300             | 434                         | SC-N14            | SC-N14                               | –           |                                       |
| 370             | 535                         | SC-N16            | SC-N16                               | –           |                                       |

Notes:

- The above table applies for an electrical durability of approx. 100,000 operations.
- Selection is based on a contactor current carrying capacity that allows for 1.3×1.15 times the capacitor's overcurrent.
- Use the following formula to convert kvar to μF:

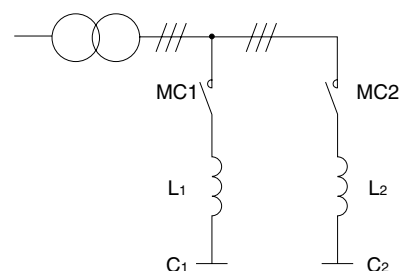
$$C = \frac{\text{kvar}}{2\pi f E^2} \times 10^9 \text{ (}\mu\text{F)}$$

E: Rated voltage  
f: Frequency

$$* K = \omega L_2 / \frac{1}{\omega C_2} = \omega L_1 / \frac{1}{\omega C_1}$$

C<sub>1</sub>: Capacity of capacitor already made  
C<sub>2</sub>: Capacity of capacitor to be made

Fig. 22



# 4 Application and Selection

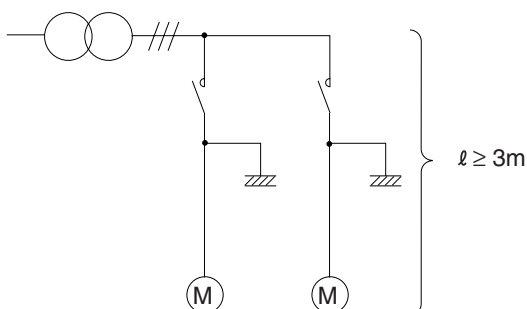
## 4-2 Load applications

### (c) Contactors for motors connected to condensive capacitors

The following table shows contactors to be used when two or more motors with power-factor regulating capacitors are operated in parallel using the same power supply.

| Motor        |              | Capacity of power-factor regulating capacitor ( $\mu\text{F}$ ) | Contactor type               |                                |          |
|--------------|--------------|---|------------------------------|--------------------------------|----------|
| Voltage      | Output (kW)  |   | $250 \times 10^3$ operations | $1,000 \times 10^3$ operations |          |
| 220V<br>50Hz | 0.4          | 20  | SC-03                        | SC-03                          |          |
|              | 0.75         | 30  | SC-03                        | SC-0, 05                       |          |
|              | 1.5          | 40  | SC-03                        | SC-4-0                         |          |
|              | 2.2          | 50  | SC-0, 05                     | SC-4-1, 5-1                    |          |
|              | 3.7          | 75  | SC-4-0                       | SC-N1                          |          |
|              | 5.5          | 100   | SC-N1                        | SC-N2                          |          |
|              | 7.5          | 150   | SC-N2                        | SC-N2                          |          |
|              | 11           | 200   | SC-N2S                       | SC-N2S                         |          |
|              | 15           | 250   | SC-N3                        | SC-N3                          |          |
|              | 18.5         | 300   | SC-N4                        | SC-N4                          |          |
|              | 22           | 400   | SC-N5                        | SC-N6                          |          |
|              | 30           | 500   | SC-N6                        | SC-N7                          |          |
|              | 37           | 600   | SC-N7                        | SC-N7                          |          |
|              | 45           | 700   | SC-N8                        | SC-N8                          |          |
|              | 440V<br>50Hz | 0.75  | 7.5                          | SC-03                          | SC-03    |
|              |              | 1.5   | 10                           | SC-03                          | SC-0, 05 |
| 2.2          |              | 15  | SC-0, 05                     | SC-4-0                         |          |
| 3.7          |              | 20  | SC-0, 05                     | SC-4-0                         |          |
| 5.5          |              | 25  | SC-4-0                       | SC-4-1, 5-1                    |          |
| 7.5          |              | 40  | SC-4-1, 5-1                  | SC-N1                          |          |
| 11           |              | 50  | SC-N1                        | SC-N2                          |          |
| 15           |              | 75  | SC-N2                        | SC-N2S                         |          |
| 18.5         |              | 75  | SC-N2S                       | SC-N2S                         |          |
| 22           |              | 100   | SC-N2S                       | SC-N3                          |          |
| 30           |              | 125   | SC-N3                        | SC-N4                          |          |
| 37           |              | 150   | SC-N4                        | SC-N6                          |          |
| 45           |              | 200   | SC-N5                        | SC-N6                          |          |

Fig. 23



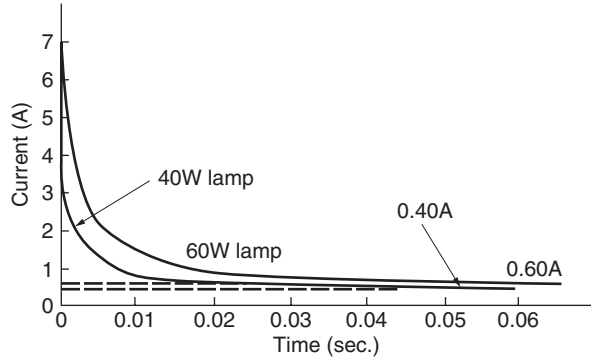
**4-2-4 Lamp load applications**  
**(1) Incandescent lamp loads**

The resistance (ohm) offered by tungsten filaments is very small just before they begin to glow. Therefore, according to theory, an inrush current 13 to 16 times the continuous current can be expected the moment voltage is applied.

However, in actual practice the inrush current is suppressed to a value 7 to 10 times the continuous current. This is due to the increase in resistance from circuit self-heating impedance.

The diagram gives an example of current-time characteristics after voltage has been applied. When selecting a contactor, it is necessary that the continuous current values of the incandescent lamps be less than the rated operational current of the contactor (category AC-3)

**Fig. 24 Current-time characteristic after voltage is applied**  
 In the case of 100V AC circuit



**Number of incandescent lamps that can be switched per contactor**

| Contactor type     | 100V AC                |      |      |      |      |      |        |        | 200V AC                |      |      |      |      |      |        |        |
|--------------------|------------------------|------|------|------|------|------|--------|--------|------------------------|------|------|------|------|------|--------|--------|
|                    | For each lamp capacity |      |      |      |      |      |        |        | For each lamp capacity |      |      |      |      |      |        |        |
|                    | 100W                   | 150W | 200W | 250W | 300W | 500W | 1,000W | 1,500W | 100W                   | 150W | 200W | 250W | 300W | 500W | 1,000W | 1,500W |
| <b>SC-03</b>       | 11                     | 7    | 5    | 4    | 3    | 2    | 1      | –      | 22                     | 14   | 11   | 8    | 7    | 4    | 2      | 1      |
| <b>SC-0, 05</b>    | 13                     | 8    | 6    | 5    | 4    | 2    | 1      | –      | 26                     | 17   | 13   | 10   | 8    | 5    | 2      | 1      |
| <b>SC-4-0</b>      | 18                     | 12   | 9    | 7    | 6    | 3    | 1      | 1      | 36                     | 24   | 18   | 14   | 12   | 7    | 3      | 2      |
| <b>SC-4-1, 5-1</b> | 19                     | 12   | 9    | 7    | 6    | 3    | 1      | 1      | 38                     | 25   | 19   | 15   | 12   | 7    | 3      | 2      |
| <b>SC-N1</b>       | 26                     | 17   | 13   | 10   | 8    | 5    | 2      | 1      | 52                     | 34   | 26   | 20   | 17   | 10   | 5      | 3      |
| <b>SC-N2</b>       | 35                     | 23   | 17   | 14   | 11   | 7    | 3      | 2      | 70                     | 46   | 35   | 28   | 23   | 14   | 7      | 4      |
| <b>SC-N2S</b>      | 50                     | 33   | 25   | 20   | 16   | 10   | 5      | 3      | 100                    | 66   | 50   | 40   | 33   | 20   | 10     | 6      |
| <b>SC-N3</b>       | 65                     | 43   | 32   | 26   | 21   | 13   | 6      | 4      | 130                    | 86   | 65   | 52   | 43   | 26   | 13     | 8      |

# 4 Application and Selection

## 4-2 Load applications

### (2) Fluorescent lamp loads

The inrush current at the time of starting a fluorescent lamp is approx. 10 times its normal running current and it takes 1 to 2 seconds to settle down. Therefore, it is necessary to select contactors in the AC-3 category which have a rated operational current exceeding that of the continuous current drawn by the fluorescent lamp circuits.

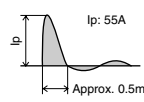
#### Number of rapid-start fluorescent lamps (high power factor type) that can be switched per contactor

| Contactor type | 100V AC                |       |            |      |          |      |              |      | 200V AC                |       |            |      |           |       |              |       |
|----------------|------------------------|-------|------------|------|----------|------|--------------|------|------------------------|-------|------------|------|-----------|-------|--------------|-------|
|                | For each lamp capacity |       |            |      |          |      |              |      | For each lamp capacity |       |            |      |           |       |              |       |
|                | 40W                    |       |            |      |          |      |              |      | 40W                    |       |            |      | 110W      |       |              |       |
|                | Lamp type              |       | FLR-40S/36 |      | FLR-110H |      | FLR-110H/100 |      | Lamp type              |       | FLR-40S/36 |      | Lamp type |       | FLR-110H/100 |       |
|                | One or two lamps       |       |            |      |          |      |              |      | One or two lamps       |       |            |      |           |       |              |       |
|                | 1                      | 2     | 1          | 2    | 1        | 2    | 1            | 2    | 1                      | 2     | 1          | 2    | 1         | 2     | 1            | 2     |
|                | Input current          |       |            |      |          |      |              |      | Input current          |       |            |      |           |       |              |       |
|                | 0.53A                  | 0.94A | 0.45A      | 0.8A | 1.3A     | 2.5A | 1.18A        | 2.2A | 0.27A                  | 0.47A | 0.23A      | 0.4A | 0.65A     | 1.25A | 0.59A        | 1.10A |
| SC-03          | 20                     | 11    | 24         | 13   | 8        | 4    | 9            | 5    | 40                     | 23    | 47         | 27   | 16        | 8     | 18           | 10    |
| SC-0, 05       | 24                     | 13    | 28         | 16   | 10       | 5    | 11           | 5    | 48                     | 27    | 56         | 32   | 20        | 10    | 22           | 11    |
| SC-4-0         | 33                     | 19    | 40         | 22   | 13       | 7    | 15           | 8    | 66                     | 38    | 78         | 45   | 27        | 14    | 30           | 16    |
| SC-4-1, 5-1    | 35                     | 20    | 42         | 23   | 14       | 7    | 16           | 8    | 70                     | 40    | 82         | 47   | 29        | 15    | 32           | 17    |
| SC-N1          | 49                     | 27    | 57         | 32   | 20       | 10   | 22           | 11   | 96                     | 55    | 113        | 65   | 40        | 20    | 44           | 23    |
| SC-N2          | 66                     | 37    | 77         | 43   | 26       | 14   | 29           | 15   | 129                    | 74    | 152        | 87   | 53        | 28    | 59           | 31    |
| SC-N2S         | 94                     | 53    | 111        | 62   | 38       | 20   | 42           | 22   | 182                    | 106   | 217        | 125  | 76        | 40    | 84           | 45    |
| SC-N3          | 122                    | 69    | 144        | 81   | 50       | 26   | 55           | 29   | 240                    | 138   | 282        | 162  | 100       | 52    | 110          | 59    |

### (3) Inverter-type fluorescent lamp loads

Even if the parameters determining the wattage and voltage of the inrush current prevention circuit and smoothing capacitor for starting inrush current are the same, the capacity will differ significantly depending on the model. The following tables give examples of specifications for commercially available Hf inverter-type stabilizers.

#### Examples of specifications for Hf inverter-type stabilizers

| Watts                      | Input power supply  | Power factor      | Combined lamp power | Smoothing capacitor capacity | Starting inrush current *   |
|----------------------------|---|-------------------|---------------------|------------------------------|---|
| 200V AC<br>32W for 2 lamps | Rated output:<br>0.36A<br>72W<br>High output:<br>0.50A<br>98W | High power factor | 32/45W              | 47μF                         |  |

Note: \* Measured values for power supply phase of 90°, giving the largest starting inrush current.

#### Number of Hf inverter-type fluorescent lamp loads per contactor that can be switched

| Contactor   | Number of switchable lamp loads |
|-------------|---------------------------------|
| SC-4-0      | 6                               |
| SC-4-1, 5-1 | 9                               |
| SC-N1       | 12                              |
| SC-N2       | 18                              |
| SC-N2S      | 25                              |
| SC-N3       | 30                              |

**(4) Mercury-arc lamp loads**

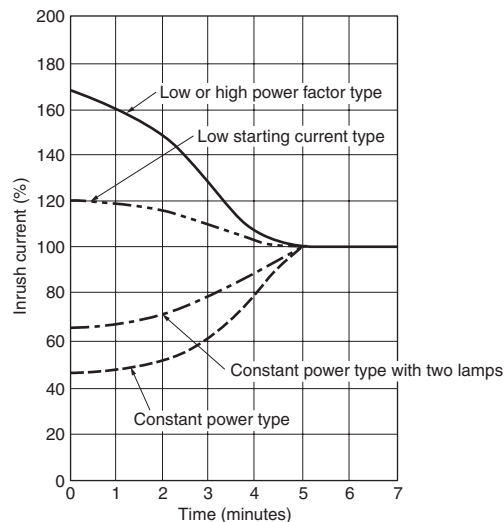
Mercury-arc lamps are equipped with a starting stabilizer to limit the current to non-destructive levels. The starting characteristics of a mercury-arc lamp depend on the characteristics of this stabilizer. Stabilizers are available in low power factor, high power factor, constant power and low starting current types.

The diagram indicates the starting characteristics of these different stabilizers.

Low power factor, high power factor and constant power types develop inrush current between 1.2 to 1.8 times the continuous running current, and their starting time is between 4 to 6 minutes.

When selecting contactors it is necessary to consider the duration of starting time and the contactor withstand values. The contactors in the SC series have an ample tolerance to withstand current having a magnitude of 1.2 to 1.8 times the rated operational current for a period of 4 to 6 minutes. The normal operating current must always remain within the rated operational current of the contactor.

**Fig. 25 Starting characteristics of mercury-arc lamp loads**



**Number of mercury-arc lamps that can be switched per contactor**

| Contactor type | 100V AC                                       |          |          |          |          |          |         |          |
|----------------|---|----------|----------|----------|----------|----------|---------|----------|
|                | For each lamp capacity                        |          |          |          |          |          |         |          |
|                | 40W   | 100W     | 200W     | 250W     | 300W     | 400W     | 700W    | 1,000W   |
|                | Input current for low-/high-power factor type |          |          |          |          |          |         |          |
|                | 0.6/1.2A                                      | 1.3/2.4A | 2.6/4.3A | 3.0/4.8A | 3.6/5.5A | 4.9/7.5A | 8.5/14A | 12.0/20A |
| SC-03          | 18/9  | 8/4      | 4/2      | 3/2      | 3/2      | 2/1      | 1/-     | -/-      |
| SC-0, 05       | 21/10   | 10/5     | 5/3      | 4/2      | 3/2      | 2/1      | 1/-     | 1/-      |
| SC-4-0         | 30/15   | 13/7     | 6/4      | 6/3      | 5/3      | 3/2      | 2/1     | 1/-      |
| SC-4-1, 5-1    | 31/15   | 14/7     | 7/4      | 6/3      | 5/3      | 3/2      | 2/1     | 1/-      |
| SC-N1          | 43/21   | 20/10    | 10/6     | 8/5      | 7/4      | 5/3      | 3/1     | 2/1      |
| SC-N2          | 58/29   | 26/14    | 13/8     | 11/7     | 9/6      | 7/4      | 4/2     | 2/1      |
| SC-N2S         | 83/41   | 38/20    | 19/11    | 16/10    | 13/9     | 10/6     | 5/3     | 4/2      |
| SC-N3          | 108/54  | 50/27    | 25/15    | 21/13    | 18/11    | 13/8     | 7/4     | 5/3      |

| Contactor type | 200V AC                                       |           |          |          |           |          |          |          |
|----------------|---|-----------|----------|----------|-----------|----------|----------|----------|
|                | For each lamp capacity                        |           |          |          |           |          |          |          |
|                | 40W   | 100W      | 200W     | 250W     | 300W      | 400W     | 700W     | 1,000W   |
|                | Input current for low-/high-power factor type |           |          |          |           |          |          |          |
|                | 0.27/0.53A                                    | 0.64/1.0A | 1.2/1.9A | 1.5/2.1A | 1.75/2.5A | 2.3/3.3A | 4.1/5.9A | 5.8/8.3A |
| SC-03          | 40/20   | 17/11     | 9/5      | 7/5      | 6/4       | 4/3      | 2/1      | 1/1      |
| SC-0, 05       | 48/24   | 20/13     | 10/6     | 8/6      | 7/5       | 5/3      | 3/2      | 2/1      |
| SC-4-0         | 66/33   | 28/18     | 15/9     | 12/8     | 10/7      | 7/5      | 4/3      | 3/2      |
| SC-4-1, 5-1    | 70/35   | 29/19     | 15/10    | 12/9     | 10/7      | 8/5      | 4/3      | 3/2      |
| SC-N1          | 96/49   | 40/26     | 21/13    | 17/12    | 14/10     | 11/7     | 6/4      | 4/3      |
| SC-N2          | 129/66  | 54/35     | 29/18    | 23/16    | 20/14     | 15/10    | 8/5      | 5/4      |
| SC-N2S         | 185/94  | 78/50     | 41/26    | 33/23    | 28/20     | 21/15    | 12/8     | 8/6      |
| SC-N3          | 240/122                                       | 101/65    | 54/34    | 43/30    | 37/26     | 28/19    | 15/11    | 11/7     |

# 4 Application and Selection

## 4-2 Load applications

### 4-2-5 DC load applications

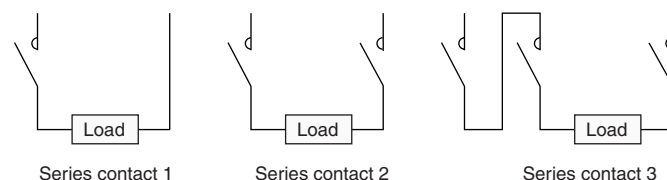
FUJI magnetic contactors in the SC series are normally used in AC circuit applications. However, they may also be used in DC circuits, and in this case their contacts must be connected in series as shown in the diagram.

When used in this manner they will be found to be more economical than using contactors exclusively designed for DC applications. Coils are available for both AC and DC. If the following ratings are observed the equipment will have an electrical durability of approx. 500,000 operations.

#### Wiring connection

Contacts must be connected in series when the contactors are used in DC applications.

Fig. 26



| Type   | No. of contacts connected in series | Rated operational current (A)         |     |      |      |  |     |      |      |
|--------|-------------------------------------|---------------------------------------|-----|------|------|--|-----|------|------|
|        |                                     | Class DC-1<br>(Resistive, L/R ≤ 1ms.) |     |      |      | Class DC-3, 6<br>(DC motor, L/R ≤ 15ms.) |     |      |      |
|        |                                     | 24V                                   | 48V | 110V | 220V | 24V                                      | 48V | 110V | 220V |
| SC-03  | 1                                   | 13                                    | 13  | 10   | 1.2  | 6  | 3   | 2    | 0.35 |
|        | 2                                   | 13                                    | 13  | 10   | 6    | 12                                       | 6   | 4    | 1.2  |
|        | 3                                   | 15                                    | 15  | 15   | 15   | 15                                       | 10  | 8    | 4    |
| SC-0   | 1                                   | 13                                    | 13  | 10   | 1.2  | 6  | 3   | 2    | 0.35 |
|        | 2                                   | 13                                    | 13  | 10   | 6    | 12                                       | 6   | 4    | 1.2  |
|        | 3                                   | 15                                    | 15  | 15   | 15   | 15                                       | 10  | 8    | 4    |
| SC-05  | 1                                   | 13                                    | 13  | 10   | 1.2  | 6  | 3   | 2    | 0.35 |
|        | 2                                   | 13                                    | 13  | 10   | 6    | 12                                       | 6   | 4    | 1.2  |
|        | 3                                   | 15                                    | 15  | 15   | 15   | 15                                       | 10  | 8    | 4    |
| SC-4-0 | 1                                   | 16                                    | 13  | 10   | 1.5  | 8  | 6   | 2    | 0.35 |
|        | 2                                   | 16                                    | 16  | 12   | 8    | 16                                       | 12  | 6    | 1.5  |
|        | 3                                   | 18                                    | 18  | 18   | 15   | 18                                       | 18  | 12   | 6    |
| SC-4-1 | 1                                   | 20                                    | 15  | 12   | 2    | 10                                       | 8   | 3    | 0.35 |
|        | 2                                   | 20                                    | 20  | 15   | 10   | 20                                       | 15  | 8    | 2    |
|        | 3                                   | 22                                    | 22  | 20   | 15   | 22                                       | 22  | 15   | 8    |
| SC-5-1 | 1                                   | 20                                    | 15  | 12   | 2    | 10                                       | 8   | 3    | 0.35 |
|        | 2                                   | 20                                    | 20  | 15   | 10   | 20                                       | 15  | 8    | 2    |
|        | 3                                   | 22                                    | 22  | 20   | 15   | 22                                       | 22  | 15   | 8    |
| SC-N1  | 1                                   | 25                                    | 25  | 15   | 2    | 15                                       | 8   | 3    | 0.35 |
|        | 2                                   | 25                                    | 25  | 25   | 20   | 25                                       | 15  | 8    | 2    |
|        | 3                                   | 35                                    | 35  | 30   | 25   | 35                                       | 25  | 20   | 8    |
| SC-N2  | 1                                   | 30                                    | 30  | 20   | 2    | 20                                       | 15  | 4    | 0.35 |
|        | 2                                   | 30                                    | 30  | 30   | 20   | 30                                       | 20  | 15   | 3    |
|        | 3                                   | 45                                    | 45  | 40   | 35   | 35                                       | 30  | 30   | 8    |
| SC-N2S | 2                                   | 60                                    | 60  | 40   | 20   | 60                                       | 30  | 20   | 3.5  |
|        | 3                                   | 60                                    | 60  | 60   | 40   | 60                                       | 60  | 60   | 13   |
| SC-N3  | 2                                   | 80                                    | 80  | 50   | 20   | 80                                       | 40  | 20   | 4    |
|        | 3                                   | 80                                    | 80  | 80   | 60   | 80                                       | 80  | 80   | 20   |
| SC-N4  | 2                                   | 80                                    | 80  | 50   | 20   | 80                                       | 40  | 20   | 4    |
|        | 3                                   | 80                                    | 80  | 80   | 60   | 80                                       | 80  | 80   | 20   |
| SC-N5  | 2                                   | 120                                   | 120 | 80   | 40   | 120                                      | 80  | 40   | 15   |
|        | 3                                   | 120                                   | 120 | 120  | 120  | 120                                      | 120 | 120  | 80   |
| SC-N6  | 2                                   | 120                                   | 120 | 80   | 40   | 120                                      | 80  | 40   | 15   |
|        | 3                                   | 120                                   | 120 | 120  | 120  | 120                                      | 120 | 120  | 80   |
| SC-N7  | 2                                   | 160                                   | 160 | 100  | 80   | 160                                      | 120 | 80   | 40   |
|        | 3                                   | 160                                   | 160 | 160  | 160  | 160                                      | 160 | 160  | 160  |
| SC-N8  | 2                                   | 200                                   | 200 | 160  | 160  | 200                                      | 160 | 120  | 60   |
|        | 3                                   | 200                                   | 200 | 200  | 200  | 200                                      | 200 | 200  | 200  |
| SC-N10 | 2                                   | 200                                   | 200 | 160  | 160  | 200                                      | 160 | 120  | 60   |
|        | 3                                   | 200                                   | 200 | 200  | 200  | 200                                      | 200 | 200  | 200  |
| SC-N11 | 2                                   | 300                                   | 300 | 200  | 200  | 300                                      | 200 | 160  | 80   |
|        | 3                                   | 300                                   | 300 | 300  | 300  | 300                                      | 300 | 300  | 300  |
| SC-N12 | 2                                   | 400                                   | 400 | 330  | 300  | 400                                      | 300 | 200  | 100  |
|        | 3                                   | 400                                   | 400 | 400  | 400  | 400                                      | 400 | 400  | 400  |
| SC-N14 | 2                                   | 600                                   | 500 | 420  | 300  | -  | -   | -    | -    |
|        | 3                                   | 600                                   | 600 | 600  | 420  | -  | -   | -    | -    |

## 4-2-6 Selection of control transformers

### (1) Selection of control transformers

When selecting control transformers, both continuous capacity and short-time capacity must be considered.

Continuous capacity refers to the holding capacity of all of the magnetic contactors. Short-time capacity refers to the capacity required when switching the circuit, and is several times the size of the normal continuous capacity. In particular, the short-time capacity is determined by the voltage drop allowed in the secondary output voltage when the contactor is closed. In this case, taking voltage fluctuations in the main power supply into consideration, 5% can be used as a rough estimate. The following table shows the coil characteristics for FUJI magnetic contactors.

#### Magnetic contactor coil characteristics

| Type   | Inrush                       |                        |                            |                               | Sealed                       |                        |                            |                               |
|--------|------------------------------|------------------------|----------------------------|-------------------------------|------------------------------|------------------------|----------------------------|-------------------------------|
|        | Power consumption<br>Ps (VA) | Active power<br>Pw (W) | Reactive power<br>Pv (var) | Power factor<br>(cos $\phi$ ) | Power consumption<br>Ps (VA) | Active power<br>Pw (W) | Reactive power<br>Pv (var) | Power factor<br>(cos $\phi$ ) |
| SC-03  | 95                           | 70                     | 65                         | 0.73                          | 9                            | 2.9                    | 8.5                        | 0.32                          |
| SC-0   | 95                           | 70                     | 65                         | 0.73                          | 9                            | 2.9                    | 8.5                        | 0.32                          |
| SC-05  | 95                           | 70                     | 65                         | 0.73                          | 9                            | 2.9                    | 8.5                        | 0.32                          |
| SC-4-0 | 95                           | 70                     | 65                         | 0.73                          | 9                            | 2.9                    | 8.5                        | 0.32                          |
| SC-4-1 | 95                           | 70                     | 65                         | 0.73                          | 9                            | 2.9                    | 8.5                        | 0.32                          |
| SC-5-1 | 95                           | 70                     | 65                         | 0.73                          | 9                            | 2.9                    | 8.5                        | 0.32                          |
| SC-N1  | 120                          | 88                     | 82                         | 0.73                          | 12.7                         | 3.7                    | 12                         | 0.29                          |
| SC-N2  | 120                          | 88                     | 82                         | 0.73                          | 12.7                         | 3.7                    | 12                         | 0.29                          |
| SC-N2S | 180                          | 97                     | 151                        | 0.54                          | 13.3                         | 4.5                    | 12.5                       | 0.34                          |
| SC-N3  | 180                          | 97                     | 151                        | 0.54                          | 13.3                         | 4.5                    | 12.5                       | 0.34                          |
| SC-N4  | 200                          | 118                    | 161                        | 0.59                          | 14.3                         | 4.8                    | 13.4                       | 0.34                          |
| SC-N5  | 80                           | 80                     | 8                          | 0.99                          | 4                            | 3.2                    | 2.4                        | 0.8                           |
| SC-N6  | 190                          | 188                    | 27                         | 0.99                          | 4.9                          | 3.4                    | 3.5                        | 0.7                           |
| SC-N7  | 190                          | 188                    | 27                         | 0.99                          | 4.9                          | 3.4                    | 3.5                        | 0.7                           |
| SC-N8  | 200                          | 200                    | 20                         | 0.99                          | 5.4                          | 4.5                    | 2.9                        | 0.84                          |
| SC-N10 | 200                          | 200                    | 20                         | 0.99                          | 5.4                          | 4.5                    | 2.9                        | 0.84                          |
| SC-N11 | 240                          | 239                    | 24                         | 0.99                          | 5.7                          | 5.3                    | 2.1                        | 0.93                          |
| SC-N12 | 240                          | 239                    | 24                         | 0.99                          | 5.7                          | 5.3                    | 2.1                        | 0.93                          |
| SC-N14 | 400                          | 400                    | 0                          | 1                             | 9.3                          | 7.9                    | 4.9                        | 0.85                          |
| SC-N16 | 400                          | 400                    | 0                          | 1                             | 9.3                          | 7.9                    | 4.9                        | 0.85                          |

#### (a) Calculation example

The control transformer capacity can be calculated using the following formula:

$$P_s = \sqrt{P_w^2 + P_v^2}$$

Ps: Apparent power (kVA)

Pw: Active power (kW)

Pv: Reactive power (kvar)

$$\text{Total power factor, } \cos\phi = \frac{P_w}{P_s}$$

For example, the following calculations are for the case where three SC-N6 contactors start operation in a configuration where one SC-N2 contactor is already operating.

#### (b) Short-time capacity

In this case, using the values in the above table, the calculation will be as follows:

Total active power,  $P_w = 3.7 + 188 \times 3 = 567.7$  (W)

Total reactive power,  $P_v = 12 + 27 \times 3 = 93$  (var)

Total apparent power,  $P_s = \sqrt{P_w^2 + P_v^2} = \sqrt{567.7^2 + 93^2} = 575$  VA

Total power factor,  $\cos\phi = \frac{P_w}{P_s} = \frac{567.7}{575} = 0.99$

Therefore, the short-time capacity required in this case is approx. 580VA with  $\cos\phi = 0.99$ .

# 4 Application and Selection

## 4-2 Load applications

### (c) Continuous capacity

After the three SC-N6 contactors start operation, using the values in the above table, the calculation will be as follows:

Total active power,  $P_w=3.7+3.4 \times 3=13.9$  (W)

Total reactive power,  $P_v=12+3.5 \times 3=22.5$  (var)

Total apparent power,  $P_s = \sqrt{P_w^2 + P_v^2} = \sqrt{13.9^2 + 22.5^2} = 26VA$

Total power factor,  $\cos\phi = \frac{P_w}{P_s} = \frac{13.9}{26} = 0.53$

Therefore, in this case, the required short-time capacity is 580VA ( $\cos\phi=0.99$ ) and the required continuous capacity is 26VA ( $\cos\phi=0.53$ ). Select a control transformer that satisfies these criteria.

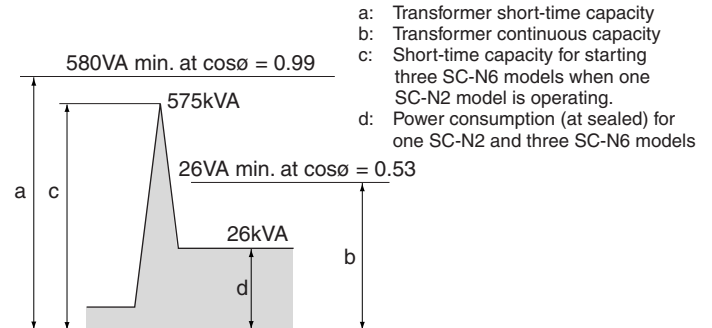
The following table only gives examples of control transformers, but applying this table to the above example would indicate that a transformer with a rated capacity of 750VA is suitable.

### Examples of overload capacity for transformers at different power factors (with voltage fluctuation at 5%)

| Rating capacity (VA) | Power factor (cosφ) |        |        |        |        |        |        |        |
|----------------------|---------------------|--------|--------|--------|--------|--------|--------|--------|
|                      | 0.3                 | 0.4    | 0.5    | 0.6    | 0.7    | 0.8    | 0.9    | 1.0    |
| 10                   | 11                  | 8.1    | 6.5    | 5.5    | 4.7    | 4.1    | 3.7    | 3.4    |
| 20                   | 21                  | 17     | 13     | 11     | 10     | 8.7    | 7.8    | 7.1    |
| 30                   | 30                  | 23     | 19     | 16     | 14     | 12     | 11     | 10     |
| 50                   | 55                  | 42     | 35     | 29     | 25     | 22     | 20     | 18     |
| 75                   | 98                  | 77     | 63     | 53     | 46     | 41     | 37     | 34     |
| 100                  | 160                 | 120    | 100    | 87     | 76     | 67     | 61     | 57     |
| 200                  | 350                 | 280    | 230    | 200    | 170    | 150    | 140    | 130    |
| 300                  | 650                 | 530    | 440    | 380    | 340    | 310    | 280    | 260    |
| 500                  | 1,000               | 850    | 740    | 660    | 590    | 550    | 510    | 510    |
| 750                  | 1,500               | 1,200  | 1,100  | 970    | 880    | 810    | 760    | 770    |
| 1,000                | 2,500               | 2,100  | 1,800  | 1,600  | 1,500  | 1,400  | 1,300  | 1,300  |
| 2,000                | 5,100               | 4,200  | 3,600  | 3,100  | 2,800  | 2,500  | 2,300  | 2,200  |
| 3,000                | 7,500               | 6,300  | 5,400  | 4,800  | 4,300  | 3,900  | 3,600  | 3,500  |
| 5,000                | 15,000              | 13,000 | 11,000 | 10,000 | 9,100  | 8,400  | 7,900  | 7,900  |
| 7,500                | 25,000              | 21,000 | 19,000 | 17,000 | 16,000 | 15,000 | 14,000 | 14,000 |
| 10,000               | 35,000              | 31,000 | 28,000 | 25,000 | 24,000 | 22,000 | 22,000 | 23,000 |
| 15,000               | 52,000              | 47,000 | 44,000 | 41,000 | 39,000 | 37,000 | 37,000 | 41,000 |
| 20,000               | 69,000              | 63,000 | 59,000 | 56,000 | 54,000 | 53,000 | 53,000 | 63,000 |

Note: The above table gives values for standard FUJI control transformers as examples.

Fig. 27 Relationship between transformer capacity and load



The following table shows the capacity of transformers required when one magnetic contactor is used.

### Transformer capacity required for 1 contactor (ε = Voltage fluctuation rate)

| Type   | Transformer capacity (VA) |              |               |
|--------|---------------------------|--------------|---------------|
|        | 2% < ε ≤ 5%               | 5% < ε ≤ 10% | 10% < ε ≤ 15% |
| SC-03  | 200                       | 100          | 75            |
| SC-0   | 200                       | 100          | 75            |
| SC-05  | 200                       | 100          | 75            |
| SC-4-0 | 200                       | 100          | 75            |
| SC-4-1 | 200                       | 100          | 75            |
| SC-5-1 | 200                       | 100          | 75            |
| SC-N1  | 200 (200)                 | 100 (100)    | 75(75)        |
| SC-N2  | 200 (200)                 | 100 (100)    | 75(75)        |
| SC-N2S | 200 (200)                 | 100 (100)    | 75(100)       |
| SC-N3  | 200 (200)                 | 100 (100)    | 75(100)       |
| SC-N4  | 200 (200)                 | 100 (100)    | 100(75)       |
| SC-N5  | 200                       | 100          | 75            |
| SC-N6  | 300                       | 200          | 200           |
| SC-N7  | 300                       | 200          | 200           |
| SC-N8  | 300                       | 200          | 200           |
| SC-N10 | 300                       | 200          | 200           |
| SC-N11 | 300                       | 500          | 300           |
| SC-N12 | 300                       | 500          | 300           |
| SC-N14 | 500                       | 300          | 200           |
| SC-N16 | 500                       | 300          | 200           |

Notes: • The above table gives values for standard FUJI control transformers as examples.  
 • The values in parentheses are for SC-N1/SE to SC-N4/SE models (with SUPER MAGNET).  
 • If devices other than contactors are connected to the secondary side of the same transformer, consideration of the permissible voltage drop of these devices is required when making a selection.



### 4-3-1 Overview of motor protection

Induction motors are the most basic source of motive power in production installations. At present, with the adoption of the dimensions specified in IEC and E-, B-, and F-class insulation, the development of products that are smaller, lighter, and capable of better performance is advancing, and these products are used in a wide range of applications. Also, along with recent developments in automation and power saving technology, applications where motors are used not only in continuous operation, but also in intermittent operation or forward/reverse operation are increasing. The potential effects of motor failure have also expanded. In addition to motor stoppages, total failure of the installation or system incorporating the motor is also possible. Preventing such failures requires a thorough consideration of the motor's heating characteristics and operation method, and a protection method that is appropriate for the application conditions is required.

Devices for protecting motors can be classified according to detection type and include current-detection devices (e.g., thermal overload relays and MCCBs for motor protection) and temperature-detection devices. The application conditions for these protective devices with respect to the motor's operation method, starting time, and protected items are shown in the following table. Also, the application conditions for quick operating type, standard type, and long-time operating type thermal overload relays and magnetic motor starters based on the starting time are given on pages 90 and 91.

Select the protective device that is best suited to the application by considering the protected items using the following tables together with consideration of economic viability, maintainability, and size. Also, for added safety, selection of a thermal overload relay with 3 elements or with phase-loss protective device (2E type) is recommended.

#### (1) Application conditions for protective devices for low-voltage motors

| Type of protection    | Motor operation method                        | Constant load, continuous load            |  |   | Fluctuating load, intermittent load               | Reverse rotation protection (Phase sequence protection) | Short-circuit protection | Leakage protection |
|-----------------------|---|---|--|---|---|---|--------------------------|--------------------|
|                       |   | Short                                     | Standard   | Long  |   |   |                          |                    |
|                       | Motor starting time                           | Short                                     | Standard   | Long  | —   |   |                          |                    |
|                       | Motor classification (example)                | Submersible motor, increased safety motor | Motors for pumps, fans, and other basic applications | Motors for ventilators, blowers, and centrifugal separation | Motors for elevators, cranes, and machine tools   |   |                          |                    |
|                       | Protected item                                | Overload, Phase-locked rotor              | Overload, Phase-locked rotor                         | Overload, Phase-locked rotor                                | Overload * <sub>1</sub> Phase-loss * <sub>1</sub> | —   | —                        | —                  |
| Protective device     | Quick operating OL relay 3-element TR-□Q      | ○    Δ                                    |  |   |   |   |                          |                    |
|                       | Standard type OL relay                        | 2-element * <sub>3</sub> TR-□             | Δ  | ○   |   | Δ   |                          |                    |
|                       |   | 3-element TR-□/3                          | Δ  | ○    Δ * <sub>2</sub>                                       |   | Δ    Δ  |                          |                    |
|                       |   | With phase-loss protection                | Δ    Δ   | ○    ○  |   | Δ    Δ  |                          |                    |
|                       | With phase-loss and phase sequence protection | Δ    Δ                                    | ○    ○   |   | Δ    Δ  | ○   |                          |                    |
|                       | Long time operating OL relay                  | 2-element * <sub>3</sub> TR-□L            |  |   | ○   | Δ   |                          |                    |
|                       |   | 3-element TR-□L/3                         |  |   | ○    Δ  | Δ   |                          |                    |
| Motor protection MCCB | EA□M  |   |  |   |   |   |                          |                    |
|                       | SA□M  | Δ   | ○    Δ * <sub>2</sub>                                |   | Δ    Δ  |   | ○                        |                    |
| Motor protection ELCB | EG□M  |   |  |   |   |   |                          |                    |
|                       | SG□M  | Δ   | ○    Δ * <sub>2</sub>                                |   | Δ    Δ  |   | ○    ○                   |                    |

Notes: ○ Applicable  
 Δ Not applicable in some cases

\*<sub>1</sub> Applicable in some cases if the operating frequency is regular.  
 \*<sub>2</sub> Phase-loss protection is possible for motors with output of 2.2kW or less.  
 \*<sub>3</sub> Does not conform to IEC, UL/CSA and JIS standards.

# 4 Application and Selection

## 4-3 Protection of motors

### (2) Application conditions for starters based on motor starting time

| Motor capacity (200 to 200V) (kW) | Quick operating type                |                        |                  | Standard type                       |                           |                  | Long-time operating type            |                        |                  | Application based on starting time (cold start: — 6In<br>- - - 5In)<br>Starting time (s)<br>0.5 1 2 3 4 5 10 20 30 |
|-----------------------------------|-------------------------------------|------------------------|------------------|-------------------------------------|---------------------------|------------------|-------------------------------------|------------------------|------------------|--|
|                                   | Starter                             | Thermal overload relay | Heater range (A) | Starter *1                          | Thermal overload relay *1 | Heater range (A) | Starter                             | Thermal overload relay | Heater range (A) |  |
| 0.2                               | —                                   | —                      | —                | SW-03/3H<br>SW-0/3H<br>SW-05/3H     | TR-0N/3                   | 0.95–1.45        | SW-03/3L<br>SW-0/3L<br>SW-05/3L     | —                      | 0.95–1.45        |  |
| 0.4                               | SW-03/3Q<br>SW-0/3Q<br>SW-05/3Q     | TR-0NQ                 | 2.2–3.4          | SW-03/3H<br>SW-0/3H<br>SW-05/3H     | TR-0N/3                   | 1.7–2.6          | SW-03/3L<br>SW-0/3L<br>SW-05/3L     | —                      | 1.7–2.6          |  |
| 0.75                              | SW-03/3Q<br>SW-0/3Q<br>SW-05/3Q     | TR-0NQ                 | 4–6              | SW-03/3H<br>SW-0/3H<br>SW-05/3H     | TR-0N/3                   | 2.8–4.2          | SW-03/3L<br>SW-0/3L<br>SW-05/3L     | —                      | 2.8–4.2          |  |
| 1.5                               | SW-03/3Q<br>SW-0/3Q<br>SW-05/3Q     | TR-0NQ                 | 5–8              | SW-03/3H<br>SW-0/3H<br>SW-05/3H     | TR-0N/3                   | 5–8              | SW-03/3L<br>SW-0/3L<br>SW-05/3L     | —                      | 5–8              |  |
| 2.2                               | SW-03/3Q<br>SW-0/3Q<br>SW-05/3Q     | TR-0NQ                 | 9–13             | SW-03/3H<br>SW-0/3H<br>SW-05/3H     | TR-0N/3                   | 7–11             | SW-03/3L<br>SW-0/3L<br>SW-05/3L     | —                      | 7–11             |  |
| 3.7                               | SW-4-0/3Q<br>SW-4-1/3Q<br>SW-5-1/3Q | TR-5-1NQ               | 12–18            | SW-4-0/3H<br>SW-4-1/3H<br>SW-5-1/3H | TR-5-1N/3                 | 12–18            | SW-4-0/3L<br>SW-4-1/3L<br>SW-5-1/3L | —                      | 12–18            |  |
| 5.5                               | SW-N1/3Q                            | TR-N2Q                 | 18–26            | SW-N1/3H                            | TR-N2/3                   | 18–26            | SW-N1/3L                            | TR-N2L/3               | 18–26            |  |
| 7.5                               | SW-N2/3Q                            | TR-N2Q                 | 24–36            | SW-N2/3H                            | TR-N2/3                   | 24–36            | SW-N2/3L                            | TR-N2L/3               | 24–36            |  |
| 11                                | SW-N2S/3Q                           | TR-N3Q                 | 34–50            | SW-N2S/3H                           | TR-N3/3                   | 34–50            | SW-N2S/3L                           | TR-N3L/3               | 34–50            |  |
| 15                                | SW-N3/3Q                            | TR-N3Q                 | 45–65            | SW-N3/3H                            | TR-N3/3                   | 45–65            | SW-N3/3L                            | TR-N3L/3               | 45–65            |  |
| 18.5                              | SW-N4/3Q                            | TR-N5Q                 | 53–80            | SW-N4/3H                            | TR-N5/3                   | 53–80            | SW-N4/3L                            | TR-N5L/3               | 53–80            |  |
| 22                                | SW-N5/3Q                            | TR-N5Q                 | 65–95            | SW-N5/3H                            | TR-N5/3                   | 65–95            | SW-N5/3L                            | TR-N5L/3               | 65–95            |  |
| 30                                | —                                   | —                      | —                | SW-N6/3H                            | TR-N6/3                   | 85–125           | SW-N6/3L                            | TR-N6L/3               | 85–125           |  |
| 37                                | —                                   | —                      | —                | SW-N7/3H                            | TR-N7/3                   | 110–160          | SW-N7/3L                            | TR-N7L/3               | 110–160          |  |
| 45                                | —                                   | —                      | —                | SW-N8/3H                            | TR-N8/3                   | 125–185          | SW-N8/3L                            | TR-N10L/3              | 125–185          |  |
| 55                                | —                                   | —                      | —                | SW-N10/3H                           | TR-N10/3                  | 160–240          | SW-N10/3L                           | TR-N10L/3              | 160–240          |  |
| 75                                | —                                   | —                      | —                | SW-N11/3H                           | TR-N12/3                  | 200–300          | SW-N11/3L                           | TR-N12L/3              | 200–300          |  |
| 90                                | —                                   | —                      | —                | SW-N12/3H                           | TR-N12/3                  | 240–360          | SW-N12/3L                           | TR-N12L/3              | 240–360          |  |
| 110                               | —                                   | —                      | —                | SW-N12/3H                           | TR-N12/3                  | 300–450          | SW-N12/3L                           | TR-N12L/3              | 300–450          |  |
| 132                               | —                                   | —                      | —                | SW-N14/3H                           | TR-N14/3                  | 400–600          | SW-N14/3L                           | TR-N14L/3              | 400–600          |  |
| 160                               | —                                   | —                      | —                | SW-N14/3H                           | TR-N14/3                  | 400–600          | SW-N14/3L                           | TR-N14L/3              | 400–600          |  |

Notes: • The selection of heater ranges in the above table is based on the full load current for standard motors. Check the value of the full load current before actual use.

• Apply the starting time at 5In to submersible pump motors.

□ Quick operating types, ▨ Standard types, ▩ Long-time operating types

\*1 Types with phase-loss protective device are also available.

**(3) Application conditions for separate mounting type thermal overload relays based on motor starting time**

| Motor capacity (200 to 220V) (kW) | Quick operating type   |                  | Standard type            |                  | Long-time operating type (for large inertia load starting) |                  | Application based on starting time (cold start: — 6In<br>- - - 5In)<br>Starting time (s)<br>0.5 1 2 3 4 5 10 20 30 |
|-----------------------------------|------------------------|------------------|--------------------------|------------------|--|------------------|--|
|                                   | Thermal overload relay | Heater range (A) | Thermal overload relay * | Heater range (A) | Thermal overload relay                                     | Heater range (A) |  |
| 0.2                               | —                      | —                | TR-0NH/3                 | 0.95–1.45        | TR-0NLH/3  | 0.95–1.45        |  |
| 0.4                               | TR-0NQH                | 2.2–3.4          | TR-0NH/3                 | 1.7–2.6          | TR-0NLH/3  | 1.7–2.6          |  |
| 0.75                              | TR-0NQH                | 4–6              | TR-0NH/3                 | 2.8–4.2          | TR-0NLH/3  | 2.8–4.2          |  |
| 1.5                               | TR-0NQH                | 5–8              | TR-0NH/3                 | 5–8              | TR-0NLH/3  | 5–8              |  |
| 2.2                               | TR-0NQH                | 9–13             | TR-0NH/3                 | 7–11             | TR-0NLH/3  | 7–11             |  |
| 3.7                               | TR-5-1NQH              | 12–18            | TR-5-1NH/3               | 12–18            | TR-5-1NLH/3  | 12–18            |  |
| 5.5                               | TR-N2QH                | 18–26            | TR-N2H/3                 | 18–26            | TR-N2LH/3  | 18–26            |  |
| 7.5                               | TR-N2QH                | 24–36            | TR-N2H/3                 | 24–36            | TR-N2LH/3  | 24–36            |  |
| 11                                | TR-N3QH                | 34–50            | TR-N3H/3                 | 34–50            | TR-N3LH/3  | 34–50            |  |
| 15                                | TR-N3QH                | 45–65            | TR-N3H/3                 | 45–65            | TR-N3LH/3  | 45–65            |  |
| 18.5                              | TR-N3QH                | 53–80            | TR-N3H/3                 | 53–80            | TR-N3LH/3  | 53–80            |  |
| 22                                | TR-N3QH                | 65–95            | TR-N3H/3                 | 65–95            | TR-N3LH/3  | 65–95            |  |
| 30                                | —                      | —                | TR-N6H/3                 | 85–125           | TR-N6LH/3  | 85–125           |  |
| 37                                | —                      | —                | TR-N6H/3                 | 110–160          | TR-N6LH/3  | 110–160          |  |
| 45                                | —                      | —                | TR-N10H/3                | 125–185          | TR-N10LH/3   | 125–185          |  |
| 55                                | —                      | —                | TR-N10H/3                | 160–240          | TR-N10LH/3   | 160–240          |  |
| 75                                | —                      | —                | TR-N12H/3                | 200–300          | TR-N12LH/3   | 200–300          |  |
| 90                                | —                      | —                | TR-N12H/3                | 240–360          | TR-N12LH/3   | 240–360          |  |
| 110                               | —                      | —                | TR-N12H/3                | 300–450          | TR-N12LH/3   | 300–450          |  |
| 132                               | —                      | —                | TR-N14H/3                | 400–600          | TR-N14LH/3   | 400–600          |  |
| 160                               | —                      | —                | TR-N14H/3                | 400–600          | TR-N14LH/3   | 400–600          |  |

- Notes:
- The selection of heater ranges in the above table is based on the full load current for standard motors. Check the value of the full load current before actual use.
  - Apply the starting time at 5In to submersible pump motors.
- Quick operating types, □ Standard types, □ Long-time operating types
- \* Types with phase-loss protective device are also available.

# 4 Application and Selection

## 4-3 Protection of motors

### 4-3-2 Overload and locked rotor protection

As long as the motor is operated within the rated specification range, the temperature of the winding insulation stays below the rated temperature, allowing the motor a normal operating life. If overloaded or if the rotor locks, current exceeding the rated current flows through the winding resulting in a rise of temperature. High temperature can cause deterioration of the winding insulation and motor burnout. To prevent damage, it is important to shut down the motor before the winding insulation reaches the critical temperature.

With current-responsive protection, an appropriate protector is selected based on the motor heating characteristic curve which shows the time taken from the beginning of overcurrent until the winding insulation reaches the critical temperature. There are two types of heating characteristic curves: the cold starting curve describing temperature rise of the winding insulation from the ambient temperature and the hot starting curve for which it rises from the rated operating temperature. Examples of cold and hot starting characteristics for a FUJI motor are shown in Fig. 28.

The operating curve of the current-responsive protector must lie below the heating characteristic curve in Fig. 28. The heating characteristics depend on the winding insulation type, degree of protection, and the number of poles. For a typical thermal overload relay (OLR) used as a current-responsive protector, the standard operating characteristics are defined for use with a standard motor (see page 42).

A standard thermal overload relay satisfies the standard operating characteristics as well as the operating characteristics of FUJI motors. When the specifications listed in the magnetic motor starter catalog are complied with, it is possible to protect a motor operating continuously with a constant load from both overload and locked-rotor overheating. The proper relationship between motor heating characteristics and thermal overload relay operating characteristics is shown in Fig. 29.

Fig. 28 Motor heating characteristics

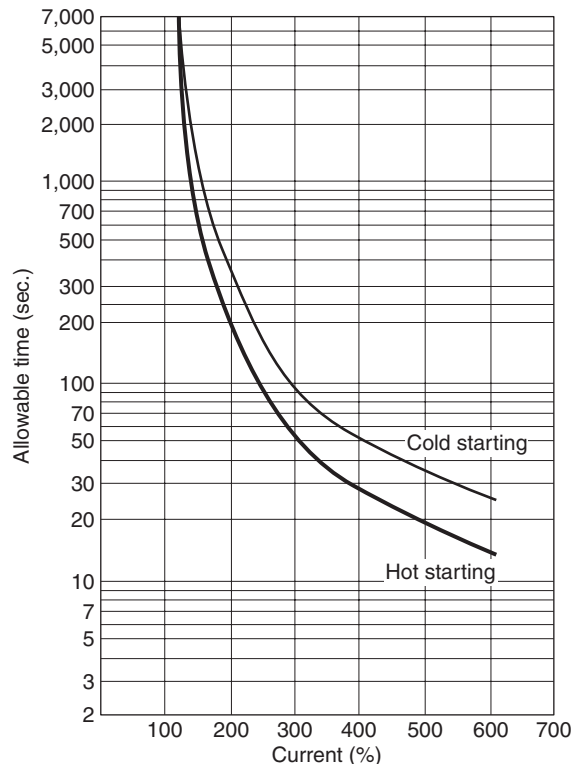
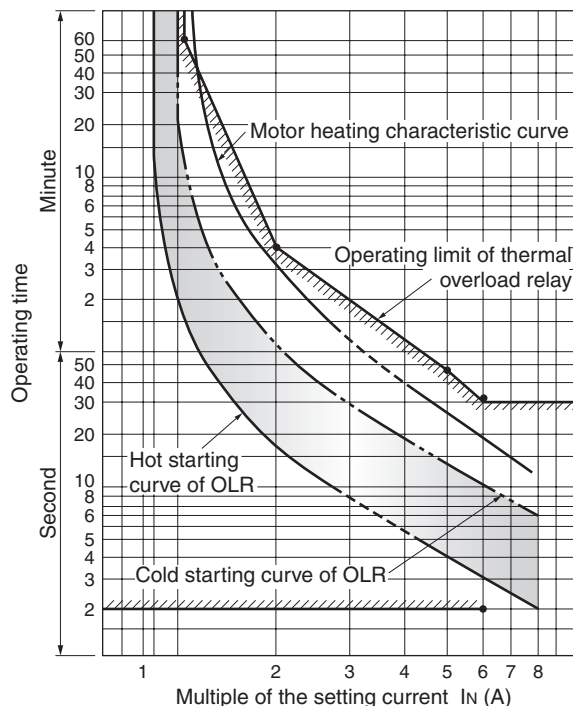


Fig. 29 Coordination between motor heating and thermal overload relay operating characteristics



### 4-3-3 Motor protection for large inertia load starting

For motors driving loads with a large moment of inertia (such as blowers, winders, separators and so on), the standard thermal overload relay cannot be used since it may trip during the long start-up sequence of the motor. For such applications, FUJI supplies long-time operating thermal overload relays and standardized magnetic motor starters for starting heavy loads. The magnetic motor starter consists of a long-time operating thermal overload relay and a magnetic contactor. When using the thermal overload relay, make sure that the motor heating characteristic curve is above the operating characteristic curve of the thermal overload relay.

### 4-3-4 Protection for compressor and submersible pump motors

The temperature of a motor through which refrigerant flows (such as a cooler compressor motor) or through which water flows (such as a submersible pump motor) does not rise abnormally even if current exceeding the rated current flows. Because of this property, compressor and submersible pump motors can be overloaded to some extent. However, if the temperature rises too abruptly in the event of a locked rotor, the motor receives little benefit from the refrigerant. In such a case, the motor must be shut down as quickly as possible. Submersible pump motors not cooled by water have been produced and put on the market. With regard to motor burnout protectors for submersible drain pump motors, JIS B 8325, the standard for submersible pump motors for waste water draining, states:

#### (1) For water sealed motors

Protectors which trip within five seconds in response to a current five times the rated motor current (such as the relays with phase-loss protective device/2E, or phase-loss and phase sequence protective device/3E) must be used.

#### (2) For hydraulic sealed and dry sealed motors

FUJI standard thermal overload relays are applicable. FUJI supplies quick operating type thermal overload relays for compressor motors and water sealed submersible pump motors, and standardized magnetic motor starters consisting of a quick operating type thermal overload relay and a magnetic contactor.

In submersible pump motor applications, phase-sequence protection is often required. In such cases, an magnetic motor starter with a 3E relay is recommended.

### 4-3-5 Phase-loss protection

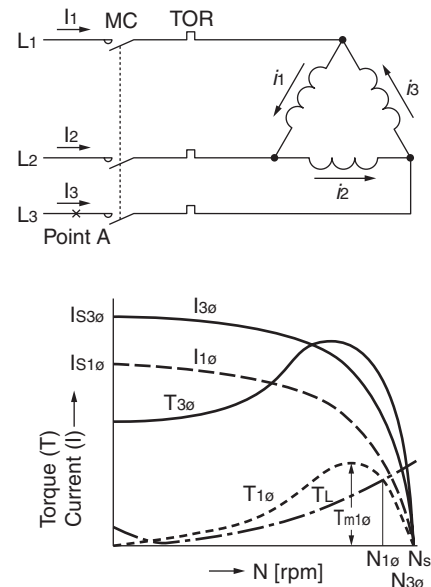
With a three-phase motor circuit, a blown fuse of any phase can cause phase-loss operation. Fig. 30 shows the current and torque characteristics of a motor with a delta-connected stator, which is operating without the L<sub>3</sub> phase.

If the motor is started without the L<sub>3</sub> phase, the motor generates no starting torque and will not start. Phase-loss starting current I<sub>S1φ</sub>, that is about 80% of three-phase starting current I<sub>S3φ</sub>, flows through the L<sub>1</sub> and L<sub>2</sub> phases, and the thermal overload relay trips. (I<sub>S1φ</sub> is also 4.8 times the rated current I<sub>N</sub>.)

If any phase is lost during operation, the result depends on the relationship between phase-loss operation torque T<sub>1φ</sub> and load torque T<sub>L</sub> as follows:

- 1) If the phase-loss starting torque T<sub>m1φ</sub> is smaller than load torque T<sub>L</sub>, the load torque brakes the motor to a stop and the thermal overload relay trips, resulting in the same conditions as in phase-loss starting.
- 2) If the phase-loss starting torque T<sub>m1φ</sub> is greater than the load torque T<sub>L</sub>, the motor continues to operate at a constant running speed of N<sub>1φ</sub>—the speed at which T<sub>1φ</sub> and T<sub>L</sub> balance.

**Fig. 30 The three- and phase-loss current and the torque-speed curve of a motor**



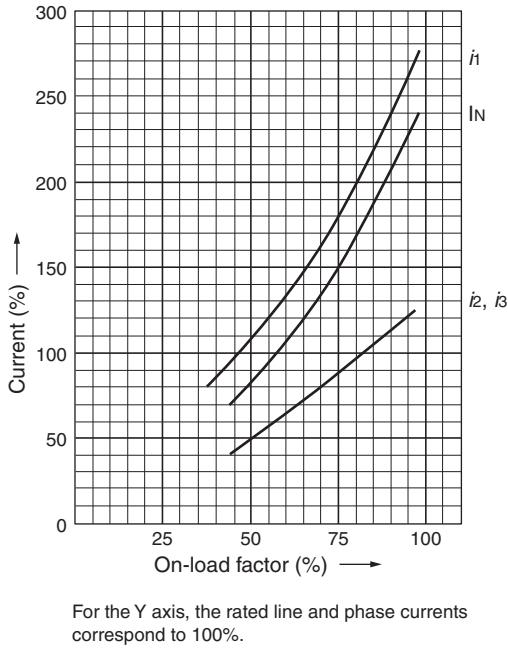
- I<sub>3φ</sub>: Three-phase current
- I<sub>1φ</sub>: Phase-loss current
- I<sub>S3φ</sub>: Three-phase starting current
- I<sub>S1φ</sub>: Phase-loss starting current
- T<sub>3φ</sub>: Three-phase torque
- T<sub>1φ</sub>: Phase-loss torque
- T<sub>m1φ</sub>: Phase-loss starting torque
- T<sub>L</sub>: Load torque
- N<sub>3φ</sub>: Rotational speed during three-phase operation
- N<sub>1φ</sub>: Rotational speed during phase-loss operation
- N<sub>s</sub>: Synchronous speed

# 4 Application and Selection

## 4-3 Protection of motors

Fig. 31 shows ratios of line and phase currents to their corresponding rated currents. When the on-load factor is  $1/\sqrt{3}$  or 58%, the line current ( $I_1$  and  $I_2$ ) becomes equal to the rated current and a phase current  $i_1$  that is 115% of the rated current flows through the phase winding to which full voltage is applied, resulting in a localized temperature rise within the motor.

**Fig. 31 Current variations during the phase-loss operation**



| Current | All 3 phases alive (at 100% load) a | Phase loss at point A (Refer to Fig. 30) (at 58% load) b | $\frac{b}{a}$ |
|---------|-------------------------------------|--|---------------|
| $I_1$   | $I_N$                               | $I_N$  | 1             |
| $I_2$   | $I_N$                               | $I_N$  | 1             |
| $I_3$   | $I_N$                               | 0  | 0             |
| $i_1$   | $\frac{I_N}{\sqrt{3}}$              | $\frac{2}{3} I_N$  | 1.15          |
| $i_2$   | $\frac{I_N}{\sqrt{3}}$              | $\frac{2}{3} I_N$  | 0.58          |
| $i_3$   | $\frac{I_N}{\sqrt{3}}$              | $\frac{1}{3} I_N$  | 0.58          |

Note:  $I_1, I_2, I_3$ : Line current  
 $i_1, i_2, i_3$ : Phase current  
 $I_N$ : Rated line current (all three phases alive)

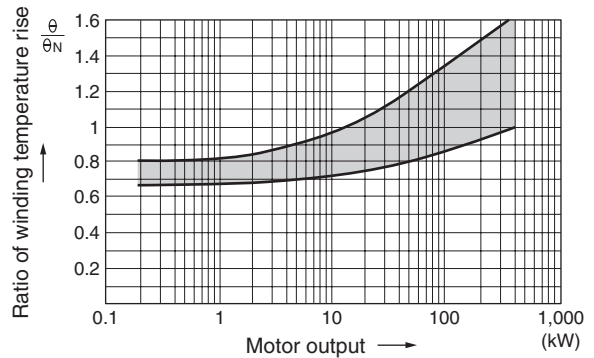
Fig. 32 shows measured values for winding temperature rises of various motor types and outputs during phase-loss and three-phase operation. During measurement the line current during phase-loss operation was made equal to the three-phase rated current. Fig. 32 shows that the ratio of temperature rise during phase-loss operation to that during three-phase operation increases with motor output.

Fig. 33 shows ratios of the winding insulator electrical durability for phase-loss operation to that for three-phase operation, assuming that the unit ratio corresponds to the electrical durability when a current that is 120% of the rated current flows during three-phase operation. Fig. 33 uses the limit operating current in the phase-loss condition as a parameter.

For motors with output of 2.2kW or lower, phase-loss protection is possible using a standard thermal overload relay (with three heater elements); for motors with output exceeding 2.2kW, phase-loss protection is possible by reducing the operating current during phase-loss operation. The IEC standard defines that the operating current must be 115% or lower of the rated limit operating current.

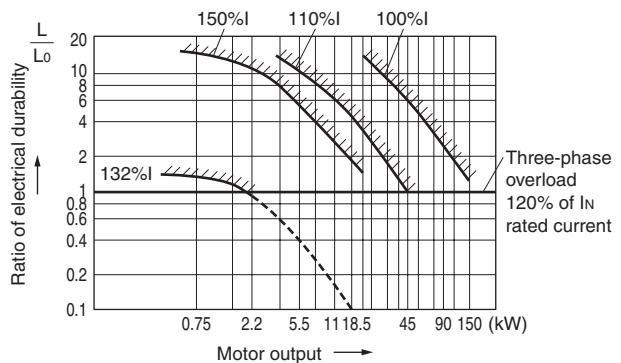
The TK series thermal overload relay (2E thermal relay) meets the requirement. If overloaded during three-phase operation, the TK series thermal overload relay operates as the standard thermal overload relay. During phase-loss operation, the differential amplifier (the ADL mechanism) of the relay operates on a current that is 115% or lower of the rated operating current, thus providing phase-loss protection.

**Fig. 32 Temperature rise during the phase-loss operation**



$\theta_N$ : Temperature rise of winding during three-phase operation  
 $\theta$ : Temperature rise of winding during phase-loss operation

**Fig. 33 Variations of the electrical durability of the windings with respect to the limit operating current in the phase-loss condition**



$L_0$ : Electrical durability of winding during three-phase overload operation  
 $L$ : Electrical durability of winding during phase-loss operation



### 4-3-6 Phase-sequence protection

The purpose of phase-sequence protection is prevention of hazards due to reverse rotation of the driven machine rather than motor protection, and whether it is necessary depends on the characteristics of the driven machine. Since the cause of improper phase-sequence is mis-wiring during installation or modification of the electrical system, phase-sequence protection may be omitted if electrical tests have been conducted carefully and strictly. However, it is recommended that a phase-sequence relay be installed to protect the motor from any possible mistake made during electrical installation. FUJI supplies the QE-20N type phase-sequence relays for use as phase-sequence protectors. By using the QE-20N type phase-sequence relay together with the 2E thermal overload relay, multi-factor protection including overload is possible.

### 4-3-7 Protective coordination with short-circuit protective devices

Starters are designed to protect motors from burnout due to overloads, locked rotor, or phase-loss, and for regular switching. They do not have the capacity to make or break a circuit when a current greater than the overload current (i.e., more than 10 times the full load current) flows due to a short-circuit. Therefore, a short-circuit protective device that has the capacity to break short-circuits, such as an MCCB or current-limiting fuse, is required to protect against excessive current caused by short-circuits. In this case, it is necessary to provide protective coordination, with a starter (thermal overload relay) protecting against overloads, locked rotor, and phase-loss, and a short-circuit protective device protecting against short-circuits. The basic principles of this kind of protective coordination are as follows:

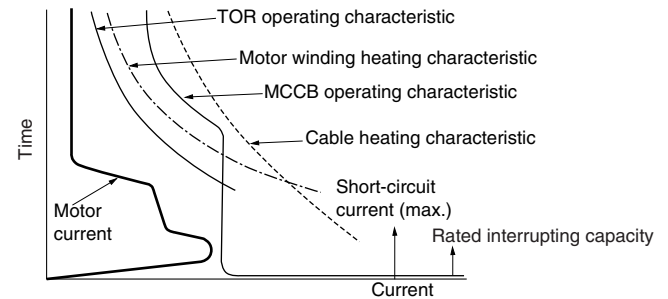
- 1) The combined protective characteristic curve for the starter and the short-circuit protective device must be under the heating characteristic curve for the motor and cables.
- 2) The protective devices must not operate at the normal running and starting currents for operation with the rated load.
- 3) The short-circuit protective device must have sufficient breaking capacity.
- 4) In the overload region, the starter must operate before the short-circuit protective device.
- 5) At currents greater than the breaking capacity of the starter, the short-circuit protective device must operate and protect the starter.

#### (1) Classification and selection of protective coordination

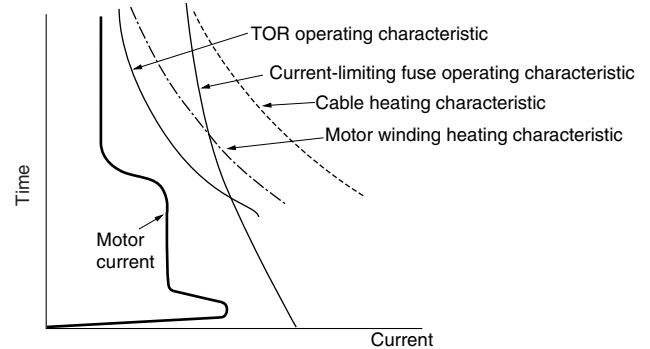
When a short-circuit current flows, although it is interrupted by the short-circuit protective device (SCPD), if the selected combination of starter and SCPD is not appropriate, burning may occur in the starter contacts or the thermal overload relay heater elements due to the electromagnetic energy of the short-circuit current.

**Fig. 34 Protective coordination characteristic curves for motor circuits**

• **When MCCB is used**



• **When current-limiting fuse is used**



#### (a) Conformance to IEC and JIS standards

The conditions for protective coordination in IEC 60947 and JIS C 8201 are divided into the following two types, and the selection of a combination of starter and short-circuit protective device that will provide protection for each is hypothesized. The prospective short-circuit current,  $r$  and rated conditional short-circuit current,  $I_q$  (which is determined by the manufacturer) are also assumed for the short-circuit current. The selection tables on pages 96 to 101 give combinations for various short-circuit currents. The type of protective coordination is classified according to the degree of burning that occurs in the starter due to short-circuits in the following way.

**Type 1:**

Burning may occur in the starter or thermal overload relay. At inspection, either partial or total replacement may be performed if necessary.

**Type 2:**

There is no burning. A mild degree of contact welding may occur. The thermal overload relay characteristics satisfy the values specified in the standards. Continuous use without replacement is possible.

#### (b) Conformance to UL and CSA standards

With UL 508 and CSA C22-2 No. 14, the prospective short-circuit current is specified, contact welding is allowed, and the degree of burning related to the current-limiting fuse and molded case circuit breaker is specified in ratings. The selection tables on pages 102 to 105 give combinations for various short-circuit currents.

# 4 Application and Selection

## 4-3 Protection of motors

### (2) Coordination with short-circuit protective devices (conformance to IEC and JIS)

#### (a) Prospective short-circuit current, $r$ (240V, 440V)

| Starter                                    |                |                                      |                          | Protective coordination        |                                     |                                |                                       |  |        |    |
|--|----------------|--------------------------------------|--------------------------|--------------------------------|-------------------------------------|--------------------------------|---------------------------------------|--|--------|----|
| Starter type                               | Contactor type | Combined thermal overload relay type | Ampere setting range (A) | Type 1                         |                                     | Type 2                         |                                       |  |        |    |
|  |                |                                      |                          | Short-circuit current $r$ (kA) | FUJI MCCB *<br>Type      Rating (A) | Short-circuit current $r$ (kA) | Fuse rating IEC 60269-1<br>gG, gM (A) | FUJI current-limiting fuse<br>Type      Rating (A) |        |    |
| SW-03/3H<br>SW-03/2E                       | SC-03          | TR-0N/3<br>TK-0N                     | 0.36–0.54                | 1                              | SA33C/3                             | 3                              | 1                                     | 2  | BLA003 | 3  |
|  |                |                                      | 0.48–0.72                | 1                              | SA33C/3                             | 3                              | 1                                     | 4  | BLA005 | 5  |
|  |                |                                      | 0.64–0.96                | 1                              | SA33C/5                             | 5                              | 1                                     | 4  | BLA005 | 5  |
|  |                |                                      | 0.8–1.2                  | 1                              | SA33C/5                             | 5                              | 1                                     | 4  | BLA005 | 5  |
|  |                |                                      | 0.95–1.45                | 1                              | SA33C/10                            | 10                             | 1                                     | 4  | BLA005 | 5  |
|  |                |                                      | 1.4–2.2                  | 1                              | SA33C/20                            | 20                             | 1                                     | 4  | BLA005 | 5  |
|  |                |                                      | 1.7–2.6                  | 1                              | SA33C/20                            | 20                             | 1                                     | 6  | BLA007 | 7  |
|  |                |                                      | 2.2–3.4                  | 1                              | SA33C/20                            | 20                             | 1                                     | 6  | BLA007 | 7  |
|  |                |                                      | 2.8–4.2                  | 1                              | SA33C/20                            | 20                             | 1                                     | 10   | BLA015 | 15 |
|  |                |                                      | 4–6                      | 1                              | SA33C/20                            | 20                             | 1                                     | 10   | BLA015 | 15 |
|  |                |                                      | 5–8                      | 1                              | SA33C/20                            | 20                             | 1                                     | 20   | BLA030 | 30 |
|  |                |                                      | 6–9                      | 1                              | SA33C/20                            | 20                             | 1                                     | 20   | BLA030 | 30 |
|  |                |                                      | 7–11                     | 1                              | SA33C/20                            | 20                             | 1                                     | 20   | BLA030 | 30 |
| SW-0/3H<br>SW-0/2E<br>SW-05/3H<br>SW-05/2E | SC-0<br>SC-05  | TR-0N/3<br>TK-0N                     | 0.36–0.54                | 1                              | SA33C/3                             | 3                              | 1                                     | 2  | BLA003 | 3  |
|  |                |                                      | 0.48–0.72                | 1                              | SA33C/3                             | 3                              | 1                                     | 4  | BLA005 | 5  |
|  |                |                                      | 0.64–0.96                | 1                              | SA33C/5                             | 5                              | 1                                     | 4  | BLA005 | 5  |
|  |                |                                      | 0.8–1.2                  | 1                              | SA33C/5                             | 5                              | 1                                     | 4  | BLA005 | 5  |
|  |                |                                      | 0.95–1.45                | 1                              | SA33C/10                            | 10                             | 1                                     | 4  | BLA005 | 5  |
|  |                |                                      | 1.4–2.2                  | 1                              | SA33C/20                            | 20                             | 1                                     | 4  | BLA005 | 5  |
|  |                |                                      | 1.7–2.6                  | 1                              | SA33C/20                            | 20                             | 1                                     | 6  | BLA007 | 7  |
|  |                |                                      | 2.2–3.4                  | 1                              | SA33C/20                            | 20                             | 1                                     | 6  | BLA007 | 7  |
|  |                |                                      | 2.8–4.2                  | 1                              | SA33C/20                            | 20                             | 1                                     | 10   | BLA015 | 15 |
|  |                |                                      | 4–6                      | 1                              | SA33C/20                            | 20                             | 1                                     | 10   | BLA015 | 15 |
|  |                |                                      | 5–8                      | 1                              | SA33C/20                            | 20                             | 1                                     | 20   | BLA030 | 30 |
|  |                |                                      | 6–9                      | 1                              | SA33C/20                            | 20                             | 1                                     | 20   | BLA030 | 30 |
|  |                |                                      | 7–11                     | 1                              | SA33C/20                            | 20                             | 1                                     | 20   | BLA030 | 30 |
| 9–13                                       | 1              | SA33C/30                             | 30                       | 1                              | 25                                  | BLA030                         | 30                                    |  |        |    |

Note: \* Combination is also possible with an SA33B/□.



| Starter                |                |                                      |  | Protective coordination      |                      |            |                              |                                    |                            |            |
|------------------------|----------------|--------------------------------------|--|------------------------------|----------------------|------------|------------------------------|------------------------------------|----------------------------|------------|
| Starter type           | Contactor type | Combined thermal overload relay type | Ampere setting range (A)                         | Type 1                       |                      |            |                              | Type 2                             |                            |            |
|                        |                |                                      |  | Short-circuit current r (kA) | FUJI MCCB *          |            | Short-circuit current r (kA) | Fuse rating IEC 60269-1 gG, gM (A) | FUJI current-limiting fuse |            |
|                        |                |                                      |  |                              | Type                 | Rating (A) |                              |                                    | Type                       | Rating (A) |
| SW-4-0/3H<br>SW-4-0/2E | SC-4-0         | TR-5-1N/3<br>TK-5-1N                 | 0.36–0.54  | 3                            | SA33C/3              | 3          | 3                            | 2                                  | BLA003                     | 3          |
|                        |                |                                      | 0.48–0.72  | 3                            | SA33C/3              | 3          | 3                            | 4                                  | BLA005                     | 5          |
|                        |                |                                      | 0.64–0.96  | 3                            | SA33C/5              | 5          | 3                            | 4                                  | BLA005                     | 5          |
|                        |                |                                      | 0.8–1.2  | 3                            | SA33C/5              | 5          | 3                            | 4                                  | BLA005                     | 5          |
|                        |                |                                      | 0.95–1.45  | 3                            | SA33C/10             | 10         | 3                            | 4                                  | BLA005                     | 5          |
|                        |                |                                      | 1.4–2.2  | 3                            | SA33C/20             | 20         | 3                            | 4                                  | BLA005                     | 5          |
|                        |                |                                      | 1.7–2.6  | 3                            | SA33C/20             | 20         | 3                            | 6                                  | BLA007                     | 7          |
|                        |                |                                      | 2.2–3.4  | 3                            | SA33C/20             | 20         | 3                            | 6                                  | BLA007                     | 7          |
|                        |                |                                      | 2.8–4.2  | 3                            | SA33C/20             | 20         | 3                            | 10                                 | BLA015                     | 15         |
|                        |                |                                      | 4–6  | 3                            | SA33C/20             | 20         | 3                            | 10                                 | BLA015                     | 15         |
|                        |                |                                      | 5–8  | 3                            | SA33C/20             | 20         | 3                            | 20                                 | BLA030                     | 30         |
|                        |                |                                      | 6–9  | 3                            | SA33C/20             | 20         | 3                            | 20                                 | BLA030                     | 30         |
|                        |                |                                      | 7–11   | 3                            | SA33C/20             | 20         | 3                            | 20                                 | BLA030                     | 30         |
|                        |                |                                      | 9–13   | 3                            | SA33C/30             | 30         | 3                            | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 12–18  | 3                            | SA53C/30             | 30         | 3                            | 32                                 | BLA040                     | 40         |
|                        |                |                                      | SW-4-1/3H<br>SW-4-1/2E<br>SW-5-1/3H<br>SW-5-1/2E | SC-4-1<br>SC-5-1             | TR-5-1N/3<br>TK-5-1N | 0.36–0.54  | 3                            | SA53C/3                            | 3                          | 3          |
| 0.48–0.72              | 3              | SA53C/3                              |  |                              |                      | 3          | 3                            | 4                                  | BLA005                     | 5          |
| 0.64–0.96              | 3              | SA53C/5                              |  |                              |                      | 5          | 3                            | 4                                  | BLA005                     | 5          |
| 0.8–1.2                | 3              | SA53C/5                              |  |                              |                      | 5          | 3                            | 4                                  | BLA005                     | 5          |
| 0.95–1.45              | 3              | SA53C/10                             |  |                              |                      | 10         | 3                            | 4                                  | BLA005                     | 5          |
| 1.4–2.2                | 3              | SA53C/20                             |  |                              |                      | 20         | 3                            | 4                                  | BLA005                     | 5          |
| 1.7–2.6                | 3              | SA53C/20                             |  |                              |                      | 20         | 3                            | 6                                  | BLA007                     | 7          |
| 2.2–3.4                | 3              | SA53C/20                             |  |                              |                      | 20         | 3                            | 6                                  | BLA007                     | 7          |
| 2.8–4.2                | 3              | SA53C/20                             |  |                              |                      | 20         | 3                            | 10                                 | BLA015                     | 15         |
| 4–6                    | 3              | SA53C/20                             |  |                              |                      | 20         | 3                            | 10                                 | BLA015                     | 15         |
| 5–8                    | 3              | SA53C/20                             |  |                              |                      | 20         | 3                            | 20                                 | BLA030                     | 30         |
| 6–9                    | 3              | SA53C/20                             |  |                              |                      | 20         | 3                            | 20                                 | BLA030                     | 30         |
| 7–11                   | 3              | SA53C/20                             |  |                              |                      | 20         | 3                            | 25                                 | BLA040                     | 40         |
| 9–13                   | 3              | SA53C/30                             |  |                              |                      | 30         | 3                            | 32                                 | BLA040                     | 40         |
| 12–18                  | 3              | SA53C/30                             |  |                              |                      | 30         | 3                            | 40                                 | BLA060                     | 60         |
| 16–22                  | 3              | SA53C/50                             |  |                              |                      | 50         | 3                            | 50                                 | BLA075                     | 75         |

Note: \* Combination is also possible with an SA33B/□ or SA53B/□.

# 4 Application and Selection

## 4-3 Protection of motors

| Starter                |                |                                      |                          | Protective coordination      |                |            |                              |                                    |                                       |                          |
|------------------------|----------------|--------------------------------------|--------------------------|------------------------------|----------------|------------|------------------------------|------------------------------------|---------------------------------------|--------------------------|
| Starter type           | Contactor type | Combined thermal overload relay type | Ampere setting range (A) | Type 1                       |                |            | Type 2                       |                                    |                                       |                          |
|                        |                |                                      |                          | Short-circuit current r (kA) | FUJI MCCB Type | Rating (A) | Short-circuit current r (kA) | Fuse rating IEC 60269-1 gG, gM (A) | FUJI current-limiting fuse Rating (A) | Ampere setting range (A) |
| SW-N1/3H<br>SW-N1/2E   | SC-N1          | TR-N2/3<br>TK-N2                     | 4-6                      | 3                            | SA63C/60       | 60         | 3                            | 25                                 | BLA040                                | 40                       |
|                        |                |                                      | 5-8                      | 3                            | SA63C/60       | 60         | 3                            | 25                                 | BLA040                                | 40                       |
|                        |                |                                      | 6-9                      | 3                            | SA63C/60       | 60         | 3                            | 25                                 | BLA040                                | 40                       |
|                        |                |                                      | 7-11                     | 3                            | SA63C/60       | 60         | 3                            | 32                                 | BLA060                                | 60                       |
|                        |                |                                      | 9-13                     | 3                            | SA63C/60       | 60         | 3                            | 32                                 | BLA060                                | 60                       |
|                        |                |                                      | 12-18                    | 3                            | SA63C/60       | 60         | 3                            | 32                                 | BLA060                                | 60                       |
|                        |                |                                      | 18-26                    | 3                            | SA63C/60       | 60         | 3                            | 50                                 | BLA075                                | 75                       |
|                        |                |                                      | 24-36                    | 3                            | SA63C/60       | 60         | 3                            | 50                                 | BLA075                                | 75                       |
| SW-N2/3H<br>SW-N2/2E   | SC-N2          | TR-N2/3<br>TK-N2                     | 4-6                      | 3                            | EA103C/75      | 75         | 3                            | 25                                 | BLA040                                | 40                       |
|                        |                |                                      | 5-8                      | 3                            | EA103C/75      | 75         | 3                            | 25                                 | BLA040                                | 40                       |
|                        |                |                                      | 6-9                      | 3                            | EA103C/75      | 75         | 3                            | 25                                 | BLA040                                | 40                       |
|                        |                |                                      | 7-11                     | 3                            | EA103C/75      | 75         | 3                            | 32                                 | BLA060                                | 60                       |
|                        |                |                                      | 9-13                     | 3                            | EA103C/75      | 75         | 3                            | 32                                 | BLA060                                | 60                       |
|                        |                |                                      | 12-18                    | 3                            | EA103C/75      | 75         | 3                            | 32                                 | BLA060                                | 60                       |
|                        |                |                                      | 18-26                    | 3                            | EA103C/75      | 75         | 3                            | 50                                 | BLA075                                | 75                       |
|                        |                |                                      | 24-36                    | 3                            | EA103C/75      | 75         | 3                            | 50                                 | BLA075                                | 75                       |
| SW-N2S/3H<br>SW-N2S/2E | SC-N2S         | TR-N3/3<br>TK-N3                     | 7-11                     | 3                            | EA103C/100     | 100        | 3                            | 32                                 | BLA060                                | 60                       |
|                        |                |                                      | 9-13                     | 3                            | EA103C/100     | 100        | 3                            | 32                                 | BLA060                                | 60                       |
|                        |                |                                      | 12-18                    | 3                            | EA103C/100     | 100        | 3                            | 32                                 | BLA060                                | 60                       |
|                        |                |                                      | 18-26                    | 3                            | EA103C/100     | 100        | 3                            | 50                                 | BLA075                                | 75                       |
|                        |                |                                      | 24-36                    | 3                            | EA103C/100     | 100        | 3                            | 50                                 | BLA075                                | 75                       |
|                        |                |                                      | 28-40                    | 3                            | EA103C/100     | 100        | 3                            | 50                                 | BLA075                                | 75                       |
| SW-N3/3H<br>SW-N3/2E   | SC-N3          | TR-N3/3<br>TK-N3                     | 7-11                     | 5                            | EA203B/125     | 125        | 5                            | 32                                 | BLA060                                | 60                       |
|                        |                |                                      | 9-13                     | 5                            | EA203B/125     | 125        | 5                            | 32                                 | BLA060                                | 60                       |
|                        |                |                                      | 12-18                    | 5                            | EA203B/125     | 125        | 5                            | 32                                 | BLA060                                | 60                       |
|                        |                |                                      | 18-26                    | 5                            | EA203B/125     | 125        | 5                            | 50                                 | BLA075                                | 75                       |
|                        |                |                                      | 24-36                    | 5                            | EA203B/125     | 125        | 5                            | 50                                 | BLA075                                | 75                       |
|                        |                |                                      | 28-40                    | 5                            | EA203B/125     | 125        | 5                            | 50                                 | BLA075                                | 75                       |
|                        |                |                                      | 34-50                    | 5                            | EA203B/125     | 125        | 5                            | 50                                 | BLA075                                | 75                       |
|                        |                |                                      | 45-65                    | 5                            | EA203B/125     | 125        | 5                            | 80                                 | BLA100                                | 100                      |
| SW-N4/3H<br>SW-N4/2E   | SC-N4          | TR-N5/3<br>TK-N5                     | 18-26                    | 5                            | EA203B/150     | 150        | 5                            | 50                                 | BLA075                                | 75                       |
|                        |                |                                      | 24-36                    | 5                            | EA203B/150     | 150        | 5                            | 50                                 | BLA075                                | 75                       |
|                        |                |                                      | 28-40                    | 5                            | EA203B/150     | 150        | 5                            | 50                                 | BLA075                                | 75                       |
|                        |                |                                      | 34-50                    | 5                            | EA203B/160     | 160        | 5                            | 50                                 | BLA075                                | 75                       |
|                        |                |                                      | 45-65                    | 5                            | EA203B/150     | 150        | 5                            | 80                                 | BLA100                                | 100                      |
|                        |                |                                      | 53-80                    | 5                            | EA203B/150     | 150        | 5                            | 100                                | BLA125                                | 125                      |

| Starter                |                |                                      |                          | Protective coordination      |                |            |                              |                                    |                            |            |
|------------------------|----------------|--------------------------------------|--------------------------|------------------------------|----------------|------------|------------------------------|------------------------------------|----------------------------|------------|
| Starter type           | Contactor type | Combined thermal overload relay type | Ampere setting range (A) | Type 1                       |                |            | Type 2                       |                                    |                            |            |
|                        |                |                                      |                          | Short-circuit current r (kA) | FUJI MCCB Type | Rating (A) | Short-circuit current r (kA) | Fuse rating IEC 60269-1 gG, gM (A) | FUJI current-limiting Type | Rating (A) |
| SW-N5/3H<br>SW-N5/2E   | SC-N5          | TR-N5/3<br>TK-N5                     | 18–26                    | 5                            | EA203B/175     | 175        | 5                            | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 24–36                    | 5                            | EA203B/175     | 175        | 5                            | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 28–40                    | 5                            | EA203B/175     | 175        | 5                            | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 34–50                    | 5                            | EA203B/175     | 175        | 5                            | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 45–65                    | 5                            | EA203B/175     | 175        | 5                            | 80                                 | BLA100                     | 100        |
|                        |                |                                      | 53–80                    | 5                            | EA203B/175     | 175        | 5                            | 100                                | BLA125                     | 125        |
|                        |                |                                      | 65–95                    | 5                            | EA203B/175     | 175        | 5                            | 100                                | BLA125                     | 125        |
|                        |                |                                      | 85–105                   | 5                            | EA203B/175     | 175        | 5                            | 125                                | BLA150                     | 150        |
| SW-N6/3H<br>SW-N6/2E   | SC-N6          | TR-N6/3<br>TK-N6                     | 45–65                    | 10                           | EA203B/225     | 225        | 10                           | 160                                | BLA200                     | 200        |
|                        |                |                                      | 53–80                    | 10                           | EA203B/225     | 225        | 10                           | 160                                | BLA200                     | 200        |
|                        |                |                                      | 65–95                    | 10                           | EA203B/225     | 225        | 10                           | 160                                | BLA200                     | 200        |
|                        |                |                                      | 85–125                   | 10                           | EA203B/225     | 225        | 10                           | 160                                | BLA200                     | 200        |
| SW-N7/3H<br>SW-N7/2E   | SC-N7          | TR-N7/3<br>TK-N7                     | 45–65                    | 10                           | SA403B/350     | 350        | 10                           | 160                                | BLA200                     | 200        |
|                        |                |                                      | 53–80                    | 10                           | SA403B/350     | 350        | 10                           | 160                                | BLA200                     | 200        |
|                        |                |                                      | 65–95                    | 10                           | SA403B/350     | 350        | 10                           | 160                                | BLA200                     | 200        |
|                        |                |                                      | 85–125                   | 10                           | SA403B/350     | 350        | 10                           | 160                                | BLA200                     | 200        |
|                        |                |                                      | 110–160                  | 10                           | SA403B/350     | 350        | 10                           | 160                                | BLA200                     | 200        |
| SW-N8/3H<br>SW-N8/2E   | SC-N8          | TR-N8/3<br>TK-N8                     | 65–95                    | 10                           | SA403B/350     | 350        | 10                           | 200                                | FCK2-250                   | 250        |
|                        |                |                                      | 85–125                   | 10                           | SA403B/350     | 350        | 10                           | 200                                | FCK2-250                   | 250        |
|                        |                |                                      | 110–160                  | 10                           | SA403B/350     | 350        | 10                           | 200                                | FCK2-250                   | 250        |
|                        |                |                                      | 125–185                  | 10                           | SA403B/350     | 350        | 10                           | 200                                | FCK2-250                   | 250        |
| SW-N10/3H<br>SW-N10/2E | SC-N10         | TR-N10/3<br>TK-N10                   | 85–125                   | 10                           | EA403B/400     | 400        | 10                           | 200                                | FCK2-250                   | 250        |
|                        |                |                                      | 110–160                  | 10                           | EA403B/400     | 400        | 10                           | 200                                | FCK2-250                   | 250        |
|                        |                |                                      | 125–185                  | 10                           | EA403B/400     | 400        | 10                           | 250                                | FCK2-300                   | 300        |
|                        |                |                                      | 160–240                  | 10                           | EA403B/400     | 400        | 10                           | 250                                | FCK2-300                   | 300        |
| SW-N11/3H<br>SW-N11/2E | SC-N11         | TR-N12/3<br>TK-N12                   | 110–160                  | 10                           | SA403B/400     | 400        | 10                           | 315                                | –                          | –          |
|                        |                |                                      | 125–185                  | 10                           | SA403B/400     | 400        | 10                           | 315                                | –                          | –          |
|                        |                |                                      | 160–240                  | 10                           | SA403B/400     | 400        | 10                           | 315                                | –                          | –          |
|                        |                |                                      | 200–300                  | 10                           | SA403B/400     | 400        | 10                           | 315                                | –                          | –          |
| SW-N12/3H<br>SW-N12/2E | SC-N12         | TR-N12/3<br>TK-N12                   | 110–160                  | 18                           | SA603R *       | 600        | 18                           | 450                                | –                          | –          |
|                        |                |                                      | 125–185                  | 18                           | SA603R *       | 600        | 18                           | 450                                | –                          | –          |
|                        |                |                                      | 160–240                  | 18                           | SA603R *       | 600        | 18                           | 450                                | –                          | –          |
|                        |                |                                      | 200–300                  | 18                           | SA603R *       | 600        | 18                           | 450                                | –                          | –          |
|                        |                |                                      | 240–360                  | 18                           | SA603R *       | 600        | 18                           | 450                                | –                          | –          |
|                        |                |                                      | 300–450                  | 18                           | SA603R *       | 600        | 18                           | 450                                | –                          | –          |
| SW-N14/3H<br>SW-N14/2E | SC-N14         | TR-N14/3<br>TK-N14                   | 240–360                  | 18                           | SA803R/800     | 800        | –                            | –                                  | –                          | –          |
|                        |                |                                      | 300–450                  | 18                           | SA803R/800     | 800        | –                            | –                                  | –                          | –          |
|                        |                |                                      | 400–600                  | 18                           | SA803R/800     | 800        | –                            | –                                  | –                          | –          |
| –                      | SC-N16         | –                                    | –                        | 30                           | S1203/1200     | 1,200      | –                            | –                                  | –                          | –          |

Note: \* Not based on IEC 60947 Type 1.

# 4 Application and Selection

## 4-3 Protection of motors

### (b) Rated conditional short-circuit current, I<sub>q</sub> (240V, 440V)

| Starter                |                |                                      |                          | Protective coordination                   |                |            |   |                                    |                            |            |
|------------------------|----------------|--------------------------------------|--------------------------|---|----------------|------------|---|------------------------------------|----------------------------|------------|
| Starter type           | Contactor type | Combined thermal overload relay type | Ampere setting range (A) | Type 1                                    |                |            | Type 2                                    |                                    |                            |            |
|                        |                |                                      |                          | Short-circuit current I <sub>q</sub> (kA) | FUJI MCCB Type | Rating (A) | Short-circuit current I <sub>q</sub> (kA) | Fuse rating IEC 60269-1 gG, gM (A) | FUJI current-limiting Type | Rating (A) |
| SW-N1/3H<br>SW-N1/2E   | SC-N1          | TR-N2/3<br>TK-N2                     | 4-6                      | 18  | SA103RA/50     | 50         | 50  | 20                                 | BLA030                     | 30         |
|                        |                |                                      | 5-8                      | 18  | SA103RA/50     | 50         | 50  | 20                                 | BLA030                     | 30         |
|                        |                |                                      | 6-9                      | 18  | SA103RA/50     | 50         | 50  | 20                                 | BLA030                     | 30         |
|                        |                |                                      | 7-11                     | 18  | SA103RA/50     | 50         | 50  | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 9-13                     | 18  | SA103RA/50     | 50         | 50  | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 12-18                    | 18  | SA103RA/50     | 50         | 50  | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 18-26                    | 18  | SA103RA/60     | 60         | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 24-36                    | 18  | SA103RA/60     | 60         | 50  | 50                                 | BLA075                     | 75         |
| SW-N2/3H<br>SW-N2/2E   | SC-N2          | TR-N2/3<br>TK-N2                     | 4-6                      | 18  | SA103RA/50     | 50         | 50  | 20                                 | BLA030                     | 30         |
|                        |                |                                      | 5-8                      | 18  | SA103RA/50     | 50         | 50  | 20                                 | BLA030                     | 30         |
|                        |                |                                      | 6-9                      | 18  | SA103RA/50     | 50         | 50  | 20                                 | BLA030                     | 30         |
|                        |                |                                      | 7-11                     | 18  | SA103RA/50     | 50         | 50  | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 9-13                     | 18  | SA103RA/50     | 50         | 50  | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 12-18                    | 18  | SA103RA/50     | 50         | 50  | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 18-26                    | 18  | SA103RA/60     | 60         | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 24-36                    | 18  | SA103RA/60     | 60         | 50  | 50                                 | BLA075                     | 75         |
| SW-N2S/3H<br>SW-N2S/2E | SC-N2S         | TR-N3/3<br>TK-N3                     | 7-11                     | 18  | SA103RA/100    | 100        | 50  | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 9-13                     | 18  | SA103RA/100    | 100        | 50  | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 12-18                    | 18  | SA103RA/100    | 100        | 50  | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 18-26                    | 18  | SA103RA/100    | 100        | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 24-36                    | 18  | SA103RA/100    | 100        | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 28-40                    | 18  | SA103RA/100    | 100        | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 34-50                    | 18  | SA103RA/100    | 100        | 50  | 50                                 | BLA075                     | 75         |
| SW-N3/3H<br>SW-N3/2E   | SC-N3          | TR-N3/3<br>TK-N3                     | 7-11                     | 18  | SA103RA/100    | 100        | 50  | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 9-13                     | 18  | SA103RA/100    | 100        | 50  | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 12-18                    | 18  | SA103RA/100    | 100        | 50  | 25                                 | BLA040                     | 40         |
|                        |                |                                      | 18-26                    | 18  | SA103RA/100    | 100        | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 24-36                    | 18  | SA103RA/100    | 100        | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 28-40                    | 18  | SA103RA/100    | 100        | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 34-50                    | 18  | SA103RA/100    | 100        | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 45-65                    | 18  | SA103RA/100    | 100        | 50  | 80                                 | BLA100                     | 100        |
| SW-N4/3H<br>SW-N4/2E   | SC-N4          | TR-N5/3<br>TK-N5                     | 18-26                    | 18  | SA103RA/100    | 100        | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 24-36                    | 18  | SA103RA/100    | 100        | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 28-40                    | 18  | SA103RA/100    | 100        | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 34-50                    | 18  | SA103RA/100    | 100        | 50  | 50                                 | BLA075                     | 75         |
|                        |                |                                      | 45-65                    | 18  | SA103RA/100    | 100        | 50  | 80                                 | BLA100                     | 100        |
|                        |                |                                      | 53-80                    | 18  | SA103RA/100    | 100        | 50  | 100                                | BLA125                     | 125        |

| Starter                |                |                                      |                          | Protective coordination                   |                       |   |                                    |                                   |     |
|------------------------|----------------|--------------------------------------|--------------------------|---|-----------------------|---|------------------------------------|-----------------------------------|-----|
| Starter type           | Contactor type | Combined thermal overload relay type | Ampere setting range (A) | Type 1                                    |                       | Type 2                                    |                                    |                                   |     |
|                        |                |                                      |                          | Short-circuit current I <sub>q</sub> (kA) | FUJI MCCB Type Rating | Short-circuit current I <sub>q</sub> (kA) | Fuse rating IEC 60269-1 gG, gM (A) | FUJI current-limiting Type Rating |     |
| SW-N5/3H<br>SW-N5/2E   | SC-N5          | TR-N5/3<br>TK-N5                     | 18–26                    | 18  | H203B/150 150         | 50  | 50                                 | BLA075                            | 75  |
|                        |                |                                      | 24–36                    | 18  | H203B/150 150         | 50  | 50                                 | BLA075                            | 75  |
|                        |                |                                      | 28–40                    | 18  | H203B/150 150         | 50  | 50                                 | BLA075                            | 75  |
|                        |                |                                      | 34–50                    | 18  | H203B/150 150         | 50  | 50                                 | BLA075                            | 75  |
|                        |                |                                      | 45–65                    | 18  | H203B/150 150         | 50  | 80                                 | BLA100                            | 100 |
|                        |                |                                      | 53–80                    | 18  | H203B/150 150         | 50  | 100                                | BLA125                            | 125 |
|                        |                |                                      | 65–95                    | 18  | H203B/150 150         | 50  | 100                                | BLA125                            | 125 |
|                        |                |                                      | 85–105                   | 18  | H203B/150 150         | 50  | 125                                | BLA150                            | 150 |
| SW-N6/3H<br>SW-N6/2E   | SC-N6          | TR-N6/3<br>TK-N6                     | 45–65                    | 25  | H203B/225 225         | 50  | 100                                | BLA125                            | 125 |
|                        |                |                                      | 53–80                    | 25  | H203B/225 225         | 50  | 100                                | BLA125                            | 125 |
|                        |                |                                      | 65–95                    | 25  | H203B/225 225         | 50  | 100                                | BLA125                            | 125 |
|                        |                |                                      | 85–125                   | 25  | H203B/225 225         | 50  | 125                                | BLA150                            | 150 |
| SW-N7/3H<br>SW-N7/2E   | SC-N7          | TR-N7/3<br>TK-N7                     | 45–65                    | 25  | H203B/225 225         | 50  | 100                                | BLA125                            | 125 |
|                        |                |                                      | 53–80                    | 25  | H203B/225 225         | 50  | 100                                | BLA125                            | 125 |
|                        |                |                                      | 65–95                    | 25  | H203B/225 225         | 50  | 100                                | BLA125                            | 125 |
|                        |                |                                      | 85–125                   | 25  | H203B/225 225         | 50  | 125                                | BLA150                            | 150 |
|                        |                |                                      | 110–160                  | 25  | H203B/225 225         | 50  | 160                                | BLA200                            | 200 |
| SW-N8/3H<br>SW-N8/2E   | SC-N8          | TR-N8/3<br>TK-N8                     | 65–95                    | 35  | H203B/225 225         | 50  | 200                                | –                                 | –   |
|                        |                |                                      | 85–125                   | 35  | H203B/225 225         | 50  | 200                                | –                                 | –   |
|                        |                |                                      | 110–160                  | 35  | H203B/225 225         | 50  | 200                                | –                                 | –   |
|                        |                |                                      | 125–185                  | 35  | H203B/225 225         | 50  | 200                                | –                                 | –   |
| SW-N10/3H<br>SW-N10/2E | SC-N10         | TR-N10/3<br>TK-N10                   | 85–125                   | 35  | SA403R/300 300        | 50  | 200                                | –                                 | –   |
|                        |                |                                      | 110–160                  | 35  | SA403R/300 300        | 50  | 200                                | –                                 | –   |
|                        |                |                                      | 125–185                  | 35  | SA403R/300 300        | 50  | 250                                | –                                 | –   |
|                        |                |                                      | 160–240                  | 35  | SA403R/300 300        | 50  | 250                                | –                                 | –   |
| SW-N11/3H<br>SW-N11/2E | SC-N11         | TR-N12/3<br>TK-N12                   | 110–160                  | 35  | SA403R/400 400        | 50  | 315                                | –                                 | –   |
|                        |                |                                      | 125–185                  | 35  | SA403R/400 400        | 50  | 315                                | –                                 | –   |
|                        |                |                                      | 160–240                  | 35  | SA403R/400 400        | 50  | 315                                | –                                 | –   |
|                        |                |                                      | 200–300                  | 35  | SA403R/400 400        | 50  | 315                                | –                                 | –   |
| SW-N12/3H<br>SW-N12/2E | SC-N12         | TR-N12/3<br>TK-N12                   | 110–160                  | 35  | SA603R * 600          | 50  | 450                                | –                                 | –   |
|                        |                |                                      | 125–185                  | 35  | SA603R * 600          | 50  | 450                                | –                                 | –   |
|                        |                |                                      | 160–240                  | 35  | SA603R * 600          | 50  | 450                                | –                                 | –   |
|                        |                |                                      | 200–300                  | 35  | SA603R * 600          | 50  | 450                                | –                                 | –   |
|                        |                |                                      | 240–360                  | 35  | SA603R * 600          | 50  | 450                                | –                                 | –   |
|                        |                |                                      | 300–450                  | 35  | SA603R * 600          | 50  | 450                                | –                                 | –   |
| SW-N14/3H<br>SW-N14/2E | SC-N14         | TR-N14/3<br>TK-N14                   | 240–360                  | 50  | SA803R/800 800        | –   | –                                  | –                                 | –   |
|                        |                |                                      | 300–450                  | 50  | SA803R/800 800        | –   | –                                  | –                                 | –   |
|                        |                |                                      | 400–600                  | 50  | SA803R/800 800        | –   | –                                  | –                                 | –   |
| –                      | SC-N16         | –                                    | –                        | 50  | SA803R/800 800        | –   | –                                  | –                                 | –   |

Note: \* Not based on IEC 60947 Type 1.

# 4 Application and Selection

## 4-3 Protection of motors

### (3) Coordination with short-circuit protective devices (conformance to UL and CSA)

| Starter                                    |                 |                                      |                          | Protective coordination    |   |   |
|--|-----------------|--------------------------------------|--------------------------|----------------------------|---|---|
| Starter type                               | Contacting type | Combined thermal overload relay type | Ampere setting range (A) | Short-circuit current (kA) | Rated current for 600V AC current-limiting fuse | Rated current for 600V AC molded case circuit breaker |
| SW-03/3H<br>SW-03/2E                       | SC-03           | TR-0N/3<br>TK-0N                     | 0.1 to 0.15              | 5                          | 1   | 15  |
|  |                 |                                      | 0.15 to 0.24             | 5                          | 1   | 15  |
|  |                 |                                      | 0.24 to 0.36             | 5                          | 2   | 15  |
|  |                 |                                      | 0.36 to 0.54             | 5                          | 3   | 15  |
|  |                 |                                      | 0.48 to 0.72             | 5                          | 3   | 15  |
|  |                 |                                      | 0.64 to 0.96             | 5                          | 3   | 15  |
|  |                 |                                      | 0.8 to 1.2               | 5                          | 5   | 15  |
|  |                 |                                      | 0.95 to 1.45             | 5                          | 5   | 15  |
|  |                 |                                      | 1.4 to 2.2               | 5                          | 10  | 15  |
|  |                 |                                      | 1.7 to 2.6               | 5                          | 10  | 15  |
|  |                 |                                      | 2.2 to 3.4               | 5                          | 15  | 15  |
|  |                 |                                      | 2.8 to 4.2               | 5                          | 15  | 15  |
|  |                 |                                      | 4 to 6                   | 5                          | 15  | 15  |
|  |                 |                                      | 5 to 8                   | 5                          | 20  | 15  |
| SW-0/3H<br>SW-0/2E<br>SW-05/3H<br>SW-05/2E | SC-0<br>SC-05   | TR-0N/3<br>TK-0N                     | 0.1 to 0.15              | 5                          | 1   | 15  |
|  |                 |                                      | 0.15 to 0.24             | 5                          | 1   | 15  |
|  |                 |                                      | 0.24 to 0.36             | 5                          | 2   | 15  |
|  |                 |                                      | 0.36 to 0.54             | 5                          | 3   | 15  |
|  |                 |                                      | 0.48 to 0.72             | 5                          | 3   | 15  |
|  |                 |                                      | 0.64 to 0.96             | 5                          | 3   | 15  |
|  |                 |                                      | 0.8 to 1.2               | 5                          | 5   | 15  |
|  |                 |                                      | 0.95 to 1.45             | 5                          | 5   | 15  |
|  |                 |                                      | 1.4 to 2.2               | 5                          | 10  | 15  |
|  |                 |                                      | 1.7 to 2.6               | 5                          | 10  | 15  |
|  |                 |                                      | 2.2 to 3.4               | 5                          | 15  | 15  |
|  |                 |                                      | 2.8 to 4.2               | 5                          | 15  | 15  |
|  |                 |                                      | 4 to 6                   | 5                          | 15  | 15  |
|  |                 |                                      | 5 to 8                   | 5                          | 20  | 15  |
| 6 to 9                                     | 5               | 30                                   | 15                       |                            |   |   |
| 7 to 11                                    | 5               | 30                                   | 15                       |                            |   |   |
| SW-4-0/3H<br>SW-4-0/2E                     | SC-4-0          | TR-5-1N/3<br>TK-5-1N                 | 0.1 to 0.15              | 5                          | 1   | 15  |
|  |                 |                                      | 0.15 to 0.24             | 5                          | 1   | 15  |
|  |                 |                                      | 0.24 to 0.36             | 5                          | 2   | 15  |
|  |                 |                                      | 0.36 to 0.54             | 5                          | 3   | 15  |
|  |                 |                                      | 0.48 to 0.72             | 5                          | 3   | 15  |
|  |                 |                                      | 0.64 to 0.96             | 5                          | 3   | 15  |
|  |                 |                                      | 0.8 to 1.2               | 5                          | 5   | 15  |
|  |                 |                                      | 0.95 to 1.45             | 5                          | 5   | 15  |
|  |                 |                                      | 1.4 to 2.2               | 5                          | 10  | 15  |
|  |                 |                                      | 1.7 to 2.6               | 5                          | 10  | 15  |
|  |                 |                                      | 2.2 to 3.4               | 5                          | 15  | 15  |
|  |                 |                                      | 2.8 to 4.2               | 5                          | 15  | 15  |
|  |                 |                                      | 4 to 6                   | 5                          | 15  | 15  |
|  |                 |                                      | 5 to 8                   | 5                          | 20  | 15  |
| 6 to 9                                     | 5               | 30                                   | 15                       |                            |   |   |
| 7 to 11                                    | 5               | 30                                   | 15                       |                            |   |   |
| 9 to 13                                    | 5               | 30                                   | 20                       |                            |   |   |
| 12 to 18                                   | 5               | 50                                   | 40                       |                            |   |   |

Note: Use a current-limiting fuse or molded case circuit breaker that is listed by UL, CSA.  
Select a breaker that is suitable for the rated operating voltage and the application.

| Starter  |                  |                                      |                          | Protective coordination    |   |   |
|--|------------------|--------------------------------------|--------------------------|----------------------------|---|---|
| Starter type                                     | Contactor type   | Combined thermal overload relay type | Ampere setting range (A) | Short-circuit current (kA) | Rated current for 600V AC current-limiting fuse | Rated current for 600V AC molded case circuit breaker |
| SW-4-1/3H<br>SW-4-1/2E<br>SW-5-1/3H<br>SW-5-1/2E | SC-4-1<br>SC-5-1 | TR-5-1N/3<br>TK-5-1N                 | 0.1 to 0.15              | 5                          | 1   | 15  |
|  |                  |                                      | 0.15 to 0.24             | 5                          | 1   | 15  |
|  |                  |                                      | 0.24 to 0.36             | 5                          | 2   | 15  |
|  |                  |                                      | 0.36 to 0.54             | 5                          | 3   | 15  |
|  |                  |                                      | 0.48 to 0.72             | 5                          | 3   | 15  |
|  |                  |                                      | 0.64 to 0.96             | 5                          | 3   | 15  |
|  |                  |                                      | 0.8 to 1.2               | 5                          | 5   | 15  |
|  |                  |                                      | 0.95 to 1.45             | 5                          | 5   | 15  |
|  |                  |                                      | 1.4 to 2.2               | 5                          | 10  | 15  |
|  |                  |                                      | 1.7 to 2.6               | 5                          | 10  | 15  |
|  |                  |                                      | 2.2 to 3.4               | 5                          | 15  | 15  |
|  |                  |                                      | 2.8 to 4.2               | 5                          | 15  | 15  |
|  |                  |                                      | 4 to 6                   | 5                          | 15  | 15  |
|  |                  |                                      | 5 to 8                   | 5                          | 20  | 15  |
|  |                  |                                      | 6 to 9                   | 5                          | 30  | 15  |
|  |                  |                                      | 7 to 11                  | 5                          | 30  | 15  |
| 9 to 13  | 5                | 30                                   | 20                       |                            |   |   |
| 12 to 18   | 5                | 50                                   | 40                       |                            |   |   |
| SW-N1/3H<br>SW-N1/2E                             | SC-N1            | TR-N2/3<br>TK-N2                     | 4 to 6                   | 5                          | 20  | 60  |
|  |                  |                                      | 5 to 8                   | 5                          | 20  | 60  |
|  |                  |                                      | 6 to 9                   | 5                          | 20  | 60  |
|  |                  |                                      | 7 to 11                  | 5                          | 20  | 60  |
|  |                  |                                      | 9 to 13                  | 5                          | 20  | 60  |
|  |                  |                                      | 12 to 18                 | 5                          | 50  | 60  |
|  |                  |                                      | 18 to 26                 | 5                          | 50  | 60  |
|  |                  |                                      | 24 to 36                 | 5                          | 50  | 60  |
| SW-N2/3H<br>SW-N2/2E                             | SC-N2            | TR-N2/3<br>TK-N2                     | 4 to 6                   | 5                          | 20  | 60  |
|  |                  |                                      | 5 to 8                   | 5                          | 20  | 60  |
|  |                  |                                      | 6 to 9                   | 5                          | 20  | 60  |
|  |                  |                                      | 7 to 11                  | 5                          | 20  | 60  |
|  |                  |                                      | 9 to 13                  | 5                          | 20  | 60  |
|  |                  |                                      | 12 to 18                 | 5                          | 50  | 60  |
|  |                  |                                      | 18 to 26                 | 5                          | 50  | 60  |
|  |                  |                                      | 24 to 36                 | 5                          | 50  | 60  |
| 32 to 42   | 5                | 70                                   | 70                       |                            |   |   |

# 4 Application and Selection

## 4-3 Protection of motors

| Starter                |              |                                      |                          | Protective coordination    |   |   |
|------------------------|--------------|--------------------------------------|--------------------------|----------------------------|---|---|
| Starter type           | Contact type | Combined thermal overload relay type | Ampere setting range (A) | Short-circuit current (kA) | Rated current for 600V AC current-limiting fuse | Rated current for 600V AC molded case circuit breaker |
| SW-N2S/3H<br>SW-N2S/2E | SC-N2S       | TR-N3/3<br>TK-N3                     | 7 to 11                  | 5                          | 20  | 60  |
|                        |              |                                      | 9 to 13                  | 5                          | 20  | 60  |
|                        |              |                                      | 12 to 18                 | 5                          | 50  | 60  |
|                        |              |                                      | 18 to 26                 | 5                          | 50  | 60  |
|                        |              |                                      | 24 to 36                 | 5                          | 50  | 60  |
|                        |              |                                      | 28 to 40                 | 5                          | 70  | 70  |
|                        |              |                                      | 34 to 50                 | 5                          | 70  | 70  |
|                        |              |                                      | 45 to 65                 | 5                          | 125   | 125   |
| SW-N3/3H<br>SW-N3/2E   | SC-N3        | TR-N3/3<br>TK-N3                     | 7 to 11                  | 5                          | 20  | 60  |
|                        |              |                                      | 9 to 13                  | 5                          | 20  | 60  |
|                        |              |                                      | 12 to 18                 | 5                          | 50  | 60  |
|                        |              |                                      | 18 to 26                 | 5                          | 50  | 60  |
|                        |              |                                      | 24 to 36                 | 5                          | 50  | 60  |
|                        |              |                                      | 28 to 40                 | 5                          | 70  | 70  |
|                        |              |                                      | 34 to 50                 | 5                          | 70  | 70  |
|                        |              |                                      | 45 to 65                 | 5                          | 125   | 125   |
| SW-N4/3H<br>SW-N4/2E   | SC-N4        | TR-N5/3<br>TK-N5                     | 18 to 26                 | 5                          | 50  | 60  |
|                        |              |                                      | 24 to 36                 | 5                          | 50  | 60  |
|                        |              |                                      | 28 to 40                 | 5                          | 70  | 70  |
|                        |              |                                      | 34 to 50                 | 5                          | 70  | 70  |
|                        |              |                                      | 45 to 65                 | 5                          | 125   | 125   |
|                        |              |                                      | 53 to 80                 | 10                         | 150   | 125   |
| SW-N5/3H<br>SW-N5/2E   | SC-N5        | TR-N5/3<br>TK-N5N                    | 18 to 26                 | 5                          | 50  | 60  |
|                        |              |                                      | 24 to 36                 | 5                          | 50  | 60  |
|                        |              |                                      | 28 to 40                 | 5                          | 70  | 70  |
|                        |              |                                      | 34 to 50                 | 5                          | 70  | 70  |
|                        |              |                                      | 45 to 65                 | 5                          | 125   | 125   |
|                        |              |                                      | 53 to 80                 | 10                         | 150   | 125   |
|                        |              |                                      | 65 to 95                 | 10                         | 150   | 125   |
|                        |              |                                      | 85 to 105                | 10                         | 150   | 125   |
| SW-N6/3H<br>SW-N6/2E   | SC-N6        | TR-N6/3<br>TK-N6                     | 45 to 65                 | 10                         | 150   | 175   |
|                        |              |                                      | 53 to 80                 | 10                         | 150   | 175   |
|                        |              |                                      | 65 to 95                 | 10                         | 150   | 175   |
|                        |              |                                      | 85 to 125                | 10                         | 150   | 175   |
| SW-N7/3H<br>SW-N7/2E   | SC-N7        | TR-N7/3<br>TK-N7                     | 45 to 65                 | 10                         | 150   | 175   |
|                        |              |                                      | 53 to 80                 | 10                         | 150   | 175   |
|                        |              |                                      | 65 to 95                 | 10                         | 150   | 175   |
|                        |              |                                      | 85 to 125                | 10                         | 150   | 175   |
|                        |              |                                      | 110 to 160               | 10                         | 200   | 225   |

Note: Use a current-limiting fuse or molded case circuit breaker that is listed by UL, CSA.  
Select a breaker that is suitable for the rated operating voltage and the application.



| Starter                |                |                                      |                          | Protective coordination    |   |   |
|------------------------|----------------|--------------------------------------|--------------------------|----------------------------|---|---|
| Starter type           | Contactor type | Combined thermal overload relay type | Ampere setting range (A) | Short-circuit current (kA) | Rated current for 600V AC current-limiting fuse | Rated current for 600V AC molded case circuit breaker |
| SW-N8/3H<br>SW-N8/2E   | SC-N8          | TR-N8/3<br>TK-N8                     | 65 to 95                 | 10                         | 225   | 400   |
|                        |                |                                      | 85 to 125                | 10                         | 225   | 400   |
|                        |                |                                      | 110 to 160               | 10                         | 225   | 400   |
|                        |                |                                      | 125 to 185               | 10                         | 225   | 400   |
| SW-N10/3H<br>SW-N10/2E | SC-N10         | TR-N10/3<br>TK-N10                   | 85 to 125                | 10                         | 300   | 400   |
|                        |                |                                      | 110 to 160               | 10                         | 300   | 400   |
|                        |                |                                      | 125 to 185               | 10                         | 300   | 400   |
|                        |                |                                      | 160 to 240               | 10                         | 300   | 400   |
| SW-N11/3H<br>SW-N11/2E | SC-N11         | TR-N11/3<br>TK-N11                   | 110 to 160               | 18                         | 300   | 400   |
|                        |                |                                      | 125 to 185               | 18                         | 300   | 400   |
|                        |                |                                      | 160 to 240               | 18                         | 300   | 400   |
|                        |                |                                      | 200 to 300               | 18                         | 300   | 400   |
| SW-N12/3H<br>SW-N12/2E | SC-N12         | TR-N12/3<br>TK-N12                   | 110 to 160               | 18                         | 300   | 400   |
|                        |                |                                      | 125 to 185               | 18                         | 300   | 400   |
|                        |                |                                      | 160 to 240               | 18                         | 300   | 400   |
|                        |                |                                      | 200 to 300               | 18                         | 450   | 600   |
|                        |                |                                      | 240 to 360               | 18                         | 450   | 600   |
|                        |                |                                      | 300 to 450               | 18                         | 450   | 600   |
| SW-N14/3H<br>SW-N14/2E | SC-N14         | TR-N14/3<br>TK-N14                   | 240 to 360               | 30                         | 800   | 800   |
|                        |                |                                      | 300 to 450               | 30                         | 800   | 800   |
|                        |                |                                      | 400 to 600               | 30                         | 800   | 800   |
| –                      | SC-N16         | –                                    | –                        | 42                         | 1,000   | 800   |

## **Safety Considerations**

- For safe operation, before using the product read the instruction manual or user manual that comes with the product carefully or consult the Fuji sales representative from which you purchased the product.
- Products introduced in this catalog have not been designed or manufactured for such applications in a system or equipment that will affect human bodies or lives.
- Customers, who want to use the products introduced in this catalog for special systems or devices such as for atomic-energy control, aerospace use, medical use, passenger vehicle, and traffic control, are requested to consult the Fuji sales division.
- Customers are requested to prepare safety measures when they apply the products introduced in this catalog to such systems or facilities that will affect human lives or cause severe damage to property if the products become faulty.
- For safe operation, wiring should be conducted only by qualified engineers who have sufficient technical knowledge about electrical work or wiring.

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