Silver Electric
Contacts and Switches

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TECC

TAIWAN ELECTRIC CONTACTS CORP.

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Silver Electric Contacts and Switches

1. PREFACE

The reliability of electric and automatic equipment used in our daily lives depends on the quality of devices such as switches, circuit breakers or relays, that connect, interrupt or isolate electric current.

Electric contacts for switches, breakers and relays play a very important role in electric industry. The experience of TECC in powder metallurgy and mechanical metallurgy techniques gained since 1979 with modern facilities which allow us to use internal oxidation and powder metallurgy techniques to produce high quality electric contacts made of AgCdO, AgNi, AgW, AgWC, CuW and $AgSnO_2$. (TECC electric contact material: http://www.tecc.com.tw)

TECC is dedicated to pursuing excellent quality, competitive price and quick delivery which aid TECC a good reputation from customers. We hope this small pamphlet may provide you the needful information.

2. PROPERTIES OF SILVER ELECTRIC CONTACTS

While choosing a material for electric contacts, below issues better be included:

(1) High electric and thermal conductivity,
(2) Good fusion resistance,
(3) High wear resistance,
(4) Good corrosion resistance,
(5) Good working properties.

2.1 High Electric Conductivity and Thermal Conductivity

Since thermal capacity of electric contact and contact support are small, the area for heat dissipation is quite limited; in this case, the adopted material for silver electric contacts must have high electric and thermal conductivity to ensure the allowable temperature rising during operating. Then it won’t affect the electric performance nor damage the insulation.

In addition to the inherent electric resistance of the material, the resistance of electric contacts mainly results from surface contact resistance. Such contact resistance **(*)** is caused by:

(1) The characteristics of the electric contact material,
(2) The surface treatment of the electric contact,
(3) The contact status between the electric contacts **(**)**, and
(4) Oil vapors, acidic gases, and dust in the air,

(*) So-called “contact resistance″ is the resistance between the opposite surfaces of two electric contacts when the current passes through. It consists of “ Transition Resistance ″ and “ Constriction Resistance ″. “Transition Resistance” may be increased by oxidation or sulfide layer which cover the contact surface and obstructs the current, and sometimes even causes an insulation effect. As the actual area that a current passing through is smaller than the surface area of the electric contact; hence, the current concentrates and flows through that smaller area, thereby comes out the “Constriction Resistance″.

(**) An electric arc occurs between two electric contacts when a switch is actuated. The high heat produced by

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the electric arc may melt the surface of the contacts and result in a transfer and flow of electric contact material. The contact surface may thereby become uneven, sometimes even form the slag. The electric conductivity of the switch will be reduced once carbon slag were formed and adhered to the contact surface.

2.2 Good Fusion Resistance

The resistance to fusion is essential for electric contact material because it is very dangerous if two contacts fuse together and fail to separate due to surface melting. The heat produced by contact resistance and the electric arc will raise the surface temperature of electric contacts. When the contact temperature reaches the melting point of contact material, it may cause sticking. A high melting point and low contact resistance characteristics are therefore required for electric contact material.

2.3 High Wear Resistance

There are two types of wear: mechanical & electric. Electric heat and electric arc may cause electric contact materials to melt, spatter and evaporate. Under a strong current, wear resulting from melting, spattering and the evaporation of material constitutes the major portion of the wear. Therefore, the electric contact material requires an appropriate hardness and high wear resistance.

2.4 Good Corrosion Resistance

Electric contact material must be stable so that, even in a high temperature environment, they will not react with ambient agents such as oxygen and sulfur nor forming a thin layer of such compounds of sulfide and oxide. Even sulfide or oxidation layers was formed, it will sublimate due to the heat generated instead of forming an insulating film.

2.5 Good Working Properties

Contacts must be easy to be riveted or welded.

3. THE MANUFACTURE OF SILVER ELECTRIC CONTACTS

3.1 Contact Material:

For general applications, pure silver is commonly used to produce silver electric contacts because of its highest electric and thermal conductivity and its good resistance to oxidation. Though it is liable to form sulfides, it is still partially constructive even after being sulfurated.

However, various switches may require different electric contact properties. Therefore, different materials are generally mixed to form suitable alloys to yield the desired results. For example, silver has high electric and thermal conductivity; nevertheless, has low corrosion resistance and poor fusion resistance due to its low hardness. Silver is hence often mixed with various metal oxides or Ni, W, WC…etc., to improve the properties.

Different electric contact material compositions may directly affect the hardness, electric conductivity and density of an electric contact. Please refer to TECC catalogue or Table 1. Table 2 shows the different properties of various electric contacts. As silver is quite expensive, bimetal rivets are used on switches for small current applications to reduce the silver cost.

In a bimetal contact rivet, only a layer of the rivet head is made of silver or silver alloy, while the lower

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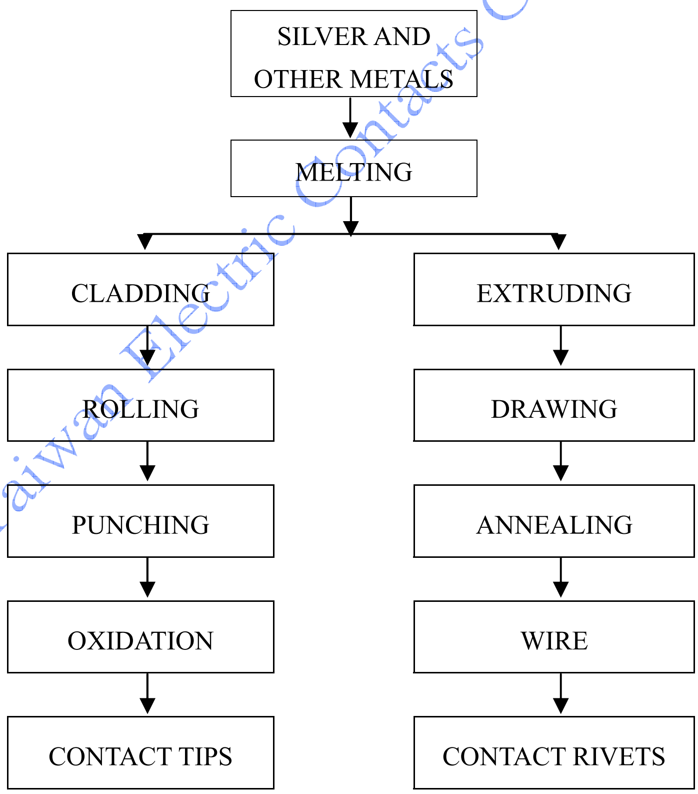
part and the shank are made of a base metal. Comparing with conventional solid contact rivets of the same specifications and the same material, bimetal ones have the same electric performance. Roughly 50% to 70% of the silver is saved in this way, thus creates more substantial economic benefits.

3.2 Manufacturing Methods for Silver Electric Contacts:

Powder metallurgy and internal oxidation are two major methods used for producing silver electric contacts. Electric contact produced by the powder metallurgy method has better fusion resistance than one produced by the later; however, with higher manufacturing cost.

The internal oxidation method allows special elements to be added for a better fusion resistance of silver electric contacts. TECC is one of the few manufacturers who is capable in employing these two manufacturing methods to meet application requirements.

(1) Internal Oxidation Process:



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(2) Powder Metallurgy Process:

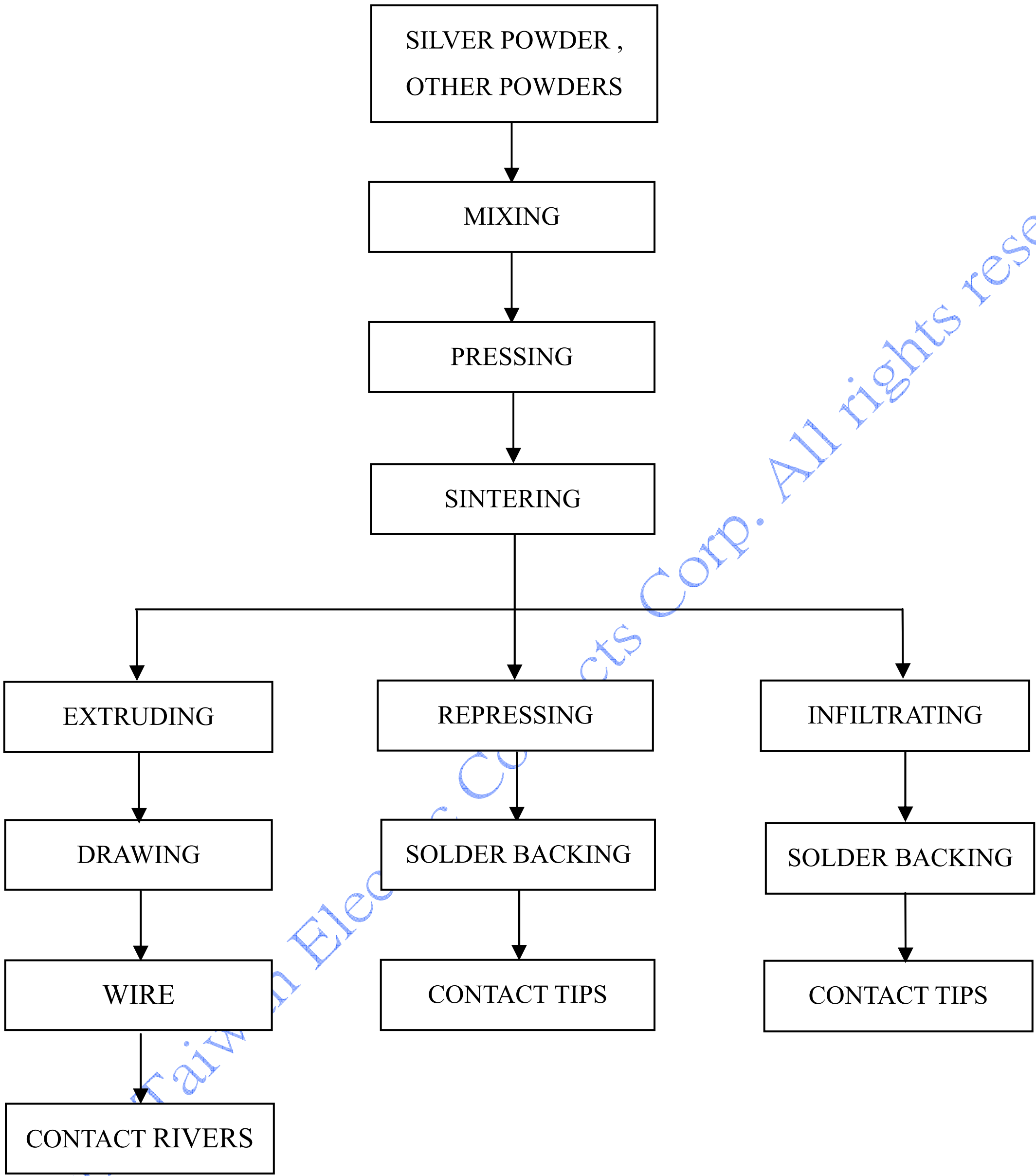

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Table 1: Properties of Electric Contact Materials

Material	Advantages	Disadvantages
Ag	Very high electric and thermal conductivity. Easily & workable.	Prone to fusion, sticking and metal transfer.
AgCu	Harder than Ag. Good resistance to wearing & tearing. Less tendency to fusion and metal transfer.	Anti-chemical wear properties are worse than Ag.
AgCdO	Good resistance to corrosion. High fusion resistance. Low temperature rising.	Contact resistance is higher than Ag.
AgNi	Harder than Ag. Higher resistance to wear and tear than Ag. Low contact resistance. Good arc extinction properties.	Electric and thermal conductivity is worse than Ag.
$AgSnO_2+\alpha$	Good fusion-resistance. Good properties in high currents. ($\alpha=In_2O_3,WO_3,MoO_3,Bi_2O_3$…)	Contact resistance is higher than AgCdO. Higher cost.
AgW	Very hard. High resistance to arc corrosion, wear and tear.	High contact resistance & low conductivity. Higher cost.
AgWC	Less tendency to oxidize. Slightly lower corrosion than AgW.	Limited workability.
AgMo	Similar to AgW but more easily cleaned by the electrical arc. The contact resistance is lower than AgW.	Lower electric wear resistance than AgW.
AgC	Very good resistance to arc welding in short circuits.	Electrical wear increases with the concentration of carbon or graphite.
CuW	Good resistance to arc corrosion. Other properties is similar to AgW. Suitable for Oil Circuit Breakers & Oil Switches.	Less resistant to oxidation. Higher contact resistance.

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4. THE SHAPES AND CONTACT MODES OF SILVER ELECTRIC CONTACTS

4.1 Shapes：

Silver electric contacts are generally classified into three types of rivet, button and tip types. Silver electric contacts of each type can be formed into various shapes. In order to speed up the delivery, to reduce manufacturing cost and to improve production capacity, the standardization of shapes and specification of electric contacts has been an important task. TECC therefore not only produces silver contacts in general standard shapes and specifications but also manufactures special dimension electric contacts on customers' request.

4.2 Electric Contact Touch Mode：

The electric contact mode is determined by the shape of the silver contact.

(1) The point-touch mode:

It's designed for weak current applications. Oval contact head is designed for current point-touch to reduce the contact resistance and the formation of an oxide layer.

(2) The surface-touch mode:

It's designed for strong current applications. Nearly planar contact head is designed for highly resistant to fusion and wear.

5. UNITING OF A SILVER ELECTRIC CONTACT AND A CONTACT SUPPORT

Uniting methods include silver brazing, riveting and spot welding.

5.1 Silver Brazing:

Silver Brazing includes electric brazing, flame brazing and high frequency brazing. The specifications and properties of frequently used solder materials are shown in table 2. Please take note when operating a brazing machine.

(1) The fluxes, brazing alloys, brazing time, pressure and cooling methods should be carefully monitored.

(2) The gas and vapor produced by the flux and solder must be expelled completely.

5.2 Riveting:

Considerations for riveting die:

(1) The cavity diameter of a riveting die should be 0.1mm larger than the head diameter of the rivet.

(2) The cavity depth of a riveting die (T') should be 0.05mm less than the head thickness of the rivet (T). If the support plate is relatively thinner, then T' is nearer to the T.

(3) The cavity angle of a riveting die should be within the ±2 degree of the rivet head.

(4) A riveting die should be maintained in a completely clean condition and free of oil, dust, stains or other substances adhering to its surface.

5.3 Spot Welding：

The so called "spot welding method" by mean of utilizing the convey of the electric current through the contact surface of parts to form a small nugget of welded metal, hence to join the materials after the current was removed.

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Table 1

The Common Usage of Welding Method

	Outline	Heat Source
Resistance Welding	By an electric welder, depends on its resistance heat to fuse & weld the parts together.	Resistance heat (Joule heat)
Blaze Welding	Perform by torch welding and oxy-acetylene flame.	Gas、Oxygen、Acetylene etc.
Furnace Brazing	Braze the components in a furnace, for most mass production applications.	Electrothermal、Gas
High-Frequency Welding	Generate by a high-frequency current through the coil, thus to produce current to weld.	High-frequency heat

Table 2

The Specification of Frequently Used Solder Materials and Properties:

AWS ASTM JIS Spec.	DIN 8513 Spec.	Composition (%)					Temperature (℃)			Electric Conductivity (IACS%)
		Ag	**Cu**	**Zn**	**Cd**		**Solid**	**Liquid**	**Brazing Temp. Range**	
BAg-1A	L-Ag50Cd	50	15.5	16.5	18		625	635	635~760	23.9
BAg-1	L-Ag45Cd	45	15	16	24		605	620	620~760	27.6
BAg-2		35	26	21	18		605	700	700~845	28.6
BAg-3		50	15.5	15.5	16	Ni3	630	690	690~815	18.0
BAg-4		40	30	28		Ni2	660	780	780~900	16.8
BAg-5	L-Ag44	45	30	25			665	745	745~845	19.0
BAg-6		50	34	16			675	775	775~870	25.9
BAg-7		56	22	17		Sn5	620	650	650~760	8.3
BAg-8	L-Ag72	72	28				780	780	780~900	77.0
BCuP-5	L-Ag15P	15	80			P5	640	815	705~815	9.9
BCuP-3	L-Ag5P	5	89			P6	640	805	705~840	9.6
BCuP-2			93			P7	705	805	735~840	7.0

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6. THE CONTACT OBSTRUCTION OF SILVER ELECTRIC CONTACTS

Contact obstruction means a silver electric contact can not function effectively and properly. While a electric current passing through, an electric contact is often impeded due to a contact obstruction. A contact obstruction may occur under below-listed circumstances:

6.1 Sulfuration: Silver reacts with sulfur then to form a sulfide. Silver electric contacts may be sulfurated by contacting with rubber bands, electric corrugated board and stickers containing a sulfur composition. Moist, damp air promotes such chemical reaction.

6.2 Contamination of Si and Al: Contact obstruction results from the adherence of SiC and/or Al_2O_3 ground powder to the surface of a silver electric contact.

6.3 Other Contaminations: Automobile exhaust gas, dust, sweat, oil, cleaners, luster and other organic substance may adhere to and contaminate contact surfaces.

6.4 Metal Corrosion: Silver electric contacts often suffer from corrosion caused by nitric acid, hydrochloric acid and vapor.

6.5 Battery Reaction: A battery reaction can be formed right at the joint of different metals which may cause corrosion of contacts.

7. DIMENSION DESIGN OF AN ELECTRIC CONTACT RIVET

(1) By utilizing common set of d, D,T,L and t, you'll have a quick delivery and free of tooling charge. Each standard tooling has a fixed shank diameter "d" and with a correspondent head diameter "D". Total head thickness "T" and shank length "L" are variable within limits indicated in below table. The common sets of d, D, T, L and t are as follows:

A. Metric System :(Unit: mm)

D+0.1 -0.1	2.5 3	3.5 4	4.5 5	5.5 6	6.5 7	7.5 8
d +0 -0.1	1.5	2.0	2.5	3	3.5	4
T+0.1 -1	0.8 1.0	0.8 1.0	1.0 1.5	1.0 1.5	1.5 2.0	2
L+0.2 -0	About 0.8-1.5mm thicker than the support riveted plate (depending on the thickness of the support plate and the tolerance of the hole punched in the support plate; the hole diameter is generally of d+0.1/-0mm.)					
t+0.1 -0.1	The optimum state is 50% (min. 25%, max. 65%) of the head thickness (T)					

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B. Imperial System: (Unit: inch)

D+0.004 -0.004	0.098 0.118	0.138 0.157	0.177 0.197	0.217 0.236	0.256 0.276	0.295 0.315
d+0 -0.004	0.059	0.079	0.098	0.118	0.138	0.157
T+0.004 -0	0.031 0.039	0.031 0.039	0.039 0.059	0.039 0.059	0.059 0.079	0.079
L+0.008 -0	About 0.03”-0.06” thicker than the support plate to be riveted (depends on the thickness of the support plate and the tolerance of hole punched in the support plate; The hole diameter is generally d+0.004/-0”.)					
t+0.004 -0.004	The optimum state is 50% (min. 25%, max. 65%) of the head thickness (T).					

(2) Avoid silver-plating on electric contact rivets, as pure silver plating might affect alloy electric contact rivet performance.

8. THE GENERAL DIMENSIONAL TOLERANCE OF ELECTRIC CONTACT RIVETS

The dimensional tolerance of an electric contact rivet is properly set as following:

(1) **D ±0.1** The tolerance for the head diameter of electric contact to be set a little larger. An exceeding small tolerance will shorten the life of riveting die since it is liable to be slightly worn out, both manufacturing cost and price of rivet will be increased.

(2) **T +0.1** **(A)** After the riveting procedure, the thickness of an electric contact rivet head **-0**T will become thinner, thus the lower limit of the tolerance is set at zero. The electric contact rivet head will be reduced by 0.05- 0.10mm of its thickness after riveting, which brings it near to reach the specified value T.

(B) The cavity depth of riveting die T’ is set to equal the value of t -0.1mm. Accordingly, if T is 0.05-0.1mm thicker than T’, then the support plate & the rivet head will be riveted closely, no gap existed.

(3) **d + 0** For a shank of electric contact rivet, the upper limit of its tolerance to be set - 0.1 at zero to prevent electric contact rivets from being unable to be inserted into the corresponding hole in the support plate when the hole is formed with the smallest allowable hole diameter.

(4) **L+0.15** The length of an electric contact rivet shank used to be made slightly longer in **-0** order to cope with situation, in which the hole in the support plate has a largest allowable diameter. By doing this, the shank electric contact rivet portion extending out of the support plate may have a bulk sufficient to allow the rivet to be tightly attached on the support plate after the rivet shank is impacted by external force.

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(5) **t±0.1** The silver layer is well configured to have a relatively thicker central portion with a relatively thinner peripheral margin. The thicker central portion is directly opposite to the rivet shank, thus it will be flattened when an impact force applied on the rivet shank of electric contact rivet during a riveting operation.

9. REQUIREMENTS FOR THE STORAGE OF SILVER ELECTRIC CONTACTS

The quality and reliability of a silver electric contact substantially depends on a clean environment during manufacturing process and storage. Therefore, environmental factors such as humidity, temperature, dust and gases should be carefully controlled during production and storage as maintaining an optimum condition.

(1) Keep silver electric contacts from exposure to harmful substances such as CCl_4, Cl_2, SO_2, H_2S, Si, Al_2O_3, H_2O, Oil vapor, tobacco smoke, automobile exhaust gas, etc., as they may cause the reduction, sulfuration or chlorination of them.

(2) Keep silver electric contacts free from dust and oil, and no hand touch. Silver electric contacts should be thoroughly cleaned after been treated with nitric acid, hydrochloric acid, cyanide, or diluted sulphuric acid. Substances such as SiC and Al_2O_3, which might adhere to silver contacts during grinding, should also keep away from electric contacts.

(3) A complete dryness is required after cleaning silver electric contacts. Preferably use a dryer to keep the humidity under 50%.

(4) Impermeable sulfur or silicon free laminated bags, cartons and stickers are preferably to use as its package.

(5) A dry dust-free storage environment is required after unpacking electric contacts. No hand touch as sweat may cause metal corrosion. Keep contacts in a closed clean chamber with humidity under 50% during humid and rainy weathers.

10. CAUSES OF SWITCH OVERHEATING

(1) Electric Contact Materials: Conductivity varies with the material. Please refer to TECC catalogue. (http://www.tecc.com.tw)

(2) The formation of an insulation layer: Contact resistance will increase once an electric contact is contaminated by substances such as H_2O, H_2S, organic matter and sweat. Carbide or slag come from high heat during switch operating will form the insulation layer..

(3) If the quality of decoloration inhibitor is not good, the switch may suffer from high temperature. The inhibitors used to prevent the silver electric contacts from carburization and oxidization.

(4) Contact resistance may also be increased due to the loose riveting or poor welding.

(5) The pre-plating process before silver flash may cause the higher temperature due to the property of pre-plating metal. (For example, a phosphorous bronze support may produce a higher temperature once it is pre-plated with nickel rather than copper. A copper support will produce a lower temperature once it is plated with silver prior to nickel treatment.)

(6) Switches consisting of electric contacts and supports should be rinsed with the cleaning agent in an ultrasonic

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machine to remove organic materials, oil, sweat and dust which may adhere on contacts while assembling to get a stable and low contact resistance in this way.

(7) The materials, shapes, sizes and designs of electric contacts support may affect the temperature rising of electric contacts.

(8) After switch operating, the contact might be loosen from copper base or formed an oxidation due to the electric arc, the over-high temperature is as a result.

(9) After switch operating, the gap between two contacts is gradually enlarged and the touching pressure between contacts will lessen, thus cause a higher temperature.

(10) An inadequate design of the switch structure will lead to poor heat dissipation and poor of arc-extinction.

(11) Elasticity fatigue of a switch or a contact support may cause the smaller contact pressure and higher temperature-rise.

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