Why Low-Loss Coax has a Foam Dielectric

QST September 2024

Coaxial Cables with Foam Dielectric

A detailed look at the physical and electrical reasons that foam is used

Reverse Math Look in low-loss coaxial cables.

QST September 2024

José Luis Giordano, CA4GIO

Within the wide array of coaxial transmission lines there's a group known as low-loss coax, whose dielectric is polyethylene foam, or PE(F). I have translated my short article, "Coaxiales con dieléctrico de espuma," originally published in Spanish in the December 2023 issue of *Radioaficionados*, that explains why this material is used.

Coaxial Cable Loss with Frequency

The electrical conductivity of the dielectric located between the conductors of a coaxial transmission line

Low-loss coaxial cables, such as LMR-400, have less loss than cables like RG-8 or RG-213 because of the increase in the diameter of the center conductor. So, coaxial cables with lower losses generally have a larger outer diameter, thus permitting a larger center conductor. Table 1 lists the characteristics of several popular types of coaxial cables, including the attenuation over 100 meters at 150 MHz in the last column.

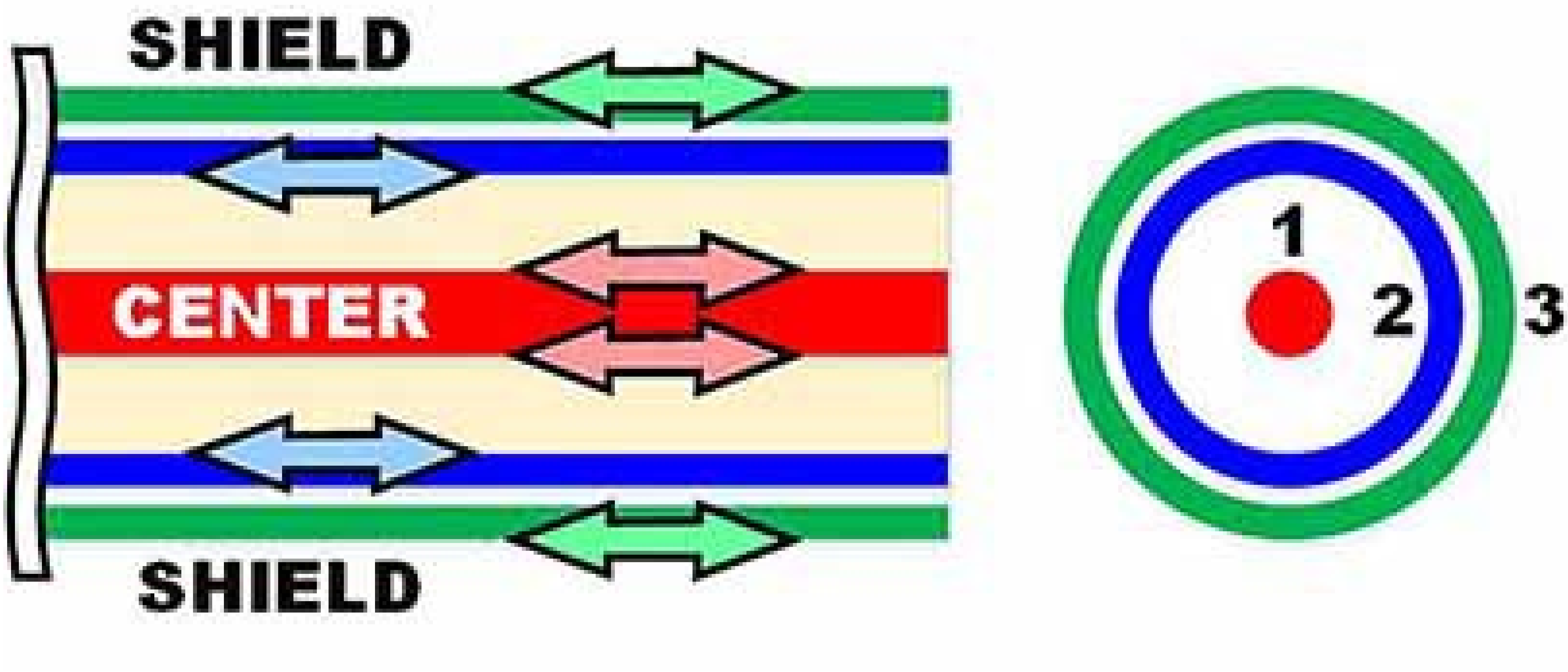
Effect of Dielectric on Impedance

To see the relationship between the dimensions and the dielectric, consider the following expression:

The Concept:

Where Does Coax Loss Take Place ?

Coax has 3 wires



Reversing Equation → Loss from Skin Effect in Conductors → d and D

CONSTANTS

CONSTANTS

LOSS

$$R' = \frac{1}{2\pi}\left(\frac{1}{d} + \frac{1}{D}\right)\sqrt{\frac{\pi f \mu_C}{\sigma_C}}.$$

Small d – high loss

MAIN SOURCE OF LOSS IN COAX

Skin Effect loss

Small center conductor

d

Low-Loss Coax

has a better d:D

Center : Shield diameter ratio

D

MUCH HIGHER Skin Effect Resistance in the smaller center conductor

LMR-400
Foam PE Dielectric

RG-8
Solid PE Dielectric

Loss in Foamed Coaxes

Table 1 — Characteristics of Popular Coaxial Cables

Type	Dielectric	*d* (mm)	*D* (mm)	V_F (%)	dB/100 m at 150 MHz
RG-58C/U	PE	0.91	2.95	65.9	20.10
RG-8X	PE(F)	1.42	3.94	84.0	11.15
RG-8A/U	PE	2.16	7.24	66.0	8.07
RG-213/U	PE	2.29	7.24	66.0	8.77
LMR-400	PE(F)	2.74	7.24	84.0	5.00

However

If we Change

Inner : Outer

→ a Problem

50Ω

$$Z_0 = ln\left(\frac{D}{d}\right) \times V_F \approx \text{constant}$$

50Ω

$$V_F = \frac{1}{\sqrt{\varepsilon_r}}$$

Solid PE

Coax must have higher dielectric constant

velocity factor

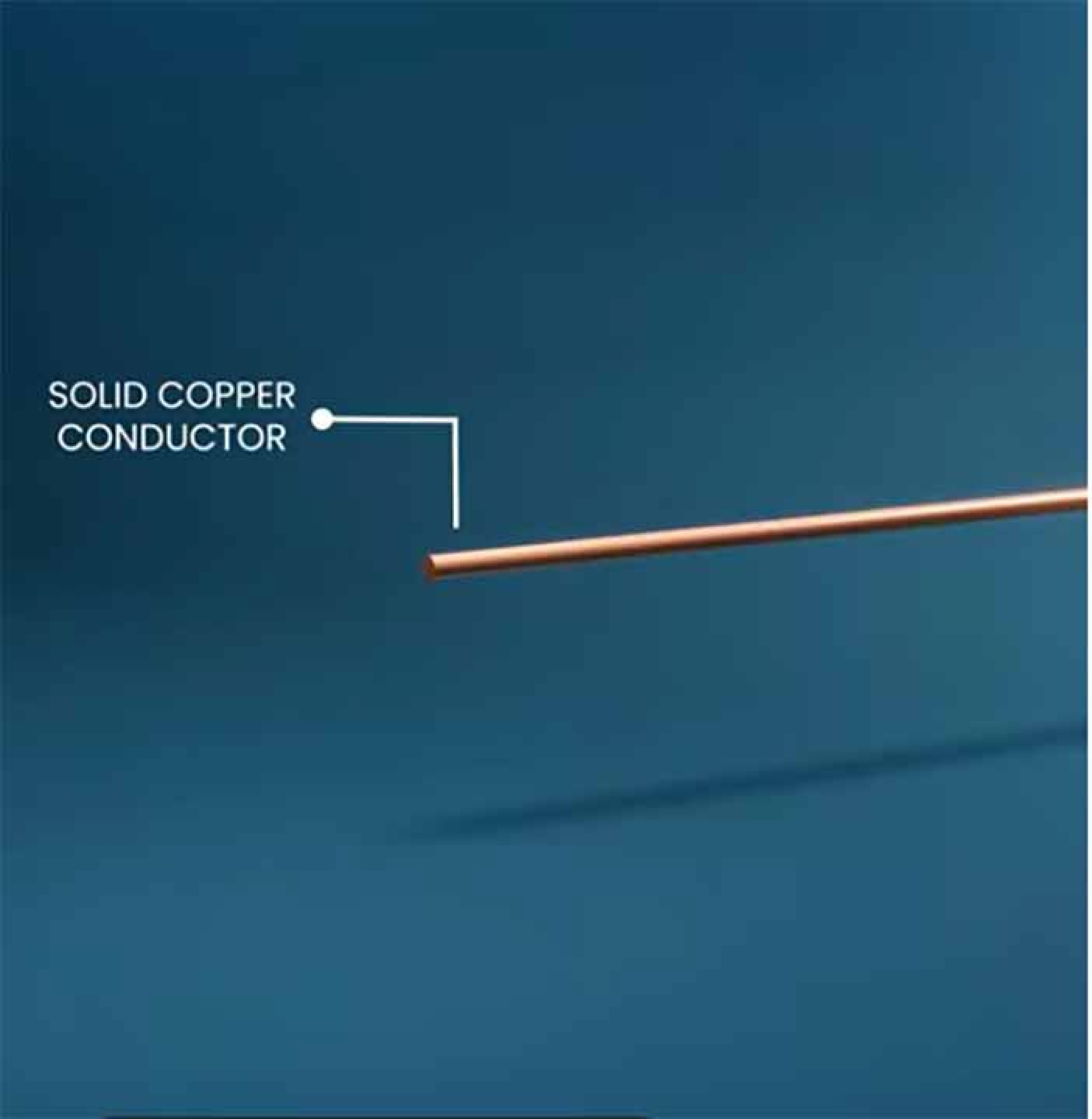
To keep low loss coax at
50 Ohms with a bigger center
conductor, the PE dielectric has
to be part bubbles
with a higher velocity factor

Again, dielectric loss is not the reason for foaming, but to compensate for the larger center conductor.

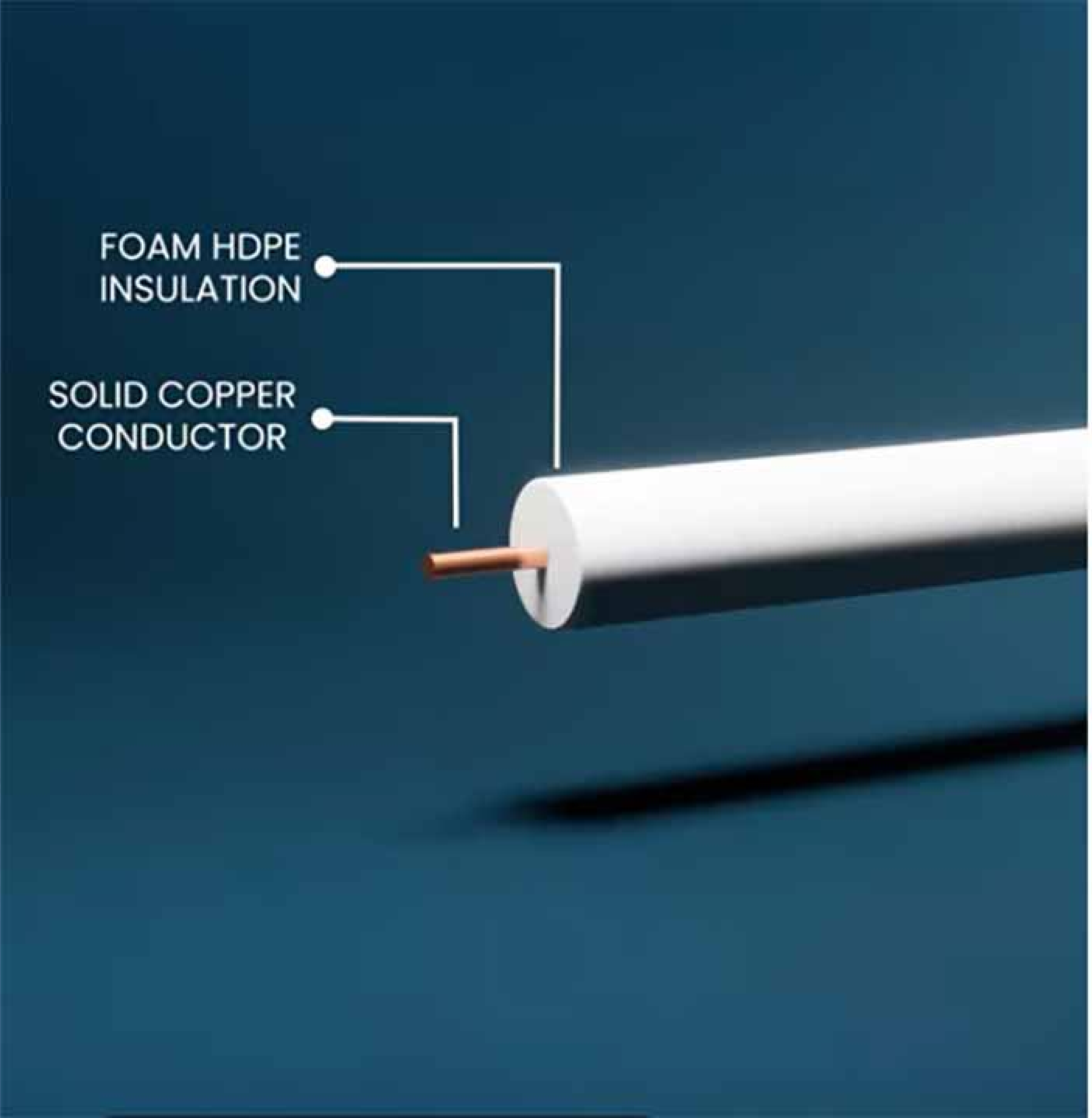
Foam Dielectric – Higher V_F

Table 1 — Characteristics of Popular Coaxial Cables					
Type	Dielectric	*d* (mm)	*D* (mm)	V_F (%)	dB/100 m at 150 MHz
RG-58C/U	PE	0.91	2.95	65.9	20.10
RG-8X	PE(F)	1.42	3.94	84.0	11.15
RG-8A/U	PE	2.16	7.24	66.0	8.07
RG-213/U	PE	2.29	7.24	66.0	8.77
LMR-400	PE(F)	2.74	7.24	84.0	5.00

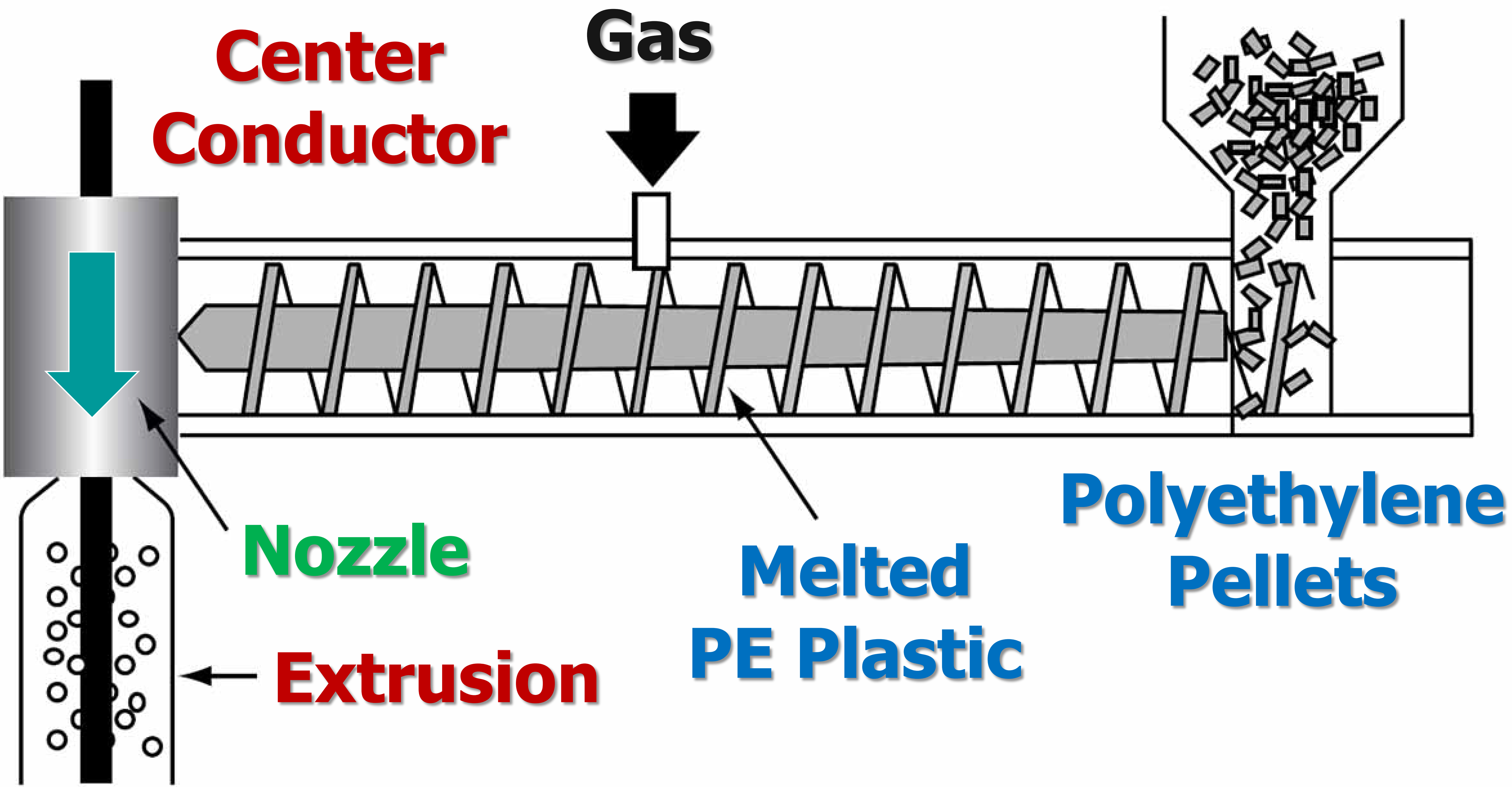
How (Foam) Coax Is Made

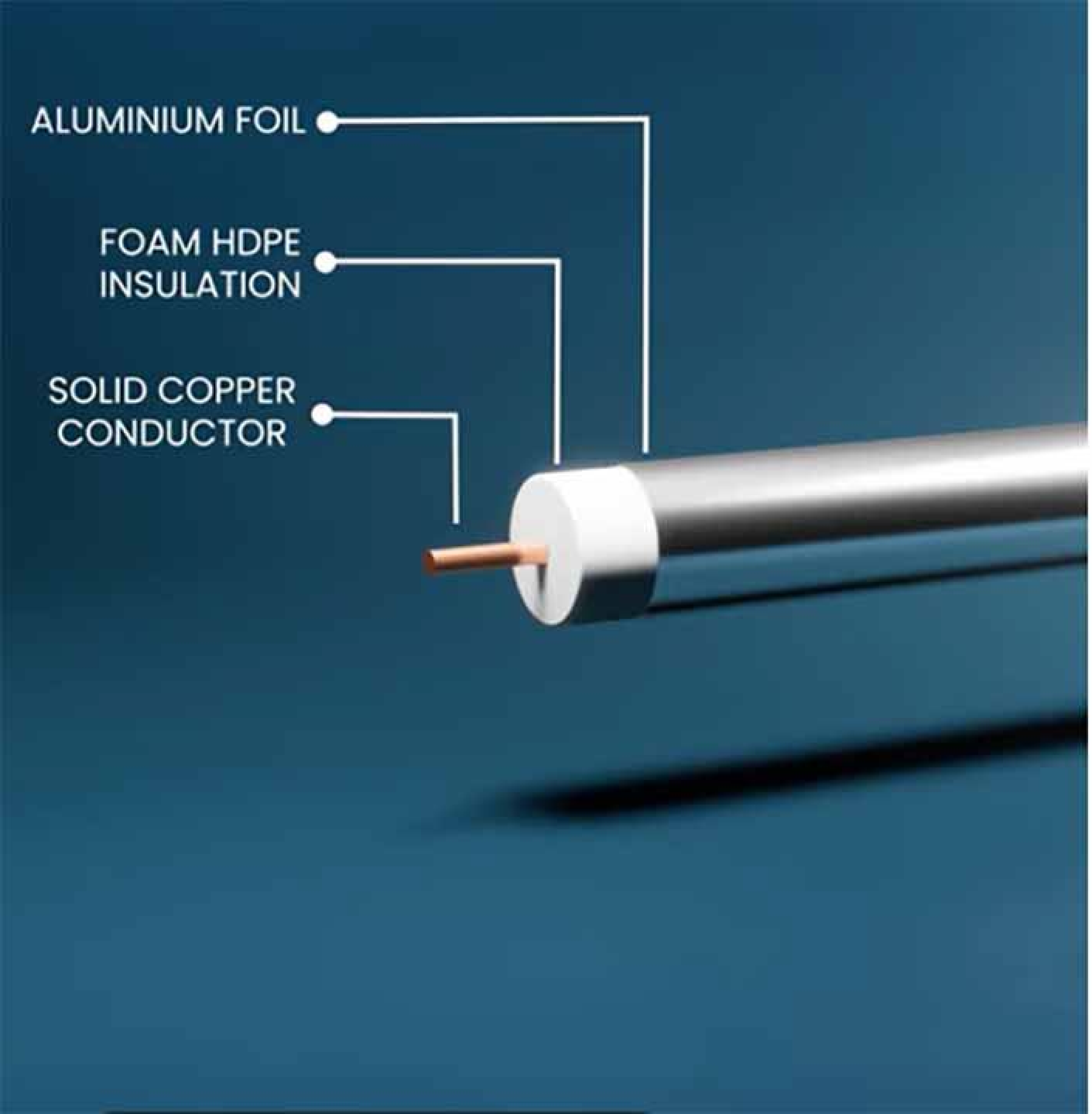


Center Conductor (Solid, Hollow)



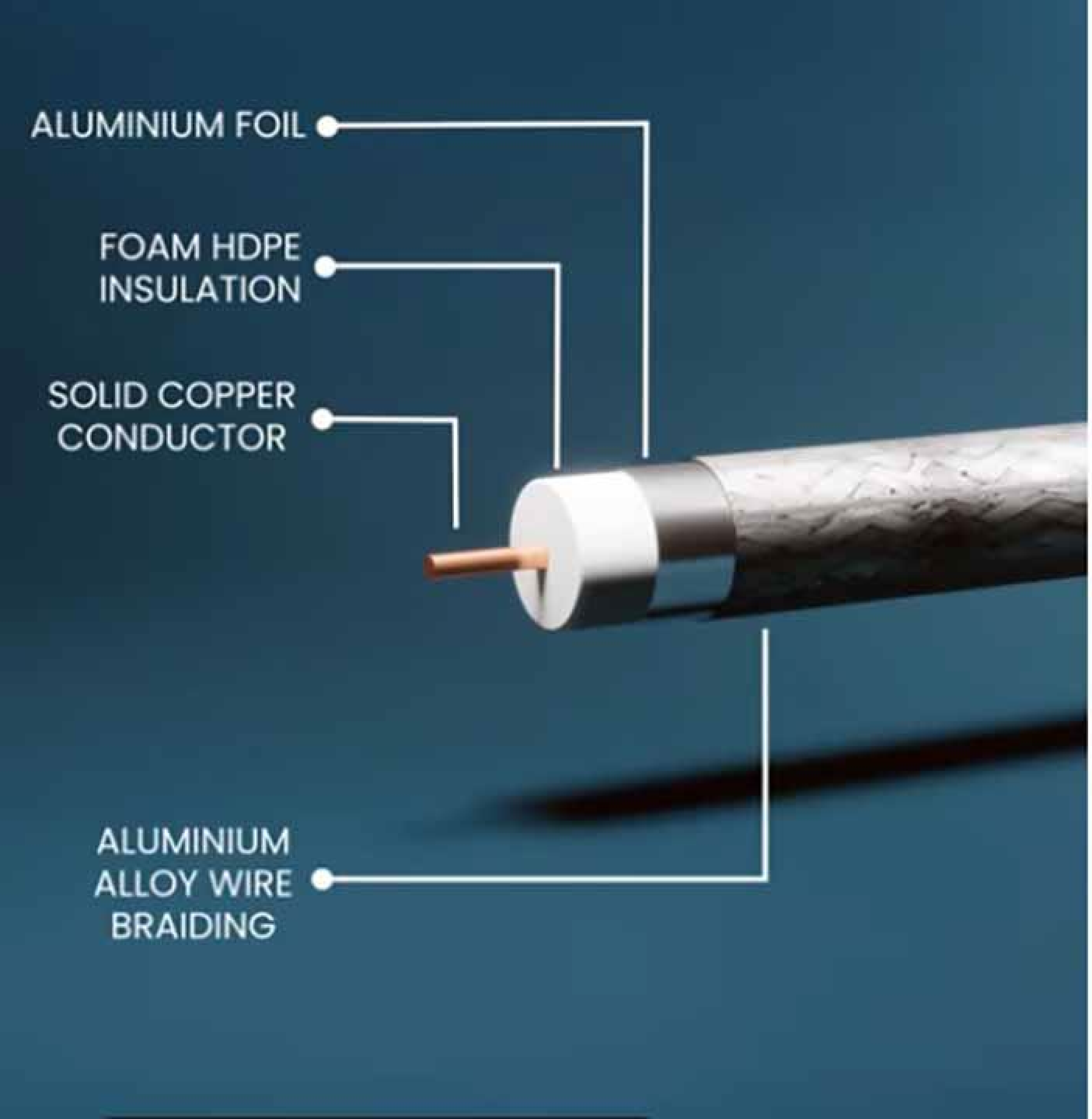
Dielectric (Solid, Foam)


Center Conductor
Gas
Nozzle
Extrusion
Melted PE Plastic
Polyethylene Pellets

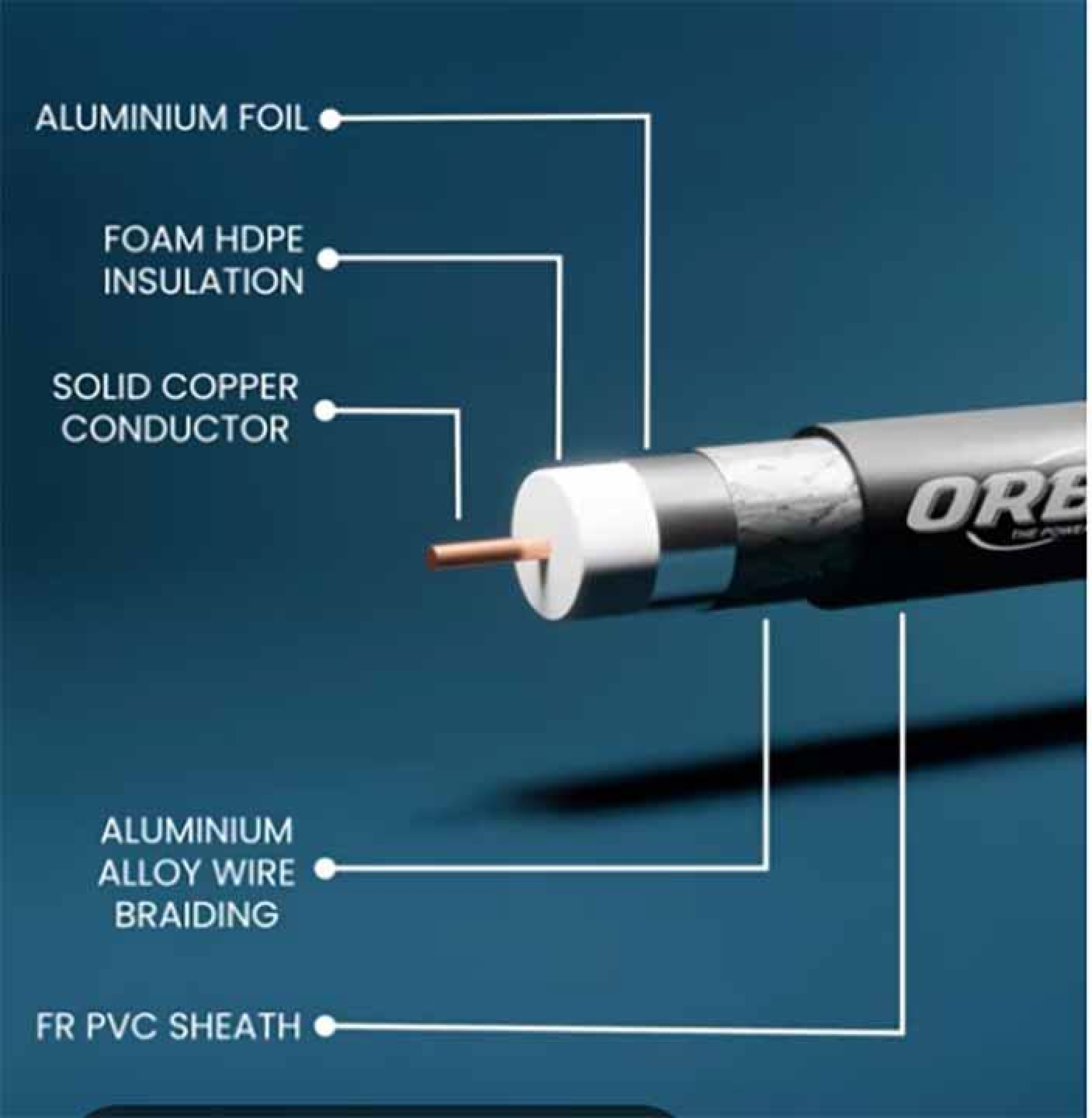


(First) Shield (Foil)

POLYETHYLENE FOAM HARDLINE



Second (Double) Shield (Braid, rigid)



Jacket (Vinyl, Poly-ethylene,)

Take Away

Conclusion *(from article)*

Coaxial cables … REDUCE LOSSES by using a larger-diameter central conductor.

However, TO MAINTAIN THE CHARACTERISTIC IMPEDANCE, the material between the conductors must have a lower dielectric constant.

For this reason, coaxial cables of this type are recognized for foam dielectric and a higher velocity factor

w6nbcmail
@gmail.com

w6nbc.com/
slides

FYI Extra

μ = magnetic permeability of space

ε = electric permittivity of space

$$\eta_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} \approx 376.73\ \Omega,$$