Quality/Purity of copper used in Jantzen Audio inductors:

All Jantzen Audio inductors, both wire and foil based are made with copper that is in accordance with ETP (Electrolytic-Tough-Pitch) C11000 and an IACS certification of a minimum of 100% conductivity.

C11000 copper has a guaranteed purity of 99.9% or higher. The copper purity will often be higher, but 99.9% is the margin which our suppliers of copper wire and copper foil will guarantee as a minimum.

The oxygen content of ETP C11000 certified copper is between 0.02 and 0.04%.

Copper types and copper purity used for audio grade inductors in general:

Oxygen free copper C10100 OFE is 99.99% pure copper wire or foil and is mainly used for appliance areas where it is important that the copper does not contain any Silver (Ag) or other foreign elements.

This can be i.e. cryogenics, aerospace or other industries where the purity and oxygen level of the copper used needs to be 99.99% pure and virtually free of oxygen.

For audio appliance using Oxygen free copper C10100 OFE copper has no advantages, as there is no possible way for the human ear to hear any difference in performance between inductors made from C10100 OFE copper or ETP (Electrolytic-Tough-Pitch) C11000 copper.

Using Oxygen free copper C10100 OFE is 99.99% in audio inductors would make them unnecessarily expensive and to our best knowledge no-one in the audio industry can claim, nor prove that they use this grade of copper with certificates or independent lab tests.

As a rule of thumb, any inductors using Oxygen free copper should be 3 to 4 times more expensive than the average market price for inductors using ETP C11000 certified copper (99.9%).

Inductors versus capacitors:

For capacitors, pure silver or Oxygen free copper C10100 OFE is often used for the lead-wires, because capacitors in their nature are more revealing when it comes to audio appliance.

Inductors play an equally important role in crossovers, but in a different way.

Inductors do not have the ability to "color" or "change" the sound profile in the same direct way that changing/upgrading capacitors does.

The role of inductors have more to do with performance in areas like increased power handling and adding dynamic headroom by choosing the right type of inductor.

As long as the inductor is well made from high quality copper the signal pathing will be as it should be.

What does it take to make a good audio grade inductor?

The most important factor for a good quality audio grade inductor is that the copper used is of a certified good quality, like the ETP (Electrolytic-Tough-Pitch) C11000 copper we use at Jantzen Audio any copper grade above this grade has no technical advantages or performance enhancing qualities for audio appliance. Using a higher grade would make inductors more expensive than necessary.

Furthermore the winding integrity has to be impeccable and also the overall quality of the inductor is of course a factor.

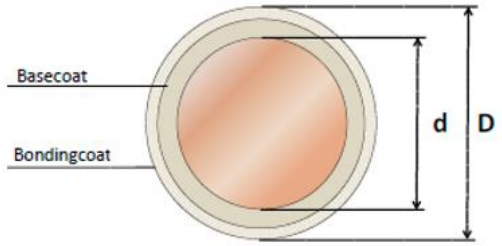
At Jantzen Audio we wind our induction coils (wire and foil) on semi-automatic machines and we use the "baked wire" technology to make wire based coils with no need for plastic bobbins.

For foil type inductors we have built our own special semi-automatic machines that allow for tight windings and full control of layering and insulation.

<u>This means we can offer these very low tolerances:</u>

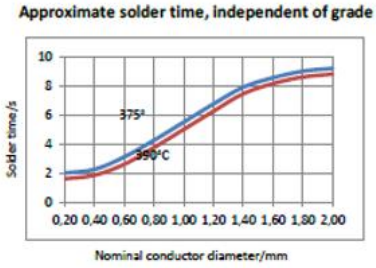
- **Air Core, Iron Core & Litz Wire inductors:** +/- 3% (inductance) & +/- 5% (RDC)
- **C-Coil inductors:** +/- 5% (inductance) & +/- 10% (RDC)
- **Wax Coil & Cross Coil inductors:** +/- 2% (inductance) & +/- 5% (RDC)

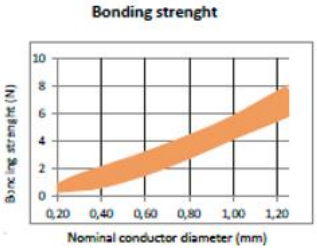
Copper wire (supplier information)



D - d = Increase

(Increase of bondingcoat may be lower than stipulated by IEC, but total increase (D-d) and bonding strenght within specifed values guaranteed)





Main characteristics	Test method	Property values	Test values for a 180 sample (1,00 mm, Gr1)
Thermal properties:			
Heat shock	IEC 60851 - 6.3	≥ 200°C	≥ 200°C
Cut-through	IEC 60851- 6.4	≥ 230°C	≥ 240°C
Temperature index	IEC 60172	≥ 180°C1)	≥ 180°C *1)
Electrical properties:			
Conductor resistance	IEC 60851 - 5.3	0,01724 Ωmm²/m	0,01724 Ωmm²/m
Conductivity	1/R	> 58 m/(Ωmm²)	> 58 m/(Ωmm²)
Breakdown voltage	IEC 60851 - 5.4	IEC 60317-0-12)	7,8 kV
Mechanical properties:			
Elongation	IEC 60851-3.3	IEC 60317-0-1 *2)	40%
Springiness	Springiness *3) IEC 60851-3.4	IEC 60317-0-12)	41°
	Springback *4)	≤ 5°	-
Flexibility	IEC 60851-3.5 - Mandrel wind.	1 x Ø	1 x Ø
Adherence	Jerktest *5) IEC 60851-3.5	No loss of adhesion	OK
	Peeltest *6)	min. 110 *7)	-
Bonding:	IEC 60851-3.7	IEC 60317-35.18	6,0 N at 190°C

1. According to supplier certificate
2. Values depend on dimension
3. Up to an including 1,60 mm
4. Over 1,60 mm
5. Up to and including 1,00 mm
6. Over 1,00 mm
7. Revolutions x nominal dimension

Values above are for information only.
All values noted are typical and can vary between lots and dimensions.

Copper wire (supplier information)

Properties:

- Class 180, grade 1B and 2B
- Directly solderable
- Short time solder
- Can be bonded at 180°C - 200°C
- Excellent resistance to mechanical stress

Specifications:

- C11000 - IEC 60317-35 – 100% IACS

Class 180:

- Temperate index ≥ 180 °C
- Heat shock ≥ 200 °C

Conductor material:

- EN 1977 - ETP1 CW003A
- EN 1977 - ETP CW004A
- ASTM B49 - ETP C11000/C11040

Insulation:

- Basecoat: Polyurethane
- Bondingcoat: Modified aliphatic polyamide

Dimension range:

- 180 – Gr. 1B = 0,200 ≤ Ø ≤ 2,000 mm
- 180 – Gr. 2B = 0,200 ≤ Ø ≤ 2,000 mm

JANTZEN AUDIO
DENMARK

Copper foil (supplier information)

Certificate of products

R-8-017A

Customer No.		YMA0017							
Raw material		TU1			Sizes		0.18*47		
Test items			STD	Value				Result	Testing tool
				1	2	3	4		
Sizes	Width（D：mm）		47$^{+0.6}_{-0}$	47.06	47.08	47.10	47.06	OK	Vernier Caliper
	Thickness（H：mm）		0.18±0.01	0.183	0.185	0.186	0.189	OK	micrometer
chemical component (%)	Element	Cu	Fe	Zn	Sn	Bi	Ni	/	FAAS
	STD	≥99.97	≤0.004	≤0.003	≤0.002	≤0.001	≤0.002		
	Results	Rest	0.0020	0.0015	0	0.00020	0.0011	OK	
RoHS (%)	Element	Cd	Pb	Hg	CR(VI)			/	x-ray fluorescence spectrometer
	STD	≤0.0005	≤0.01	≤0.05	≤0.01				
	Results	ND	ND	ND	ND			OK	
Surface	Smooth, flawless							OK	
Notes:	ND means No,or ≤2PPm								
Result:	OK								

JANTZEN AUDIO
DENMARK

Independent lab test

INSTITUTE OF NON-FERROUS METALS
ANALYTICAL CHEMISTRY DEPARTAMENT

44-100 Gliwice, Sowińskiego 5, tel. 32 2 380 278, fax 32 2 316 933
e-mail:ewasz@imn.gliwice.pl

REPORT OF TESTING No: 0464/2016

Date	2016-07-27
Page	1/1

1. **Customer**

   Polink Wilkowo sp. z o.o.

   66-200 Świebodzin

   Wilkowo 62

2. **Testing objects, properties**

   Testing objects : two samples marked as „Cu – foil and Cu – winding wire"

   Kind of tests: semi-quantitative analysis

   Date of receiving the samples for testing : July 2016

3. **Testing methods**

   - X-ray fluorescence method (XRF).

4. **Results of tests**

Sample „Cu - foil"	
Element	Concentration, %
Cu	99,9
Si	0,04
S	0,03
Fe	0,02
Cl	0,02
Al	0,01

Sample „Cu – Winding wire"	
Element	Concentration, %
Cu	99,8
Si	0,05
Mn	0,04
Zn	0,04
S	0,03
Al	0,03

.....End of Report.....

Contractor

Z-ca Kierownika
Zakładu Chemii Analitycznej
mgr inż. Andrzej Hrynkszyn
Chief of Departament

- **Results presented in the report concern only the objects mentioned in the report.**
- **Written complaint could be turn up to 30 days from the date of receiving the report.**
- **After testing, the test object shall be deposited in the archives, where it is stored for a period of two months. Report could be duplicated only entirely. Permission of Institute of Non-Ferrous Metals is necessary for each duplication.**

Important notes regarding the independent lab test

- Polink Wilkowo Sp.z.o.o. is the name of our production company / factory in Poland.
- The test was done by an independent government funded institute for non-ferrous metals (chemical analysis department)
- The X-Ray fluorescence method (XRF) can only show 1 digit for purity measurements. Different contaminants found are shown in percentages on their own, then deducted from 100% pureness factor.
- The test has a tolerance of three hundreds in precision (+/- 0.03%)
- When comparing the purity measurement of a lab test with the purity statement issued by suppliers, one must take into account that the purity measurements done by copper suppliers are based on measuring the first processing of copper mass/rods and not further processed copper products like winding wire or foil.
- Once the raw copper mass has been processed, outside contaminants like Sulphur (S), other airborne impurities and impurities originating from the processing process are inevitable and will lower the purity slightly compared to the raw unprocessed copper.
- The independent lab test shows that the processed copper we use have the following purity (factored in with a +/- 0.03% margin as shown below):

  Copper foil: 99.85% to 99.91% purity

  Copper wire: 99.78% to 99.84% purity

Datasheet - Iron powder material (cores and discs for iron cored coils)

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances/Mixtures

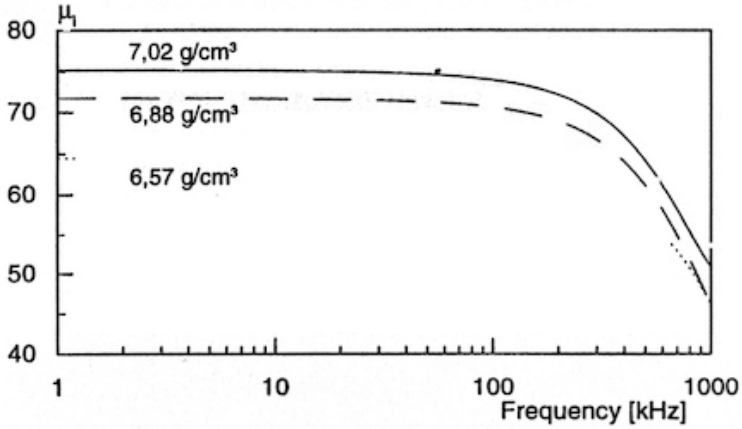
Chemical Name	EC No.	CAS No.	Weight-%	Classification according to Regulation (EC) No 1272/2008	REACH Registration Number	Substance with an OEL-value
Iron	231-096-4	7439-89-6	>97	-	01-2119462838-24 -XXXX	*

9.1 Information on basic physical and chemical properties

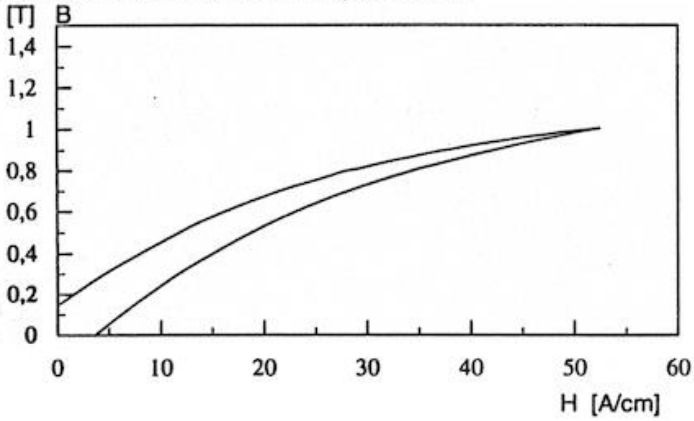
Physical state	Powder
Appearance	Light grey Fine-grained metal Powder.
Odor	Odorless
Odor Threshold	Not applicable
Particle size	No information available

Property	**Values**	**Note**
pH	Not applicable	
Melting/freezing point	1538°C @ 1013hPa	
Boiling point/boiling range	2861°C @ 1013hPa	
Flash Point		Not relevant for inorganic substances
Evaporation rate	Not determined	Solid with a melting point >300°C
Flammability (solid, gas)	Not flammable.	According to Method A10, EU- Regulation 440/2008
Flammability Limits in Air		
Upper flammability or explosive limit	No information available	
Lower flammability or explosive limit	No information available	
Vapor pressure	Not applicable	Solid with a melting point >300°C
Vapor density	No information available	Solid with a melting point >300°C
Relative density	7,87g/cm3 @ 20°C	
Water Solubility	0,015 mg/l @ 22°C	
Solubility in other solvents	No information available	
Partition coefficient: n-octanol/water	Not applicable	Not relevant for inorganic substances
Autoignition temperature	Not classified.	UN test N.4
Decomposition temperature	No information available	Not relevant for inorganic substances
Viscosity	Not applicable	Solid with a melting point >300°C
Explosive properties	Not explosive	The substance contains no chemical groups associated with explosive properties.
Oxidizing Properties	Not oxidizing	The substance is incapable of reacting exothermically with combustible materials on the basis of the chemical structure.

Effect of Frequency on Initial Permeability



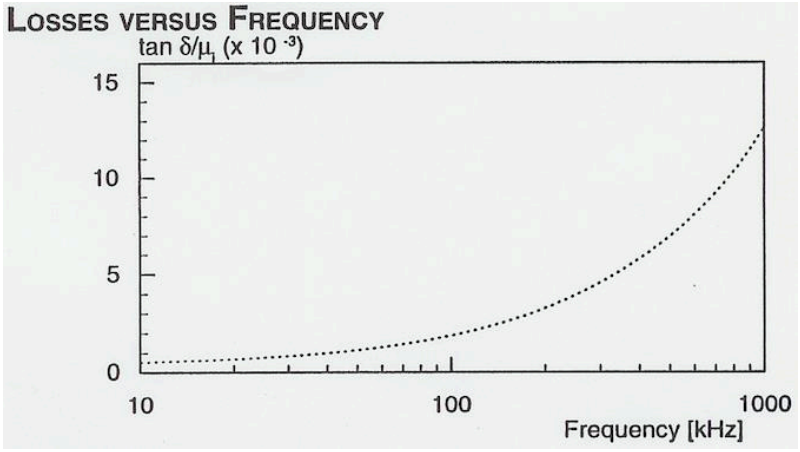
Hysteresis Characteristics, 500 Hz

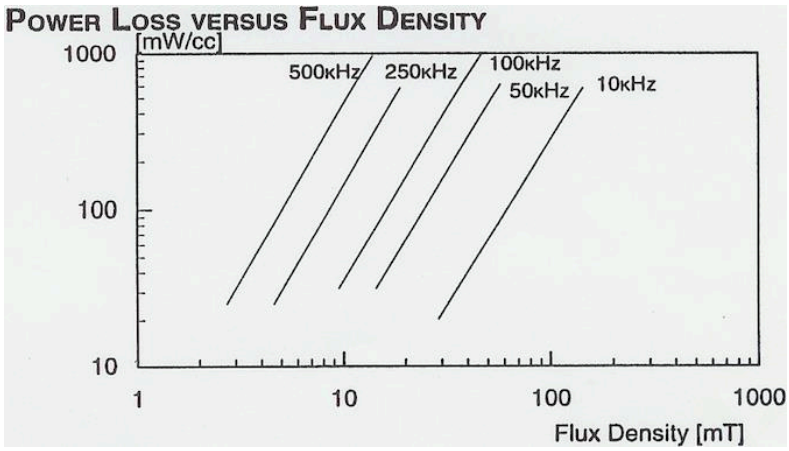


TYPICAL PROPERTIES	
Apparent Density	2.74 g/cm³
Flow	30 sec/50 g
Particle Size	<150 µm

PRESS READY MIX	
Green Density[1]	6.96 g/cm³
Strength[1,2]	27 N/mm²

[1] Compacting 600 MPa
[2] Curing 150 °C 60' in air

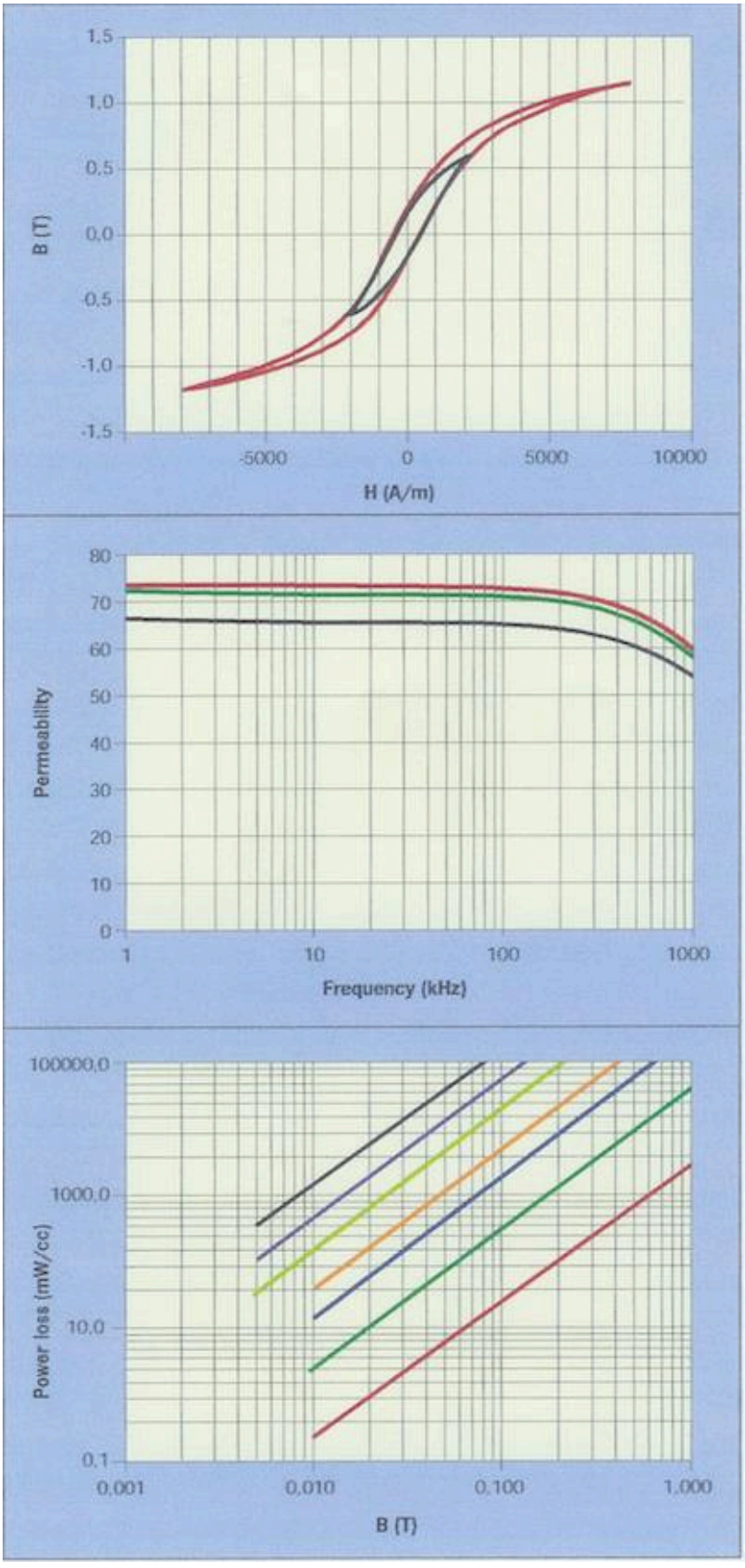




Testing

Physical properties were determined in accordance with the applicable ISO standards.

Magnetic properties were measured on toroids with the following dimensions: outer diameter 35 mm, inner diameter 14 mm, height 10 mm. The number of wire turns was 25.


1,5
1,0
0,5
0,0
-0,5
-1,0
-1,5
B (T)
-5000
0
5000
10000
H (A/m)
80
70
60
50
40
30
20
10
0
Permeability
1
10
100
1000
Frequency (kHz)
100000,0
1000,0
10,0
0,1
Power loss (mW/cc)
0,001
0,010
0,100
1,000
B (T)