

**COLUMBIC COPPER™
REINFORCED WIRES,
CONDUCTORS
& WIRE ROD**



NANOSELECTRO

superwires

COLUMBIC COPPER

AS STRONG AS IT GETS

COLUMBIC COPPER IS A **NEW CLASS OF NANO-STRUCTURED ELECTROTECHNICAL ALLOYS** BASED ON COPPER AND **NIOBIUM**. IT IS CHARACTERIZED BY A **UNIQUE COMBINATION OF HIGH STRENGTH AND HIGH CONDUCTIVITY**.

NIOBIUM IS AN EXTREMELY REFRACTORY METAL, RESISTANT TO MANY AGGRESSIVE ENVIRONMENTS.

IT IS NOT SUSCEPTIBLE TO THE INFLUENCE OF ANY ACIDS, EXCEPT FOR HYDROFLUORIC ACID.

NIOBIUM 41

Nb

92.91



OUR COMPANY

«NANOSELECTRO» LLC was founded in 2011 in Moscow, Russia as a joint venture of RUSNANO, Russia's largest nanotechnology corporation, which invests in projects with substantial economic potential or social benefit, and Bochvar Scientific Research Institute for Inorganic Materials, known globally as an R&D institution working in the field of precious metals and alloys.

Bochvar Institute is a subsidiary of another Russian giant company, ROSATOM, a corporation supplying unique, integrated solutions in nuclear engineering including a wide range of products and services worldwide.



STRATEGY

The company aims at development, production and global marketing of the innovative designs of electricity conductors based on nano-structured materials.



ENVIRONMENT SUSTAINABILITY

NANOSELECTRO strives to reduce environmental impact of its operations. Our initiatives vary from smart energy use and minimized water use to recycling of the materials used in production.

PRODUCTS

- Large section conductors;
- Hollow conductors;
- Thin wires;
- Super slim wires;
- Composite contact wires for high-speed railway transport;
- Durable yet strong wires for aviation, space and defense industries;
- Wire rod.

PARTNERS & COLLABORATORS

RUSNANO

ROSATOM

Bochvar Scientific Research Institute for Inorganic Materials (VNIINM)

RZD — Russian Railways

Los Alamos National Lab

CERN

Forschungszentrum Dresden-Rossendorf

Westmoreland Mechanical Testing & Research Inc.

Chepetsk Mechanical Plant

Kurchatov Nuclear Institute

Various research institutions and laboratories in the U.S., Belgium, Netherlands, Germany, Switzerland, Poland and other countries.

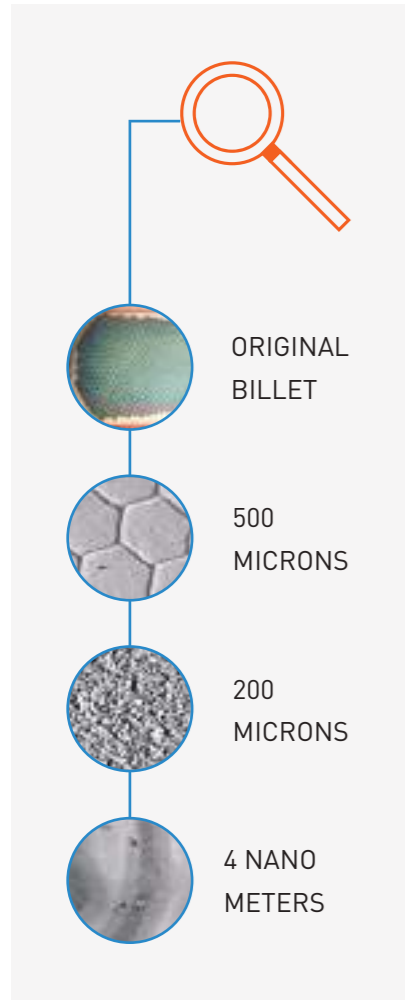
TECHNOLOGY

THE FOUNDERS OF THIS TECHNOLOGY HAVE BEEN WORKING FOR MORE THAN 20 YEARS TO DISCOVER UNIQUE PROPERTIES OF COPPER ALLOYS.

Their experiments unveiled high strength and high conductivity in-situ nano composite CuNb alloys that are used in wire production, we named it Columbic Copper.

It was evident that transitioning to nano-scaled microstructure resulted in a different rate of increase of mechanical strength for Columbic Copper wires. To explain this difference, it was decided to take into account the elastic moduli of the components for different crystallographic directions back grounding on the strong texture created in the FCC-BCC micro composites during the cold deformation by drawing.

Our researchers conducted analysis of how prolonged heat treatments influence mechanical strength and conductivity of nano-structured FCC-BCC micro composites. They revealed high stability of the microstructure of Columbic Copper wires. UTS values as high as 1100 MPa were maintained for the fine Columbic Copper micro composite wires 0.1 ÷ 0.3 mm in diameter after 2600 hours of heat treatment at 350°C. Conductivity for these wires remained at the level of 70 ÷ 85 % IACS.



AWARDS

Our technology has been recognized by many global and local organizations, including Business Eureka, Los Alamos National Lab, Westmoreland Mechanical Testing & Research Inc. and many others.

PRODUCTION PROCESS



METAL CASTING/MELTING

Columbic Copper alloy ingots ($d \geq 200$ mm and length of up to 1500 mm) are melted in vacuum-inducing furnaces. Other production option consists of casting the ingots ($d \geq 195$ mm and length of up to 1000 mm) in vacuum electric arc furnace with consumable electrodes.

METAL FORMING/DRAWING

Ingots and billets based on Columbic Copper and other materials are emitted in hydraulic extrusion machines of 1600 tf from containers with diameters of 180, 150, 130, 100 and 95 mm equipped by a ram rate precise regulation system and billets heating system with a temperature up to 1100°C.

Metal forming through the use of various rolling mills sequences makes it possible to produce super thin and micro wires with diameter of 50 microns.

DEVELOPMENT OF SPECIAL-PURPOSE COMPOSITE SUPERCONDUCTORS

«NANOSELECTRO» LLC has all necessary facilities and expertise to develop and manufacture internal tin Nb₃Sn superconductors with diameters of 0.1 ÷ 0.3 mm, at the same time ensuring critical current density up to 2500 A/mm² (12 T, 4.2 K), strength up to 1000 MPa, and hysteresis losses of less than 1500 mJ/cm³.

METALLOGRAPHIC TESTING AND MEASUREMENT

Tensile-test machines LFMZ-10 and LFZM-100 with forces from 1 to 100 kN are used to measure mechanical properties (UTS, $Y_{S_{0.2}}$, Conductivity δ) of conductors.

METAL MECHANICAL PROCESSING

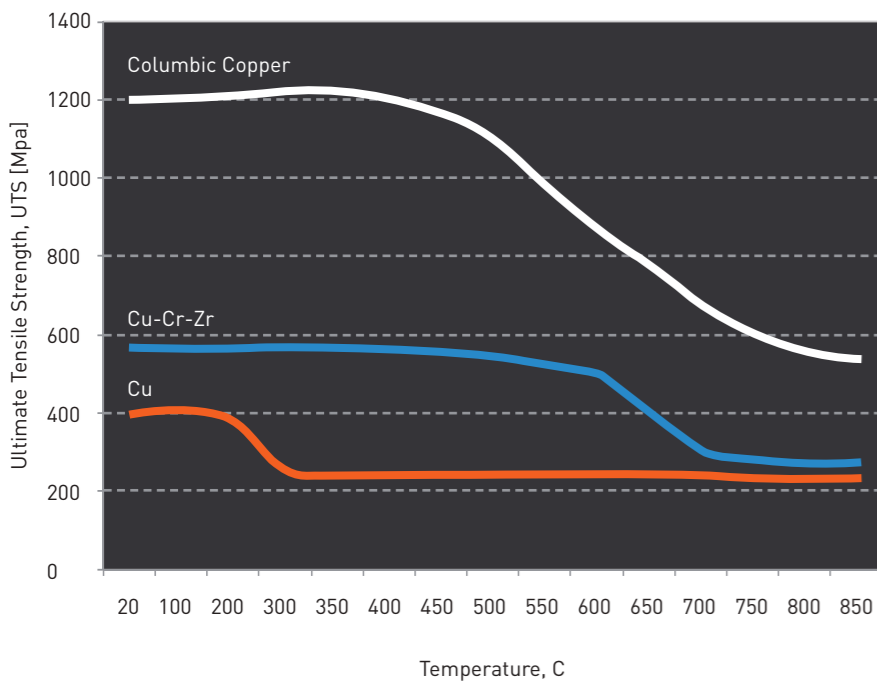
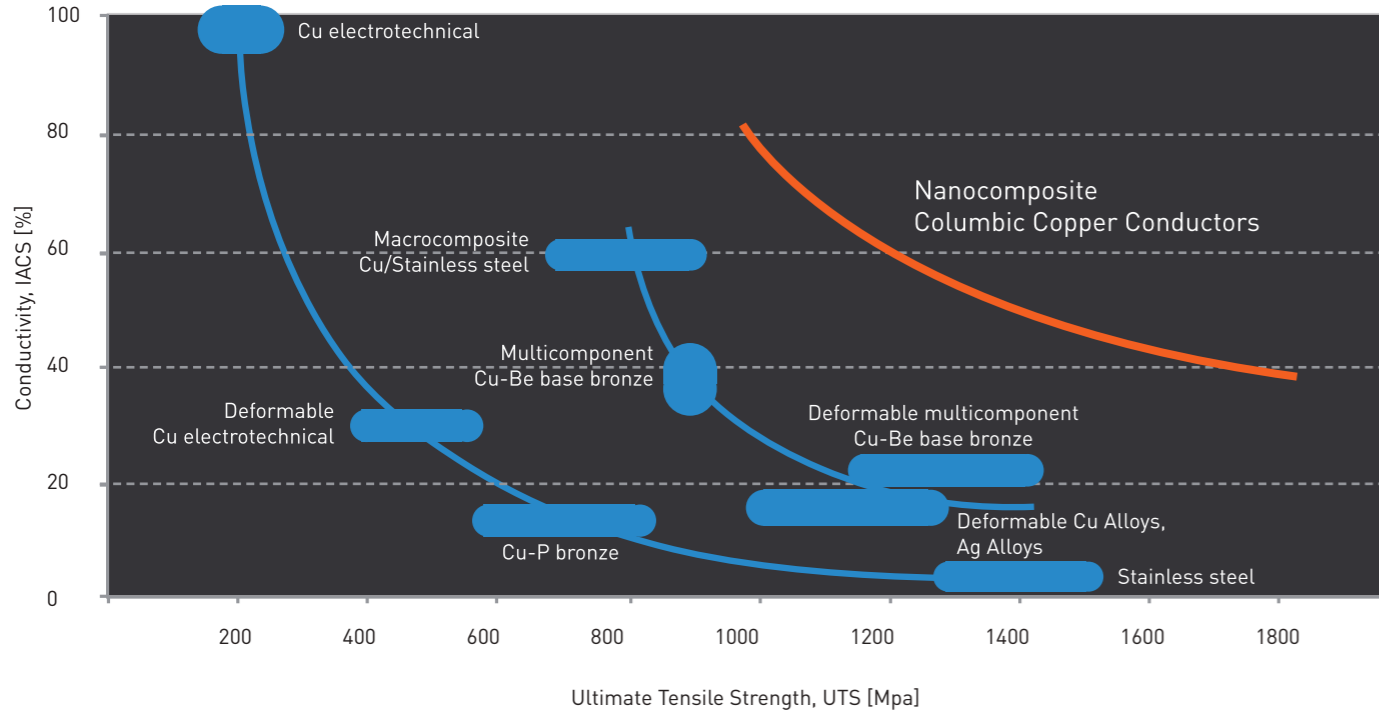
The company operates on a wide range of equipment and hardware for various metal processing operations.

METAL HEAT TREATMENT

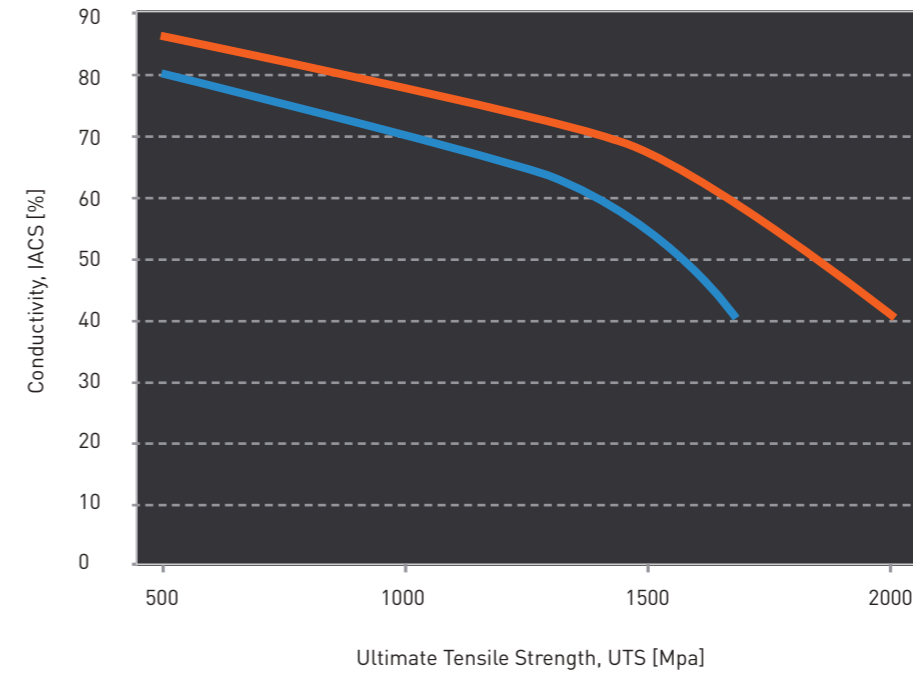
Ingots and billets with diameters up to 500 mm and 9000 mm in length are treated with heat, wire coils area treated at a temperature of 1200°C in air and vacuum furnaces where vacuum level is not less than 10 mm Hg.

PROPERTIES

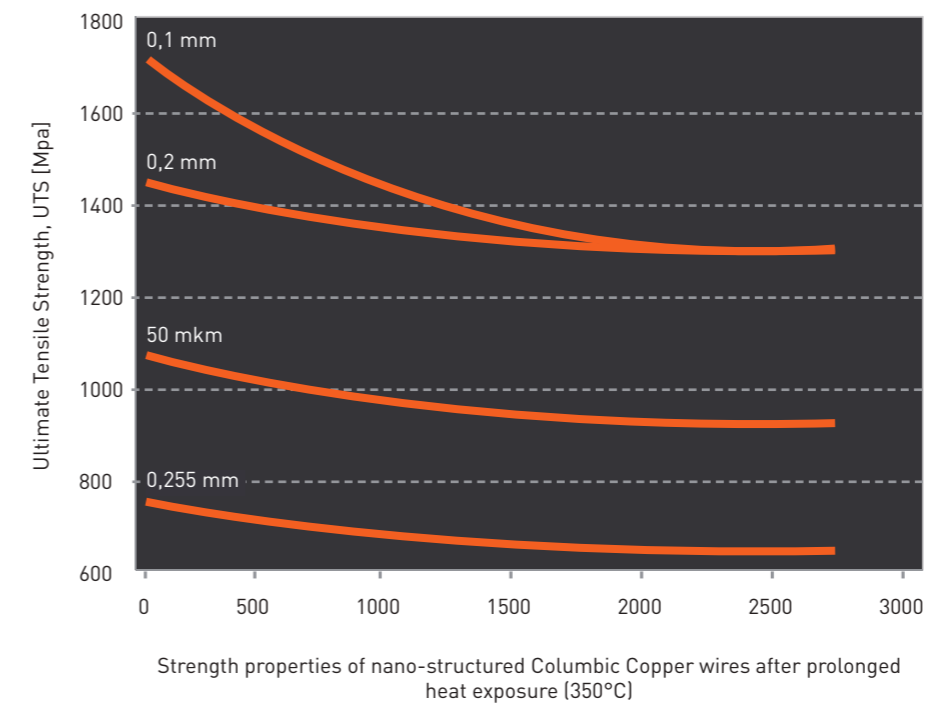
THE MANUFACTURED PRODUCTS HAVE UNIQUE COMBINATION OF HIGH STRENGTH AND ELECTRICAL CONDUCTIVITY AS WELL AS RECORD-LEVEL ANTIFATIGUE PROPERTIES.



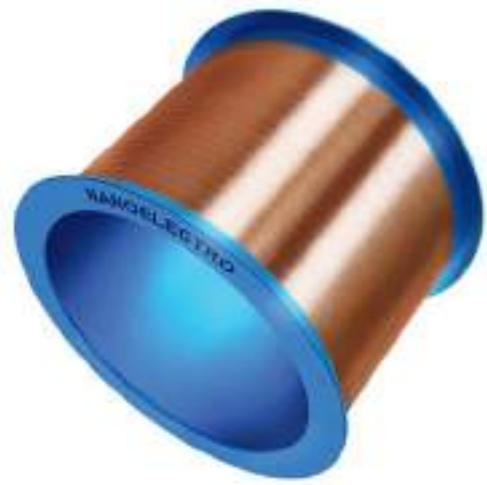
Nano composite wires possess mechanical strength comparable to steel rigidity (1200 ÷ 1500 MPa), electric conductivity capability reaches 70 ÷ 85 % compared to pure annealed copper. The technology is known as unique to date in Russia and in the rest of the world and provides the possibility to manufacture long composite wires from a cutting-edge and innovative material. An effect of an irregular increase of strength and electrical conductivity in the nano composite material is resulted from its nano metric structure and associated with the formation of a new type of inter-phase semi coherent boundary lines of wire components. «NANO ELECTRO» LLC bears 22 patents of Russian Federation and possess a modern state-of-the-art production equipment.



This picture demonstrates an interval of values for the combination of strength and conductivity of Columbic Copper wires. Red graph (upper red line) limits maximum values for the combination of strength and conductivity of these wires. Lower blue graph characterizes average level for these values.



This graph shows nano-structured conductors of various diameters during the experiments carried out at 350°C. The graph illustrates high stability of the properties possessed by Columbic Copper. Even after 2,660 hours at 350°C, strength of thin wires and micro wires is much higher than strength of more traditional electrical conductors.



NANOMUSCLE™ MICROWIRES

UTS = 900 ÷ 1700 MPA
CONDUCTIVITY = 54 ÷ 80% IACS



SLIMPOWER™ THINWIRES

UTS = 1200 ÷ 1900 MPA
CONDUCTIVITY = 40 ÷ 70% IACS

MATERIAL	VARIETY	APPLICATION
Columbic Copper nano composite alloy.	Micro wires in diameter of 0.020 ÷ 0.09 mm	<ul style="list-style-type: none"> • Microelectronics; • Electronics; • Robotics; • Electric motor assembly; • Precious machinery; • Aircraft and space industry; • Military industry.

MATERIAL	VARIETY	APPLICATION
Columbic Copper nano composite alloys.	Thin wires with diameter of 0,1—1 mm	<ul style="list-style-type: none"> • Power transmission lines; • Robotics; • Electronics; • Precious machinery; • Aircraft and space industry; • Defense industry.

PRODUCT BENEFITS

- Extremely high strength for such small dimensions;
- High level of flexibility;
- A number of “bend-unbend” examinations by 180° at a room temperature is 10 times greater than for ordinary copper wires.

PRODUCT BENEFITS

- Improved reliability for electrical transmission lines and electronic parts in various devices;
- Increased reliability in avionics through weight and size reduction;
- Increased durability of power transmission lines under unfavorable weather conditions through wire weight reduction that ultimately reduces operational costs and extends power lines operational life.

SOLUTIONS

Springs, bonding, winding wires, anywhere there is a need for high strength and high conductivity for especially small diameters.

SOLUTIONS

Springs, winding wires and conductors exposed to environments with high temperatures and high strength demands.



MAGNETOPOWER™ LARGE SECTION WIRE CONDUCTORS

UTS = 900 ÷ 1100 MPA
CONDUCTIVITY = 60 ÷ 75% IACS

WELDMUSCLE™ HOLLOW WIRE CONDUCTORS

UTS = 1100 ÷ 1250 MPA
CONDUCTIVITY = 68 ÷ 78% IACS



MATERIAL

Columbic Copper nano composite alloy.

VARIETY

Wire conductors of round, square and rectangular cross-section of 1.4 ÷ 37.4 mm² and linear dimensions of 0.8 ÷ 5.2 mm in thickness and of 1.5~7.2 mm in width.

APPLICATION

- High-pulsed magnets able to generate induction of 70 ÷ 100 Tesla;
- Scientific research;
- Precious electro energy equipment;
- Magnetic metal treatment.

MATERIAL

Columbic Copper nano composite alloy.

VARIETY

Hollow square wire conductors from 4 x 4 mm to 9 x 9 mm with wall thickness of 1 ÷ 2 mm.

APPLICATION

- Precious machinery;
- Magnetic metal treatment: stamping, welding, forming.

PRODUCT BENEFITS

- Extremely high strength for such small dimensions;
- High level of flexibility;
- A number of "bend-unbend" examinations by 180° at a room temperature is 10 times greater than for standard copper wires.

PRODUCT BENEFITS

- Increased operational life for inductors and reduced cost for the magnet treatment operations;
- Can be used for connecting with wide variety of materials, including connections with non-metallic materials for magnet treatments;
- Provides precise stamping in just one operation when used with magnet metal treatment devices.

SOLUTIONS

Springs, winding wires for high power magnetic field reducers, which can sustain record voltage levels.

SOLUTIONS

Magnetic-pulse treatment machines.



WIRE ROD

UTS = 420 ÷ 460 MPA
 CONDUCTIVITY = 85 ÷ 95% IACS

CONTACT WIRES

UTS = 750 ÷ 950 MPA
 CONDUCTIVITY = 80 ÷ 90% IACS



MATERIAL	VARIETY	APPLICATION
Columbic Copper nano composite alloy.	Wire rod in thickness of 1,00 ÷ 4,00 mm.	Raw material for producing microwires and thinwires.

MATERIAL	VARIETY	APPLICATION
Columbic Copper nano composite alloy.	Standard contact wires with cross-sections of 100 ÷ 150 mm ²	High speed railroad electricity supply lines.

PRODUCT BENEFITS

For overseas markets NANOSELECTRO can offer not only the finished products, but also the wire rod or drawn wire used to produce custom conductors for your industry and more.

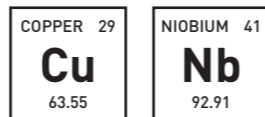
- ### PRODUCT BENEFITS
- Added capability of building the railroad electricity supply lines with increased straightness to facilitate train speeds faster than 350 km/h;
 - Increased durability and reliability of railroad contact lines operation;
 - Increased length span of power lines, which leads to reduction of the number of contact towers.

SOLUTIONS

Custom-made conductors.

SOLUTIONS

High speed railroad transportation.



PRODUCT SPECIFICATIONS

COLUMBIC COPPER

WIRE MATERIALS	DIAMETER	UTS, MPa		CONDUCTIVITY, IACS, %		LINEAR RESISTANCE, Ohm/km		LINEAR WIRE WEIGHT [calc.], kg/m
		REINFORCED	HIGHLY CONDUCTIVE	REINFORCED	HIGHLY CONDUCTIVE	REINFORCED	HIGHLY CONDUCTIVE	
Columbic Copper	0,1 ÷ 0,2	1400 ÷ 1700	1100 ÷ 1200	50 ÷ 58	64 ÷ 68	4390,1 ÷ 946,3	3430 ÷ 806,9	[0,071 ÷ 0,267] x 10 ⁻³
	0,39 ÷ 0,50	870 ÷ 1000	750 ÷ 850	72 ÷ 75	82 ÷ 85	200,5 ÷ 117,1	176,0 ÷ 103,3	[1,066 ÷ 1,776] x 10 ⁻³
	0,668 ÷ 0,686	1100	780	68	78	72,3 ÷ 68,6	63,0 ÷ 69,8	[3,108 ÷ 3,286] x 10 ⁻³
	0,798 ÷ 1,10	920 ÷ 1070	680 ÷ 760	72 ÷ 73	77 ÷ 79	47,9 ÷ 24,9	44,8 ÷ 23,0	[4,44 ÷ 8,436] x 10 ⁻³
	1,128 ÷ 1,311	1000	550 ÷ 680	70	79 ÷ 80	24,6 ÷ 18,2	21,8 ÷ 16,0	[8,88 ÷ 11,99] x 10 ⁻³
	1,514 ÷ 1,954	690	420	81	84	11,8 ÷ 7,1	11,4 ÷ 6,8	[15,98 ÷ 26,64] x 10 ⁻³
	2,257	820	400 ÷ 520	77	83 ÷ 87	5,6	5,2 ÷ 5,0	35,52 x 10 ⁻³

*IACS - INTERNATIONAL ANNEALED COPPER STANDARD. 100 % IACS = 1,7241 MICRO-OHM*CM AT 20°C.

COLUMBIC COPPER NANO WIRES

PRODUCT TYPE	SQUARE OF RECTANGULAR CROSS-SECTIONS	MEASUREMENT TEMPERATURE 293K			77K	CONDUCTIVITY, IACS, %*	ELECTRICAL RESISTIVITY AT 20°C MICRO-Ohm*cm	RESIDUAL RESISTIVITY RATIO, RRR _{293K/77K}
		ULTIMATE TENSILE STRENGTH, UTS, MPa	YIELD STRESS YS _{0.2} MPa	ELONGATION, %				
IS1708	1150÷1170	900÷910	3÷5	1520	63÷64	2,74÷2,69	4,1÷4,6	
IS23_350	5,8 (2 x 3)	1200÷1250	940÷1000	3,5÷5	> 1400	2,78÷2,65	4,0÷4,3	
IS235_350	7,0 (2 x 3,5)	1130÷1160	900÷930	4,3÷5,7	1330÷1360	2,69÷2,65	4,3÷4,6	
IS34_391	12 (3 x 4)	1150÷1200	900÷950	2,5÷3,0	> 1250	2,43÷2,42	4,2÷4,6	
IS358_600	17 (3 x 5,8)	1100÷1200	950÷1000	>5	1450÷1480	2,65÷2,46	4,2÷4,6	
IS46_745	24 (4 x 6)	1100÷1130	950÷1000	>5	> 1300	2,43÷2,33	4,6÷4,8	
IS01_09	Ø 0.1±0.9	1100±1500	900±1000	1.5÷4	1360±2000	2,65±2,30	4,0÷5,5	
IS1_10	Ø1÷10	750÷780	>550	>8	> 1000	2,16÷2,10	4,5÷5,8	



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