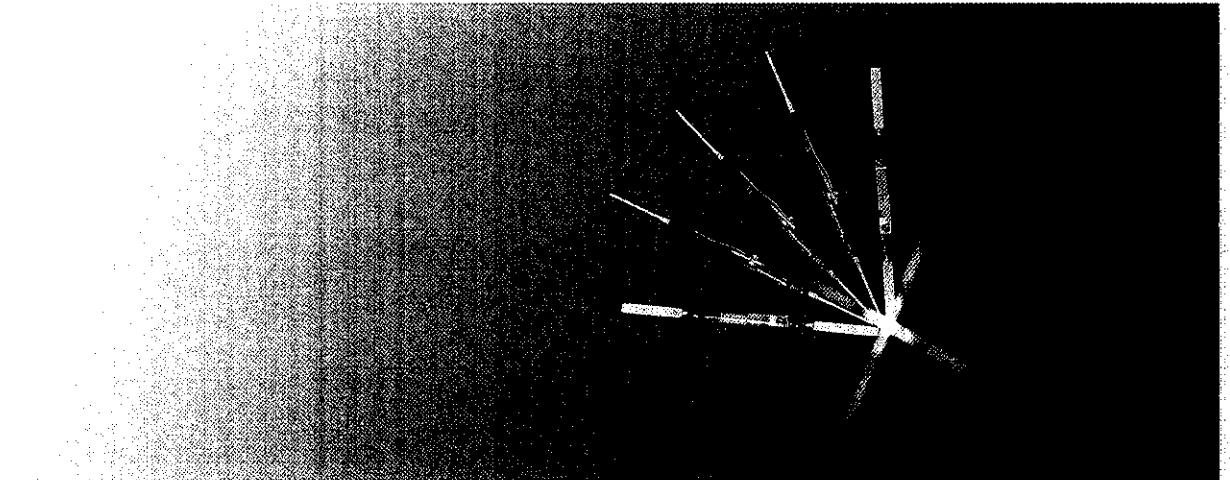


Yaskawa Hermetically Sealed Contact

BESTACT

DC switching capability of BESTACT R15 contact



BESTACT

1 CONSTRUCTION AND OPERATION MECHANISM OF BESTACT CONTACT

Extremely Reliable Contact Employing New Materials and Innovate Designs such as Wiping and Hammering Action, Bifurcated Contact and Back-Stop Mechanism

FEATURES

- 1 Sealed with an inert gas, ensuring freedom from aging and influences exerted by external environment.
- 2 The twin contact and wiping effect assures outstanding contact reliability, probability of failure is extremely low.

* $\lambda_{60} = 9.2 \times 10^{-10}$ (1/operations 5V 1mA)
- 3 Quick action permits a larger make and break capacity and longer service life.
- 4 Can switch both AC and DC, permitting direct control over a wide range from low level load to electromagnetic power load.

R15 type : 1V 1mA to 240VAC 1A
(10A making)
230VDC 40W(Solenoid valve)
NEMA Contact Ratings : C600, B300(AC), Q300(DC)
NEMA HP Ratings : 1/6HP(120Vac), 1/2HP(240Vac)

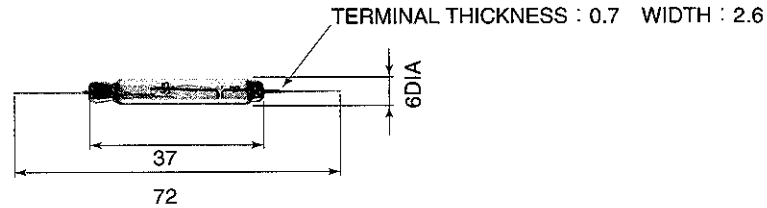
- 5 Small surge/noise during switching of inductive load.

Note : *

$$\lambda_{60} = \frac{\text{No. of failures} \times \text{Contant}^{**}}{\text{No. of tested contacts} \times \text{No. of tested operations}}$$

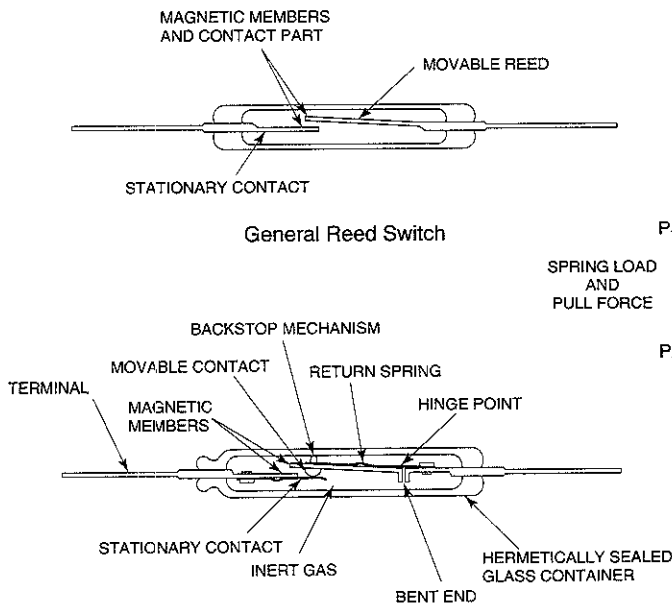
** Applying JIS(Japanese Industrial Standard)
60% reliability level, 0.917 for zero failure

DIMENSIONS (mm)



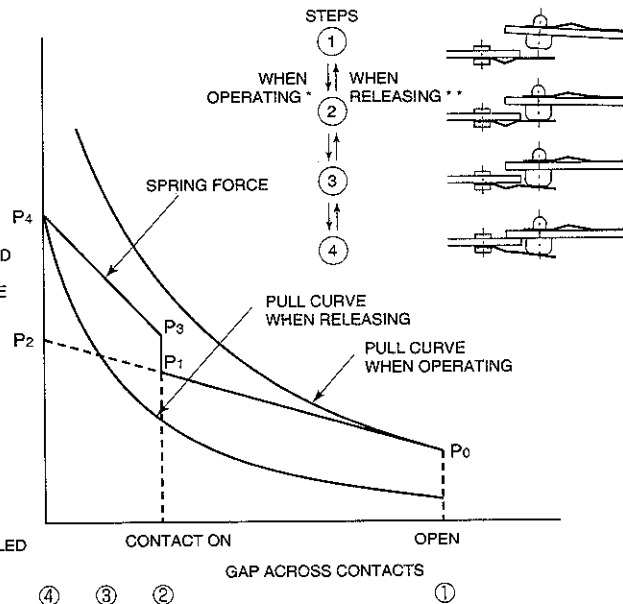
CONSTRUCTION AND OPERATION MECHANISM

Conventional reed switches are constructed simply. The contact for disconnecting current also serves to conduct the magnetic circuit. Bestact uses a separate magnetic member and contact unit (carrying current arcing section), each using different materials and designs suited for their functions.



Bestact R15

P₀ : INITIAL RETURN SPRING FORCE
P₃-P₁ : INITIAL CONTACT PRESSURE
P₄-P₂ : FINAL CONTACT PRESSURE



2 MATERIAL TRANSFER AT BREAKING DC INDUCTIVE LOADS

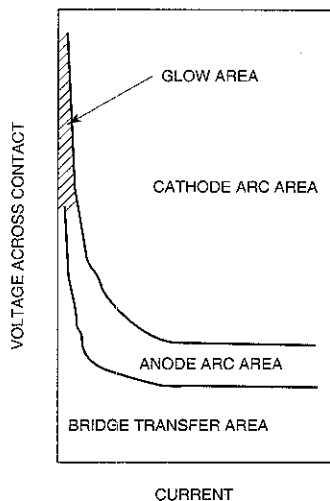
When switching DC inductive load, molten bridge, anode arc, glow or cathode arc may be generated. The contact transfer and wear is typified by the following phenomena.

(1) Phenomena at switching and contact transfer and wear

Switching phenomena	Material transfer of the switch	Contact Wear Pattern	Remarks
Molten bridge	Anode to cathode ⊕ → ⊖		In the area under the minimum arc voltage (10 V and less) and arc current, the contact wear is in proportion to the cube of the current value. The height of contact is in proportion to the current value and its surface is round.
Anode arc	Anode to cathode ⊕ → ⊖		This is inductive of the showering arc area. Sharp craters and pips structure are formed and they can cause mechanical locking.
Glow	Cathode to anode ⊕ ← ⊖		As the density of breaking current is small, the electric discharge on a wide contact surface results in small wear. Sharp craters and pips structure are not formed, and the contact surface is evenly consumed.
Cathode Arc	Cathode to anode ⊕ ← ⊖		Contact wear is heavy, however, sharp craters and pips structure are not easily formed.

(2) General transfer pattern

The voltage and the current where the above explained phenomena occur can be generally illustrated as shown in Fig. 1. For the switching phenomena of Bestact, the boundary line between the anode arc + the glow discharge and the arc discharge is separated by the breaking current. On the other hand, as the melting point of the molybdenum contact is approx. 2600°C and that for the silver alloy contact is approx. 980°C. The melting point of the molybdenum material is higher and the minimum arc current becomes bigger (molybdenum contact is approx. 0.7 A, silver alloy contact is approx. 0.4 A). Accordingly, the polarity connection of the molybdenum contact, which is more difficult to transfer by the switching phenomena results in a longer DC load switching life.



The voltage-current characteristics in the DC circuit can be generally illustrated as shown in the above figure.

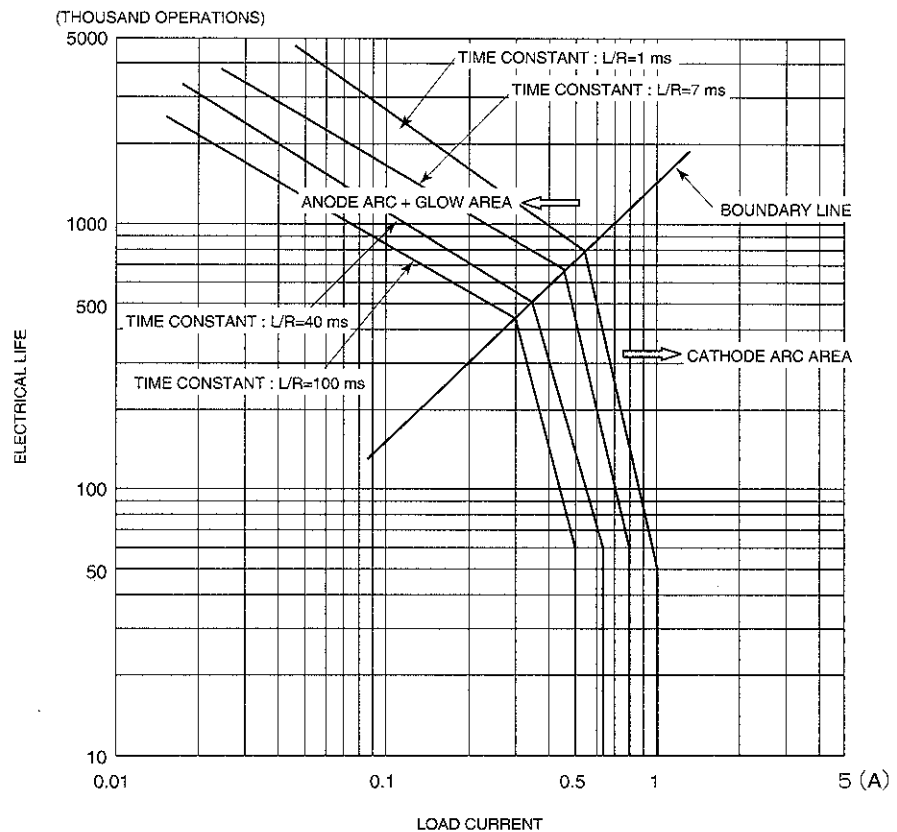
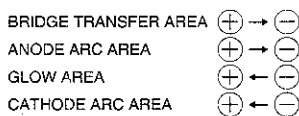


Fig. 1

Fig. 2 Electrical Life in 100 VDC Circuit

3 MAXIMUM BREAKING CURRENT

A typical inductive load in transit vehicle application is a VM-13 solenoid valve load. Fig. 3,4 shows the maximum breaking current for 2 contacts in series breaking simultaneously various VM-13 solenoid valve loads.

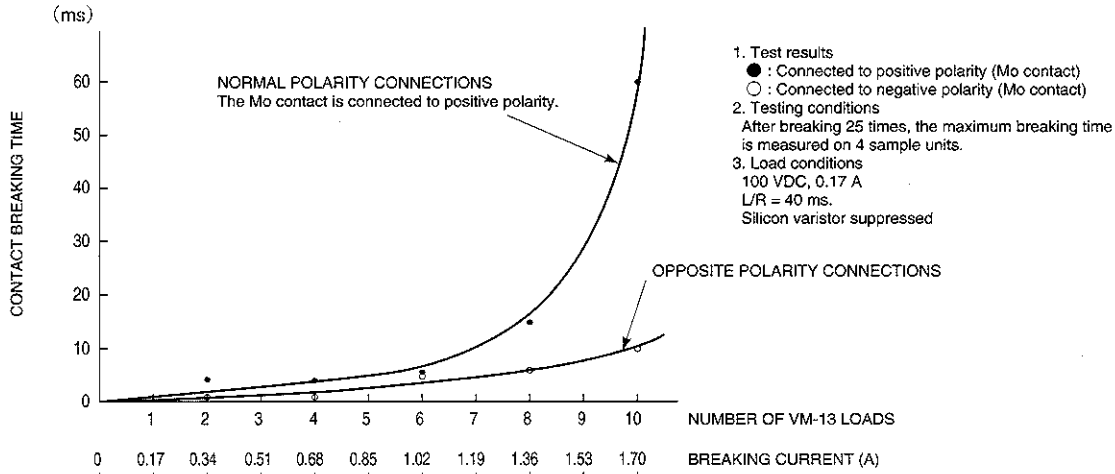
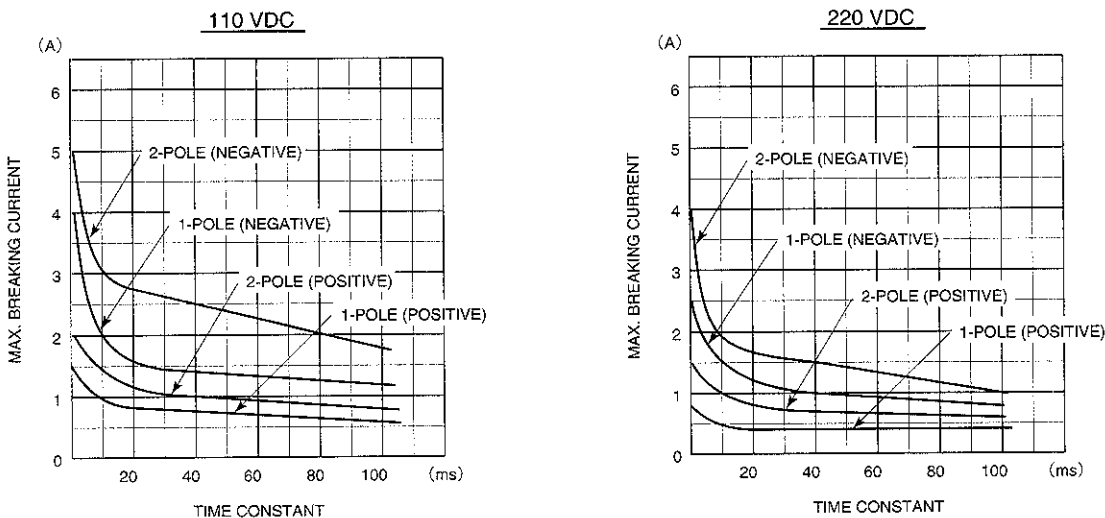


Fig 3 Breaking Characteristics with VM-13 Valve Load

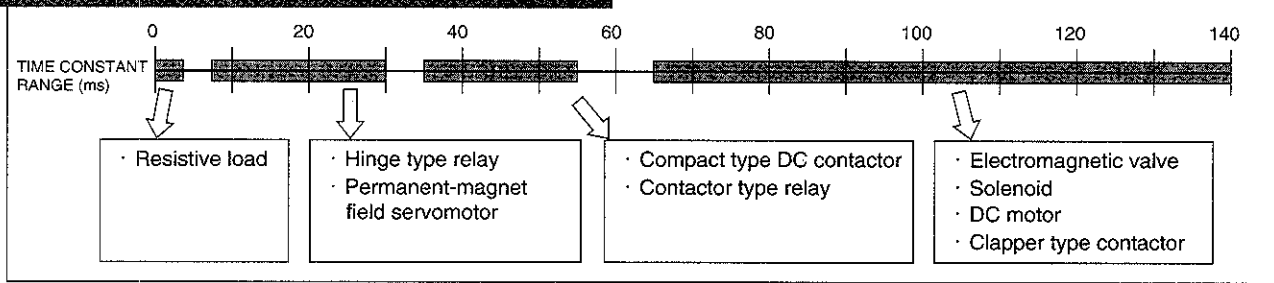
Number of Breaking Poles		Max. Breaking Current (A)			
Connected Polarity (Mo contact)		1-pole Breaking		2-pole Breaking	
Voltage	Time constant	Positive connection	Negative connection	Positive connection	Negative connection
110 VDC	100ms	0.6	1.2	0.8	1.8
	40ms	0.8	1.4	1.0	2.5
	10ms	1.0	2.0	1.5	3.0
	1ms	1.5	4.0	2.0	5.0
220 VDC	100ms	0.4	0.8	0.6	1.0
	40ms	0.4	1.0	0.7	1.5
	10ms	0.5	1.6	1.0	2.0
	1ms	0.8	2.5	1.5	4.0



Note : The maximum breaking current is measured in conformity with JEM1230, with an arcing time of 30 ms.

Fig 4 DC Load Maximum Breaking Current (Bestact R15)

<Reference> Time Constants with Various Loads



4 MAXIMUM MAKING CAPACITY

In electrical utility applications where the trip command contacts are used in circuit breakers, making capacity for large inrush currents is necessary.

In accordance with the JEC standards, the Bestact has proved its capability to withstand 10,000 make operations (refer to Table 1).

Table 1 Max. Making Capacity Life Data

Contact Polarity	Actual Load Circuit	Voltage	Current	Remarks	Test Results	Failure Mode
Connected to the positive polarity of R15 stationary contact		287 VDC	30 A	Load time constant : L/R=5 ms conducted for 0.2 sec. after turning the contact ON	1) 8 circuits tested 2) No fault after 10,000 operations	
		250 VDC	30 A	Load time constant : L/R= 0.05 ms conducted for 0.2 sec. after turning the contact ON	1) 7 circuits tested 2) Welded at the 20th and 30th operation	Contact open fault
Connected to the negative polarity of R15 stationary contact		100 VDC	20 A	Load time constant : L/R= 0.05 ms conducted for 0.2 sec. after turning the contact ON	1) 5 circuits tested 2) WEIBULL sharp parameter : m=0.9 Random failures 3) 90 % reliability life R0.9=1,150 operations	Contact open fault

5 RELATIONSHIP BETWEEN FUSE CHARACTERISTICS AND CONTINUOUS CURRENT

The characteristics with a molded case circuit breaker of 50 A rated current has been tested to check if contact weld occurs before the functioning of the built-in circuit fuse in case a dead short to earth should happen.

Fig.5 shows the contact damage endurance characteristics.

The × mark shows the limit value which indicates the failure mode where the hermetically sealed glass container breaks after the internal contact has physically melted away, while the ○ mark shows the contact is normal value.

Contact Damage Endurance Characteristics

Max.-Min. Operation Characteristics
DB31, 32, 33
Rated current 50 A or less

BESTACT

○ : normal value

× : limit value

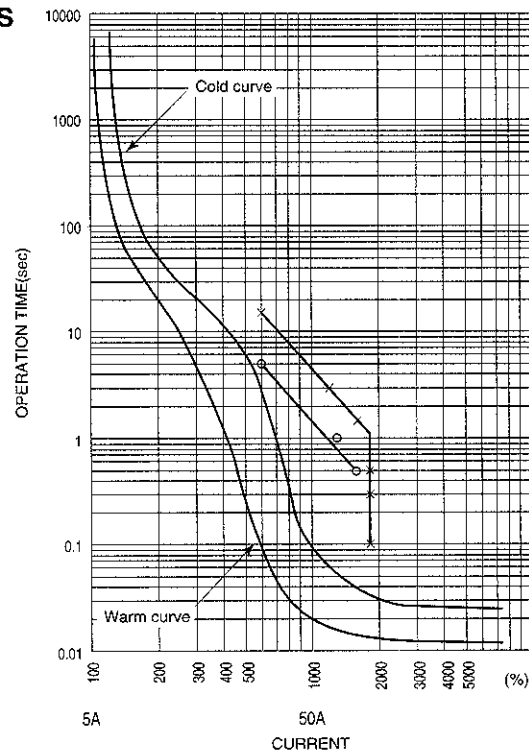


Fig 5 Relationship between Fuse Characteristics and Continuous Current

6 CONTACT RELIABILITY TEST DATA FOR LOW-LEVEL LOAD

Table 2 Contact Reliability Test for Low-level Load

Contact Polarity	Actual Load Circuit	Voltage	Current	Remarks	Test Results	Failure Mode
Connected to the stationary contact		5 VDC	10 mA	Opto-coupler drive circuit Contact fault check : Voltage drop between contacts (1 V or less)	1) 20 circuits tested 2) No fault during 30,000,000 operations 3) Contact reliability : $\lambda_{60}=1.53 \times 10^{-9}(\text{1/operation})$	No failure
		20 VDC	1 mA	Hypothetical the 24 VDC opto-coupler input circuit Contact fault check : Voltage drop between contacts (1 V or less)	1) 20 circuits tested 2) No fault during 15,000,000 operations 3) Contact reliability : $\lambda_{60}=3.1 \times 10^{-9}(\text{1 /operation})$	No failure

7 SWITCHING LIFE DATA WITH ACTUAL LOAD FOR VEHICLES

As the Bestact is a contact sealed in an inert gas, the laboratory results can be realized in the field with high contact reliability for most of the applications. However, for capacitive and lamp loads which have in herently high inrush currents, there may be cases when contact fault occurs within a short period. Also, note that incorrect connection of the polarity may shorten contact life.

When the switching life tests are conducted, the voltage between loads in the comparator circuit are measured each time after the contact is operated.

Table 3 Switching Life with Actual Load for Vehicles

Contact Polarity	Actual Load Circuit	Voltage	Current	Remarks	Test Results	Failure Mode
Connected to the stationary contact		100 VDC	0.006 A	Load time constant : L/R=22 ms	1) 8 circuits tested 2) 1 circuit : Open fault at the 18,500,000th operation 3) 7 circuits : No contact fault during 20,000,000 operations	Contact open fault
		100 VDC	0.009 A	Load time constant : L/R= approx. 30 ms With a built-in surge suppressor	1) 1 circuit tested 2) No fault during 5,000,000 operations	
		100 VDC	0.127 A	Load time constant : L/R=34 ms	1) 2 circuits tested 2) WEIBULL sharp parameter : m=5.3 Normal wear failures 3) 90 % reliability life : $R_{0.9}=3,300,000$ operations	Contact open fault
		100 VDC	0.125 A	Load time constant : L/R=17 ms 2-relay load in parallel connection	1) 5 circuits tested 2) No fault during 10,000,000 operations	
		100 VDC	0.19 A	Load time constant : L/R=108 ms	1) 3 circuits tested 2) WEIBULL sharp parameter : m=7 Normal wear failures 3) 90 % reliability life : $R_{0.9}= 6,600,000$ operations	Contact open fault
		100 VDC	0.35 A	Load time constant : L/R=75 ms	1) 4 circuits tested 2) WEIBULL sharp parameter : m=5 Normal wear failures 3) 90 % reliability life : $R_{0.9}= 2,600,000$ operations	Contact open fault
		100 VDC	0.51 A	Load time constant : L/R=40 ms	1) 4 circuits tested 2) WEIBULL sharp parameter : m=4.6 Normal wear failures 3) 90% reliability life : $R_{0.9}=3,200,000$ operations	Contact open fault
		100 VDC	0.51 A	Load time constant : L/R=40 ms Silicon varistor in parallel connection	1) 4 circuits tested 2) WEIBULL sharp parameter : m=4.6 Normal wear failures 3) 90 % reliability life $R_{0.9}=3,750,000$ operations	Contact open fault

Table 3 Switching Life with Actual Load for Vehicles (cont'd)

Contact Polarity	Actual Load Circuit	Voltage	Current	Remarks	Test Results	Failure Mode
Connected to the stationary contact		100 VDC	0.24 A	Load time constant : L/R=104 ms Contact polarity is reversed every 2000 operations.	1) 2 circuits tested 2) 1 circuit : Open fault at the 5,890,000th operation	Contact open fault
		100 VDC	0.24 A	Load time constant : L/R=104 ms Contact polarity is reserved every 2000 operations. Silicon varistor in parallel connection	1) 2 circuits tested 2) No fault during 10,000,000 operations	
		100 VDC	0.35 A	80-point series connection	1) 80 circuits tested 2) No fault during 2,850,000 operations 3) Contact reliability Failure rate : $\lambda_{60} = 2.3 \times 10^{-9}$ (1/operation)	
Connected to the negative polarity of R15 stationary contact		100 VDC	0.44 A	Load time constant : L/R=160 ms Surge absorber connected	1) 1 circuit tested 2) No fault during 2,020,000 operations	
		100 VDC	1.5 A	Load time constant : L/R=120 ms 2-contact series-connected switching	1) 3 circuits tested 2) WEIBULL sharp parameter : $m=7$ Normal wear failures 3) 90 % reliability life : $R_{0.9}=260,000$ operations	Contact open fault
		100 VDC	5.0 A	Load time constant : L/R= 1 ms 2-contact series-connected switching	1) 2 circuits tested 2) No fault during 10,000 operations	
		100 VDC	1.5 A	Load time constant : L/R = 120 ms Silicon varistor in parallel connection	1) 1 circuit tested 2) Open fault at the 4,600,000th operation	Contact open fault
		100 VDC	1.1 A	Load time constant : L/R=230 ms Silicon varistor in parallel connection	1) 1 circuit tested 2) Open fault at the 140,000th operation	Contact open fault
		100 VDC	1.1 A	Load time constant : L/R=230 ms Silicon varistor in parallel connection 2-contact in series and parallel connection	1) 4 sets of circuits tested 2) No fault during 1,380,000 operations	
		100 VDC	3.5 A making 0.5 A breaking	Used as economy NC contact 2-contact series-connected switching GTO circuit	1) 2 circuits tested 2) No fault during 100,000 operations	
		100 VDC	3.0 A	Load time constant : L/R=40 ms 3-contact series-connected switching	1) 3 circuits tested 2) No fault during 10,000 operations	

Yaskawa Hermetically Sealed Contact

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DC switching capability of BESTACT R15 contact

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