Cryogenic thermal anchoring using Cu braids versus Cu strips.

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Change Record

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Introduction

This document describes the results of a test designed to compare the thermal gradient of two materials used as thermal anchors (TA) by the LNA group at the Yebes Observatory. This temperature gradient is determined by measuring the temperature difference between the two ends of a thermal anchor in a setup that mimics everyday cryogenic measurements.

The two materials compared are:

- A 10 cm OFHC Cu strip (C101OFE soft temper 0.2 x 15 mm) procured by IRAM (see Appendix A for additional details). This material was assembled into a thermal anchor in two ways:
 - By mechanical pressure using Au plated Cu blocks connected by M3 screws (see figure 1)
 - Attaching the sample to a 1 mm thick Cu slab plated with soft gold using SnPb solder¹ (see figure 1)
- A 10 cm Cu braid (tinned soft copper wire braid with a 12 x 2.3 mm section and a surface area of 9.3 mm²) purchased from RS (RS identifier 365-559, data sheet provided in Appendix B). This material was assembled into a thermal anchor using SnPb solder¹ to attach it to a 1 mm thick Cu slab plated with soft gold (see figure 1). This material and thermal anchor production method have constituted the usual solution for active and passive device cooling at the LNA lab in the Yebes Observatory.

Temperatures are measured using in-house calibrated Lakeshore DT-670 sensors. The temperature gradient of the thermal anchor is determined by measuring the temperature of a) the Cu slab which is mechanically fixed to the cold plate of the cryostat (this temperature will be referred to as T_{CP}) and b) the Cu slab at other end of the thermal anchor which is fixed to a LNA (referred to as T_{LNA}). The purpose of the LNA is to act as a controlled heat source that generates the temperature gradient in the thermal anchor (see figures 2 and 3). Several dissipated power values are tested in each experimental setup in order to obtain a more realistic idea of the thermal anchor to the cold plate of the cryostat and to the LNA are considered negligible in comparison to the gradient in the thermal anchor.

¹ SN60





Figure 1. Thermal anchors tested (left) and detail of the two assembly mechanisms used in the case of the Cu strip: mechanical pressure using M3 screws (top right) and SnPb solder (bottom right).



Figure 2. Experimental setup used to evaluate the temperature gradient of the thermal anchor fabricated using Cu braid.



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Figure 3. Experimental setup used to evaluate the temperature gradient of the thermal anchor fabricated using Cu strip.

1. Measurements

Five different thermal anchor setups were prepared and tested:

- Setup #1: one 10 cm Cu braid soldered to a Cu slab plated with soft gold

LNA diss. power (mW)	T _{CP} (K)	T _{LNA} (K)	ΔT (K)
45.0	16.6	19.1	2.5
10.2	16.6	18.2	2.2
7.0	16.6	18.1	2.1
5.4			
4.5	16.6	18.1	2.1
Cryostat intermediate sta	age temperati	ıre: 60.0 K	

Table 1. Measurement results obtained for setup #1

- Setup #2: one 10 cm Cu strip adhered mechanically to a Cu slab plated with soft gold

I able 2. Wiedsuit	Table 2. Measurement results obtained for setup #2.								
LNA diss. power (mW)	Т _{СР} (К)	T _{lna} (K)	ΔT (K)						
45.0	15.5	18.1	2.6						
10.2	15.2	17.4	2.2						
7.0	15.1	17.3	2.2						
5.4	15.1	17.3	2.2						
4.5	15.1	17.3	2.2						
Cryostat intermediate sta	age temperati	ıre: 60.0 K							

Table 2. Measurement results obtained for setup #2



- Setup #3: two 10 cm Cu strips adhered mechanically to a Cu slab plated with soft gold

LNA diss. power (mW)	Т _{СР} (К)	T _{LNA} (K)	ΔT (K)
45.0	15.9	17.2	1.3
10.2	15.6	16.7	1.1
7.0	15.5	16.7	1.2
5.4	15.5	16.7	1.2
4.5			
Cryostat intermediate sta	age temperati	ıre: 59.9 K	

Table 3. Measurement results obtained for setup #3.

Setup #4: three 10 cm Cu strips adhered mechanically to a Cu slab plated with soft gold

LNA diss. power (mW)	Т _{СР} (К)	T _{LNA} (K)	ΔT (K)
45.0	16.2	17.1	0.9
10.2	15.8	16.6	0.8
7.0	15.7	16.5	0.8
5.4	15.7	16.5	0.8
4.5	15.7	16.5	0.8
Cryostat intermediate sta	ige temperati	ıre: 61.0 K	

Table 4. Measurement results obtained for setup #4.

- Setup #5: two 10 cm Cu strip soldered to a Cu slab plated with soft gold

LNA diss. power (mW)	T _{CP} (K)	T _{LNA} (K)	ΔT (K)
45.0	15.7	17.1	1.4
10.2	15.4	16.6	1.2
7.0	15.3	16.5	1.2
5.4	15.3	16.5	1.2
4.5	15.3	16.5	1.2
Cryostat intermediate st	tage temperati	ıre: 59.3 K	

Table 5. Measurement results obtained for setup #5.

2. Conclusions

The main conclusions that can be drawn for this experiment is that the performance of a single Cu braid is very close to the performance of a single Cu strip and that additional Cu strips present a clear advantage in cooling capability.

A greater number of Cu strips allow for better performance although the upper limit could be considered to be three due to the rigidity that appears when additional strips are used.

In the case of using Cu strips, the cooling capability with both tested assembly methods, mechanical pressure and SnPb solder, can be considered identical. Mechanical pressure is considered to be most convenient because it allows for easy reassembly into new configurations with different number of Cu strips and lengths.



We conclude that the tested Cu strips could be useful in the following situations:

- To anchor parts of the cryogenic setup which are relatively fixed in position and do not require frequent manipulation.
- Special setups which require achieving the lowest possible temperatures.



Cryogenic thermal anchoring using Cu braids versus Cu strips.

3. Appendix A

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4. Appendix B

RS PRO	ENGLISH
	SPECIFICATION SHEET 365559
SC	OFT TINNED COPPER WIRE BRAID 2536P
CONSTRUCTION :	24x12x0.20mm
CSA :	9.05mm2
RESISTANCE :	1.91 OHMS/KM STANDARD RESISTANCE @ 20 DEG C.
YIELD :	96.5KGS/KM
TENSILE :	N/A
WIRE :	MANUFACTURED TO BS4109 C101.0
RoHS :	COMPLIANT
RS, Professionally Approved Pro been testified by engineers as g	ducts, gives you professional quality parts across all products categories. Our range has iving comparable quality to that of the leading brands without paying a premium price.