Gravitational Soldering

By Dr Beldar, L1AR

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That worker of wonderous works, Dr Beldar, L1AR, has once again hit upon a method that could revolutionize the way we think about soldering. That is, unless you're prone to vertigo!

At a recent hamfest, I looked over a handful of coax jumpers--a true hamfest bargain. Everybody always runs short of jumpers, don't they? Due diligence required a thorough inspection of the connectors, so I unscrewed the PL-259 back shells and had a look. Ugh! Some of the connectors weren't soldered at all and those that were had a little pea of solder in the holes instead of a good, well-flowed joint. I tossed 'em back into the vendor's bin and kept on looking.

Dr Beldar, L1AR, closely examines the condition of a connector he soldered using the gravitational method.

I couldn't stop thinking about those little solder balls, though. It looked like little BB's had been dropped into each hole. Hmmm. Dropped. Into the hole. Naturally, I recalled the giant hole punched into the Arizona desert just east of Flagstaff: Meteor Crater. I also recalled reading that when the meteor hit "... all of its kinetic energy was turned instantly to heat ..." Turned to heat. In the hole.

And suddenly it hit me--not actually--that lead bullets melt when they hit a rock, so why wouldn't a solder ball melt when it hit a PL-259 with sufficient velocity? The soldering could be done using the earth's gravitational energy for free! Gravitational Soldering!

Grabbing a handy napkin, I started calculating. How much energy would it take for a solder ball to be able to form a solder joint between a PL-259 and the braid below?

To answer that question, you have to figure out how much of the PL-259 you have to heat up and to what temperature. Obviously you have to get the material up to the melting point of solder. Assuming we use the 63/37 eutectic solder, the melting point is 180°C. I also assumed that to get a good bond, we'd have to heat up a layer of PL-259 inside its hole and the top layer of the cable's copper braid to a depth of 0.5 mm. If the PL-259 is made from brass and the braid is copper, it takes 2.54 Joules (see note 1).

Could a solder ball acquire that much energy just falling through air under the influence of gravity? Exactly how big is this solder ball, anyway? I measured a few PL-259's and the infamous holes are 3 mm in diameter and the material thickness 0.5 mm on average.

A solder ball small enough to fit a PL-259's hole would reach terminal velocity pretty quickly due to air resistance. What is a solder ball's terminal velocity? That equation wasn't in any of my handbooks--hey, I'm an electrical guy! A quick email exchange with a Stanford professor I know and I had the answer--Stoke's Equation! I can hear you muttering, "Of course, you idiot!"

It turns out that the terminal velocity is 252,500 cm/sec or 2525 m/sec. (note 2) Zippin' right along, isn't it? Comfortably faster than the speed of sound in air (331.3 m/sec) that sets the upper limit of the ball's velocity. At the speed of sound the 3 mm solder ball has 71.4 Joules of kinetic energy. (note 3) So our solder ball at its ultimate gravity-driven velocity has way more energy than required!

Well, then, just how far does the solder ball have to fall to acquire the necessary energy? It turns out that the ball has to have a velocity of 6250 cm/sec which requires a drop of 199.3 meters. (note 4)

Hmmm. Now where could I find a structure that high? All of the skyscrapers are high enough, but their windows don't open. We don't have any bridges that high and besides, I can't hold a boat still enough to hit with a rock, much less a solder ball. Even Home Depot doesn't have a ladder that tall. Then, it hit me -- our local icon, the Space Needle!! Yes! A quick check on the web informed me that the Needle was 188.4 meters high. All I would need to do is to make up for being 10.9 meters short is to toss the ball downwards at a starting velocity of 2.83 m/sec. (note 5)

Therefore -- to solder a PL-259 using gravitational soldering techniques, all I have to do is stand on the Space Needle's observation deck, lean way-y-y-y-y over, and gently toss a 3 mm solder ball of 63/37 solder at 2.83 m/sec so that it falls squarely into the hole of the PL-259 body 188.4 meters below. Any volunteers to hold the connector?

Editor's Note: Dr. Beldar's origins are somewhat mysterious, but his fame is widespread. The enigmatic ham, researcher and scientist's exact residence and age are unknown, and the ITU does not even recognize the L1 prefix, presumably to help keep his identity a secret. Dr. Beldar has published numerous ham-related articles, including his world-famous and groundbreaking treatise on extra-RF amateur operation. Beldar can be contacted through his US agent, QST Contributing Editor H. Ward Silver, N0AX.

Notes

1. A 3 mm hole implies a total volume of .0048 cm3. The specific heats of the PL-259's brass (ignoring the obnoxious nickel plating) and copper braid are similar enough that an average value of .092 cal/g can be used. The solder ball is required to heat this amount of material from 23°C to 180°C, so E = specific heat x m x (final temp--starting temp).

2. The density of solder is 9.43 g/cm3 and the density and viscosity of air are .001145 g/cm3 and 183

micropoises at standard temperature and pressure. Vterminal = 2g x r2 x (density of solder -- density of air) / 9 x viscosity of air (Stoke's Equation). g is the acceleration of gravity or 980 cm/sec2.

3. A 3 mm solder ball with a volume of 0.014 cm3 has a mass of 1.3 grams. E = ½ m x v2 works out to 7.14 x 108 ergs or 71.4 Joules of energy.

4. 2.54 Joules of energy requires the ball to have a velocity of v = Ö(2 x E / m) or 6250 cm/sec. Ignoring drag far below terminal velocity, it will take t = v / g = 6.38 seconds, which requires a drop of h = ½ g x t2 = 19930 cm or 199.3 meters.

5. The required extra velocity is 6250 - (2g x h)1/2 = 2.83 m/sec.