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SOLITRONICS ENGINEERING LTD.
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KINDS AND CHARACTERISTICS OF CONTACT MATERIALS

System	Composition	Melting Point	Electrical Conductivity (IACS%)	Hardness (Hv)	Tensile Strength (kg/mm)	Density	Properties	Applications
Au	Au	1086	75	25-65	14-30	19.3	Very high resistance against acid and sulphur. Contact resistance constant over long periods. Recommended for low contact pressure.	Relay, Control switch, Micro-switch. (light duty) Generally used for electroplating.
	90Au-10Ag 80Au-20Ag 70Au-30Ag	1055 1045 1037	16 16	60 33-105	17 21	17.3 16.5 15.4	Additions of silver increase resistance to mechanical wear. Resistance to chemical attack remains unaltered.	Switching contact e.g. Telephone relays.
	69Au-25Ag-6Pt	1100	11	60	25	16.0	Good resistance to corrosion. High resistance to wear and tear. Low contact resistance.	Usual material for telecommunications.
Pt	Pt	1770	16	38-110	35-125	21.4	High melting point, which decreases material loss and reduces sticking under high local temperature conditions. Good resistance to corrosion or film formation which contributes to a low contact resistance.	Switching contacts with very low currents and volgages, e.g. measureing instrument.
	90Pt-10Ir	1800	7	150-200	35-63	21.6	Additions of iridium considerably improve resistance to mechanical wear, leaving resistance to chemical attack unchanged. High resistance to arc-erosion, mechanical wear and metal transfer.	Motorcar switches, Motor switches.
Pd	Pd 70Pd-30Ag 60Pd-40Ag 50Pd-50Ag 40Pd-60Ag 30Pd-70Ag 10Pd-90Ag	1550 1430 1395 1350 1290 1225 1080	16 4.3 4.3 5.7 8.2 11.5 30	4-110 90 80 75 65 60 55	14-35 38-77 38-66 40-70 42-77	12.0 11.5 11.4 11.2 11.1 10.9 10.6	Good mechanical strength. High resistance to chemical attack. Palladium-silver alloys with from 40% palladium are resistant to tarnishing in sulphurous atmospheres.	Switching contact, e.g. telephone relays and selectors.
	40Pd-30Ag-30Cu	1065	5.0	200-450	70-140	10.6	Highly wear and tear resistant	Sliding contact in precision potentiometer.

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System	Composition	Melting Poing (°C)	Electrical Contuctivity (IACS%)	Hardness (Hv)	Tensile Strength (kg/mm²)	Density	Properties	Applications
Ag	Ag	960	106	25	20-42	10.5	Highest electrical and thermal conductivity.	For all types of contacts for light duty instruments.
	90Ag-10Cd 85Ag-15Cd	877 877	50 35			10.3 10.2	Electrical conductivity is lower considerably than that of pure silver; relatively low contact resistance. Good arc-quenching properties	Switchgear up to medium electric power. Switching contact for Automobiles.
	Ag-CdO	960					Lower arc-erosion. Very good anti-welding properties. Much harder than silver. Contact resistance slightly higher than 90Ag/10Ni.	Medium duty relays, Switches, Thermostats.
	Ag-SnO2	960					Higher arc-crossing resistance than silver cadmium oxide. Highest resistance to welding. Comparatively high electrical conductivity. Cadmium less. Higher contact resistance than silver cadmium oxide.	Relay for vehicle. Heavy duty relays(multi purpose). Industrial start motors.
	90Ag-10Cu 80Ag-20Cu 60Ag-40Cu	778 778	86 82	62 85		10.3 10.2	Harder and more resistant to wear and tear than silver. Less resistant to chemical attack. Less tendency to welding. Recommended when low contact resistance and wiping action present.	Switches for vehicles. Household electric appliances. Rotary switch. Commutator.
	75Ag-24.5Cu-0.5Ni	810	68	135	56	10.1	Less tendency of material transfer; high resistance to wear and tear.	Relay for vehicles.
	92Ag-6Cu-2Cd	880	43	65	25-45	10.2	Arc-quenching properties. Low contact resistance kept with high contact pressure.	D.C. motor.
	90Ag-10Ni 85Ag-15Ni	960 960	91 88	65 73	25-40 25-40	10.3 10.3	Comparatively low contact resistance with good resistance to arc-erosion and sticking.	Relay for vehicles. Thermostats. Power relays. Electromagnetic switches.

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Silver Tin Oxide Contact Materials

Because of good resistance to welding and its low, stable contact resistance, silver cadmium oxide has been used universally for many switching devices. For the last ten years, newly developed contact materials have been partially replacing silver cadmium oxide as well as other silver alloys in applications where the electric burden has exceeded the capabilities of those conventional materials.

$AgSnO_2$ exhibit the following advantages.

1. Higher arc-erosion resistance than silver cadmium oxide. This property makes it possible to reduce the contact volume by 10~20%. Holding, its rating constant or to retain the present volume while boosting its electrical rating.
2. Highest resistance to welding.
3. Comparatively high electrical conductivity.
4. Cadmium less.
5. Excellent workability

Our $AgSnO_2$ has proved to be the optimum contact materials for many switching devices such as relays, switches , circuit breakers, electromagnetic relays and so on. One property peculiar to these material is their ability to cope with “inrush current” approximately ten times higher than the rated.

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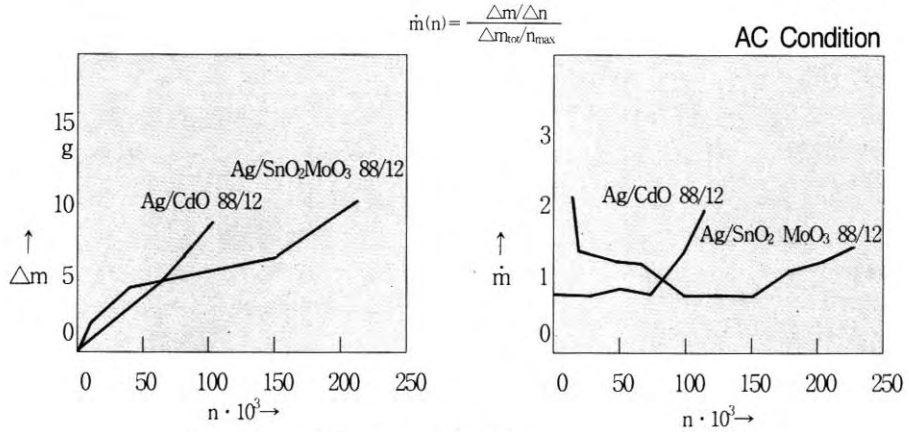
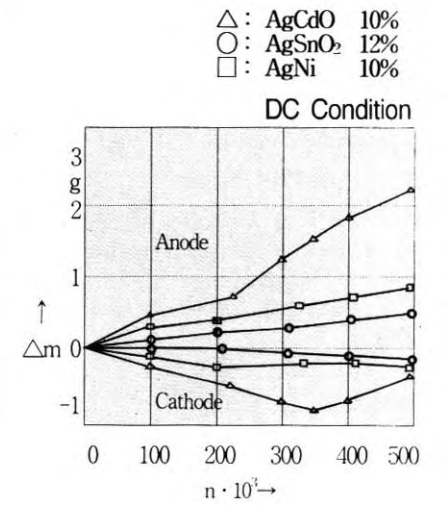
Group		Composition			Physical Properties			Electrical Properties			
		Ag	SnO_2	Others	Density	Electrical Conductivity (IACS%)	Hardness (HV)	Contact resistance	Resistance to arc-erosion	Resistance to welding and sticking	Resistance to wear and tear
Ag-SnO_2	SD-6	93	6	α 1, α 2	10.2	90	110	Good	Good	Fair	Good
	SD-8	91	8	α 1, α 2	10.1	78	115	Fair	Good	Fair	Fair
	SD-10	89	10	α 1, α 2	10.1	73	120	Poor	Good	Good	Fair
	SD-12	87	12	α 1, α 2	10	69	125	Poor	Good	Good	Fair



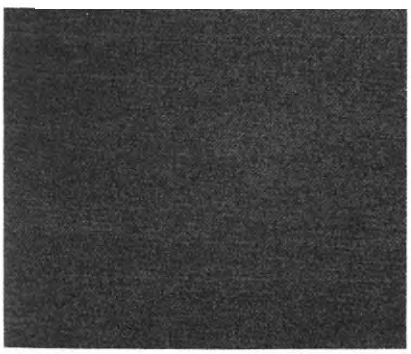
Ag-SnO_2 12% Ag-CdO 12%

Erosion behavior of AgCdO 12% and $AgSnO_2$ 12%



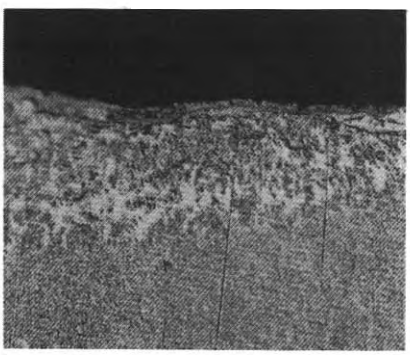
Transference property of contact materials

Ag- SnO_2 standard micro-structure



SD-12(×550)

Micro sections of the two contact materials after operations



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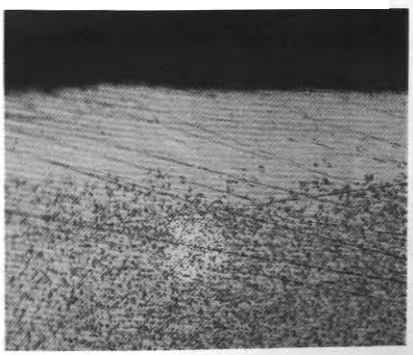

SK-202(×550)

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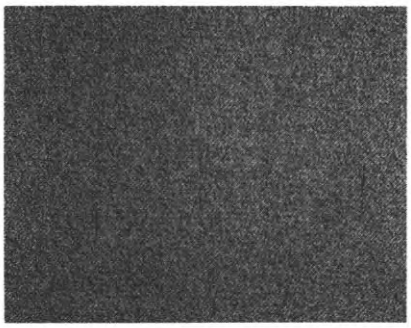
Silver Cadmium Oxide Contact Materials

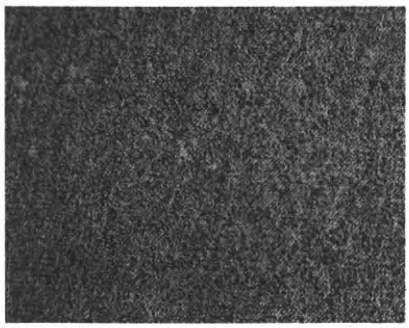
Except for fine silver, silver cadmium oxide is the most widely used contact materials for medium to high current duty the cadmium oxide remains as discrete particles uniformly and finely dispersed throughout the silver matrix and each component retains its individual characteristics. With the presence of cadmium oxide in silver, arc-extinction properties are also provided without the reduction of high electrical conductivity of the silver base.

Group		Composition			Physical Properties			Electrical Properties			
		Ag	CdO	Others	Density	Electrical Conductivity (IACS%)	Hardness (HV)	Contact resistance	Resistance to arc-erosion	Resistance to welding and sticking	Resistance to wear and tear
Ag-CdO	SK-110	90	10	-	10.2	76	65	Good	Poor	Poor	Poor
	SK-202	87.5	12	α1	10.2	72	70	Good	Poor	Poor	Poor
	SK-204	86	13.5	α1, α2	10.1	70	85	Fair	Fair	Good	Good
	SK-205	84.5	15	α1	10.1	65	85	Fair	Good	Fair	Good
	SK-206	83	16	α1, α2	10	65	100	Poor	Good	Good	Good

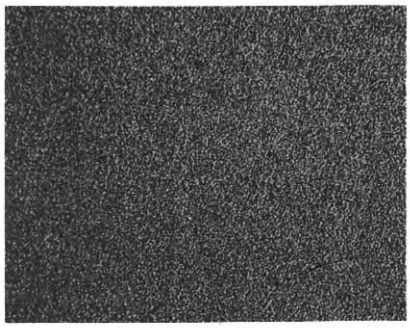
Ag-CdO standard micro-structure



SK-202(×100)



SK-204(×100)



SK-206(×100)

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Contact materials for Circuit Breaker

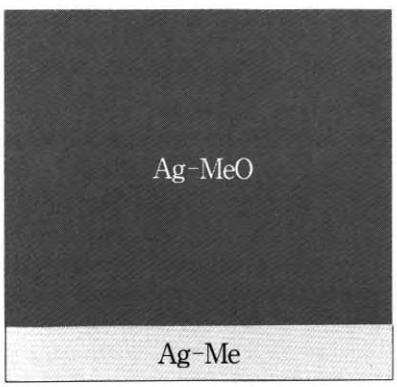
There are three types in contact materials for circuit breaker.

1. One side oxidization method
   - Whole oxidation zone in the core of the contact material.
   - Excellent junction strength.

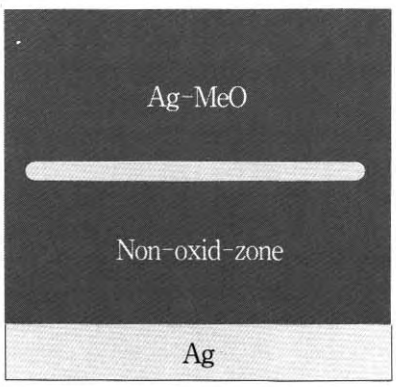
2. Two side oxidization method
   - Non-oxidation zone in the core of the contact material.
   - Unstable junction strength.

3. Tri-Metal Type
   - Easy to make automatic brazing.

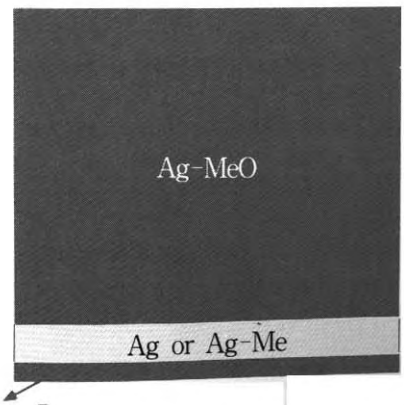
Group		Composition (wt%)			Physical Properties			Properties
		Ag	MeO	Others	Density	Electrical Conductivity (IACS%)	Hardness (HV)	
Ag-CdO	SKF-214	86	13.5	α1, α2	10.2	65	90	-Stable contact resistance -Lower welding property -Poor short-circuit property then Ag-SnO_2 - The ranges of using 30A-200A
	SKF-215	84	15	α1	10.1	65	95	
	SKF-216	82	17	α1, α2	10	60	100	
Ag-SnO_2	SDF-8E	91	8	α1	10.2	75	115	- Higher arc-erosion - Excellent short-circuit property - Excellent welding property - the ranges of using 30A-400A
	SDF-10S	89	10	α1, α2	10	70	125	
	SDF-40S	87	12	α1, α2	9.9	67	130	



One-side oxid-method



Two-side oxid-method



Tri-metal type

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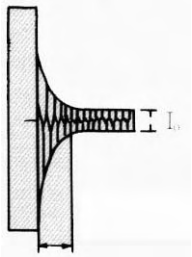
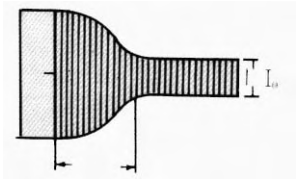
TECHNICAL DATA FOR CONTACT DESIGN

Inrush-current according to kinds of the load

Load and inrush current ranges as well as on-off speed are very close points to welding and wearing out of contact points. In a comparison with both type of contacts with high and low inrush current under same regular current, low inrush current contact is more damageable than other one.

<table>
<tr>
<td>(1) Normal electric bulb
Load I/I0=10~15times
about 1/3 seconds
  </td>
<td>(2) Mercury lamp load
I/I0=3times
3~5minutes
  </td>
<td rowspan="2">Inrush current / current amp
= I/I0</td>
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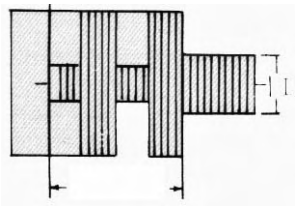
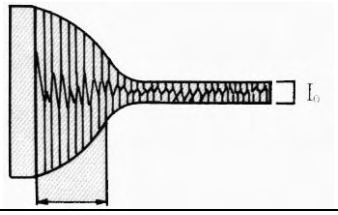
<tr>
<td>(3) Fluorescent lamp load
I/I0=5~10times
Within 10 seconds
  </td>
<td>(4) Motor
Motor Load
I/I = 5~10 times
0.2~0.5seconds
  </td>
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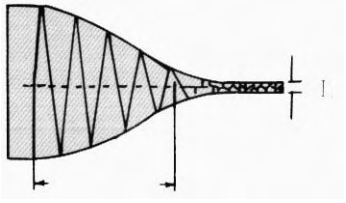
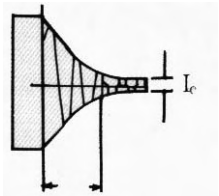
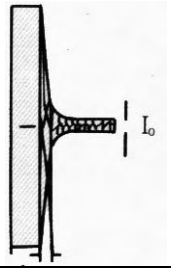
<td>(5) Solenoid
Solenoid load
I/I=10~20times
0.07~0.1 seconds
  </td>
<td>(6) Magnetic connecter load
I/I0=3~10times
1~2 seconds
  </td>
<td>(7) Condenser
Condenser load
I/I0=20~40times
1/2~1 Cycle
1/120/1/30seconds
  </td>
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Materials and Current Amp(A) / Per square (mm²)

For the best choice of materials and sizes of contacts points for replay and switches, current amphere should be mostly considered and the general data devided by using current to square of contact surface are shown as below.

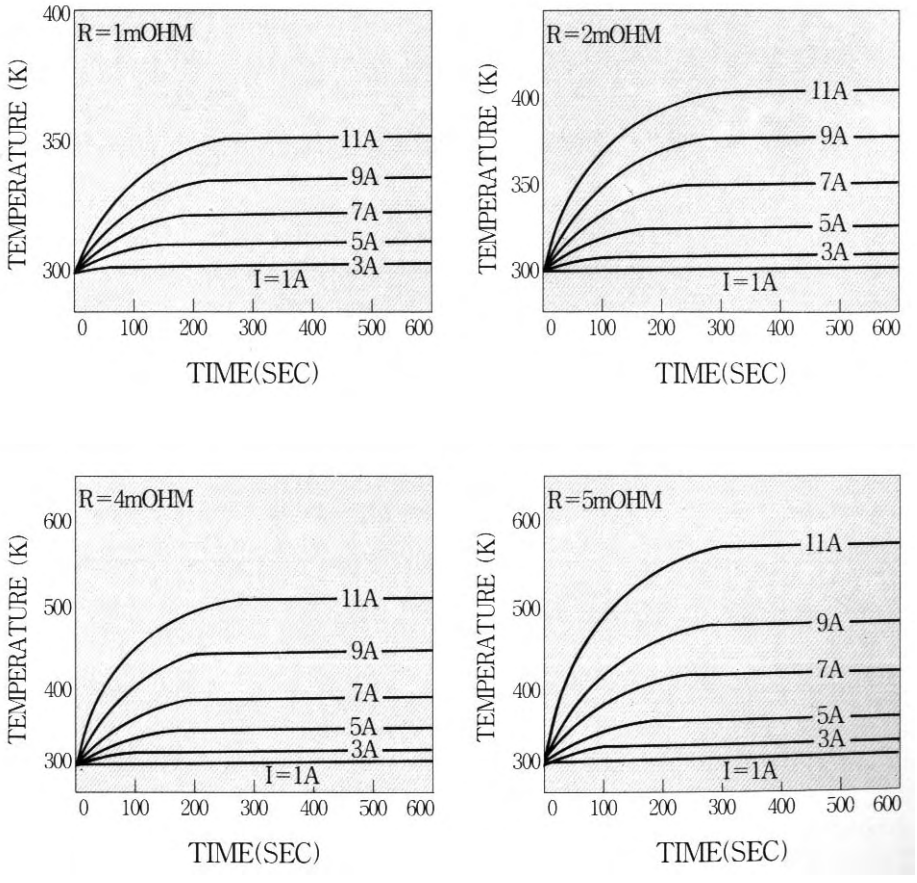
Contact Material	Current Amp(A)/Contact Square (mm²)	
	Rely	Switch
Ag	0.8-1.0	1.4-1.5
Ag-Ni	1.0-1.2	1.6-1.9
SK-110	1.0-1.2	1.6-2.0
SK-112	1.1-1.3	1.9-2.1
SK-204	1.3-1.6	2.0-2.4
SK-205	1.3-1.5	2.0-2.4
SD-6	1.3-1.7	2.1-2.6
SD-10	1.5-1.9	2.3-2.7
SD-12	1.9-2.3	2.6-3.0

Increasing temperature graph according to changes of contact resistance

Condition : Contact radius 1.5mm (constant)

Contact resistance 1-5mΩ(change)

Current Amp 3-12A (change)



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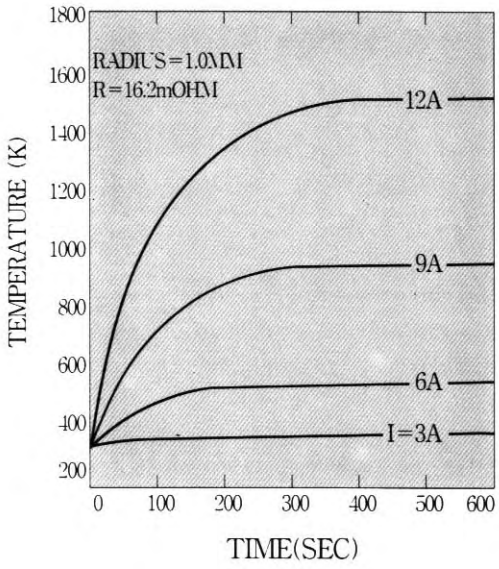
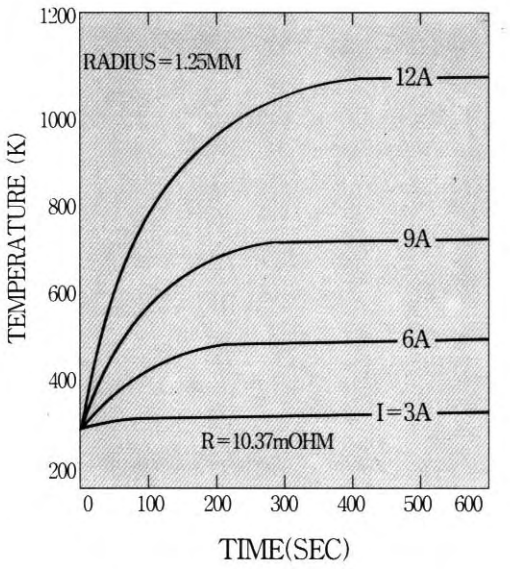
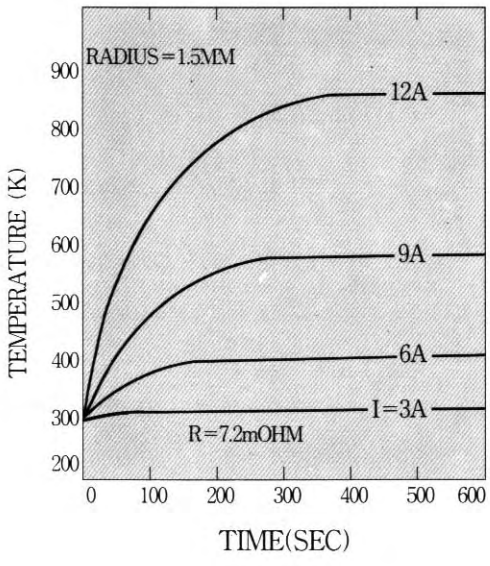
Increasing temperature graph according to changes of contact size

Condition : Constant contact material
Current Amp 3-12A
Contact radius 1.0/1.25/1.5mm







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Properties of the different groups of contact materials in relation to application

Group	Subgroup	Typical Example	Typical Application					
				W	R	E	M	Q
Ag/MeO	Ag/CdO i.o.	Ag/CdO 90/10	Contactor	A	E	A	E	E
		Ag/CdO 85/15	MCCB	E	E	E	A	E
	Ag/CdO p.m.	Ag/CdO 90/10	Contactor	A	E	A	E	E
		Ag/CdO 88/12	Contactor	A	E	E	A	E
		Ag/CdO 85/15	Contactor	E	E	E	A	E
	Ag/SnO_2 i.o	Ag/SnO_2 88/12	Contactor, MCCB	E	P	E	A	A
	Ag/ZnO	Ag/ZnO 92/8	MCCB	E	P	E	A	A
		Ag/Ni 90/10	Contactor, control switch	P	E	P	E	A
		Ag/Ni 80/20	Contactor	A	A	A	E	A
		Ag/Ni 80/20*	Starter	A	E	A	E	A
		Ag/Ni 70/30*	CLB	A	A	A	E	A
		Ag/Ni 60/40*	CLB	A	A	A	E	A
		Ag/C 97/3* *	Miniature CLB	E	E	P	P	A
		Ag/C 96/4*	Starter					
		Ag/C 95/5*	CLB	E	E	P	P	A
	Ag/W	Ag/W 40/60	MCCB	A	P	E	P	P
	Ag/WC	Ag/WC 60/40	Miniature MCCB	A	P	E	P	P

* Asymetric contact pairing Ag/Ni-Ag/C

** Asymetric contract pariting Ag/C-Cu

Note:

E excellent

A acceptable

P poor

MCCB molded-case circuit breaker

W welding

R resistance

E erosion

CLB current-limiting breaker

M arc mobility

Q quenching