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LONG RANGE TELECOMMUNICATION CABLES WITH SMALL COAXIAL
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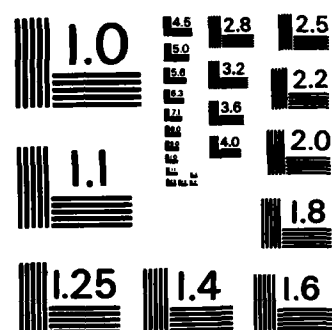


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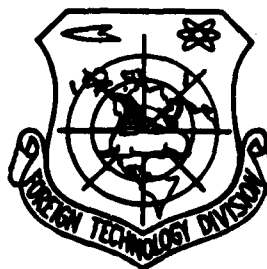
FOREIGN TECHNOLOGY DIVISION



LONG RANGE TELECOMMUNICATION CABLES WITH
SMALL COAXIAL PAIRS

by

Tadeusz Lapinski



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PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

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LONG RANGE TELECOMMUNICATION CABLES WITH SMALL COAXIAL PAIRS

Tadeusz Lapinski M. Eng

In the second half of 1977, the Cable Factory in Ozarowo Mazowieckie started production of long range telecommunication cables with small coaxial pairs of the type 1,2/4,4. These cables are used for transmission of analog signals in the frequency range up to 12.5 MHz (2700-fold telephony) and for transmission of digital signals up to 150 Mbit/s. This production in our country of small dimension coaxial cables is dictated by an increased need for telecommunication in the long range network, arising from the dynamic growth of the country's economy. These cables will find application in the intercity network, intraregional (voyevodship) network, and within long range railway systems.

The construction design of cables, their production process, and their quality conform with modern requirements of industry and represent the highest level of cable technology.

On the basis of experience of various telecommunication administrations, it was decided to accept the design of coaxial cables without the layers of symmetric bundles. These are homogenous cables as opposed to mixed ones. This choice was made to ensure the maximum reliability and operating certainty for the connections.

The production program of the Cable Factory in Ozarowo Mazowieckie comprises the following types of small coaxial telecommunication cables:

- a) Long range telecommunication cables with small coaxial pairs of the type 1,2/4,4 mm with aluminum cover and polyethylene coating - ALTKDWx;

- b) Long range telecommunication cables with small dimension coaxial pairs of the type 1,2/4,4 mm with aluminum cover and polyethylene coating, reinforced with steel tapes (Ft), with external polyethylene shield - AlTKDWxFtx;
- c) Long range telecommunication cables with small dimension coaxial pairs of the type 1,2/4,4 mm with aluminum cover and polyethylene coating, reinforced with round steel wires, with external polyethylene shield.

Coaxial cables will be produced with 4, 6, 8 and 12 pairs of small dimension 1,2/4,4 types. Moreover, each cable profile will also have three symmetric foursomes and one localization strand. It is understood that, at the request of customer, coaxial mixed cables can be produced, to contain one or several symmetric star foursomes, in addition to coaxial pairs. To follow the pattern, the star foursomes (quads) should have a diameter of 0.9 or 1.2 mm, polyethylene foam insulation and effective capacity of 38.5 nF/km.

The small dimension coaxial pairs are manufactured under license from a French company, Societe Anonyme de Telecommunications, representing the highest world level in this area of technology.

The internal strand of the coaxial pair is made of copper wire of diameter 1.18 mm. It is insulated with polyethylene tubing with wall thickness 0.4 mm, cyclicly pinched at determined intervals, of nominal external diameter 4.4 mm (balloon insulation). The external strand of the coaxial pair is a tube with oblong gap, wound from a copper tape of nominal thickness 0.15 mm and width 14.43 mm. The edges of the copper tape are corrugated in order to improve resistance to mechanical deformations. On this copper tube there is deposited an electromagnetic screen in the form of winding with two steel tapes copper-coated, of nominal thickness 0.09 mm. The first steel tape 10 mm wide is wound on the external strand with a slight clearance, and the second tape 12 mm wide is wound onto the first tape in the direction opposite to the direction of winding of the

first tape, with overlap of 2 mm. Each pair has insulation made in the form of wrapping with synthetic foil.

Supplementary bundles consist of star foursome (quad) bundles, twisted from copper strands of nominal diameter 0.6 mm, insulated with uniform polyethylene of thickness 0.18 mm. The construction of strands in foursomes, and of foursomes themselves, is the same as in local telecommunication cables. The colors of the strand insulations in particular bundles are given in Table 1.

TABLE 1. Colors of strand insulation in supplementary bundles

No. of bundle	<u>Colors of strand insulation in foursomes</u>			
	a	b	c	d
1	red	natural	green	grey
2	blue	natural	green	grey
3	yellow	natural	green	grey

Twisted symmetric bundles may be wrapped with paper tapes, polyolefin, or polyester tapes.

The localization strand is made of copper wire with nominal diameter of 0.9 mm insulated with polyethylene. This polyethylene insulation of the localization strand is cyclicly damaged down to the bare strand, in intervals not larger than 100 mm.

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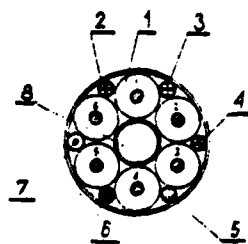
The coaxial pairs, supplementary bundles and localization strands are twisted as layers into the cable center.

The cable center (core) may contain 4, 6, 8 or 12 coaxial pairs. In centers containing 4, 6 or 8 pairs these coaxial pairs are placed in one layer twisted around the central filling. In the free space between coaxial pairs there are placed in the order: the localization strand, supplementary bundles, and possibly fillings - of brown, natural, green and grey color. The first coaxial pair is

located between the first and the second supplementary bundle, the second pair - between the second and the third supplementary bundle, and the last - between the localization strand and the first supplementary bundle. The remaining coaxial pairs are located between the third supplementary bundle, colored fillings (in order of colors given above), and the localization strand.

The cable center containing 12 coaxial pairs consists of a core containing three coaxial pairs and a layer containing nine coaxial pairs. The three coaxial pairs of the core are placed in turn between fillings of red, blue and yellow colors - here the first pair is between the red and blue fillings. In the free space between coaxial pairs in the layer there are placed in turn: the localization strand, supplementary bundles, and fillings - of brown, natural, green, grey and black color. The metering coaxial pair is located between the first and the second supplementary bundle, the directional coaxial pair - between the second and the third supplementary bundle, and the last pair - between the localization strand and the first supplementary bundle. The remaining coaxial pairs are located between the third supplementary bundle, colored fillings (in order of colors given previously), and the localization strand. The direction of counting the coaxial pairs in the core and in the layer is the same.

For illustration, the cross section of a cable center with six coaxial pairs is shown below.



Cross section of a cable center with six coaxial pairs:

- 1 - coaxial pair
- 2 - supplementary foursome red
- 3 - blue foursome
- 4 - yellow foursome
- 5 - brown filling
- 6 - natural filling
- 7 - localization strand
- 8 - central filling

The twisted centers are provided with center insulation in the form of wrappings with paper tapes - smooth and corrugated. At the same time these wrappings function as a thermal barrier, protecting the center from possible damage by elevated temperature.

In turn, the cable is covered with an aluminum shield, made from aluminum tape placed lengthwise and contact welded. The cover of cables having four coaxial pairs is smooth, and of the remaining cables - wavy. The thickness of aluminum cover of cables with four coaxial pairs is 0.9 mm, with six pairs - 0.7 mm, and with eight and twelve pairs - 0.9 mm.

Because of the corrosion tendency of aluminum, its shields are covered with elastic layers of bituminous coating. The bituminous tar fills cavities in the wavy aluminum cover. The layer of this bituminous coating may be covered with winding of polyester tape with overlap and then again may be treated with bituminous tar. Then, an anticorrosion shield is pressed out from high-pressure polyethylene, with nominal wall thickness 2 mm.

The reinforced cables have a cushion under their "armor" in the form of wrapping from smooth or corrugated paper tape or a polypropylene string. On this cushion there is an armor of two steel tapes of thickness 0.5 or 0.8 mm wound with some clearance, or a winding of round zinc-plated steel wires with diameter 2.5 or 3.0 mm, depending on the diameter of cable. The steel tapes are wound screw-like in such a way that the width of the gap between turns of each layer does not exceed 50% of the width of tape, and the upper tape covers the gap between turns of the lower tape. The wires are wound screw-like coil after coil. The armor of steel wires is then covered by the spiral of a thin steel tape wound in the direction opposite to the direction of winding of steel wires. In turn, the armor of the cable is now covered by a protective shield of extruded high-pressure polyethylene, with the addition of soot, of nominal thickness 2 mm.

All cables have a mark of the producer, containing the letter symbol of the cable, name of manufacturer and year of production, embossed on the cable cover.

The small dimension coaxial cables are produced in sections of 500 m. Other lengths of fabrication sections can be made at the request of the customer. All fabrication sections of cables are terminated tightly by means of metal hoods (caps), and remain under positive pressure 8 N.

Nominal diameters of the cable centers, average outside diameters (OD) of cables, and the smallest radii of the bending of cables are given in Table 2.

TABLE 2. Diameters of cables and radii of their bending.

Cable type	Number coaxial pairs	Cable center diameter (mm)	Cable outside diameter (mm)	Smallest radius of cable bending (m)
AlTKDWx	4	16	24	0.7
	6	19.5	32	0.7
	8	23	36	0.7
	12	26	41	0.7
AlTKDWxFtx	4	16	34	0.7
	6	19.5	42	0.7
	8	23	47	0.7
	12	26	52	0.7
AlTKDWxFox	4	16	35	0.7
	6	19.5	43	0.7
	8	23	48	0.7
	12	26	53	0.7

The resistance of a strand of an internal coaxial pair in the cable, measured with direct current and referred to the temperature 20°C, does not exceed 16.3 Ω /km. 121

The resistance of insulation of the internal strand relative to the external strand of each coaxial pair in the cable is at least 10 gigaohms.km.

The insulation of the internal strand of each coaxial pair withstands (without damage during one minute) the test alternating potential of frequency 50 Hz and effective value 2000 V, or direct potential of 3000 V; the potential is applied between the internal strand and the external strand of the pair, connected with grounded coating of the cable. The external insulation of each coaxial pair withstands without damage for one minute the alternating potential of effective value 2000 V or direct potential of 3000 V, when applied to external strands connected to remaining conducting elements of the center and grounded metal cover.

The nominal value of capacity of coaxial pair in the cable is 50 nF/km.

The real component of wave impedance of coaxial pairs at the frequency 1 MHz does not differ from the nominal value of 75 Ω by more than $\pm 0.75\Omega$.

The maximal value of the coefficient of the echo, determined by means of impulse of the direct current at a duration of the half-height no larger than 100 ns, does not exceed 0.4% in any pair of coaxial cable in the fabricated section (the decay of the echo is not smaller than 48 dB). In the group consisting of sections not longer than 500 m, the maximal value of the coefficient of the echo, for coaxial pairs in 80% of fabrication sections, should not be larger than 0.2% (suppression of the echo no less than 54 dB). And

in the group consisting of fabrication sections longer than 500 m, the maximal value of the coefficient of the echo, for coaxial pairs in 80% of sections, does not exceed 0.3% (noise suppression for the echo no less than 50.5 dB).

The unit wave decay for coaxial pairs, at the frequency 1 MHz and temperature 20°C, is 5.4 dB/km.

The approaching-penetrating decay at the frequency 60 kHz between any two coaxial pairs of the fabricated section of the cable, is at least 115 dB for a length of section no longer than 500 m, and 110 dB - for sections longer than 500 m.

A sample of coaxial pair, after the test of winding under a load, withstands without damage for one minute the test alternating potential of effective value 2000 V, applied between the internal strand and grounded external strand.

Polyethylene tubing, cyclicly crimped on the internal strand of the coaxial pair, 5 meters long was subjected at one end to a positive pressure of the column of water 1 meter high and after 24 hours showed no outflow of water whatsoever at the other end.

An increase in the capacity of a sample of coaxial pair 50 m long, immersed in water with the exception of both ends for 24 hours, does not exceed 1% in relation to the capacity measured directly after the immersion.

The resistance of primary leads of supplementary bundles of the cable, for direct current and temperature 20°C, does not exceed 131.8 Ω /km.

The resistance of insulation of each strand of any supplementary bundle, with respect to remaining conducting elements of the cable connected with the cover, is at least 5 gigaohm.km.

The insulation of each strand of the supplementary bundle withstands without damage for one minute the test alternating potential at 50 Hz of the value of 500 V, or direct potential of 750 V, applied between strands a and b joined together of all bundles, and strands c and d of all these bundles joined together and with a grounded metal cover. It withstands without damage 2000 V of alternating potential or 3000 V of direct potential, when applied between all connected conducting strands of supplementary bundles and grounded metallic cover of the cable.

The effective capacity of primary leads in the supplementary bundles does not exceed 60 nF/km.

The value of volume asymmetry of primary leads, belonging to the same four-core bundle (k) in a fabrication section 500 m long, does not exceed 400 pF, while the asymmetry of the ground primary leads (e_1 , e_2) does not exceed 1250 pF.

The resistance of the localization strand at direct current and temperature 20°C, does not exceed 28.5 Ω /km.

The resistance of insulation of the localization strand with respect to the remaining conducting elements, connected with its cover, is no less than 5 gigaohms.km. This insulation withstands for one minute without damage the test alternating potential (50 Hz) of effective value 350 V, or direct potential of 500 V, when applied between the localization strand and all the conducting elements of the cable joined together and connected with the grounded metallic cover of the cable.

This article gives the technical parameters which are allowable for the cables and which do not deteriorate their use performance. The acceptance of such technical values ensures the highest quality of cables. In practice, the cables will have even better quality than expected from the accepted parameters.