USER GUIDE

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CONTACT US

SuperOx
20 Nauchny proezd, bld.2
117246 Moscow, Russia
TEL +7 495 669-79-95
EMAIL info@superox.ru

IMPORTANT

Read this guide before handling and disposing of this product. Pass this information on to employees, customers and eventual end users.

INTRODUCTION

SuperOx Standard Superconducting Cable Wire is designed specifically for superconducting power cable and magnet applications. This type of superconductor is made of two second generation HTS wires laminated face to face (f2f) with stabilization and isolation options. To achieve high performance while at competitive price, this superconducting wire contains non-superconducting, yet very low resistance joints.

This guide includes product specification, material safety data sheet, and handling instructions. Please notice the values presented in this Guide are given for reference and may be indicative. Please refer to documents supplied alongside with the superconducting product for more specific information.

ABBREVIATIONS

DC	direct current
HTS	high temperature superconductor
Ic	critical current
LN_2	liquid nitrogen
MSDS	material safety data sheet
TBD	to be described
SF	self (magnetic) field

CONTENT

TECHNICAL SPECIFICATION (1/3)

SECTION 1 – PHYSICAL PROPERTIES		
Property	**Value**	**Unit**
Width	4.80 ± 0.05	mm
Standard piece length	300[(1)]	m
Max piece length without joints	120[(2)]	m
Thickness	0.34 ± 0.01	mm
Mass per meter	13	g/m
Recommended handling diameter @ 100% Ic	100	mm
Minimum bending diameter @ 95% Ic	8	mm
Minimum diameter for 30^0 twist @ 95% Ic	10	mm
Maximum tensile force @ 300 K	500	N
Minimum delamination strength @ 300 K	11	MPa
Electrical resistance @ 300 K	19 ± 1	$\mu Ohm \cdot m^{-1}$
Electrical resistance @ 100 K	6 ± 1	$\mu Ohm \cdot m^{-1}$

[(1)] piece length up to 700 m is available upon request
[(2)] longer piece length without joints is available upon request

SECTION 2 – PROPERTIES AT JOINT VISCINITY		
Property	**Value**	**Unit**
Width	4.80 ± 0.05	mm
Thickness	0.51 ± 0.01	mm
Recommended handling diameter @ 100% Ic	100	mm
Minimum bending diameter @ 95% Ic	30	mm
Minimum diameter for 30^0 twist @ 95% Ic	10	mm
Maximum tensile force @ 300 K	350	N
Electrical resistance of joint @ 77 K	less than 40	nOhm

TECHNICAL SPECIFICATION (2/3)

SECTION 3 - CHEMICAL COMPOSITION	
Element	**Content, wt.%**
Copper	59.0
Nickel	11.8
Lead	11.5
Tin	10.1
Chromium	3.3
Silver	1.6
Iron	1.2
Tungsten	0.9
Cobalt	0.5
Manganese	0.2
Others	< 0.1

SECTION 4 – CRITICAL CURRENT

Critical current is routinely measured by 4 point method with Ic criterion of 0.1 μV/cm. There are three basic types of the wire, with minimum Ic(77K, sf) of 100, 140 and 180 A. Other types of wires are available on request.

SECTION 6 – ENVIRONMENTAL TESTS(1)	
Environment	**Result of test**
Water to LN_2 cycling	Sustainable
Air, 140°C, 24 hours	Sustainable

(1) the superconducting wire is resistant to most typical types of environment, however we recommend users to follow handling instructions.

TECHNICAL SPECIFICATION (3/3)

SECTION 5 - LIFT FACTORS[1]								
Temperature, K	**Transverse magnetic field, mT**							
	sf	**20**	**40**	**50**	**100**	**200**	**300**	**500**
80	0,68	0,63	0,60	0,56	0,48	0,37	0,31	0,23
77	1,00	0,95	0,92	0,87	0,76	0,61	0,52	0,41
75	1,21	1,16	1,13	1,07	0,95	0,77	0,65	0,51
72	1,59	1,54	1,51	1,45	1,31	1,09	0,94	0,75
70	1,80	1,75	1,72	1,65	1,49	1,24	1,07	0,86
67	2,18	2,13	2,10	2,03	1,85	1,57	1,37	1,10
65	2,45	2,40	2,36	2,30	2,10	1,80	1,58	1,28

Temperature, K	**Parallel magnetic field, mT**							
	sf	**20**	**40**	**50**	**100**	**200**	**300**	**500**
80	0,67	0,59	0,52	0,41	0,30	0,21	0,17	0,12
77	1,00	0,94	1,04	0,76	0,57	0,41	0,33	0,25
75	1,21	1,17	1,11	0,97	0,73	0,52	0,42	0,32
72	1,59	1,55	1,65	1,40	1,14	0,85	0,69	0,53
70	1,80	1,78	1,74	1,63	1,32	0,97	0,79	0,60
67	2,17	2,17	2,27	2,03	1,72	1,29	1,06	0,82
65	2,43	2,43	2,40	2,31	2,00	1,52	1,25	0,97

(1) the ratio between the minimum critical current value at given B,T conditions (at all angles) to the minimum critical current value at 77K, sf.

MATERIAL SAFETY DATA SHEET (1/4)

SECTION 1 – PRODUCT IDENTIFICATION

Identity High temperature superconductor wire
Chemical Family Metal Alloy
Formula Each layer of wire contains chemical elements formulated in different concentrations, refer also to Technical Specification Sec.III.

SECTION 2 – HAZARDOUS INGREDIENTS

CONSTITUENT	CAS Number	Cable wire (Est. %)	OSHA PEL[1] (mg/m^3)	ACGIH TLV[2] (mg/m^3)
Aluminum (Al)	7429-90-5	<0.1	Dust 15 Respirable 5	Respirable 1
Chromium (Cr)	7440-47-3	3.3	Metal 1 Cr II & III, as Cr 0.5 Cr VI 0.05	Metal and Cr III 0.5 Soluble Cr VI 0.05 Insoluble Cr VI 0.01
Cobalt (Co) [3]	7440-48-4	0.5	0.1	0.02
Copper (Cu) [3]	7440-50-8	5.9	Dust 1 Fume 0.1	Dust 1 Fume 0.2
Iron (Fe)	7439-89-6	1.2	Fume 10	Fume 5
Lead (Pb)	7439-92-1	11.5	0.075	0.15
Magnesium (Mg)	7439-95-4	<0.1	Airborne 15	Respiratable 10
Manganese (Mn)	7439-96-5	0.2	5 Ceiling	0.2
Molybdenum (Mo)	7439-98-7	<0.1	5	Insoluble 10 Soluble 5
Nickel (Ni) [3]	7440-02-0	11.8	1	Metal 1.5 Insoluble Compounds 0.2
Silicon (Si)	7440-21-3	<0.1	Total 15 Respirable 5	Total 10 Respirable 3
Silver (Ag) [3]	7440-22-4	1.6	0.02	0.1
Tin (Sn)	7440-31-5	10.1	2	2
Tungsten (W)	7440-33-7	0.9	Total 15 Respirable 5	5 10 STEL
Yttrium (Y)	7440-65-5	<0.1	1	1

(1) https://www.osha.gov/annotated-pels
(2) https://www.acgih.org/science/tlv-bei-guidelines/
(3) Identifies substances that are subject to the requirements of Section 313 of Title III of Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

MATERIAL SAFETY DATA SHEET (2/4)

SECTION 3 – PHYSICAL DATA

Color	Grey
Physical State	Solid
Melting point (°F)	Not applicable
Specific Gravity (H_2O=1)	13 g/m
Solubility in water	Negligible
Evaporation rate	Negligible
% volatiles by volume	0.0
pH	Not applicable

SECTION 4 – FIRE AND EXPLOSION HAZARD DATA

Flash point (Method Used)	Non flammable
Extinguishing Media	Dry sand, metal extinguishing powders or other class "D" extinguishing media.
Special Fire Fighting Procedures	Use NIOSH/MSHA approved self-contained breathing apparatus and full protective clothing if involved in fire.
Hazardous Bi-products	Various metal oxides if metal reaches melting point.
Unusual Fire and Explosion Hazards	None anticipated

SECTION 5 – HEALTH HAZARD DATA

Metallic product poses little or no immediate hazard in solid form. Potential exposure to elements listed in Section II is increased if material is melted, cast, pickled, chemically cleaned, heat treated, cut, welded, ground, sanded, polished, milled, crushed, or otherwise heated or abraded in a manner that liberates particulate. Exposure may also occur during repair or maintenance activities on contaminated equipment used during secondary manufacturing. Hands, gloves, and clothing contaminated by particulate can be transferred to the breathing zone and inhaled if proper hygiene practices are not followed.

Route(s) of entry (solid form):

Inhalation	Not likely in solid form
Ingestion	Not likely in solid form
Skin	Chromium, nickel, tungsten can cause irritation or allergic dermatitis to sensitive individuals.

Route(s) of entry (dust and fume):

Inhalation	Likely if airborne
Ingestion	Possible due to cross contamination
Skin	Chromium, copper, cobalt, nickel, or their oxide forms can cause irritation or allergic dermatitis to sensitive individuals.

MATERIAL SAFETY DATA SHEET (3/4)

Exposure Hazards:
Exposure to metal dusts and/or fumes may cause irritation to the eyes, skin or respiratory tract. Some metals may also act as an allergen causing dermatitis to exposed skin.

Emergency and First Aid Procedures:

Skin	Flush thoroughly with water.
Eyes	Flush with water, call physician.
Ingestion	Induce vomiting in a conscious person, call physician.
Inhalation	Remove victim to fresh air, call physician.
Carcinogenicity	**NTP**(1) has classified hexavalent chromium and nickel compounds as known carcinogens. NTP has classified nickel metal as a reasonably anticipated carcinogen. **IARC**(2) has listed hexavalent chromium as a Group I carcinogen. IARC has also listed and nickel as a Group 2B compound, possibly carcinogenic to humans.

(1) National Toxicology Program
(2) International Agency for Research on Cancer

Note: Superconducting wire products are in solid form and as such present no significant health hazard in their original form. Secondary processing activities performed on the materials could potentially liberate dust and/or fumes that may result in increased risk of exposure.

SECTION 6 – REACTIVITY DATA

Stability	Stable
Incompatibility (Materials to Avoid)	May react with some acids. Avoid liberation of airborne dust that can be explosive.
Hazardous Decomposition Products	None under normal conditions of use. At temperatures above the melting point metallic oxide fumes may be evolved.
Hazardous Polymerization	Will not occur.

SECTION 7 – SPILL OR LEAK PROCEDURES

No special clean-up procedures necessary if material remains in solid form. Dust generated from secondary processing of alloy tapes may present an exposure hazard. Clean-up procedures that minimize exposure to airborne particulate are recommended. Vacuuming of dust with a high efficiency particulate air (HEPA) filtered system is preferred. Do not use compressed air for cleaning. Place waste material in properly labelled closed waste container for appropriate disposal. Use appropriate approved respiratory protection, if possible, if dust and/or fume exposure exists.

Steps to be Taken in Event Material is Released or Spilled:
No special cleanup precautions necessary if material is released in original form.

Waste Disposal Method:
Copper and silver metals are normally collected to recover value. Should waste disposal be deemed necessary, follow federal, state and local regulations as necessary.

MATERIAL SAFETY DATA SHEET (4/4)

SECTION 8 – SPECIAL PERSONAL PROTECTION INFORMATION

Respiratory Protection	Grinding, cutting or welding operations performed on superconducting wire could generate airborne dust and fume. If local exhaust ventilation is proven ineffective, use NIOSH approved respirator appropriate for condition of use.
Ventilation	Use local exhaust ventilation to control airborne dust/fume emissions below recommended limits shown in Section II.
Engineering Controls	Use adequate ventilation to keep dust and/or fume concentrations below the occupational exposure limits shown in Section II.
Eye Protection	Safety glasses when risk of eye injury exists.
Skin Protection	Gloves to protect against possible cuts and abrasions during handling. Coveralls when dusts/fumes from secondary processing or cleaning activities is expected.

SECTION 9 – SPECIAL PRECAUTIONS

Precautions to be Taken in Handling and Storing: Good housekeeping must be practiced during storage, transfer, handling and use to avoid excess dust release. Good personal hygiene procedures should be observed at all times.

SECTION 10 – TOXICOLOGICAL INFORMATION

This product has not been evaluated in whole for potential toxicity.

SECTION 11 – ECOLOGICAL INFORMATION

This product can be recycled.

SECTION 12 – DISPOSAL CONSIDERATIONS

When recycled, this material is not classified as hazardous waste under federal law. Unused material and/or particulate should be sealed inside two plastic bags, placed in a DOT approved container, and labeled appropriately. When product is declared a solid waste (i.e., cannot be recycled), materials must be properly labeled, managed and disposed of in accordance with federal, state and local requirements.

SECTION 13 – TRANSPORT INFORMATION

There are no regulations that apply to packaging or labeling of these materials as shipped.

SECTION 14 – REGULATORY INFORMATION

DISCLAIMER OF LIABILITY

The information contained in this MSDS was obtained from sources SuperOx believe reliable upon the date issued. SuperOx however does not warrant or guarantee their accuracy or reliability, and SuperOx shall not be liable for any loss or damage arising out of the user thereof. The information and recommendations are offered for the user's consideration and examination, and it is the user's responsibility to satisfy itself that they are suitable and complete for its particular use.

HANDLING INSTRUCTIONS

UNWINDING AND REWINDING

1. Keep the wire spooled when not in use.
2. Safe bending diameter is 100 mm, don't bend over a small diameter, don't fold.
3. Minimum bending diameter is 10 mm.
4. Use strong scissors to cut the wire, don’t cut the wire with inappropriate tools.
5. To avoid Ic degradation, we recommend that a customer’s device winding system apply no more than 5 kg/mm^2 tension on the spool of wire.

PHYSICAL HANDLING

1. Remove moisture by fan or lint-free fabric. The moisture that condenses on cool wire surface (after testing in LN_2 bath, for example) might cause minor oxidation spots.
2. Wear nitrile or latex gloves when handling the cable wire, to avoid surface oxidation promoted by fingerprints. Gloves should be changed frequently.
3. If touched by human hand, the wire can be cleaned with acetone or alcohol, followed by a lint-free fabric.
4. It is advisable to ensure that the wire is at room temperature and dry before winding it up after low temperature exposure.

SOLDERING

1. Clean the surface of the wire and the area on the fixture or current lead to which the cable is to be soldered.
2. Use 1-methyl-2-pyrrolidone (C_5H_9NO) to dissolve the polyurethane (PU) varnish for 20 minutes.
3. Use alcohol rosin flux for soldering. Most other conventional flux formulations will work well, apart from acids like hydrochloric (HCl), sulfuric (H_2SO_4), nitric (HNO_3) or phosphoric (H_3PO_4).
4. Commercial solder material with melting point below 120°C is recommended, like Rose or Indium alloys.
5. The soldering temperature should be kept below ~140°C, especially for long processing time, to avoid possible degradation of superconducting properties.
6. Apply solder to contact surface and to the wire.
7. Gently press the wire to the contact surface and apply appropriate heat until solder material melts.