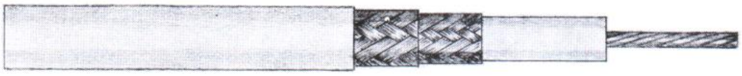
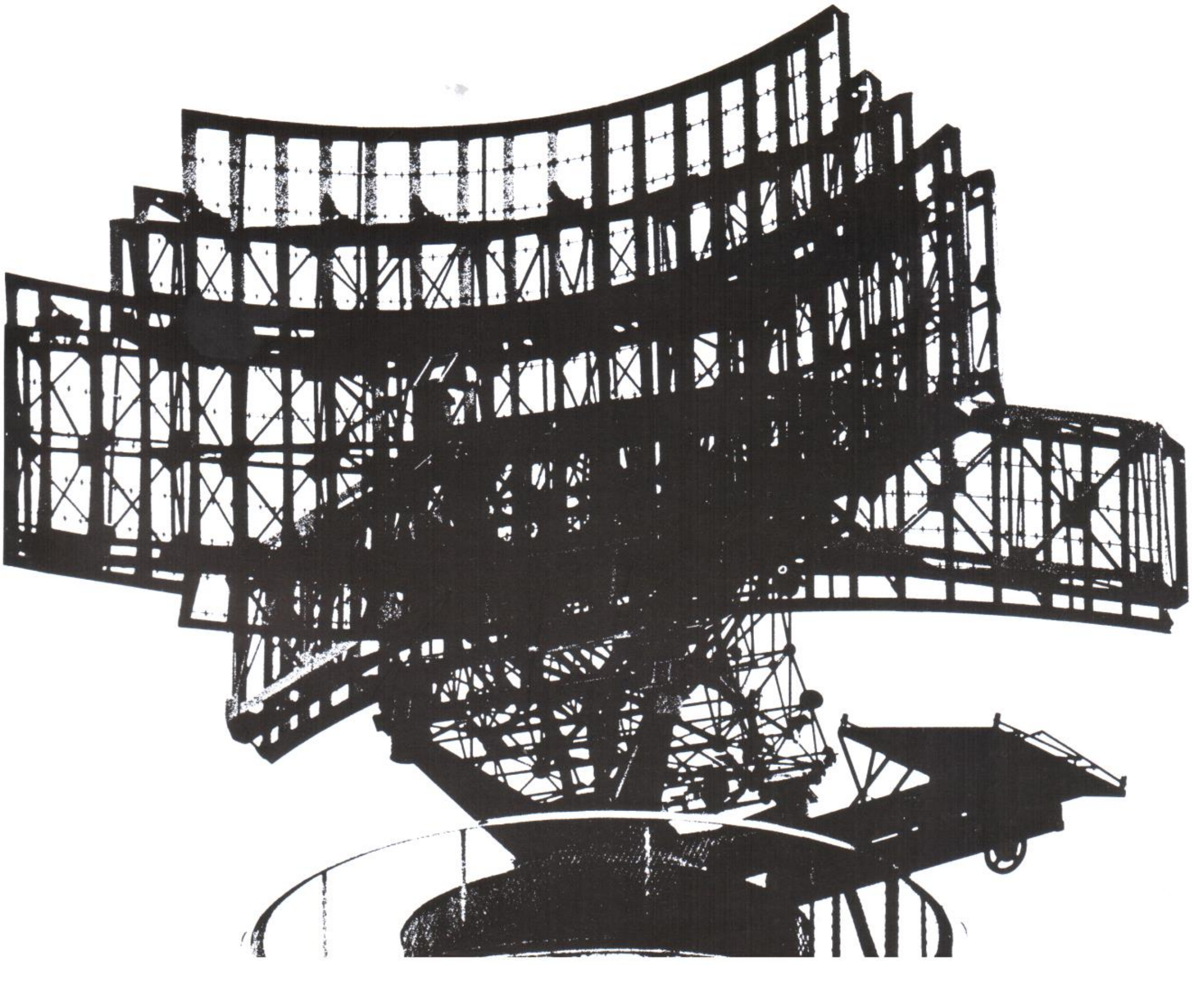
HABIA
CABLE

COAXIAL CABLES





Basic material data

1. Conductor material

For coaxial cable conductors below 1 mm in diameter, a copper-covered steel (copperweld) is the most common material, because of its optimum combination of good electrical and thermal conductivity, good mechanical strength, low price and its ability to be coated with other metals. A copper surface discolours (oxidizes) at normal storage temperature. This oxide has poor electrical conductivity and cannot be soldered. The copper surface (of e.g. copper-covered steel, copper alloy or pure copper) is coated with silver to get high conductivity (important at HF) and is easily soldered. Copper-covered steel is magnetic and this is a disadvantage especially for space use.

When non-magnetic properties are required, a copper alloy is used which has excellent mechanical properties and electrical conductivity.

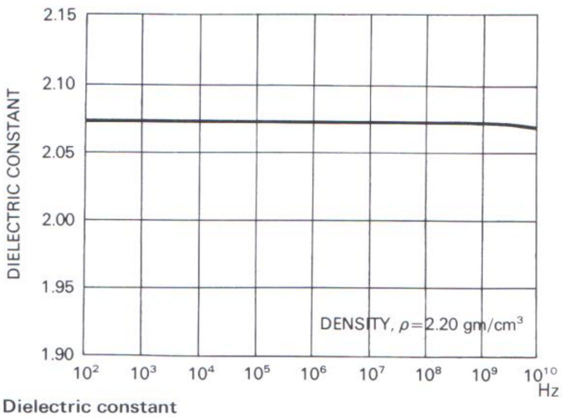
For coaxial cable conductors over 1 mm in diameter, the mechanical properties become less important so here a copper conductor is sufficient.

Below is some information about the conductor materials:

	Electrical conductivity	Mechanical properties	Magnetic	Tested acc. to
Silverplated copperweld	40%	Excel.	Yes	ASTM B 452 ASTM B 298
Silverplated copper alloy	85%	Excel.	No	ASTM B 298
Silverplated copper	100%	Good	No	ASTM B 3 ASTM B 298

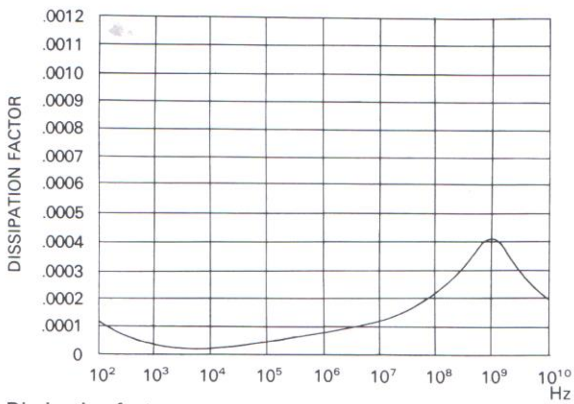
2. Dielectric material

Almost all of Habia's coaxial cables have Teflon PTFE dielectric. We will present here only the most important properties of this material. For basic information on PTFE, see under jacket material.



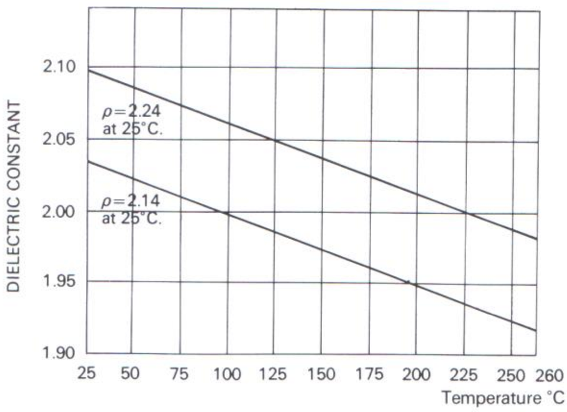
Dielectric constant

The dielectric constant of Teflon PTFE is essentially independent of frequency.

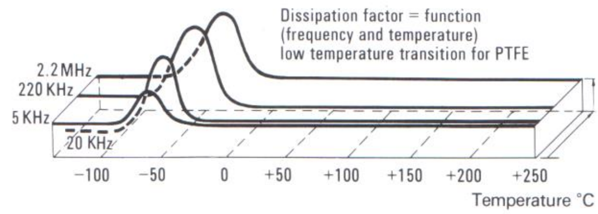


Dissipation factor

The low dissipation factor of Teflon PTFE is insignificant in the majority of uses for coaxial cables.



The dielectric constant decreases at higher temperatures due to density changes.



Basic material data/Coaxial theory

3. Jacketing material

The jacket of a coaxial cable is mainly used as protection for the metal shield. The most popular type is Teflon FEP (type IX), which combines the following advantages: economy, flexibility, easy to process, excellent mechanical properties, can be used within wide temperature range.

If a tougher lighter jacket is needed, Tefzel (type XI) is recommended but then the cable also will become stiffer.

If a more flexible cable is needed, thermoplastic rubber (type XII) would be required. The former jacket construction of silicone impregnated glassbraid is not recommended for new designs.

Below are the most important characteristics of jacketing materials:

Du Pont trade mark	TEFLON PTFE	TEFLON FEP	TEFLON PFA	TEFZEL ETFE	
Polymer name	Polytetra-fluoro-ethylene	Fluorinated ethylene-propylene	Perfluor-alkoxy fluorocarbon	Ethylene-tetrafluoro-ethylene	Thermoplastic rubber-polyester
Tensile strength kg/cm^2	200	200	200	420	415
Elongation %	250	250	300	150	800
Flexural modulus kg/cm^2	6650	6650	6650	14000	492
Hardness	D55	D55	D55	D75	D40
Melting point °C	327	279	305	270	168
Max. service temp. °C	260	200	260	150	90
Low temperature °C	−200	−200	−200	−200	−50
Non flammability	Excellent	Excellent	Excellent	Very good	Good
Water absorption 20°C %	<0.01	<0.01	<0.01	<0.01	<0.5
Weather resistance	Excellent	Excellent	Excellent	Excellent	Good
Density g/cm^3	2.1	2.1	2.15	1.7	1.2
Dielectric constant	2.1	2.1	2.1	2.6	6.0
Dissipation factor	0.0002	0.0002	0.0002	0.0008	0.6
Resistance to organic solvent	Excellent	Excellent	Excellent	Excellent	Good
Resistance to acids and alkalies	Excellent	Excellent	Excellent	Excellent	Good
Flexibility	Good	Good	Good	Fair	Excellent
Radiation resistance rad	10^5	10^6	10^6	10^8	10^7

Coaxial theory

1. What does the RG number mean?

Habia coaxial cables are generally manufactured according to MIL-C-17 E, US military specification. As new materials (conductors, dielectrics, shields and jackets) are being developed, we have introduced some of them suitably modified to obtain better electrical, mechanical or economic results.

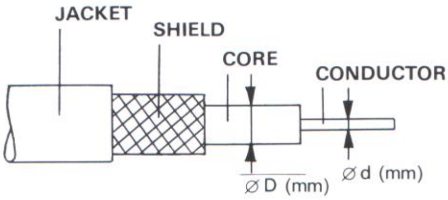
The MIL-C-17 E covers coaxial cables with different RG numbers. What does the RG number mean: e.g. RG 115/U

R stands for Radio frequency
G stands for Government
115 is the number assigned to government approval
/U stands for universal specification

If the letter A, B or C appears before the /, it means a specification modification or revision.

Polyethylene to TEFLON PTFE coaxial conversion chart

Polyethylene	Habia reference	Impedance	RG type
RG 4/U	54503-400-3	50	RG 400
RG 5 B/U	54503-304-1	50	RG 304
RG 8	54503-165-3	50	RG 165
RG 29/U	54503-400-3	50	RG 400
RG 55 A/U	54503-400-1	50	RG 400
RG 58 C/U	54503-400-3	50	RG 400
RG 59 B/U	54503-302-1	75	RG 302
RG 174/U	54503-316-1	50	RG 316
RG 213/U	54503-165-3	50	RG 165
RG 214/U	54503-393-1	50	RG 393
RG 215/U	54503-165-3	50	RG 165



2. Impedance

Impedance is the term expressing the ratio of voltage to current in a cable of indefinite length. For coaxial cables it is called the characteristic impedance in ohms. Usually coaxial cables are manufactured with 50, 75 and 95 ohms impedance, but Habia will produce cables with other impedances on request.

The characteristic impedance is calculated as follows:

$$Z_0 = \frac{138}{\sqrt{\epsilon}} \, {}^{10}\log \frac{D}{d} \quad \text{or} \quad Z_0 = \frac{3097}{V_p \cdot C}$$

3. Capacitance

Capacitance is the property of a coaxial cable which allows storage of electrostatic energy. The capacitance is expressed in picofarads/m

$$C = \frac{24{,}1 \cdot \epsilon}{{}^{10}\log \frac{D}{d}}; \quad C = \frac{3326 \cdot \sqrt{\epsilon}}{Z_0}$$

4. Percent of coverage

Percent of coverage for the shield of a coaxial cable is calculated as follows:

$$\text{tg } a = \frac{2\pi (D + 2 d_1)\, p}{10\, c}$$

$$F = \frac{N\, p\, d_1}{10 \sin a} \qquad P = (2F - F^2) \times 100$$

P = percent shield coverage
N = number of strands per group
p = picks per centimeter
d = diameter of shield strand in mm
a = angle of shield strands with cable-axis in degrees
D = core diameter in mm
c = number of groups of strands in the shield

5. Velocity of propagation

Velocity of propagation is the ratio between the signal speed in a coaxial cable and the velocity in the air (dielectric constant = 1,0).

The velocity of propagation is expressed as a fraction or as a percentage. For solid Teflon the V_p is 0,69

$$V_p = \frac{1}{\sqrt{\epsilon}}; \quad V_p = \frac{3097}{Z_0 \cdot C}$$

V_p = Velocity of propagation
ϵ = Dielectric constant
Z_0 = Characteristic impedance in ohm
C = Capacitance in pf/m

6. Attenuation

Attenuation is the loss of power expressed in decibels/m at a specific frequency. The attenuation is due to the ohmic resistance of the conductor plus the dielectric loss. Theoretical values become lower than in practice.

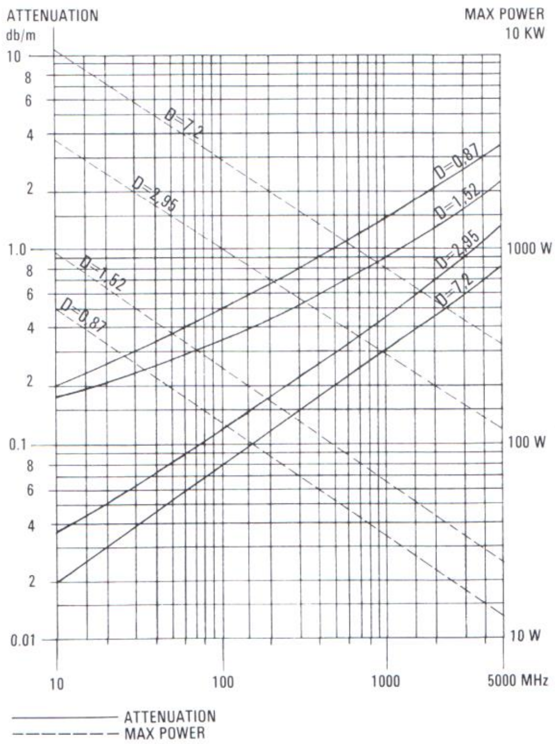
$$A = \frac{1{,}43 \cdot R}{Z_0} + 9{,}15 \sqrt{\epsilon} \cdot f \cdot F$$

$$R = 25{,}4 \left(\frac{1}{d} + \frac{1}{D}\right) \sqrt{f}$$

Z_0 = Characteristic impedance in ohms
ϵ = Dielectric constant
D = Core diameter in mm
d = Conductor diameter in mm
V_p = Velocity of propagation, fraction of free space velocity
C = Capacitance pf/m
A = Total attenuation in db/100 m
R = The equivalent conductor resistance at frequency f
f = Frequency in MHz
F = Dissipation factor

7. Attenuation and power rating

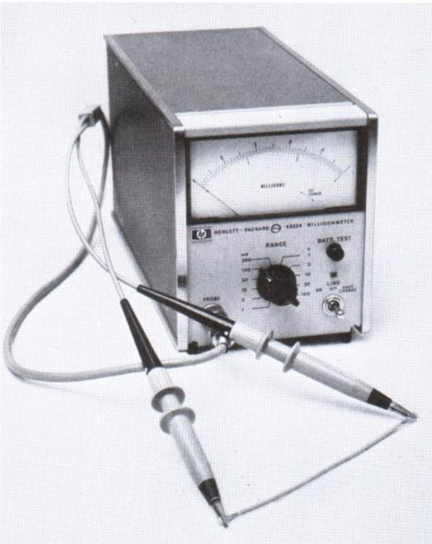
As almost all of our coaxial cables have Teflon dielectric, we present here the attenuation and maximum power rating with core diameter as parameter. Conditions for the power rating are: conductor temperature 199°C. Ambient temperature 40°C and altitude is 1 atm. Below graphs for 50 ohms cables.



HABIA CABLE

RG coaxial cables

Military Number RG/U	RG Type		Jacket OD mm	Jacket Type[1])	Shield [2])		Dielectric[1])		Conductor [2])			Weight g/m	Connector series	Comments
					Outer	Inner	OD mm	Material	Stranding	Material	OD mm			
303/U		54501- -303-1	4.43	IX	SPC	–	2.95	IV	1×0.99	SCWH	0.99	44	TNC.BNC. N.C.UHF	Old conductor construction see 54503-400-3
304/U		54500- -304-1	7.25	IX	SPC	SPC	4.7	IV	1×1.5	SCWS	1.5	113	N.C.	
316/U		54500- -316-1	2.60	IX	SPC	–	1.52	IV	7×0.17	SCWS	0.51	14	BNC. Submin.	Standard stock item
	316	54502- -316-4	2.40	X	SPC	–	1.52	IV	7×0.17	SPTF	0.51	13	BNC. Submin.	Lighter, tougher than 54500-316-1, non magnetic
	316	54500- -316-7	2.60	XII	SPC	–	1.52	IV	7×0.17	SCWS	0.51	12	BNC. Submin.	Extra flexible
393/U		54503- -393-1	10.1	IX	SPC	SPC	7.2	IV	7×0.79	SPC	2.40	235	N.C.HN. UHF	Standard stock item non magnetic
	393	54503- -393-4	10.0	X	SPC	SPC	7.2	IV	7×0.79	SPC	2.40	225	N.C.HN. UHF	Lighter tougher than 54503-393-1, non magnetic
	393	54503- -393-7	10.1	XII	SPC	SPC	7.2	IV	7×0.79	SPC	2.40	220	N.C.HN. UHF	Extra flexible, non magnetic
400/U		54503- -400-1	5.1	IX	SPC	SPC	2.95	IV	19×0.20	SPC	1.0	56	TNC.BNC. N.C.UHF	Standard stock item Better shielding than 54503-400-3, non magnetic
	400	54503- -400-3	4.2	IX	SPC	–	2.95	IV	19×0.20	SPC	1.0	38	TNC.BNC. N.C.UHF	Non magnetic
	400	54503- -400-7	4.2	XII	SPC	–	2.95	IV	19×0.20	SPC	1.0	38	TNC.BNC. N.C.UHF	Extra flexible, non magnetic



With the milliohmmeter we are able to measure the conductor resistance fast and accurately.

[1]) For further information about insulating material see page 4.
IV Extruded Teflon PTFE
V Glassbraid silicone impregnated
VII Wrapped Teflon PTFE
IX Teflon FEP extruded
X Tefzel ETFE extruded
XI Teflon PFA extruded
XII Thermoplastic rubber

[2]) Further information about conductor material see page 3.
SPC = Silverplated copper
SCWH = Silverplated copperweld hard
SCWS = Silverplated copperweld soft
TPC = Tinplated copper
C = Copper
SPTF = Silverplated copper alloy non magnetic

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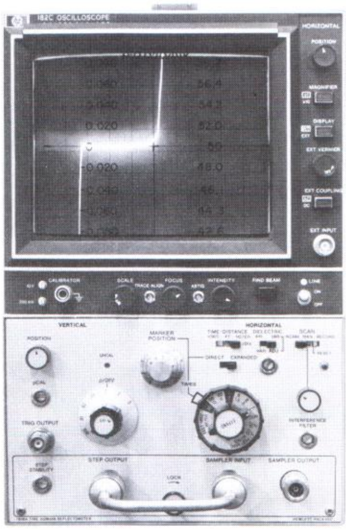
Service temperature		Impedance ohms	Capacitance PF/m nom.	Velocity of propagation %	Attenuation nom db/100 m[3]				Max power Watts[3]			
low	high				10 MHz	400 MHz	1GHz	10 GHz	10 MHz	400 MHz	1 GHz	10GHz
−90°C	200°C	50	97	69	3.4	25.8	48	>340	6000	810	430	63
−90°C	200°C	50	97	69	2.9	19.7	32.7	179	8700	1250	750	160
−90°C	200°C	50	97	69	15,0	57.5	107	>350	770	270	155	–
−90°C	150°C	50	97	69	15,0	57.5	107	>350	770	270	155	–
−50°C	90°C	50	97	69	15,0	57.5	107	>350	310	110	60	–
−90°C	200°C	50	97	69	2.0	15.5	26.0	126	15000	2000	1200	260
−90°C	150°C	50	97	69	2.0	15.5	26.0	126	15000	2000	1200	260
−50°C	90°C	50	97	69	2.0	15.5	26.0	126	6000	800	480	105
−90°C	200°C	50	97	69	3.4	25.8	48	340	6000	810	430	63
−90°C	200°C	50	97	69	3.4	25.9	48	>340	6000	810	430	63
−50°C	90°C	50	97	69	3.4	25.9	48	>340	2400	325	170	25

[3] For further information see page 5.



The new TDR (time domain reflectometer) technique, enables us to study the impedance extension along a coaxial cable up to a length of 300 meters.