

Proton Source Cesium Boiler Tube Heater Brazing

David B. Augustine

Fermilab

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Introduction

The purpose of this document is to detail the necessary equipment and steps to create a vacuum tight braze of an AerOcoax heater , figures 14 and 15, onto a Cajon VCR vacuum flange, figure 2, from here on known as heater and flange.

Equipment Needed

A 10 lb Oxy-Acetylene torch set with a "0" tip, Lucas Milhaupt handy flux type B-1 for low temperature brazing, Lucas Milhaupt easy-flo 3 brazing wire, a combination clamp and chill block assembly, brazing glasses, snoop, leak test fixture, leak detector, ohm meter. See photos at end of document in the appendix.

Oxy-Acetylene Torch Set up and testing

Due to the flammable and oxidant nature of a oxy-acetylene torch . The following steps should be taken each time prior to igniting the torch. Remove flammables from work area. Insure good ventilation. Prior to assembly, check all connections for dirt, grease or damage. The operator should clean or replace as needed. The operator should have acquired skill or training to use oxy-acetylene equipment. Connect regulators to oxygen and acetylene tanks, connect hoses to regulators, connect torch handle to hoses, connect "0" size tip to torch handle. Make sure the oxygen and acetylene valves on the torch handle are closed. The regulator pressure adjustments should be backed out all the way. Open the tank valve on the acetylene tank. Set the acetylene regulator to 5 psig. Note that this is the recommended acetylene pressure required for "0" tip. Use soapy water solution to leak test all connections on the acetylene side from the tank to the torch handle. Repair any found leaks. Open the tank valve on the oxygen tank. Set the oxygen regulator to 5 psig. Note that this is the recommended oxygen pressure required for "0" tip. Use soapy water solution to leak test all connections on the oxygen side from the tank to the torch handle. Repair any found leaks. Torch tip and pressure setting information can be found in the appendix.

The heater design is coaxial. The outside skin is Inconel 600. The flange is 316L stainless steel. The heater/flange in rough assembly is shown below in Figure 1.



Figure 1: Rough assembly of heater and flange

The heater and flange should be cleaned in advance and free of grease, oil, or other surface contaminants that would interfere with the brazing process. The heater should be inserted into the flange and aligned for depth. See Figure 2 below showing the heater assembly. The heater is the part slightly protruding from the end of the tube.

SS-4-VCR-3-4TA

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**316 Stainless Steel VCR Face Seal Fitting, Tube Adapter
Gland, 1/4 in. VCR x 1/4 in. Tube Adapter**

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Figure 2: VCR Gland flange



Figure 2: Assembly showing heater depth alignment

Once aligned, the heater and flange will be installed into the clamp chill block. One may mark the heater with an ink pen to check alignment prior to brazing. This can be cleaned off with alcohol prior to brazing. The block is then tightened enough so that the flange does not fall out. The photograph in Figure 3 below shows the VCR flange in the cooling block. Only the narrow end of the VCR flange sticks out of the cooling block.

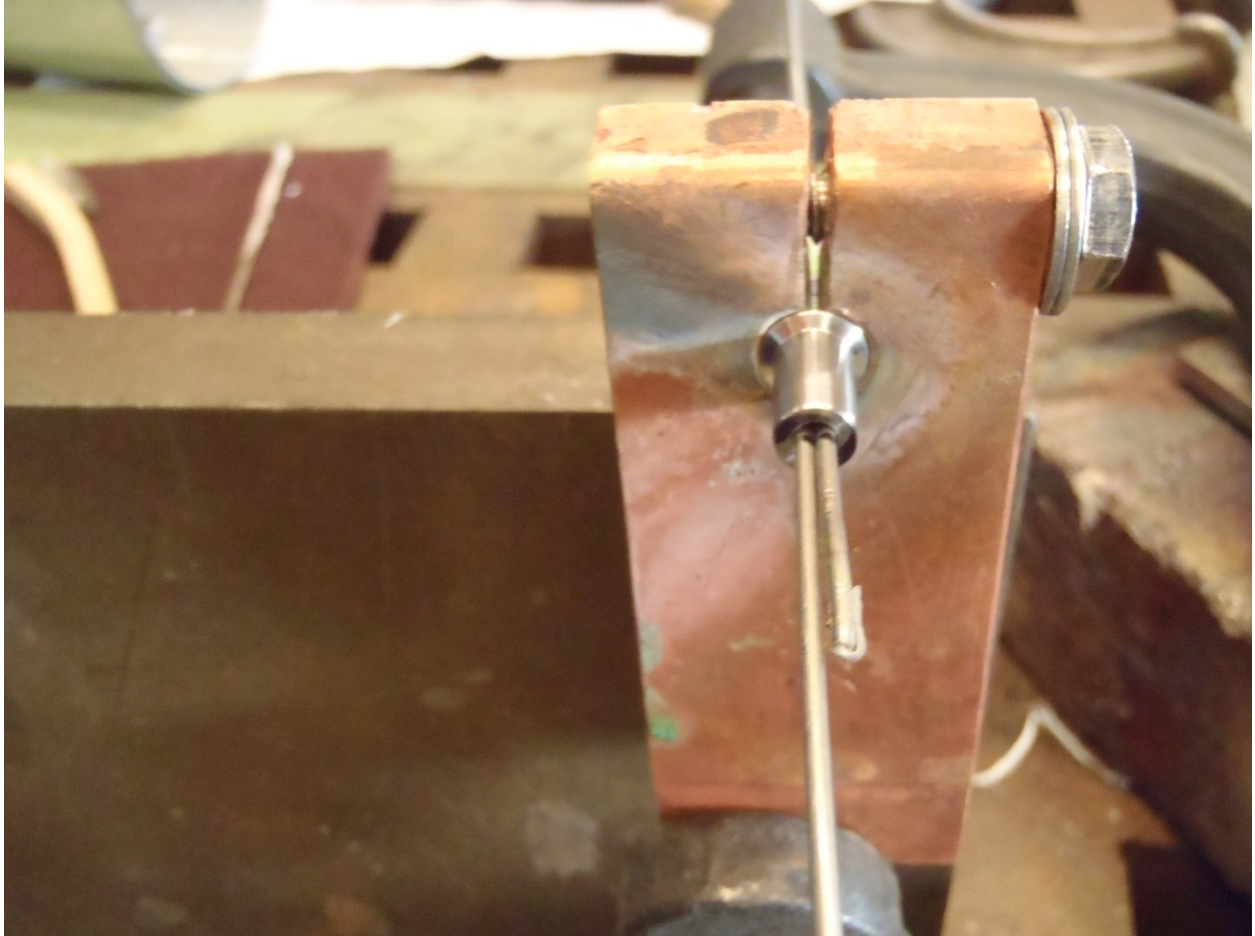


Figure 3: VCR flange clamped in the cooling block

Apply flux sparingly to the narrow end of the flange tube and on the heater forcing some flux inside the flange tube. The photograph in Figure 4 below is an example of the modest amount of flux required.

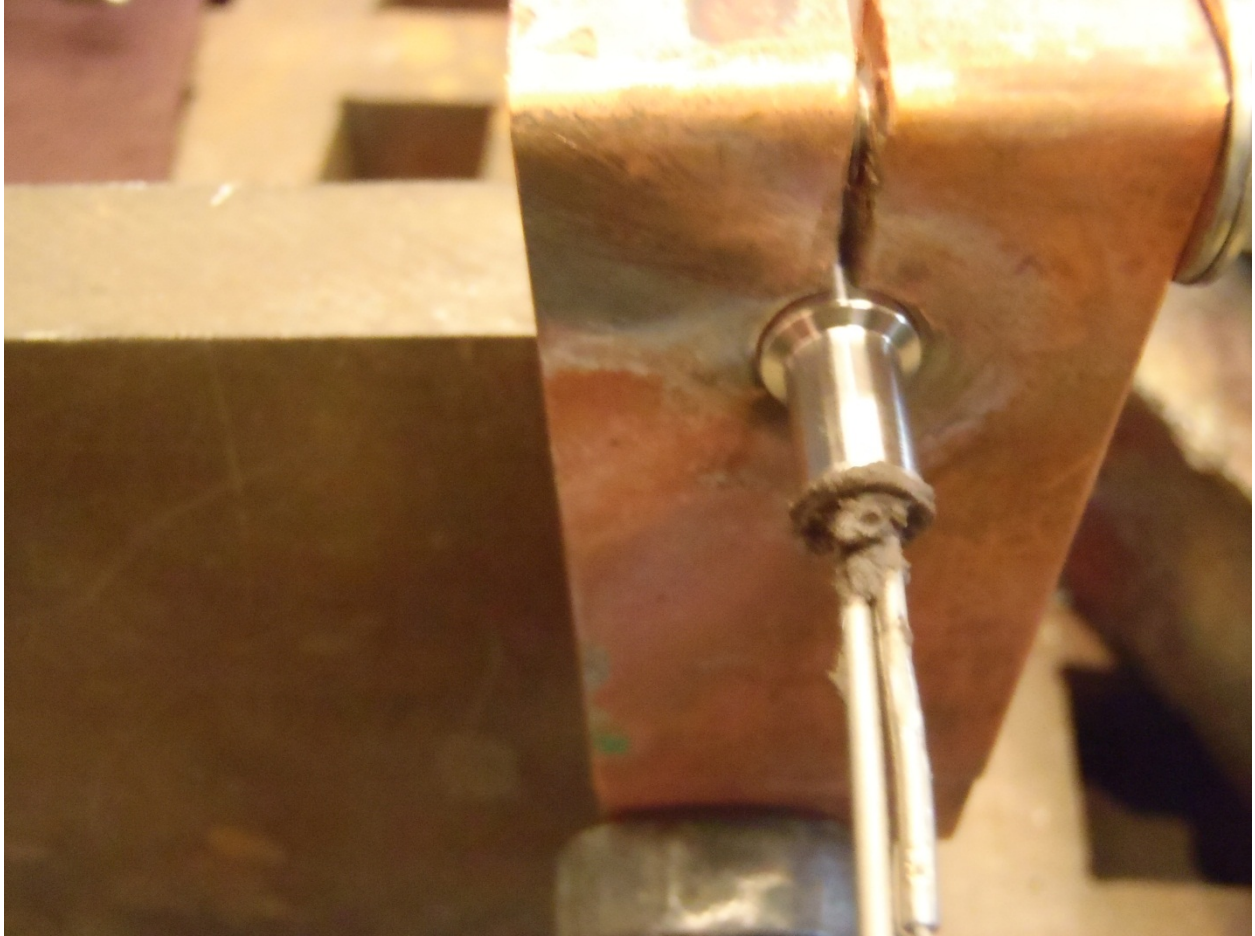


Figure 4: Modest amount of flux applied to heater and flange

Light torch and adjust for neutral flame. Heat the narrow end of the flange only. The heater wire is very delicate and can be readily damaged by the heat of flame. Play the flame over the narrow end of the flange. The heater wire will be conduction heated from the flange. The narrow part of the VCR flange will become dull cherry red and the flux will start to run and turn clear. This is the point when the silver brazing wire is applied to the end of the narrow part of the flange. As the silver wire is melting, ensure that enough material is melted to completely seal the end of the flange tube and around the heater conductors. Then move the torch and turn it off. The photograph in Figure 5 below is a representation of the actual brazing process.

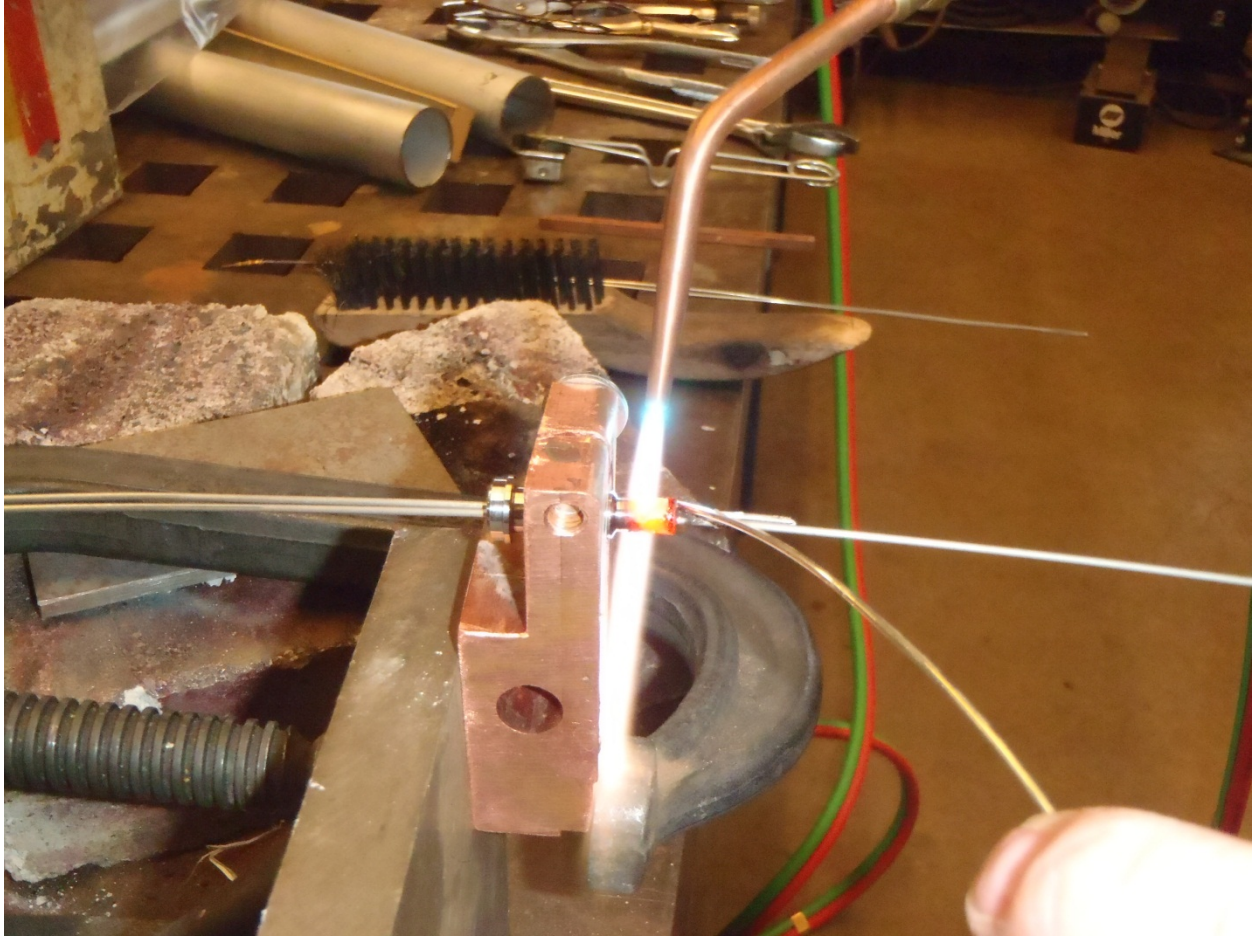


Figure 5: Brazing process

When cool, remove heater assembly from chill block. The excess solid flux can be removed with boiling water and a stainless steel brush. Do not completely immerse heater ends in water. The oxidization on the stainless fitting will have to be sanded clean.



Figure 6: Brazed assembly prior to cleaning

The heater assembly braze joint to flange must be leak tested on a helium mass spectrometer. It should not leak to a sensitivity of 2×10^{-10} Torr-Liters/second, figure 8. The heater must also pass an electrical continuity and resistance test to determine if it was damaged during the brazing process. The heater must not be shorted or open. The resistance should be ~ 5 ohms, figure 7.

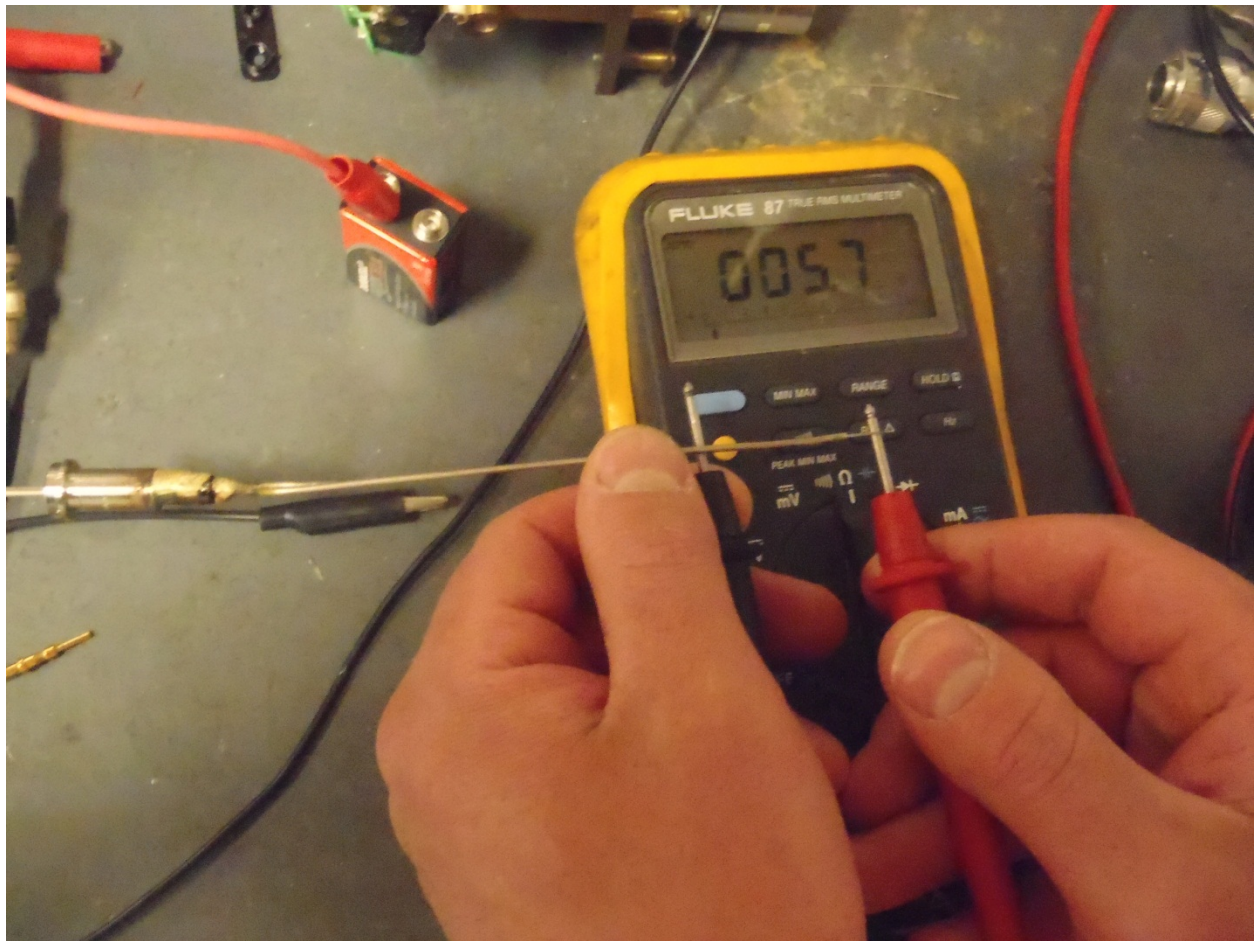


Figure 7: Electrical resistance test



Figure 8: Vacuum leak test

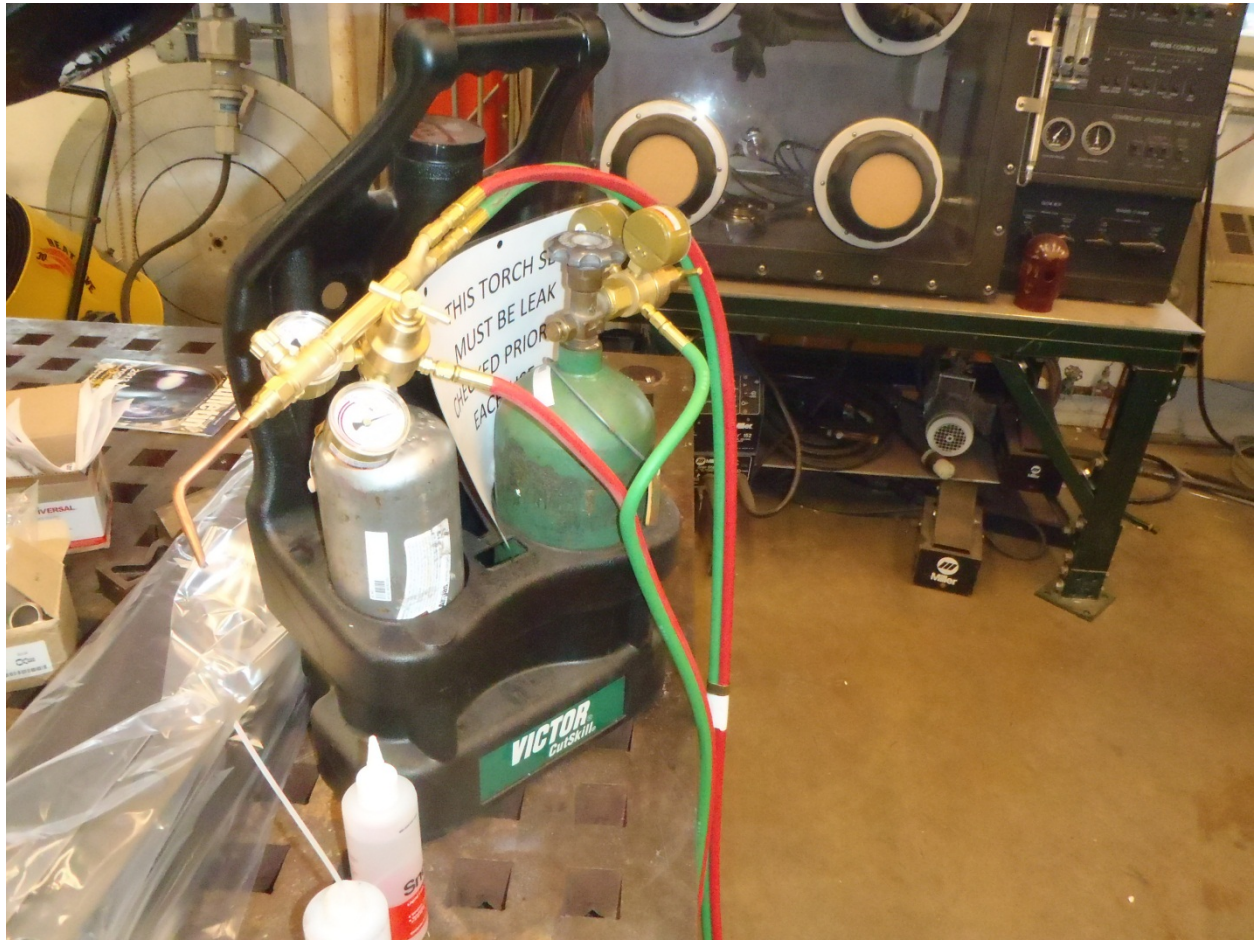


Figure 9: Oxy-Acetylene torch set, 10lb

WELDING NOZZLE FLOW DATA

Metal Thickness	Tip Size	Drill Size	Oxygen Pressure (PSIG)		Acetylene Pressure (PSIG)		Acetylene Consumption (SCFH)	
			Min	Max	Min	Max	Min	Max
Up to 1/32"	000	75 (.022)	3	5	3	5	1	2
1/16" - 3/64"	00	70 (.028)	3	5	3	5	1 1/2	3
1/32" - 5/64"	0	65 (.035)	3	5	3	5	2	4
3/64" - 3/32"	1	60 (.040)	3	5	3	5	3	6
1/16" - 1/8"	2	56 (.046)	3	5	3	5	5	10
1/8" - 3/16"	3	53 (.060)	4	7	3	6	8	18
3/16" - 1/4"	4	49 (.073)	5	10	4	7	10	25
1/4" - 1/2"	5	43 (.089)	6	12	5	8	15	35
1/2" - 3/4"	6	36 (.106)	7	14	6	9	25	45
3/4" - 1 1/4"	7	30 (.128)	8	16	8	10	30	60
1 1/4" - 2"	8	29 (.136)	10	19	9	12	35	75
2 1/2" - 3"	10	27 (.144)	12	24	12	15	50	100
3 1/2" - 4"	12*	25 (.149)	18	28	12	15	80	160

Figure 10: Victor tip chart for welding



Figure 11: Low temperature flux



Figure 12: Easy Flo brazing wire

LUCAS-MILHAUPT, INC.

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CERTIFICATION OF COMPLIANCE -- DO NOT DESTROY

Packing List 721336.0
Customer WELDSTAR COMPANY
Customer P.O. 5436
Customer Part# .062 (1/16) X 50 KO Rev

Date Shipped August 5, 2009

Mark Pkg P.O. 5436
Quantity Shipped 50.00 TO

Chemical analysis is for alloy EASY-FLO 3
Type Of Cert COMPLIANCE

lot# 206568

Symbol	%	Symbol	%
AG	49.570	CU	15.460
ZN	15.800	CD	16.100
NI	3.060		

We Certify That The Material Identified Above Complies With Specification:
AWS A5.8 BAG-3 2004 SFA5.8 BAG-3 1992
MATERIAL IS FREE FROM MERCURY CONTAMINATION
TOTAL OTHERS: .15 MAX

Figure 13: Easy Flo brazing wire specification sheet



ARI Industries Inc

AerOcoax

SHEATH DIAMETER		CONTINUITY RESISTANCE		INSUL. SPACING	NORMAL LENGTH		SHEATH MATL.	PART NUMBER
Inch ±0.005	mm ±0.13	Ohms/ft ±10%	Ohms/mtr ±10%	Inch ±15%	Feet See Note 1	Meter	See Note 2	
0.040	1.0	16.3	53.5	0.009	500	152	B	IHN040B- 16.3
.063	1.6	1.6	5.2	.011	1000	304	B	IHN063B- 1.6
.063	1.6	6.5	21.3	.014	200	61	B	IHN063B- 6.5
.080	2.0	3.9	12.8	.023	150	46	B	IHN080B- 3.9
.093	2.4	3.0	9.8	.023	700	213	B	IHN093B- 3.0
.093	2.4	1.5	4.9	.023	800	244	B	IHN093B- 1.5
.125	3.2	0.24	0.79	.018	900	274	B	IHN125B- 0.24
.125	3.2	0.40	1.3	.024	900	274	B	IHN125B- 0.40
.125	3.2	0.80	2.6	.030	900	274	B	IHN125B- 0.80
.125	3.2	1.6	5.2	.034	400	122	B	IHN125B- 1.6
.180	4.6	0.18	0.59	.033	400	122	B	IHN180B- 0.18
.180	4.6	0.73	2.4	.048	400	122	B	IHN180B- 0.73
.188	4.8	0.70	2.3	.051	800	244	B	IHN188B- 0.70
.250	6.4	0.35	1.1	.070	200	61	B	IHN250B- 0.35

AerObiax

0.040	1.0	30.0	98.4	0.004	500	152	B	2HN040B- 30.0
.063	1.6	13.0	42.6	.007	200	61	B	2HN063B- 13.0
.093	2.4	6.0	19.7	.011	400	122	B	2HN093B- 6.0
.125	3.2	3.2	10.5	.016	900	274	B	2HN125B- 3.2
.188	4.8	1.4	4.6	.024	400	122	B	2HN190B- 1.4
.250	6.4	0.70	2.3	.031	200	61	B	2HN250B- 0.70

Note

BULLETIN 5.1

FEBRUARY 1992

Figure 14: AerOcoax heater catalog page

This cable is made by a multiple pass drawing operation. When shipped, the ends are sealed to prevent moisture absorption by the MgO insulation. Once the seal is broken, the MgO will absorb moisture from the atmosphere and rapid loss of insulation resistance and dielectric strength can occur. Destructive arcing between the wire and sheath can occur if the wet cable is energized. Unsealed cable can be dried by a 24 hour oven bakeout at 250°F or higher or by self-heating at low voltage.

In general, there is very little temperature difference between the sheath and wires. With the cable sheath operating at temperatures less than 1000°F, ARi recommends not exceeding 150 watts/in (area measured at the sheath surface), when ends are properly terminated.

As temperature increases above 1000°F, the maximum watt density should be decreased.

Heater life in any specific application is difficult to predict. However, life generally decreases as temperature and/or the number of thermal cycles increases.

Maximum recommended operating temperature is 1800°F.

Sheath:	Inconel* 600
Insulation:	Magnesia, compacted. Minimum content of MgO is 99.4%
Wire:	Nickel-Chrome-Iron with resistivity of 620 OHMS/CMF @20°C (68°F)
Tolerances:	Sheath Diameter — ± 0.005 inches (± 0.13 mm) Continuity resistance — $\pm 10\%$ of nominal
Insulation Resistance:	1000 megohm — ft. @ 500 VDC @ 20°C (68°F) 100 megohm — ft. @ 500 VDC @ 317°C (600°F)
Dielectric Strength:	100 volts/.001 inch of insulation thickness — Straight cable 50 volts/.001 inch of insulation thickness — 5D radius bend. Cable ends must be coated to prevent arcing

*Registered Trademark of International Nickel Corp.

HOW TO ORDER:

1. Specify "Part Number" and total quantity.
2. Best pricing is to accept material in random lengths. Random lengths will be 40 ft. or longer except 10% or less of the total quantity ordered can be as short as 15 feet.
3. All items shown are normally stocked.

See Bulletin 5.2 for finished heaters made from AerObiax electric heater cable.

ARi Industries Inc

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Figure 15: AerOcoax heater catalog page