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Standard Guide for Silver-Cadmium Oxide Contact Material[1]

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1. Scope

1.1 This guide provides guidelines for users and manufacturers of silver-cadmium oxide material produced in strip, rod, wire, and part form for electrical contact applications.

1.2 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.3 It is the responsibility of the user to become familiar with all hazards including those identified in the appropriate Material Safety Data Sheet for this product/materials as provided by the manufacturer.

2. Referenced Documents

2.1 *ASTM Standards:*

B 311 Test Method for Density of Cemented Carbides[2]

B 476 Specification for General Requirements for Wrought Precious Metal Electrical Contact Materials[3]

C 914 Test Method for Bulk Density and Volume of Solid Refractories by Wax Immersion[4]

NOTE 1—Test Method B 311 is applicable to fully dense forms. Specification B 476 is applicable to strip, rod, or wire only. Test Method C 914 is applicable to forms less than 99 % dense.

3. Terminology

3.1 *lot*—(*usage involving discrete manufactured parts*)—all parts of the same form, and dimensions, from the same alloy melt or batch of particulate (if manufactured by consolidation), processed under the same conditions, and submitted for inspection at the same time.

4. Significance and Use

4.1 Silver-cadmium oxide is a popular contact material that has been used in a wide range of applications in switches, relays and contactors for switching lamps, motors and resistive loads. Silver-cadmium oxide is a composite material consisting of a metal matrix, silver, with a metal oxide, cadmium oxide, dispersed throughout the matrix. Compositions of up to 30 % cadmium are made, but most applications use silver-cadmium oxide in the range of 10 to 15 % cadmium oxide by weight. Several different processes are used for manufacturing silver-cadmium oxide material and it should be understood that the manufacturing method has an influence on the properties of the material such as arc erosion resistance, welding resistance, arc mobility and contact resistance. Since the performance of contacts in a device is dependent on numerous factors outside the contact itself (opening speed, closing speed, contact pressure, contact bounce and many more device parameters), the guide cannot ensure performance in specific applications.

4.2 Arc erosion resistance and welding resistance are improved by the addition of cadmium oxide to the silver matrix. The contact resistance is raised by this addition but still is low. Cadmium oxide and silver do not alloy so the silver matrix retains its high conductivity. Silver-cadmium oxide contacts are used in current ranges of a few amperes to several hundred amperes.

4.3 Silver-cadmium oxide contact material is available as wire, silver-clad wire, sheet, strip, toplay, inlay and overlay sheet or strip, discrete contact parts, brazed contact assemblies, solid and composite rivet contacts and clad contact tapes.

4.4 Materials with higher cadmium oxide contents have lower material costs but may have higher processing costs due to lower formability.

5. Manufacture

5.1 Since the manufacturing method has a significant influence on the properties and microstructure of silver-cadmium oxide materials, it is important to understand some basic information on the types of manufacturing. Silver-cadmium oxide manufacturing can be first divided in two categories: Internal Oxidation and Power Metallurgy.

5.1.1 Internal oxidation means that the cadmium oxide particles are formed by diffusion of oxygen into the silver alloy to combine with cadmium atoms to form cadmium oxide particles. This process can be further divided into the categories of post and pre-oxidized materials. The post-oxidized process consists of performing the diffusion process after the finished parts have been formed. The pre-oxidized process

[1] This test method is under the jurisdiction of ASTM Committee B-2 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B2.05 on Precious Metals.

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[2] *Annual Book of ASTM Standards*, Vol 02.05.

[3] *Annual Book of ASTM Standards*, Vol 02.04.

[4] *Annual Book of ASTM Standards*, Vol 15.01.

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consists of oxidation of slugs and the forming of wire or strip from the oxidized slugs and then forming the final parts. The cadmium oxide particle size distribution is dependent upon the grain structure of the silver cadmium alloy, any additive concentration, and oxidation conditions (for example, temperature, oxygen partial pressure).

5.1.2 For powder metallurgy silver-cadmium oxide, the material is made from a blend of silver and cadmium oxide powder or other cadmium compounds such as cadmium carbonate, which can be thermally decomposed to cadmium oxide in a subsequent step. There are two basic types of this process, one in which the contacts are pressed and sintered and repressed into the final shape, and the other where a billet is made from blended powder which is then formed into strip and wire and made into the final contact shapes.

5.1.3 All of these processes have many variations. There are also hybrid processes such as internally oxidized powders which are then processed by powder metallurgy. The user should obtain the basic information as to the type of material being purchased.

5.1.4 For purposes of attachment to bare metal supports, silver-cadmium oxide contact material is often produced with a conductive or brazable layer of material or backing. Incorporation of such a layer is often an integral part of the silver-cadmium oxide manufacturing process.

5.1.5 Silver-cadmium oxide materials vary from full theoretical density to about 95 % of theoretical density depending on the specific manufacturing method.

5.1.6 The flexibility of the silver-cadmium oxide materials system allows many additional manufacturing methods to be introduced, and those mentioned here are not a comprehensive listing. The cadmium-oxide particle size, distribution, and uniformity in combination with the contact density and chemical composition (see 6.2 Additives and Impurities) determine the performance characteristics of the electrical contacts in service. It may be of importance to specify the type of microstructure, in which case, it is recommended that photographs of acceptable microstructures be agreed upon between the producer and the user, as well as photographs illustrating unacceptable types of microstructures. It is highly recommended that these attributes be considered in making selection or replacement decisions and that full qualification tests be performed by the user or purchaser including functional electrical tests for new or altered selections and manufacturing sources.

5.2 No substantive change shall be made in the manufacturing processes or materials, or both, of the silver-cadmium oxide contact material without notification to and approval by the user.

6. Chemical Composition

6.1 Material produced under this guide shall meet the composition of silver and cadmium oxide agreed upon by the vendor and user. Popular compositions and suggested tolerances are given in Table 1. In the case of material supplied with a distinct brazable or conductive backing, such backing shall not be considered to be included in the silver-cadmium oxide material composition.

6.2 *Additives and Impurities*:

TABLE 1 Suggested Chemistries and Theoretical Densities

	90 Silver/10 Cadmium-Oxide	86.5 Silver/ 13.5 Cadmium-Oxide	85 Silver/15 Cadmium-Oxide	80 Silver/20 Cadmium-Oxide
Chemistry				
Cadmium-Oxide weight %	10.0 ± 1.0	13.5 ± 1.0	15.0 ± 1.0	20.0 ± 1.0
Silver weight % , min	89.0	85.5	84.0	79.0
Other elements	(see 6.2)			
Theoretical Densities at Nominal Composition:				
Mg/m^3	10.2	10.1	10.1	9.92
troy oz./in.^{3}	5.37	5.32	5.30	5.23

6.2.1 A wide variety of chemical additives have been made to silver-cadmium oxide materials for processing and performance purposes. The merits of these additions remain a point of contention. Additionally, various impurities may remain in these materials from raw materials or processing which have been found to be either detrimental or helpful depending on the residual level and the individual application. Chemical requirements for such elements and analytical methods to be employed shall be mutually agreed to by the producer and user.

6.3 No substantive change shall be made to additives or impurities without notification to and approval by the user.

7. Other Properties

7.1 Mechanical properties of silver-cadmium oxide contact materials are very dependent on the manufacturing method. For this reason, only guideline properties are given.

7.1.1 Table 2 indicates guideline properties for some discrete part contacts of popular silver-cadmium oxide compositions in the annealed state.

7.1.2 Properties in coined, repressed, headed, or other states will vary due to the effects of coldworking. Additives and oxidation method also alter these properties.

7.1.3 Guideline properties are given in Table 3 for popular silver-cadmium oxide compositions in wire and strip form.

7.2 Specific properties and tolerances shall be established and agreed to between the producer and user for any particular commercial designation of silver-cadmium oxide material and temper required.

8. Sampling and Inspection

8.1 Material or parts furnished under this guide shall be inspected by the producer listed as follows. Results of such inspection shall conform to values agreed to between the producer and user.

8.1.1 *Strip and Wire Procured to Temper* shall be sampled and tested in accordance with Specification B 476 (when specified and applicable).

8.1.1.1 Such other properties as are required to verify the quality of the material produced under this guide.

8.1.2 *Discrete Contact Parts* produced under this guide shall be sampled and tested on a lot basis. For the purpose of this guideline, a lot is defined in 3.1.

8.1.2.1 For *Dimensional Conformance.*

8.1.2.2 *Other Properties* as are required to verify the quality of the material produced under this guide.

TABLE 2 Typical Part Properties Made by Powder Metallurgy (Annealed[A] State)

NOTE 1—Due to lack of commercially available information, some values are not listed.

	90 Silver/10 Cadmium-Oxide	86.5 Silver/13.5 Cadmium-Oxide	85 Silver/15 Cadmium-Oxide	80 Silver/20 Cadmium-Oxide
Type A: Parts processed so as to be "full dense."				
Density:				
Mg/m^3, min	9.96	9.89	9.82	9.73
troy oz/in.^{3}	5.25	5.21	5.17	5.13
Electrical resistivity:				
nΩm, min	19.2	20.3	21.0	22.4
nΩm, max	23.9	23.9	26.9	27.4
Electrical conductivity:				
% IACS, min	72	72	64	63
% IACS, max	90	85	82	77
Hardness:[B]				
HR30T, min	17	20	20	25
HR30T, max	51	51	52	53
Type B: Parts processed to conventional repressed densities and annealed.				
Density:				
Mg/m^3, min	9.46	—	9.33	—
troy oz/in.^{3}	4.98	—	4.92	—
Electrical resistivity:				
nΩm, min	20.3	—	24.6	—
nΩm, max	24.6	—	34.5	—
Electrical conductivity:				
% IACS, min	70	—	50	—
% IACS, max	85	—	70	—
Hardness[B]				
HR30T, min	43	—	28	—
HR30T, max	57	—	45	—

[A] Annealed state achieved by heating 600°C min, for 20 min minimum.

[B] Ranges indicate values reported by many different manufacturing methods and are much broader than would be expected for any specific product.

9. Rejection and Rehearing

9.1 Material that fails to conform to the requirements of this guide may be rejected. Rejection should be reported to the producer or supplier promptly within 30 days of the receipt of the shipment and in writing. When results of the test are not satisfactory, the producer or supplier may make claim for a rehearing.

10. Keywords

10.1 cadmium oxide; cadmium; contacts; internal oxidation; powder metallurgy; silver-cadmium oxide; silver; wrought

TABLE 3 Properties (Strip and Wire)

NOTE 1—Due to a lack of commercially available information, some values are not listed. %IACS is volume basis and "red," equals reduction.

	90 Silver/10 Cadmium-Oxide		86.5 Silver/13.5 Cadmium-Oxide		85 Silver/15 Cadmium-Oxide		80 Silver/20 Cadmium-Oxide	
Density:								
Mg/m^3, min	9.99		9.89		9.86		9.73	
troy oz/in. ^{3}	5.26		5.21		5.19		5.13	
	Typical Ranges		Typical Ranges		Typical Ranges		Typical Ranges	
	min	max	min	max	min	max	min	max
Wire:								
Ultimate tensile:								
Annealed, MPa	207	310	221	331	241	345	276	350
(0% red), ksi	30	45	32	48	35	50	40	54
1/4 hard, MPa	290	380	303	414	317	427	331	440
(21 % red), ksi	42	55	44	60	46	62	48	65
hard, MPa	345	448	355	464	380	496	390	496
(60 % red), ksi	50	65	50	68	55	72	55	72
Elongation:								
Annealed % (2 in.) (0 % red)	25	—	14	—	14	—	13	—
1/4 hard % (2 in.) (21 % red)	3	—	3	—	2	—	1	—
hard % (2 in.) (60 % red)	1	—	—	—	—	—	—	—
Electrical resistivity:								
Annealed nΩm (0 % red)	—	19.2	—	20.8	—	—	—	—
1/4 hard nΩm (21 % red)	—	19.2	—	21.6	—	—	—	—
hard nΩm (60 % red)	—	19.2	—	—	—	—	—	—
Electrical conductivity:								
Annealed MS/m	43.5	—	39.4	—	—	—	—	—
(0 % red)% IACS	75	—	68	—	—	—	—	—
1/4 hard MS/m	41.8	—	37.7		—	—	—	—
(21 % red)% IACS	72	—	65	—	—	—	—	—
hard MS/m	40.0	—	—	—	—	—	—	—
(60 % red)% IACS	69	—	—	—	—	—	—	—
Strip:								
Hardness:								
Annealed HR30T (0 % red)	20	51	23	52	25	52	28	55
1/4 hard HR30T (11 % red)	45	65	45	65	46	66	48	70
hard HR30T (37 % red)	50	72	52	72	53	73	55	75
Electrical resistivity:								
Annealed nΩm (0 % red)	—	19.2	—	—	—	21.6	—	—
1/4 hard nΩm (11 % red)	—	20.3	—	—	—	21.6	—	—
hard nΩm (37 % red)	—	20.8	—	—	—	21.8	—	—
Electrical conductivity:								
Annealed MS/m	41.8	—	—	—	37.7	—	—	—
(0 % red)% IACS	72	—	—	—	65	—	—	—
1/4 hard MS/m	40.6	—	—	—	37.1	—	—	—
(11 % red)% IACS	70	—	—	—	64	—	—	—
hard MS/m	40	—	—	—	36.5	—	—	—
(37 % red)% IACS	69	—	—	—	63	—	—	

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