

APPENDICES

Appendix A1

Compositions and properties of typical commercial silver-base contact materials manufactured by PM route :

Nominal composition	Density g/cc	Elec. conductivity m/Ω mm ² % IACS		Hardness	Ref.
100 Ag	10.5	60	-	30 (Hv10)	11
95 Ag-5C	8.6	43	-	40 (Hv10)	Doduco
90 Ag-10C	7.4	35	-	31 (Hv10)	Databook
85 Ag-15C	6.5	22	-	26 (Hv10)	
90 Ag-10 Ni	10.2	50	-	50-80 (Hv10)	1
80 Ag-20 Ni	10.0	46	-	60-90 (Hv10)	
70 Ag-30 Ni	9.8	41	-	85-100 (Hv10)	
50 Ag-50 W	13.06 - 13.33	-	57 - 70	50-65 HRB	
35 Ag-65 W	14.32 - 14.62	-	50 - 58	75-85 HRB	1
25 Ag-75 W	15.32 - 15.64	-	45 - 52	85-95 HRB	
50 Ag-50 WC	12.05 - 12.30	-	43 - 50	77-87 HRB	1
35 Ag-65 WC	12.80 - 13.06	-	32 - 37	95-105 HRB	
95 Ag- 5CdO	9.50 - 10.14	-	80 - 90	32 HRF	
90 Ag-10CdO	9.30 - 9.80	-	72 - 85	42 HRF	
85 Ag-15CdO	8.60 - 9.58	-	55 - 75	45 HRF	
92 Ag-8ZnO	10.2	49	-	60 (Hv10)	Doduco sales literature
88 Ag-12 SnO ₂ - In ₂ O ₃	9.9	30	-	100-120(Hv10)	

Appendix - A2

Toxicity data of cadmium and cadmium oxide [135]

Details	Cadmium	Cadmium Oxide
i) Properties	m.p 320 .9 °C, b.p.767 °C, density 8.642 g/cc, vapour pressure 1 mm of Hg at 394 °C, silver-white malleable metal	m.p./decomposition temp. 950 °C, b.p. 155 °C, density 8.15 g/cc vapour pressure, brown crystals
ii) OSHA PEL	TWA 0.1 mg (Cd) / m ³ , ceiling 0.6 mg (Cd) / m ³ (fumes)	TWA 0.2 mg (Cd) / m ³ , ceiling 0.6 mg (Cd) / m ³ (dust)
iii) ACGIH TLV	TWA 0.01 mg (Cd) / m ³ ((dust) ; human carcinogen	TWA 0.01 mg (Cd) / m ³ (dust) ; human carcinogen
iv) NIOSH REL	Reduce to lowest feasible level	Reduce to lowest feasible level
v) Listing	Listed in Community Right to know list	Listed in Community Right to know list and EPA 's Extremely Hazardous substances list
vi) Toxic effects	A poison by inhalation, ingestion and most other routes. A carcinogen and teratogen	A poison by ingestion, inhalation and intraperitoneal routes. A carcinogen.
vii) Symptoms	Pulmonary edema, dyspnea, cough tight chest, substernal pain ; headache ; chills, muscle aches ; nausea diarrhea ; anosmia, anemia ; proteinourea	Changes in the sense of smell, changes in heart rate, blood pressure increase, kidney or bladder changes, proteinourea

APPENDIX A3

Assembly language programme for AC contact testing

ADDRESS LOCATION	OP. CODE	MNEMONICS	DESCRIPTION
CO 00	3E	MVI A, 90 H	Initialization of 8255
CO 01	90		
CO 02	D3	OUT 13 H	
CO 03	13		
CO 04	11	LXI D 30D4	Set trial counter
CO 05	D4		for 12,500 op.
CO 06	30		
CO 07	01	LXI B, 0000	Set failure counter to zero
CO 08	00		
CO 09	00		
CO 0A	31	LXI Sp, C 300	Set stack pointer
CO 0B	00		
CO 0C	C3		
Again : CO 0D	3E	MVI A, 80 H	Relay ' ON ' bit 7 of port B.
CO 0E	80		
CO 0F	D3	OUT 11 H	
CO 10	11		
CO 11	CD	CALL DELAY	delay of 1 sec.
CO 12	10		
CO 13	C2		
CO 14	00	IN 10 H	Feedback comparison
CO 15	00		
CO 16	00	CPI 80 H	
CO 17	00		
CO 18	00	JZ NO ERR 1	If error, increment failure count
CO 19	00		
CO 1A	00		
CO 1B	00	INX B	
NO ERR 1 : CO 1C	3E	MVI A, 00	Relay OFF, bit 7 of port B, make 0
CO 1D	00		
CO 1E	D3	OUT 11 H	
CO 1F	11		
CO 20	CD	CALL DELAY	1 sec. delay
CO 21	10		
CO 22	C2		
CO 23	DB	IN 10 H	Comparison for feedback
CO 24	10		
CO 25	FE	CPI 00 H	
CO 26	00		
CO 27	C2	JZ NO ERR 2	If failed, increment failure register
CO 28	2B		
CO 29	CO		
CO '2A	03	INX B	

ADDRESS LOCATION	OP. CODE	MNEMONICS	DESCRIPTION
NO ERR 2 : CO 2B	1B	DCX D	Decrement trial counter
CO 2C	7A	MOV A, D	If trial counter not zero do once ; again
CO 2D	B3	ORA E	
CO 2E	C2	JNZ	
CO 2F	0D		
CO 30	C0		
CO 31	78	MOV A, B	Store total no. of failures in memory location C 200 and C 201 in hexadecimal format
CO 32	32	STA C 201 H	
CO 33	01		
CO 34	C2		
CO 35	78	MOV A, C	
CO 36	32	STA C 200 H	
CO 37	00		
CO 38	C2		
CO 39	3E	MVI A, 80 H	Relay on 10 minutes
CO 3A	80		
CO 3B	D3	OUT 11, H	
CO 3C	11		
CO 3D	11	LXI D, 04B0 H	10 minutes delay routine
CO 3E	B0		
CO 3F	04		
Back : CO 40	21	LXI H, B8F4 H	
CO 41	F4		
CO 42	B8		
CO 43	CD	CALL DLY	Basic delay routine
CO 44	13		
CO 45	C2		
CO 46	1B	DCX D	Count for 10 min. and stay in loop
CO 47	7A	MOV A, D	
CO 48	B3	ORA E	
CO 49	C2	JNZ Back	
CO 4A	40		
CO 4B	C0		
CO 4C	3E	MVI A, 00	make relay OFF after 10 minute
CO 4D	00		
CO 4E	D3	OUT 11	
CO 4F	11		
CO 50	2A	LHLD C200 H	Call display unit
CO 51	00		
CO 52	C2		
CO 53	06	MVI B, 00 H	
CO 54	00		
CO 55	CD	CALL MODIAD	
CO 56	62		
CO 57	03		
CO 58	CF		

Appendix A 4

Standards in Electrical Contacts

Following is a brief list of relevant standards useful in electrical testing of contact materials :

- * ASTM B 542 - 75 : Standard definitions of terms relating to electrical contacts and their use.
- * ANSI / ASTM B 193 - 78 : Standard test method for resistivity of electrical conductor materials
- * ASTM B 539 - 70 : Standard methods for measuring contact
(Reapproved 1975) resistance of electrical connections (static contacts)
- * ASTM B 497 - 79 : Standard recommended practice for measuring voltage drop on closed arcing contacts.
- * ANSI / ASTM B 576 - 79 : Standard recommended practice for designing an arc erosion test for electrical contact materials
- * ANSI / ASTM B 182 - 49 : Standard method of life test of electrical contact
(Reapproved 1975) materials
- * ASTM B 277- 72 : Standard test method for hardness of electrical contact materials
- * ASTM B 477 - 72 : Standard specifications for general requirements for wrought precious metal electrical contact materials

- **Standards as per IEC 947 : Low-voltage Switchgear and Controlgear**
- IEC 947 - 1 (1988) Part 1 : General rules
- IEC 947 - 2 (1989) Part 2 : Circuit-breakers
 - Amendment 1 (1992)
 - Amendment 2 (1993)
- IEC 947 - 3 (1990) Part 3 : Switches,disconnectors,switch-disconnectors and fuse combination units
 - Amendment 1 (1994)
- IEC 947-4-1(1990) Part 4 : Contactors and motor -starters
 - section one : Electromechanical contactors and motor starters
- IEC 947-5-1(1990) Part 5 : Control circuit devices and switching elements
 - section one : Electromechanical control circuit devices
 - Amendment 1 (1994)
- IEC 947-5-2 (1992) Part 5 : Control circuit devices and switching elements
 - section two : proximity switches
- IEC 947-6-1 (1989) Part 6 : Multiple function equipment
 - section one: Automatic transfer switching equipment
- IEC 947-6-2 (1992) Part 6 : Multiple function equipment
 - section two : Control and protective switching devices (or equipment) (CPS)
- IEC 947-7-1 (1989) Part 7 : Ancilliary equipment
 - section one : Terminal blocks for copper conductors
- IEC 1095 (1992) : Electromechanical contactors for household and similar purposes

Appendix A 5

Publications from present research work.

1. Preparation and characterization of Ag-ZnO powders for applications in electrical contact materials
Published in Jr. of Materials Science Letters, UK, 14 (1995) pp.1099-1101.
2. Powder metallurgical silver-metal oxide electrical contacts by an electroless coating process
Published in Jr. of Advanced Powder Technology, Japan Vol.7, No.2, (1996) pp.121-130.
3. Processing of electrical contacts grade Ag ZnO powders by alternative routes
Published in Quarterly International Journal, Powder Metallurgy Science and Technology, Vol. 6, No.2, Jan (1995) pp 26-34.
4. Electrical contacts grade silver-zinc oxide powders by spray-coprecipitation technique- Processing and characterization
Published in Transaction of Powder Metallurgy Association of India, Vol. 21 (1994) pp.27-29.
5. Applications of silver-base composite electrical contact materials
Published in Proceedings of Seminar on ' Silver and its Engineering applications ' organised by Indian Institute of Metals, Baroda chapter, held on 22 nd April'95
6. New powder metallurgical silver-zinc oxide electrical contacts by mechanical alloying
Communicated to Journal of Advanced Powder Technology, Japan for publication
7. Effects of Li addition on density and oxide phase morphology of Ag-ZnO electrical contact materials
Communicated to Journal of Materials Letters, Netherlands for publication.