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LONG LIFE, ADVANCED FUNCTIONS NEW SMALL CONTACTORS SC SERIES

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1. FOREWORD

Many contactors are used in facilities automation and labor-saving. Contactors also play an important role in production facilities. To deal with the increased complexity and higher performances of systems, the demand for contactors with, of course, higher operating reliability, low energy consumption, and easier mounting and wiring and maintenance and inspection, as well as longer life to reduce maintenance man-hours and advanced functions for use in various applications, is becoming stronger.

The new SC series are long life, advanced functions, and easy to use 2.2 to 4kW (220V) motor capacity contactors developed to meet these market demands. This new series is outlined below. An exterior view of this series is shown in *Fig. 1*.

2. SERIES COMPOSITION AND RATINGS

The new small contactors SC series line-up and the thermal relays combined with them are shown in *Table 1*. The types manufactured are shown in *Table 2*, and their ratings are listed in *Table 3*.

In Japan, contactor auxiliary contacts are mainly single contacts for 2.2kW (220V) motor capacity, single

Fig. 1 New small contactors SC series

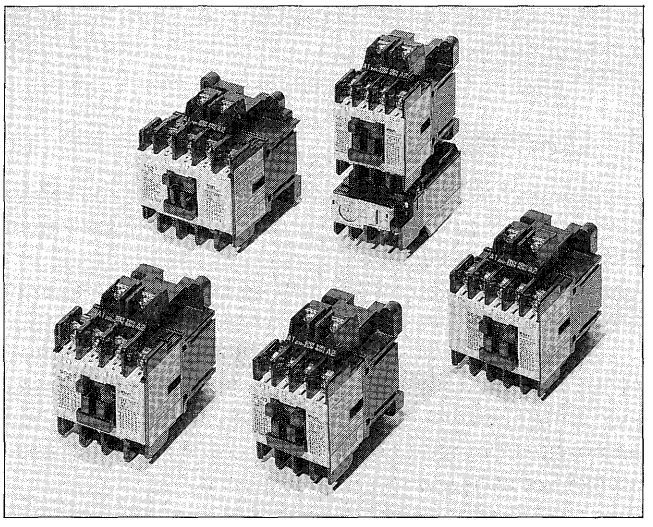

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Table 1 New SC series line-up

Motor capacity (kW)	220V	2.2	2.7	3.7	4
	440V	2.7	4	5.5	7.5
Contactor	1 auxiliary contact	SC-03	SC-0	SC-4-0	SC-4-1
	2 auxiliary contacts	–	SC-05	–	SC-5-1
Thermal relay	1E	TR-0N		TR-5-1N	
	2E	TK-0N		TK-5-1N	

Table 2 New small contactors SC series manufacturing line-up

	Model		Type designation □:03~5-1	Remarks
Open type	Standard type		SC-□	Track mounting also possible
	Mechanically interlocked reversing type		SC-□RM	
	DC operated		SC-□/G	
	Mechanically held type	Mechanically held AC operated	SC-□/V	
		Mechanically held DC operated	SC-□/VG	
	OFF-delay release			Used by combining DC operated type and OFF-delay release type
	For single-pole resistance load			Used by combining 3-phase parallel terminal board with body
	With extra pick-up operating coil		SC-□/U	
	With coil surge suppression device			Used by combining coil surge suppression unit with body
Enclosed type	Standard type		SC-□C	
	Dust tight/light corrosion resistant		SC-□LG	

Table 3 Ratings of new SC series typical types

Type designation		Rated capacity (kW)								Rated operational current (A)					Rated thermal current (A)
Magnetic contactor	Magnetic switch	Single-phase motor		3-phase squirrel-cage motor (AC3)			Induction motor (AC2B)			3-phase squirrel-cage motor (AC3)			Resistive load (AC1)		
		100V	200V	200V~ 240V	380V~ 440V	500V~ 550V	200V~ 240V	380V~ 440V	500V~ 550V	200V~ 240V	380V~ 440V	500V~ 550V	200V~ 240V	380V~ 440V	
SC-03	SW-03	0.4	0.8	2.2	2.7	2.7	2.2	2.7	2.7	11	7	6	20	20	20
SC-0	SW-0	0.5	1.0	2.7	4	5.5	2.7	4	5.5	13	9	9	20	20	20
SC-05	SW-05	0.5	1.0	2.7	4	5.5	2.7	4	5.5	13	9	9	20	20	20
SC-4-0	SW-4-0	0.75	1.5	3.7	5.5	7	3.7	5.5	7	18	13	13	25	25	25
SC-4-1	SW-4-1	0.8	1.6	4	7.5	9	4	7.5	9	18 (19)	17	17	32	32	32
SC-5-1	SW-5-1	0.8	1.6	4	7.5	9	4	7.5	9	18 (19)	17	17	32	32	32

<Note 1> Rated operational current ratings in ( ) apply when used as a magnetic contactor without thermal relay.
<Note 2> Temperature inside the applicable panel is 50°C or less.

contact and double contacts for 2.7kW (220V) motor capacity, and double contacts for 4kW (220V) motor capacity.

On the other hand, in the United State, contactor auxiliary contacts are mainly single contacts with an auxiliary contact block added as required.

A 3.7/4kW auxiliary single contact series was added to the new SC series and the construction was made such that an auxiliary contact block can be added.

3. FEATURES AND CONSTRUCTION

Besides the many features of the old series, the new small contactors SC series have longer life and more advanced functions. Their main features and construction are summarized below.

3.1 Features

(1) Long life

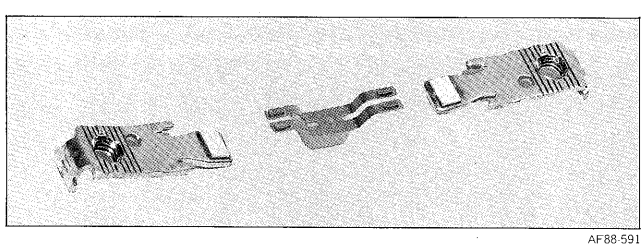
The AC3 (three-phase squirrel-cage induction motor direct-on-line starting, switching off) electrical life of the main contacts was made 2,000,000 operations or more by using metal oxide contacts and reducing contact bounce by using a new damping construction. This is the highest level not only in Japan, but also in the world.

(2) High reliability auxiliary contacts

Recently, the popularity of electronification of control systems has been amazing, and a need has arisen for even the auxiliary contacts of contactors meet this electronification.

The auxiliary contacts of the new small contactors SC Series all use bifurcated contacts as standard. Together with a dust tight construction, high contact reliability was achieved. This made a minimum operating voltage and current of DC5V and 3mA and direct input to electronic devices possible. An exterior view of the bifurcated contacts is shown in *Fig. 2*.

Fig. 2 Bifurcated contacts



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(3) Easy maintenance and inspection

Because contact life differs with the usage conditions, maintenance and inspection are necessary.

To simplify maintenance and inspection of the new small contactor SC series, mounting and dismounting of the contact cover was made one-touch and the construction was made such that the contacts can be replaced easily with tweezers and a screwdriver.

The operating coil was made a cassette coil and the construction was made such that fastening of the top and bottom frames is screwless and the operating coil can be mounted and dismounted by one-touch by merely separating the top and bottom frames with a screwdriver. At this time, parts other than the operating coil are fastened to the frame. There are no dropped out parts and handling is improved.

(4) Track mounting mechanism

The contactors can be mounted to a panel, etc. by both screw mounting and track mounting.

Track mounting uses a track mounting mechanism that allows one-touch mounting and dismounting to and 35mm wide tracks conforming to IEC and DIN standards.

Screw mounting matched to 5mm integer multiple dimensions mounting holes conforming to IEC standards, as well as to mounting holes compatible with the old type, is available.

(5) Front marking of type and rating.

The type and rating markings are displayed on the front of the body so that the panel mounting state can be seen at a glance. The rated voltage of the operating coil is displayed on the operating coil so that it can be verified from the front.

(6) Conform to world standards

The construction, of course, conforms to Japanese standards and also to IEC, VDE, BS, NEMA, UL, CSA, BV, Lloyd, and other major world standards.

(7) Terminal numbers meet IEC standards

IEC standards specify the terminal numbers. The trend is toward worldwide unification. The new SC Series uses IEC terminal numbers as an international product.

(8) Various optional units

Besides an auxiliary contact block, mechanical interlock unit, coil surge suppression unit, main circuit surge suppression unit, and operation counter, various other optional units are available so that coping with multi-functionalization is one step easier. For the optional units, see "Option Units Which Increase the Functions of Magnetic Switches and Application Type" of this issue.

3.2 Construction

An example of the construction of the new small contactors SC series is shown in *Fig. 3*. The main contact part is responsible for reducing the size and increasing the capacity of the contactors. In the past, 200V was the main rated voltage of motors, but from the standpoint of energy saving, 600V rated voltage is also used worldwide. The demand for longer contact life is also becoming stronger from the standpoint of reduction of maintenance man-hours.

The voltage drop at motor starting caused by low power supply capacity and the voltage drop due to the wiring length cause contact bounce due to incomplete attraction of the contactor and abnormal contact wear and contact fusing. To secure operation reliability and small size had high performance even in these applications, contact magnet innovations and suitable coordination of these have become necessary.

On the other hand, consideration must also be given to advanced functions to easily cope with higher performance and the addition of an auxiliary contact block, coil surge suppression unit, and other applications. How these are incorporated structurally is an important point.

3.2.1 Main contacts

Contact wear is caused mostly by the arc which is generated at current switching. When the contact bounce at contact closing is large when the making current is large (approximately 6In) and the breaking current is small, like AC3, etc., since the starting current is switched only during the duration of this bounce, contact wear becomes large and causes a drop in the contact life. When switching the starting current, like AC4 (inching operation), etc., the rise of the arc causes the contacts to melt and splatter or to peel from the contact base metal or to drop off and lowers their life.

Therefore, to reduce contact wear and extend contact life, contact bounce must be minimized and joining of life, contact bounce must be minimized and joining of the contacts with the contect base metal must be strengthened.

With the new small contactors SC series, contact bounce has been successfully reduced to one-half that of the past by improving the contact pressure, optimizing the contact wipe, and contact and magnet coupling section damping construction innovation.

Peeling of the contacts from the contact base metal was prevented strength by developing a new joining method and together with the use of new metal oxide contacts, an electrical life 2,000,000 operation in AC3 use was achieved. Long life in even capacitor applications was achieved.

Arc blast was also minimized by using a contact cover with a new construction and application to 660V was made possible by securing an ample isolation distance by top frame and contact support partition innovations.

3.2.2 Coordination of magnet attraction force and load force

To obtain contacts strong against power supply voltage fluctuations, the load force and attraction force were coordinated so that the contactor operates smoothly up to completion of attraction at the start of the attraction operation. Similarly, the release operation must also be completed smoothly and the voltage region at which magnet and contact bounce occurs must be eliminated. The relationship between load force and attraction force is shown in *Fig. 4*.

For the E type core of an AC electromagnet, the leak-

Fig. 3 Example of contactor construction

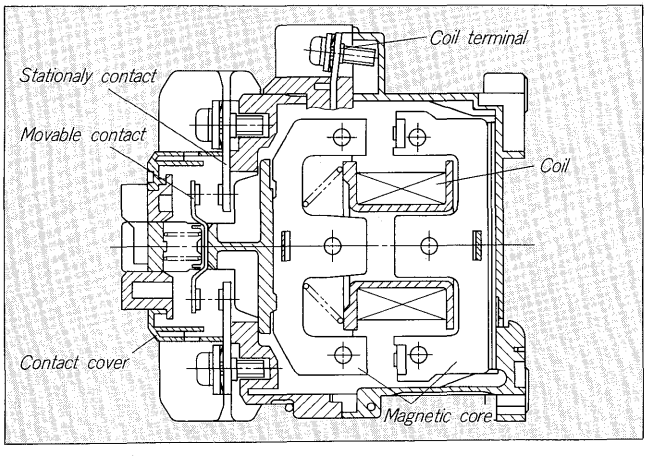


Fig. 4 Load force and attraction force

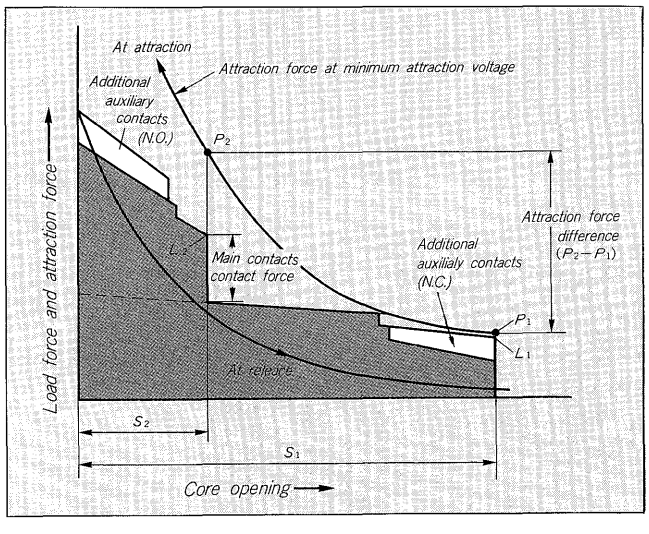


Fig. 5 Leakage rate and attraction force

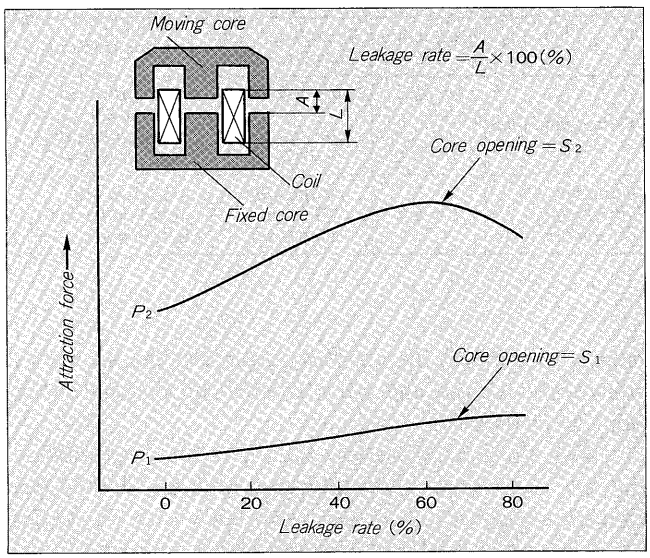
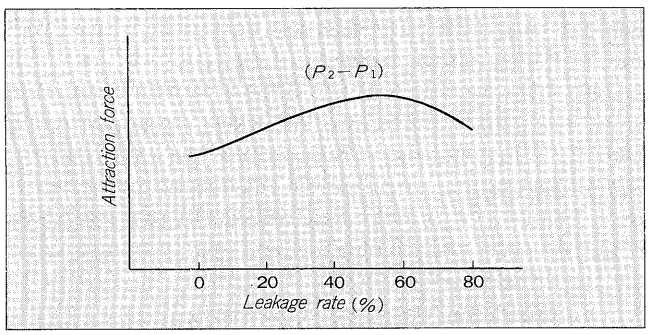


Fig. 6 Leakage rate and attraction force difference



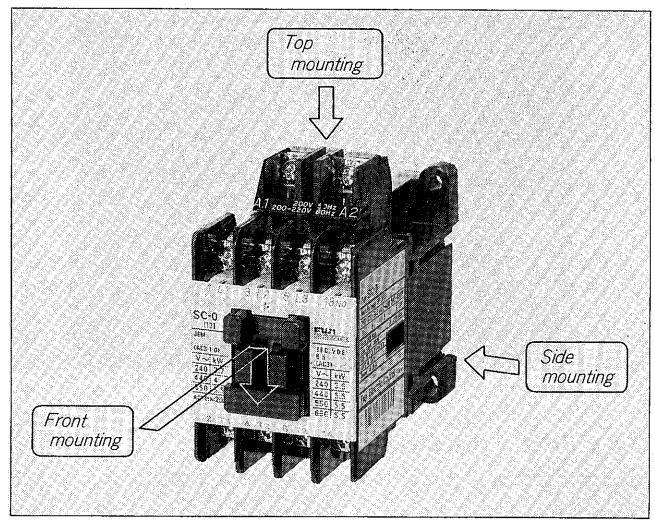
age magnetic flux and attraction change with the position of the iron core placed in the coil. The ratio relative to the length of the coil of the moving core in the coil is called the leakage rate. The change of attraction force versus leakage rate is shown in *Fig. 5*. When the leakage rate is changed here, the attraction force maximum value exists and the condition for obtaining maximum attraction force can be found.

When coordination with the load force is considered, as shown in *Fig. 4*, the point at which the difference $(P_2 - P_1)$ between attraction force P_1 at the operation start position and the attraction force P_2 at the contacts contact position is made maximum becomes the optimum leakage rate. The leakage rate at which $P_2 - P_1$ becomes maximum is set from *Fig. 6*.

On the other hand, the load force changes not only with the load force of the contactor body, but also with the addition of auxiliary contacts, etc. In this case also, if the minimum attraction voltage is not changed and the relationship between attraction force P_2 and load force L_2 is not changed, load force and attraction force coordination becomes difficult.

With the new SC series, the load power of the additional auxiliary contacts is set to the position at which

Fig. 7 Optional units mounting positions



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the attraction force at the minimum attraction voltage is not affected, as shown by the reverse displayed part of *Fig. 4*. The attraction force and load force were coodinated by selecting the optimum magnet and setting the optimum load force like this.

3.2.3 Standardization of parts

All the contactors (SC-03, 0, 05, 4-0, 4-1, 5-1) and auxiliary relays (SH-4, 5) use a common magnet. Therefore, since the operating coil is also common, spare parts procurement and storage are easy.

The auxiliary contacts part and other parts are also standardized and parts procurement at assembly is also easy. A construction suitable for automatic assembly and an immediately delivery system were also considered.

3.2.4 Optional units mounting construction

The optional units mounting positions are shown in *Fig. 7*.

The top mounting unit is constructed so that the two terminals of the operating coil are located at the power supply side and wiring is completed simultaneously with mounting of the unit. The front mounting unit is constructed to be mounted by sliding it at a hook part provided at the head of the contactor. The mounting dimensions of the side mounting unit are selected to match the functions of each unit. The unit is constructed to be mounted to the hook part, connecting groove, etc.

All of these units can be mounted by one-touch. The top mounting unit and front mounting unit, in particular, can be mounted with the contactor mounted to a panel.

4. PERFORMANCE AND TESTS

The new SC series are high performance, advanced function products with many features, like those described above. Regarding evaluation for achieving these, of course, verification as an international product based on each national standard was performed and confirmation tests were conducted by considering actual application condi-

Fig. 8 Contact bounce oscillogram

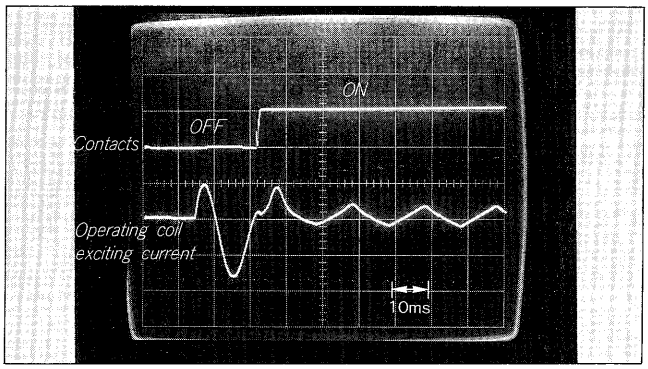


Fig. 9 State of contacts after electrical life test

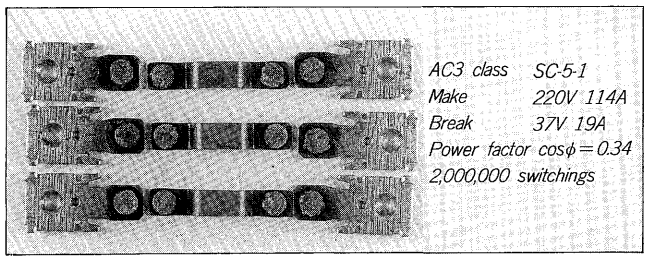
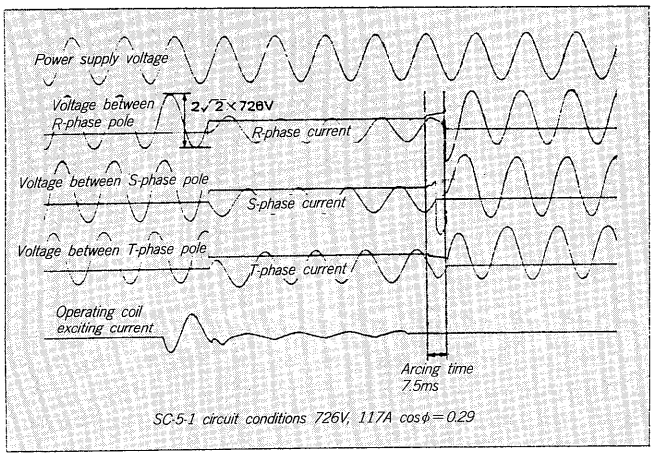


Fig. 10 Oscillogram at 660V breaking test



tions and assuming cases which are considered from the standpoint of actual use.

The main performances and tests are described below.

4.1 Electrical life

Long life was achieved by optimizing the magnet and vibration system and minimizing contact wear by minimizing contact bounce as described previously. An example of contact bounce is shown in *Fig. 8*. The state of the contacts the electrical life test is shown in *Fig. 9*.

4.2 Switching performance

The contact cover reduces the arc blast at breaking and prevents arc shorting at the outside. If the arc blast is reduced too much, there is the danger that the arc and gas will fill the interior and cause internal shorting and insulation degradation.

With the new SC series, the shape and dimensions of the arc blast port were optimized and the desired performance was obtained even for 660V use. A typical oscillogram of a 660V breaking test is shown in *Fig. 10*.

Table 4 Vibration test conditions

	Frequency (Hz)	Amplitude and acceleration	Measurement
Resonance test	1~13.2	Amplitude 2mm	Resonant point observed. Resonance multiplier: 5 or less
	13.2~100	Acceleration 0.7g	
Constant vibration durability test	10~55	Amplitude 0.5mm (2 hours)	Operation and appearance shall be normal.

4.3 Operating characteristics

JIS and IEC standards specify that operation of the contacts and other parts shall not be abnormal even when the operating circuit voltage is changed over the rated voltage 85% to 100% range. Generally, there are many cases when this is sufficient, but when the power supply capacity is low and the voltage drop of the wiring is large, the motor starting surge current may cause the voltage to drop below 85% of the rated voltage. In such cases, the contacts close while bouncing and main contact fusing and abnormal wear occur easily.

Consideration was given to the new SC series so that they do not operate abnormally even when the voltage drops to 75% of the rated voltage at a momentarily voltage drop like the above.

4.4 Special environmental tests

From the standpoint of standards, the normal usage state of the contactors is specified as (1) ambient temperature −5 to 40°C. (2) relative humidity 45 to 85%, and (3) altitude 2000m or less, and they should be used under these conditions. However, there may be cases when maintaining these conditions in the actual usage state is difficult.

The new SC series were tested under various environments and satisfactory results were obtained. The main tests are described below.

(1) Heat and humidity cycle test

To check the behavior when the contact surface of the electromagnet exceeded the normal usage limit and was rusted abnormally, tests were performed under conditions at which dew formed on the contact surface. The test was repeated for 10 cycles of two hours each at a temperature of 55°C and relative humidity of 95 to 100% and a temperature of 20°C and relative humidity of 80 to 100%. The results confirmed that there was some rusting of the contact surface, but the operating characteristics, etc. were not abnormal.

The test conditions specified by marine standards

are two cycles.

(2) High temperature switching test

Switching was performed more than 2,500,000 times at an ambient temperature of 60°C, excitation of 105% of the rated voltage, and a frequency of 1800 times/hour and no abnormalities were recognized in the operating characteristics, etc.

(3) Vibration test

A vibration test was performed under the conditions of *Table 4* and there was no resonant point and no damaged parts and no change in the characteristics before and after the test.

5. CONCLUSION

We are confident that the new small contactors SC series are revolutionary contactors incorporating long life, advanced functions, ease of use, and internationalization based on Fuji Electric's technology and experience accumulated over many years. In the future, we plan farther completion based on the comments of users and request the support over all users.