ZOTEFOAMS

Technical Information Sheet TIS-18

ELECTRICAL PROPERTIES

INTRODUCTION

As the use of electronic devices in all areas of society continues to increase, the importance of a material's electrical properties becomes more important for a wide range of applications.

- **Conductive** foams are able to be used to absorb unwanted electromagnetic waves that can interfere with electronic equipment.
- **Static dissipative** and **conductive** grades are able to safely package Electrostatic Discharge (ESD) sensitive items.
- **Electrically insulating** foams have their own benefits, with low dielectric constant and loss, they can be effectively invisible to electromagnetic waves.

Zotefoams' product range boasts insulating, static dissipative and conductive foams. These categories can be defined using surface or volume resistance/resistivity values. Surface resistance is a measure of how much the material resists the flow of current across the surface, whereas volume resistance is a measure of how much the material resists the flow of current through the bulk of the material.

According to ANSI/ESD S541: Packaging Materials for the Protection of Electrostatic Discharge Susceptible Items, the categories are defined as:

Category	Surface or Volume resistance (Ω)
Conductive	$< 1.0 \times 10^{4}$
Static Dissipative	$1.0 \times 10^{4} \leq 1.0 \times 10^{11}$
Insulating	1.0×10^{11}

Resistivity is an intrinsic property of a material, whereas resistance depends on the dimensions of the material the charge is traveling through. The equations below demonstrate how the properties are measured:

$$Surface\ Resistance\ (R_s) = \frac{U}{I_s}$$

$$Surface\ Resistivity\ (\rho_s) = R_s * \frac{L}{D}$$

U = DC Voltage
I_s = Surface Current
L = Length between electrodes
D = Width of electrodes

$$Volume\ Resistance\ (R) = \frac{U}{I}$$

$$Volume\ Resistivity\ (\rho) = R * \frac{A}{t}$$

I = Current
A = Surface area of electrodes
t = Thickness of material

The definitions of each category vary between different standards and test methods have different limits of what they can measure. For example, Zotefoams measures the surface resistivity of static dissipate foams to ANSI/ESD STM11.11-2015, whereas Zotefoams' conductive foams are measured by volume resistivity to ASTM D991.

Material	Apparent density [kg/m^3]	Surface resistivity [Ω/sq]	Volume resistivity [Ω.cm]
LD30SD	30	1×10^7	
LD40SD	40	1×10^7	
LD32CN	32		2045
LD50CN	50		2078
EV45CN	45		2430

ADVANTAGES OF ZOTEFOAMS’ SD/CN MATERIALS

The formulation used to produce Plastazote® SD and CN grades overcomes the problems typically associated with the production of conductive and static dissipative polymer foams:

- For **anti-static or static dissipative foams**, general approaches to modification of polyethylene foams include surface treatment with chemicals, chemical additives such as amides or amines and conductive fillers.
  - **Surface treatments** are unreliable, as they are able to be washed or rubbed off and often don’t function in low humidity environments. This is more difficult to fabricate into a product because as soon as the surface is cut the conductive pathway is broken.
  - **Chemical additives** such as amines rely on migration of the additive to the surface of the material, and the chemicals used can leach out the material and damage the electrical equipment that is meant to be protective. This mechanism also relies on humidity to form a conductive pathway.
- For **conductive foams**, carbon fillers are used, often in post-impregnation of the material. The resultant materials can shed particles and mark products that they come into contact with.

Zotefoams’ CN and SD grades are formulated with a special carbon black which is compounded with the polymer, so it is fully encapsulated by the polymer. This results in foams with consistent long-term electrical properties, which do not shed particles and are effectively non marking. Through extensive formulation development, we have been able to create foams both in the conductive and static dissipative ranges of resistance. Combined with the high-purity, uniform cell structure, high strength to weight ratio associated with all Zotefoams products, Plastazote CN and SD grades are ideal for applications where high performance is required.

Since the conductive carbon is encapsulated in the polymer matrix, AZOTE® SD and CN materials can be cut, routed, shaped, welded, laminated, and thermoformed into finished products without compromising their electrical properties.

APPLICATIONS FOR STATIC DISSAPATIVE (SD) FOAMS

When a static charge is created on the surface of the material, static dissipative foams offer a slow, controlled transfer of a static charge to ground, minimising the risk of an electrostatic discharge event that could damage electronic equipment. This, combined with good cushioning properties, allows Plastazote SD materials to be used for packaging electronic devices. Suitable for inter process wafer interleaving, box liners, end caps, top/bottom frames, corner blocks and case inserts.

Static dissipative foams can also be of use in ATEX environments. These are areas where there's a risk of explosion due to flammable substances like gases, vapours, or dusts. Materials used in ATEX controlled environments must minimise risk of sparks, which could ignite flammable substances.

APPLICATIONS FOR CONDUCTIVE (CN) FOAMS

Plastazote CN grades are ideal for shunting component leads and PCB edge connections to equalize the charge in individual circuits. Evazote® EV45CN can be used where enhanced durability and flexibility are valued. Evazote conductive grades are used in a variety of other ESD applications including wrist straps, earth straps, grounded bench mats, floor covering, anti-fatigue mats and conductive footwear where both comfort/wearability and conductivity are valued properties. The conductive nature of the CN range of foams also lends itself to use in military and stealth applications, where shielding is required. It is seen that an increase in thickness, density and electrical conductivity of the foam are factors in increasing shielding effectiveness (between a frequency of 1 – 18 GHz).

DIELECTRIC MATERIALS (INSULATING FOAMS)

Most of Zotefoams' product range are classed as insulating foams. These materials can become polarised when exposed to an external electromagnetic field and are able to store electrostatic energy. Materials with a dielectric constant (or relative permittivity) close to 1 and dielectric loss (loss tangent) close to zero are ideal for use where insulating materials are required. It is worth noting that the dielectric constant and loss of a material will vary depending on the frequency of electromagnetic radiation in question.

Dielectric constant and loss of a range of our materials are provided below. Testing at a frequency of 1 MHz was conducted according to the ASTM D150-22 Air Gap Method, while testing at 3 GHz was tested using the ASTM D2520 High Frequency S-band Perturbation Technique:

Material	Dielectric constant [3 GHz]	Dissipation Factor [3 GHz]	Dielectric constant [1 MHz]	Dissipation Factor [1 MHz]
Ecozote PP35	1.03	2.4E-05	1.10	2.0E-03
Ecozote PP90	1.10	2.7E-05	1.10	2.0E-03
Plastazote HD115	1.10	2.9E-05	1.09	2.0E-03
Plastazote HD30	1.03	3.0E-05	1.03	2.0E-03
ZOTEK F41HT	1.03	2.1E-03	1.08	1.7E-02
ZOTEK F OSU XR120	1.08	5.3E-03	1.25	4.4E-02

APPLICATIONS FOR LOW DIELECTRIC FOAMS

An example application where dielectric foams are required are radomes - structures that are used to protect antenna from weather conditions, animals, and other debris. The radome must be effectively invisible to electromagnetic waves, so it does not interfere with the function of the antenna. Stiff dielectric materials, such as our Plastazote HD or Ecozote® PP range of foams, provide rigidity and thermal insulation, alongside the desired dielectric properties. Where low flammability is required or recyclability important, our Ecozote PP foams should be considered. ZOTEK® F provides the benefit of UV resistance, where this is a critical factor, however the dielectric loss is not as low as that of HD and PP foams.

Exclusion of Liability

Any information contained in this document is, to the best of the knowledge and belief of Zotefoams plc and of Zotefoams Inc. (together herein referred to as ZOTEFOAMS), accurate. Any liability on the part of ZOTEFOAMS or any subsidiary or holding company of ZOTEFOAMS for any loss, damage, costs or expenses directly or indirectly arising out of the use of such information or the use, application, adaptation or processing of any goods, materials or products described herein is, save as provided in ZOTEFOAMS' conditions of sale ("Conditions of Sale"), hereby excluded to the fullest extent permitted by law.
Where ZOTEFOAMS' goods or materials are to be used in conjunction with other goods or materials, it is the responsibility of the user to obtain from the manufacturers or suppliers of the other goods or materials all technical data and other properties relating to those other goods or materials. Save as provided in the Conditions of Sale no liability can be accepted in respect of the use of ZOTEFOAMS' goods or materials in conjunction with any other goods or materials.

Where ZOTEFOAMS' goods or materials are likely to come into contact with foodstuffs or pharmaceuticals, whether directly or indirectly, or are likely to be used in the manufacture of toys, prior written confirmation of compliance with relevant legislative or regulatory standards for those applications may be requested from ZOTEFOAMS, if appropriate. Save as provided in the Conditions of Sale no liability can be accepted for any damage, loss or injury directly or indirectly arising out of any failure by the user to obtain such confirmation or to observe any recommendations given by or on behalf of ZOTEFOAMS.

ZOTEFOAMS MAKES NO WARRANTIES EXPRESS OR IMPLIED, EXCEPT TO THE EXTENT SET OUT IN THE CONDITIONS OF SALE, AND HEREBY SPECIFICALLY EXCLUDES ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO ANY GOODS, MATERIALS OR PRODUCTS DESCRIBED HEREIN.

Zotefoams plc Management systems are covered by the following:

UK Authorised Economic Operator

Quality
FM 01870 / ISO 9001:2015

Safety
OHS 52538 / ISO 45001:2018

Environment
EMS 36270 / ISO 14001:2015

ZOTEFOAMS plc
675 Mitcham Road
Croydon, Surrey CR9 3AL
United Kingdom
Tel: +44 (0) 20 8664 1600
Email: azote@zotefoams.com

ZOTEFOAMS Poland SP z.o.o.
Parkowa 26
49-318 Skarbimierz,
Osiedle

ZOTEFOAMS inc
55 Precision Drive Walton, Kentucky
41094 USA
Tel: +1 859 371
Freephone: (800) 362 8358 US only

AZOTE®, Ecozote®, Evazote®, Plastazote®, Supazote®, T-FIT®, Zotefoams®, Zote®, ZOTEK® are registered trademarks of Zotefoams plc.

If you would like more information email:
techsupport@zotefoams.com
or visit our website
www.zotefoams.com