CERAMIC TO METAL TECHNICAL INFO.

CERAMIC-TO-METAL SEAL TERMINALS POSSESS A UNIQUE COMBINATION OF DESIRABLE ELECTRO-MECHANICAL, THERMAL AND CHEMICAL CHARACTERISTICS, SOME OF WHICH ARE LISTED:

Ceramics are mechanically stronger than glass and withstand higher temperatures, both continuously and sudden temperature spikes.

Terminals constructed with ceramic-to-metal seals can be more thoroughly outguessed with vacuum pumping with resultant longer life. This is because they are dense and nonporous..

Dielectric properties of ceramics are superior to those of glass, and electrical resistance remains high even at high temperatures..

Vacuum tight seals are readily obtained and gas permeation through the ceramic body itself is below detectable limits.

Ceramics are more chemically inert than glass, unaffected by acids, strong alkalies and organic solvents and electrolytes.

Ceramic-to-metal seal terminals exhibit outstanding performance characteristics at extremes of temperature, humidity and pressure, and under physical shock or in corrosive environments.

Ceramic terminals withstand extreme vibration and shock with no effect on the seal. Regardless of the harsh conditions,ceramic terminal will withstand rated current and voltage, they maintain high insulation resistance, and do not exhibit any excessive shunt capacitance or dielectric losses.

• CERAMIC PROPERTIES

The properties of ceramic that are of interest in applications of ceramic-to-metal seal terminals are listed in (Table A below). Vacuum tightness of a ceramic body reflects its integrity in terms of absence of connected pore, fissures and cracks. A reliable test for vacuum tightness is based on the permeation of helium, which is injected on one side of the terminal and detected on the other side by a mass spectrometer with a sensitivity of 10^{-19} c.c. atm / sec.

Generally, physical properties of ceramics improve as alumina content increases; i.e., resistively dielectric strength, thermal conductivity and chemical resistance.

• CHARACTERISTICS OF CERAMICS USED IN TERMINALS

The ceramic-to-metal seal is a true high vacuum seal capable of withstanding temperature extremes up to 870°C and as low as -270°C (in liquid helium). Repeated submersion into liquid nitrogen (-200°C) and return to ambient temperature has shown no evidence of ceramic or seal deterioration. Ceramics offer chemical stability that is vastly superior to glass.

Table A

PROPERTIES*		UNITS	TEST	ENVIROPTICS INSULATORS Nom. 94% Al_2O_3	Nom. 96% Al_2O_3
SPECIFIC GRAVITY			ASTM C20-70	3.62	3.72
HARDNESS	ROCKWELL	R45N	ASTM E18-67	78	78
	KNOOP	GPa	1000-g load	11.1	11.1
WATER ABSORP.			ASTM C373-72	NONE	NONE
COLOR				WHITE	WHITE
COMPRESSIVE STRENGTH	25ºC	MPa (kpsi)	ASTM C773-74	2103 (305)	2068 (300)
	1000ºC			345 (50)	- (-)
FLEXURAL STRENGTH	TYP., 25ºC	MPa (kpsi)	ASTM F417-75T	352 (51)	358 (52)
	MIN., 25ºC***			317 (46)	324 (47)
	TYP. 1000ºC			138 (20)	172 (25)
	MIN., 1000ºC***			117 (17)	138 (20)
TENSILE STRENGTH	25ºC	MPa (kpsi)	ACMA TEST #4	193 (28)	193 (28)
	1000ºC			103 (15)	96 (14)
THERMAL CONDUCTIVITY	20ºC	(g-cal)/ (sec) (cm^2) (ºC/cm)	ASTM C408-58	18.0 (0.043)	24.7 (0.05)
	100ºC			14.2 (0.035)	18.8 (0.045)
	400ºC			7.9 (0.017)	10.0 (0.024)
	800ºC	W/m-K		5.0 (0.010)	5.4 (0.013)
SPECIFIC HEAT	100ºC	J/kg-K (cal/g/ºC)	ASTM C351-61	880 (0.21)	880 (0.21)
DIELECTRIC STRENGTH	6.35mm	kv/mm (volts/mil)	ASTM D116-69	AC	AC
	3.18mm			8.7 (220)	8.3 (210)
	1.27mm SPEC			11.8 (300)	10.8 (275)
	0.64mm THICK			16.7 (425)	14.6 (370)
	0.25mm			21.6 (550)	17.7 (450)
				28.3 (720)	22.8 (580)
DIELECTRIC CONSTANT				25ºC	25ºC
	1 kHz		ASTM D150-70	8.9	9.0
	1 MHz		ASTM D2520-70	8.9	9.0
	100 MHz			8.9	9.0
DISSIPATION FACTOR	1 kHz			.0002	.0011
	1 MHz		ASTM D150-70	.0001	.0001
	100 MHz		ASTM D2520-70	.0005	.0002

They are unaffected by acids, strong alkalis and most organic solvents. Five - year test evaluations of ceramic (96% alumina) in 30 weight percent of potassium hydroxide have shown no measurable weight loss or physical property changes.

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• ELECTRICAL CHARACTERISTICS

A high insulation resistance is the basic requirement for a good terminal. Ceramic insulation's used at EnvirOptics are non-porous, non-hygroscopic and have high insulation resistance.

Most insulating materials exhibit transient leakage under direct current voltage. This phenomenon is known as charging current or transient polarization. Other factors, however, also enter into insulation resistance measurements: while a material may be considered as an insulator, it still contains movable electrons. Therefore, to obtain an accurate measurement, it is necessary that enough voltage stress be applied to a sample so that movable electron is affected. EnvirOptics uses a standard of 500 VDC to achieve reproducible results. Since the insulating material of a terminal should have a high intrinsic resistively, if means are taken to limit surface leakage, the measured resistance should also be high. Any low resistance readings would indicate a flaw in the insulation. This testing requires the cleaning of all dirt, moisture and fingerprints from the ceramic surface. EnvirOptics terminals have a minimum insulation resistance of 10 10 ohms at ambient temperature .

"ALUMINA" CERAMIC INCULATOR BODY

VOLUME RESISTIVITY VS. TEMPERATURE

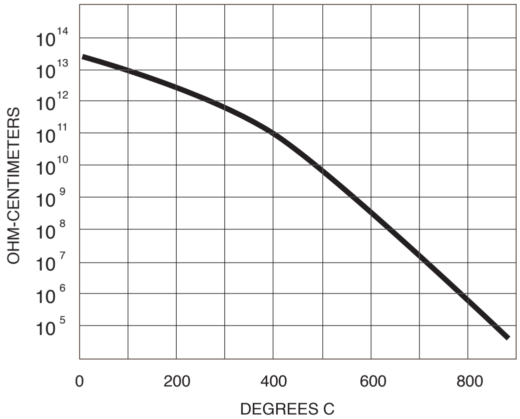
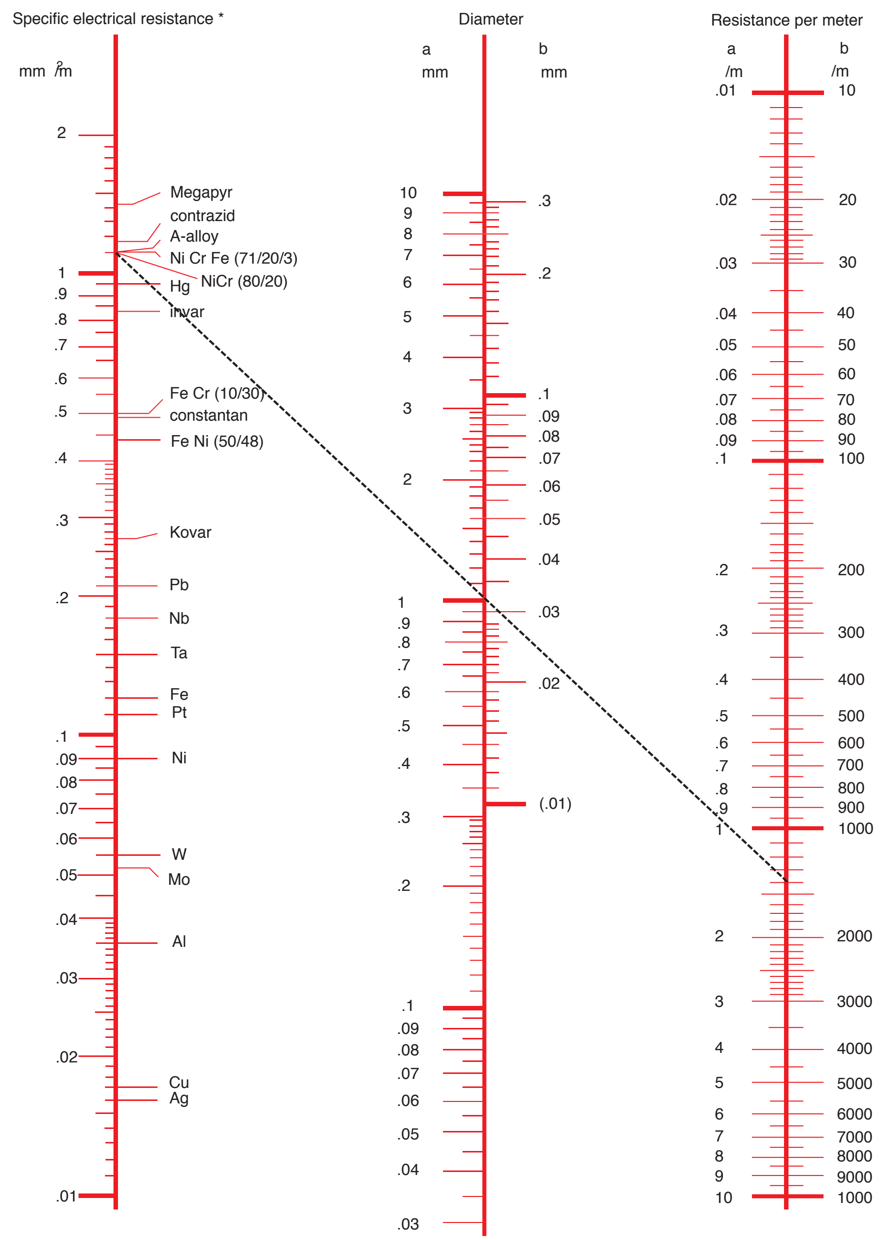


CHART B

CHART C
NOMOGRAPH FOR DETERMINATION OF METER RESISTIVELY OF METAL WIRES



* for • cm, mulitply by 10^{-4}

Nickel caps brazed over moly pins are used where both excellent chemical stability and good thermodynamic match are needed, usually with center conductors larger than .50.

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• CENTER CONDUCTOR

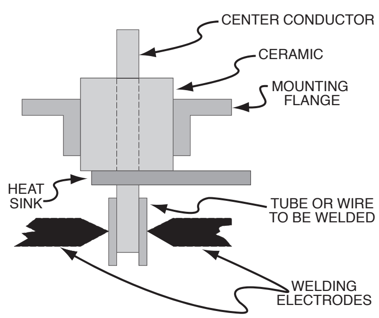
Molybdenum pins, nickel tubes and nickel caps over moly pins are used in EnvirOptics terminals. Molybdenum pins exhibit near perfect thermal dependent characteristics for integral seals to alumina. Their high tensile strength, electrical conductivity and high melting point combine to provide excellent current carrying center conductor. Nickel tubes are used where chemical stability is required.

While nickel's linear coefficient of expansion match is not good as molybdenum, temperature range and shock capabilities are more than adequate for most applications. Use of the nickel tube (a thin wall type) provides the elasticity required for a good seal. Nickel tubes may be used up to .50" in diameter, and are excellent for electrical and thermocouple feedthroughs. EnvirOptics, in an effort to help the engineer as much as possible, is now furnishing thermocouple flange assemblies with brazed - in thermocouples with 2" extensions at both ends to simplify prototyping. We offer this capability to meet your specific thermocouple requirements.

• WELDING TO CENTER CONDUCTOR

Welding to molypins should be accomplished under a protected atmosphere, if possible. Molybdenum terminal conductors are available with protective plating such as gold, copper and nickel. Nickel caps and nickel tubes may be welded in air.

Welding should be accomplished so that the current does not pass through the pin in the insulator inner face. In other words, the welds should be made where both welding electrodes are on the same side of the terminal. This will minimize thermal shock. If possible, heat sinks should be used during welding and soldering operations. (Refer to figure below)



• MOUNTING CERAMIC-TO-METAL SEAL TERMINALS

The different configurations of EnvirOptics terminals lend themselves to a variety of attachment and mounting methods. Several soldering and filler brazing methods can be used with good results. The particular method employed will be the result of both end use requirements and equipment availability.

Keep in mind that EnvirOptics will mount your prototype and production quantities for you. Aside from brazing, we also offer projection welding where terminals and devices can be designed for this mounting method.

FOLLOWING ARE BRIEF DESCRIPTIONS OF THE VARIOUS TERMINAL MOUNTING TECHNIQUES:

• FURNACE BRAZING

Furnace brazing is by far the most preferred brazing method. Brazing performs, placed at the required joint, melt and flow to achieve a good seal. Furnace atmospheres which may be employed include hydrogen, cracked ammonia, forming gas, inert gases and vacuum. A continuous belt feed furnace with a gradual rise to and from braze melt point is desirable (600C/hour rate of rise).

• INDUCTION HEATING

Induction heating usually induces heat only in the metal parts. Thus care is necessary so that the heating is slow enough to heat the insulator by conduction from the adjacent metal parts. This method is useful where a terminal or a header is used to seal components into a case or box, since only the local area around the terminal need be heated.

• ELECTRON BEAM AND LASER

1. Weld bead should be kept as far as possible from metal to ceramic inner face (a minimum of .20" is desirable).
2. Heat sinking should be used whenever possible.
3. Mounting hole or port should be positioned so that close tolerance for weld can be maintained (typically + .002", -. 000") without causing unnecessary stress.
4. Time duration and intensity should be kept to minimums. However, it should be pointed out that EnvirOptics ceramic seals could withstand much more adverse welding condtions than their glass counterparts.

• PROJECTION WELDING (RESISTANCE)

1. There are specific seal designs used with heat directors to minimize unwanted heat build-up.
2. Time duration and intensity should be kept to minimums.
3. Proper alignment of electrodes over heat directors is critical.
4. Take care to assure that just enough pressure is used to maintain good surface contact between the weld projection and header surface to be welded without collapsing or crushing projection.

Note: Our Methods of high temperature metallizing and brazing allow you to join these terminals by most the most conventional joining methods without adversely effecting the hermeticity of these seals, when intelligently and carefully processed.