

# E-20, E-40, and E-60 E- Material

Effective: March 23, 2012

Revision F

## 1.SCOPE

This specification defines the requirements of three grades of beryllium - beryllium oxide Metal Matrix Composites designated as E-XX, where the XX designates the nominal BeO loading in volume percent.

## 2.CHEMICAL COMPOSITION

2.1. The chemical composition shall conform to the following:

	Material		
	E-20	E-40	E-60
Beryllium Oxide, wt. % max.	32.25	54.80	73.20
Beryllium Oxide, wt. % min.	25.80	49.50	69.40

Be shall be determined by titration. BeO shall be determined by difference using the following calculations:

$$\% \text{ Oxygen} = 100\% - (\text{Titrated Be} + \text{Impurities})$$

$$\% \text{ BeO} = \% \text{ Oxygen} \times 1.5631$$

### 3.DENSITY

- 3.1. The bulk density shall be equal to or greater than a minimum value. The minimum bulk density of each grade of E Material is listed below:

MATERIAL	DENSITY	
	g/cm <sup>3</sup>	lbs/in <sup>3</sup>
E-20	2.045	(0.0739)
E-40	2.277	(0.0823)
E-60	2.513	(0.0908)

- 3.2. Density shall be determined using the water displacement method.

### 4.MODULUS

- 4.1. Typical minimum tensile modulus for the materials at room temperature is listed below:

MATERIAL	Msi	Gpa
	E-20	42
E-40	44	303
E-60	46	316

Tensile Modulus results can be reported for informational purposes when requested.

- 4.2. When required, mechanical properties shall be determined for each lot of material, defined by each combination of powder lot (blend) and HIP run. The properties may be determined from a sample shape (component) or from material produced as an integral part (prolongation) of a shape (component) from the lot.

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## 5.THERMAL CONDUCTIVITY

- 5.1. The thermal conductivity of the three grades shall be no less than:

MATERIAL	THERMAL CONDUCTIVITY	
	<u>K Btu/hr•ft°F</u>	<u>W/m- °K</u>
E-20	115	200
E-40	118	205
E-60	121	210

- 5.2. The thermal conductivity of the materials may be determined using one of two methods: flash thermal diffusivity, an indirect method, or direct measurement by the axial rod method.

- 5.3. The thermal diffusivity is reduced to the thermal conductivity by the following relationship:

$$K = (\rho) \times (Cp) \times (a)$$

K = Thermal Conductivity

p = Density (From Section 3)

Cp = Specific Heat (See Table 5.5)

a = Thermal Diffusivity (Experimentally Determined)

Using this equation, the thermal conductivity of acceptable material shall not be less than the values listed in 5.1.

- 5.4. The density value used to determine compliance with Section 3 is also used for this calculation.

- 5.5. The specific heat of the materials at 77°F( 25°C) is listed in the following Table.

This data is for use at 77°F( 25°C) only.

MATERIAL	SPECIFIC HEAT at 77°F( 25°C)	
	<u>Btu/ft-°F</u>	<u>cal/g-°C</u>
E-20	0.379	1.584
E-40	0.336	1.407
E-60	0.310	1.260

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- 5.6. If the thermal conductivity is measured directly, the value measured must be equal to or greater than the values reported in 5.1 for the material to be considered acceptable.

## 6. COEFFICIENT OF THERMAL EXPANSION (CTE)

- 6.1. The Mean Coefficient of Thermal Expansion of the three grades of E- Materials for the temperature range between 25°C and 100°C shall lie within the ranges specified below:

MATERIAL		COEFFICIENT OF THERMAL EXPANSION	
		ppm/°F	ppm/°C
E-20	Minimum	5.3	9.5
	Maximum	6.1	11.0
E-40	Minimum	4.4	8.0
	Maximum	5.3	9.5
E-60	Minimum	3.6	6.5
	Maximum	4.4	7.9

- 6.2. Coefficient of Thermal Expansion testing will be conducted in accordance with ASTM E228 or ASTM E289.

## 7. TOLERANCES

- 7.1. Materials furnished under this specification shall conform to the dimensions and dimensional tolerances as established by the purchase order and applicable drawings. If tolerances are not specified by the purchase order, the following standard tolerances shall apply employing ANSI 14.5M:
- 7.2. Thickness:  
 For thickness up to 0.100" (2.5 mm), tolerance will be +/- 0.003" (0.076 mm).  
 For thicknesses from 0.100" (2.5 mm) to 0.500" (12.7 mm), tolerance will be +/- 0.004" (0.102 mm).  
 For thickness over 0.500" (12.7 mm), tolerance will be +0.125"/- 0" (+3.175 mm/-0 mm)
- 7.3. Width and Length:  
 For width and length up to 15" (381 mm), tolerance will be +0.125"/- 0" (+3.175 mm/-0 mm)

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7.4. Flatness: 0.001 inch/inch (0.025 mm/mm) maximum.

7.5. Surface Finish: 125 RMS maximum.

## 8.REPORTS

Certification of Compliance with this specification will be furnished on request and, when specified, actual test results and calculations will be provided. Testing in accordance with individual customer instructions will be performed if mutually acceptable and actual test results will be certified.

Note: The reported density and tensile properties shall be representative of the machined shapes in the condition delivered.

## 9.MARKING

9.1. Each lot of material shipped to the customer will be appropriately identified, packaged and labeled to include the following:

Materion Brush Inc.

Lot Number

Specification Number

Purchase Order Number

Warning Beryllium

9.2. Additional marking and serialization can be performed at customer request.

## 10.INFORMATION

10.1. Additional information on the physical, thermal and mechanical properties are available from Materion Brush Inc.

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## 11. SAFETY / ENVIRONMENTAL

- 11.1. Handling Beryllium Containing Material in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on Beryllium Containing Material, contact Materion Brush Beryllium & Composites, EH&S Product Steward @ 216-383-4040

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