MarkeTech International Inc
MARKETING ADVANCED TECHNOLOGY

High Temperature Superconducting Composite Current Leads

MarkeTech's **High Temperature Superconducting Current (HTSC) Leads** are designed to bring high power currents between ambient temperatures and/or liquid nitrogen temperatures and liquid helium superconducting temperatures with minimal heating.

Conventional vapor cooled leads and direct metal conductors used to power magnets in cryostats provide a direct heat leak to ambient, thereby increasing the helium consumption or load on a cryocooler. A dramatic reduction in this heat leak is accomplished by placing a low thermally conductive ceramic directly in the heat path of the electrical conductor. Also, since the ceramic is superconducting, there is no resistive heating factor to add to the heat load.

The use of Bi-2223 HTSC material brings not only the highest critical temperatures of Bi based superconductors but also, when properly treated, a high critical current density with a lowered sensitivity to the external magnetic field.

The specific advantages of our HTSC leads are:

- Low Heat Conduction
- Low Heat Dissipation
- Reduced Helium Consumption
- Remarkably Low Coolant Costs
- Useful Cold End Temperature 25 - 4°K or below

The remarkable reduction in helium loss and dissipation of heat into the helium reservoir is accomplished by a multi--stage design:

- Power is first carried from ambient temperature to about 77°K via conventional copper leads or via vapor cooled leads.
- The conventional lead is connected to our specially designed high temperature superconducting composite leads.
- The cold end of the lead is then connected either to a copper wire or to a low temperature superconducting wire that is joined to the magnet.

NOTE: The **critical current** is the amount of current a HTSC lead can carry before loosing its superconducting properties.

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The Effect of Temperature and Magnetic Field on Critical Current

Size and Grade			Minimum self field critical current*		Approx. critical current* (77K) at longitudinal** magnetic field		
Diameter (mm)	Length (mm)	Grade	77 K	64 K	25 mT	50 mT	100 mT
7	70	1	60 A	120 A	20 A	13 A	8 A
7	70	2	100 A	200 A	33 A	20 A	13 A
10	80	1	100 A	200 A	30 A	20 A	12 A
10	80	2	170 A	340 A	50 A	30 A	20 A
12	80 – 160	1	150 A	300 A	50 A	33 A	20 A
12	80 – 160	2	250 A	500 A	90 A	33 A	20 A
12	80 – 120	3	370 A	740 A	180 A	110 A	70 A
18	80 – 120	1	300 A	600 A	120 A	80 A	50 A
18	80 – 120	2	450 A	900 A	200 A	120 A	80 A
18	80 – 120	3	750 A	1500 A	430 A	300 A	190 A
26	120	1	600 A	1200 A	270 A	180 A	110 A
26	120	2	900 A	1800 A	450 A	270 A	180 A
26	120	3	1500 A	3000 A	1000 A	720 A	450 A

* Values at 64 K and at double magnetic field are twice higher than the values at 77 K.
** Respective values at transversal magnetic field are lower by approximately 20%.

Conductive heat leak per pair between temperatures

(Values without vapor cooling. If cooled in vapor the values are substantially lower)

Diameter (mm)	Length (mm)	Grade	77 K – 4 K	64 K – 4 K
7	70	1,2	0.08 W	0.05 W
10	80	1,2	0.10 W	0.07 W
12	80	1,2,3	0.17 W	0.12 W
12	120	1,2,3	0.10 W	0.07 W
12	160	1,2	0.07 W	0.05 W
18	80	1,2,3	0.40 W	0.30 W
18	120	1,2,3	0.20 W	0.16 W
26	120	1,2,3	0.60 W	0.40 W

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Fabrication of Leads

In order to ensure a quality lead, we begin by fabricating our own BSCCO ceramic powders under carefully controlled laboratory conditions. The powder is then isopressed around a mandrel and fired under strict time, temperature procedures. Following the firing of a silver conductive band, each tube is checked for critical current, temperature characteristics.

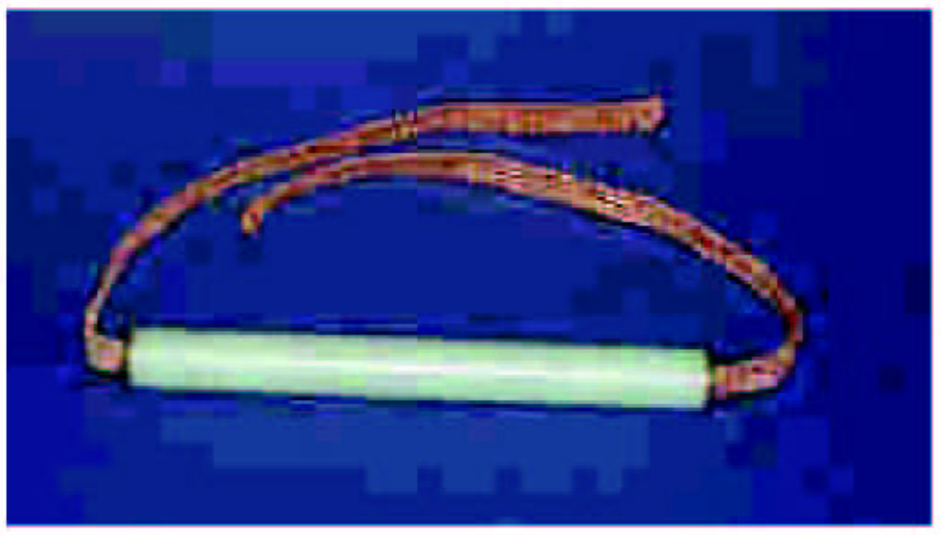
These tubes are produced in several standard diameters and lengths. In addition, we offer three material grades, which are selected based on the final design specifications.

Bare leads with silvered ends are available for the customer to attach their own metal conductors and final fabrication design, however, most prefer that Marketech supply a complete package, ready for installation. We have three standard composite HTSC lead options.

Composite Current Leads

We begin by soldering flexible copper braid to the warm end of the tube and either a copper braid or a low temperature SC wire to the cold end. This is normally encased in either a G-10 Fiberglass tube or a NiCu or stainless steel tube.

Superconducting Current leads in G-10 Fiberglass Casing
The entire ceramic lead and a short portion of the metal leads are secured in a G-10 fiberglass tube with epoxy and sealed with fiberglass end caps. This ensures the completed assembly is protected environmentally as well as from external shock and rough handling.



Superconducting Safety Current leads in Metal Casing
Superconducting Bi based 2223-phase tubes are encased in either a SS or a CuNi casing for protection against mechanical strains and any accidental operating temperature increase.

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Projected Helium Consumption

MarkeTech HTSC Leads vs. Conventional Vapor-Cooled Leads

Current Rating (Amperes)	He Consumption MarkeTech lead* (litres/hr)	He Consumption Vapor-Cooled lead** (litres/hr)	Savings (litres/hr)	%
20	0.05	0.07	0.02	28
100	0.19	0.32	0.13	41
150	0.24	0.48	0.24	50
200	0.29	0.64	0.35	55
300	0.39	0.96	0.57	59
500	0.59	1.60	1.01	63
1000	1.10	3.20	2.10	66
1500	1.60	4.80	3.20	66

*Lead consisting of conventional He vapor cooled lead from ambient to 77K and HTSC to 4K
*Reported values for conventional He vapor cooled leads

Key Applications for MarkeTech HTSC leads

- MRI Magnet Systems
- Superconducting Magnetic Separators
- High Energy Particle Accelerators
- SMES Systems
- Large Superconducting Magnet Systems
- Superconducting Generators and Motors

For nearly any application where high currents are being conducted from a region of 77°K to colder regions, MarkeTech leads can reduce coolant costs.

Superconducting magnet systems requiring current from 100 to more than 1000 amps can benefit from the significantly reduced helium consumption provided by our HTSC leads.

MarkeTech can help you design a complete current lead system to accommodate your design and performance requirements for low temperature superconducting applications.

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