

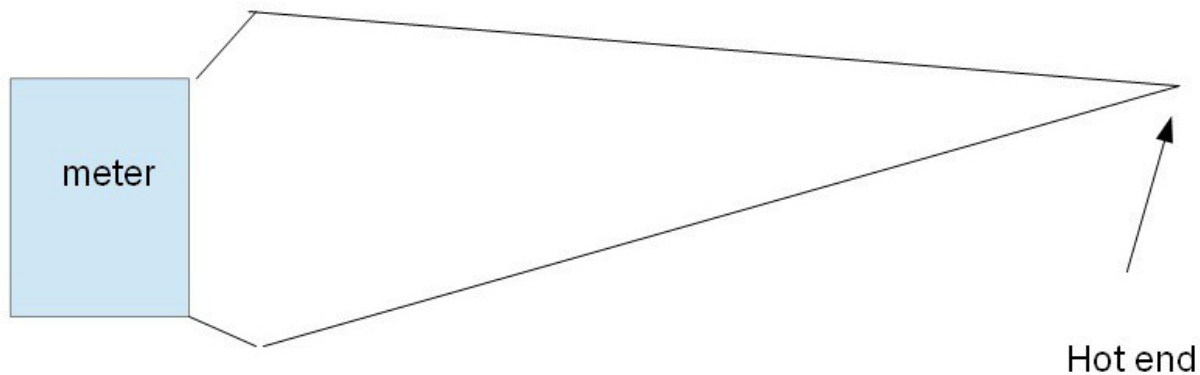
Every foundry man needs an accurate pyrometer, one that he can dip into molten metal without dissolving the probe. The backyard foundry man also needs for it to be inexpensive. There have been a lot of posts on this forum over the years about pyrometers, but to search through them is quite a chore. In this thread I will lay out in clear, concise terms what I, and some others here, have learned regarding making and using pyrometers.

Pyrometer Basics

We are dealing with Type K pyrometers, which are good up to a little over 2300 F. (1260 C.) Even there you are close to melting the wire. (I've done it.)

A pyrometer consists of a thermocouple and a millivolt meter.

A Type K thermocouple is simply two wires, one made of Nickel-Chromium the other of Nickel-Aluminum, connected electrically at each end, usually welded at the hot end. When one of the connections is heated to a higher temperature than the other connection, an electrical current flows in the wires. In our case, instead of connecting the un-heated wire ends directly, we connect the two wires together electrically through a millivolt meter. We can then measure the temperature of the hotter connection by measuring the voltage of the current.



The reading in millivolts is converted to temperature degrees by referencing a conversion table which is available as a PDF file here:

<http://www.omega.com/temperature/Z/pdf/z218-220.pdf>

One thing that confuses people, but is actually quite simple—and it is something you do need to know—is that a thermocouple does not measure the absolute temperature at the hot joint, but measures the difference between two joints in the thermocouple circuit. In our case, since the millivolt meter is acting as the second joint, for all practical purposes we are measuring the difference between the temperature of the welded joint and the temperature of the meter. If the temperature of the meter is 100 F and the welded joint in your molten metal is 2000 F, then the meter will indicate 1900 F. (Fancy multi-meters with built-in thermocouple scales compensate for this, but I use six dollar multi-meters

from Harbor Freight.)

An additional complication is that conversion charts assume that the second joint (the meter) is in ice water (32 F). Therefore if you estimate the temperature of your meter (I figure 100 F.—it's hot in my foundry) and the meter reads 48 millivolts (which on the chart converts to 2151 F.), that would be the temperature of my molten bronze if the meter were in ice water. But the meter is not in ice water; it is in my foundry which is 100 F., 68 degrees hotter than ice water, so my bronze is actually 68 degrees hotter than 2151, which is 2219 F.

So a rule of thumb would be to figure the temperature of your meter, subtract 32 degrees from that and add the result to whatever the chart says the temperature is. And relax about it. If you are 50 or 100 degrees off, remember, it probably doesn't matter, unless you are casting parts for Pratt and Whitney jet engines.

For Under Fifty Dollars

You need a thermocouple, a millivolt meter, a sheath to protect the thermocouple from the molten metal, and some Nickel-Chromium and Nickel-Aluminum wire.

The thermocouple comes from McMaster-Carr. Cat. number 3859K44 Price \$6.29. Plus shipping.

<http://www.mcmaster.com/#catalog/120/610/=sqo0h5>

Once again the multi meter from Harbor freight. Price \$5.95.

The wire from McMaster-Carr costs about \$1.00 a foot. Four feet is plenty. Cat. number 3870K35

<http://www.mcmaster.com/#catalog/120/613/=sqo0w9>

I made my sheath from 5/8 inch graphite gouging rods, sold by McMaster-Carr in packages of five for \$9.34. Catalog number 7979A18.

<http://www.mcmaster.com/#catalog/120/3392/=szwbn3>

Again you need to fabricate a wand to hold the sheath and the thermocouple probe. I made this from 1/2 inch thin wall electrical conduit. The inside diameter is right at 5/8 inch. I cut off a short piece and welded it onto the long piece at an angle. Welded, not brazed. (Brazed joints have no business being around a 3000 degree furnace.)



I ran the extension wires in ceramic insulators down to the end of the handle. If you use fiberglass insulated wire it will be fine without the insulators.



I cut a shallow groove in the top of the graphite sheath to wrap a piece of wire in to keep the sheath from slipping out of the tube.

Drilling the sheath is the tricky part. I set up a jig in the drill press, so the drill bit and the sheath were exactly parallel. I then drilled a 1/4 inch hole with a standard length bit.



Then I finished drilling the hole with a 12 inch long 1/4 inch bit. (Don't drill all the way through and out the bottom.) Use a new bit, not a dull one or a re-sharpened one. New bits cut straight and true.

I held the electric drill in a vise and fed the graphite rod onto the long bit by hand. The hole which I had already drilled in the drill press with the standard length bit acted as a guide for the long bit to keep it running straight.



You can see the McMaster-Carr thermocouple on the bench by the drill bit.

The ceramic insulators of the thermocouple probes are nominally 1/4 inch in diameter, but I had to sand them some to get them to slide into the 1/4 inch hole in the sheath. It would be best to use a 19/64 drill bit 12 inches long. (They cost about \$20.00. 1/4 inch foot long bits are about \$7.00.) Or you can make a bit to enlarge the 1/4 inch hole with a piece of 1/4 inch cold rolled rod. Just hammer the end a little wider and grind it so it will cut a tiny amount. (It ain't rocket science.)

These graphite sheaths dissolve over time in the molten bronze. I don't know about aluminum—I don't melt aluminum. You can see that beginning to happen here. I minimize this by heating the tip in the furnace exhaust before plunging it in the molten metal.



While I was set up I drilled all five rods which should last me for several years in my occasional use. I am a sculptor and melt bronze maybe three times a month. One advantage of these over the Mifco Inconel probes is that molten metal just slides off of the graphite; you don't have to scrape them after use.

When you connect the extra thermocouple wire you bought to the probe, you must connect the Nickel-Chromium to the Nickel-Chromium and the Nickel_Aluminum to the Nickel-Aluminum. If you mix them up you will get very bad readings. You can distinguish between the two types of wires with a small magnet because one of them is slightly magnetic.

I weld my wires with a small oxy-acetylene torch, but if you don't have one, a propane torch might possibly do it. Or if not, some copper cable clamps such as this one do fine.



Just twist the wires together and clamp them. I don't think silver solder is a good idea. You would have a thin layer of copper/silver alloy between the thermocouple wires which may affect the readings adversely.