On Making a High-Current Electric Match
For Meeting
No-Fire Requirements at Government Ranges

By William Colburn

Introduction:

As Amateur Experimental Rocketry becomes more sophisticated, it is foreseen that a time will come when this group will often use government ranges. Strict requirements must be met to use these ranges, and the 1amp/1 watt electric match is one that is addressed in this paper. Currently, the least expensive cartridge to meet these requirements cost about 50 dollars and they can easily run to hundreds. By creating the basic element and building pressure cartridges, igniters, etc. around the simple design, these costs can be greatly reduced. These High Current Electric Matches (HCEM) are fairly simple to create. While slow in their action time compared to the real thing, appropriate timing can usually be accommodated in your design.

Match Construction:

Duplex PVC insulated .015 inch solid copper wire was used; cut to your desired length- short leads for on-board squibs, long leads for safety for hooking up igniters. One leg was cut back 0.5 inch and then both legs were stripped 1/8 to 3/16 inch. The Bridgewire was .007 inch Tophet with a resistance of 12 ohms per foot. A little over 1 inch was used for each match. The wire was inserted behind the lower stripped wire, wrapped three times tightly around the wire and insulation, then spiraled up the insulation for three full wraps and then around the upper stripped wire at least three times. The legs of the Tophet wire are trimmed; the copper wire left as is. The resistance now should be 0.8 to 1.2 ohms. If it is not, adjust it by increasing or decreasing the turns on the insulation. If it is very high, the wraps were not made tightly enough. When 1 amp is passed through this bridgewire, it will get decidedly warm, but not hot. When 2 amps is passed through it will glow red. The addition of the primer will drop the temperature slightly.

The Primer:

This is made from Potassium Perchlorate, Aluminum and Bullseye Clear Shellac and Denatured Alcohol as thinner. Make it up 1 to 2 grams at a time; this is enough for 20 to 30 matches. Use a ratio of two to one KP to Al. The KP is first placed on a sheet of copy paper and triturated until it is an impalpable powder. It had been weighed first, so the proper amount is on the paper. Use a wooden tongue depressor to reduce the KP. The KP is then placed in a small aluminum weighing dish, 3 drops of the shellac added for every gram of mix, and some alcohol to dilute it. The weighed aluminum, bronzing aluminum sold in paint stores, is then added to this moistened mass and it is stirred thoroughly, mixing it at the same time. By wetting out the KP first, the danger of accidental ignition is greatly reduced, although safety glasses, gloves, apron and a Lexan shield should still be employed. Make up the primer only as you need it, within minutes of dipping the bridgewires. Any primer left over should be carefully burned, never more than ½ gram at a time. Remember, this is FLASH powder and in disposing of it all precautions must be met as well as all permits and local licenses that are required for handling such materials.

Dipping the Bridgewires:

You will need a raised surface over which the ends of the dipped matches may hang; the edge of a table, a book covered with a plastic bag, etc. Take each match and roll the tip in the primer. The primer may have to dry out a bit if it is too thin, or alcohol may have to be added if it is too thick. A mudlike consistency is just right. After rolling the tip, it is inspected and if the wire is covered well, it is placed aside, overhanging the edge as mentioned above. It will take overnight to completely dry the primer. They may be placed near a non-sparking, non-flame heat source for gently heating to speed the drying. Putting them in the sun works perfectly.

Testing HCEM for sensitivity and No-Fire:

You will need a power supply with adjustable current output and a way to accurately measure the current. You are going to subject the bridgewire/prime to a current of 1.0 amp for 5 minutes without a reaction (smoke or flame) in order to qualify it as a 1-amp/1 watt device. To actually “qualify”, the device would have to be put through many other tests and a large number of units would be involved. After this test the unit is allowed to cool down and then it is subject to 1.5, 1.75, 2.0 amps etc. until it fires within five seconds. Allow the unit to cool between each trial. Using five or more units for this “qualification test” will assure that the units are cool by the time you run through them. Each batch of 20 to 30 that you make should be tested in this manner and the current at which they fire should be noted.

If you wish to be a little more sophisticated, you would run a stair-step test on the units in accordance with a statistical method such as a Bruceton Arsenal Series or a Langlie Series. Here a number of devices are functioned according to rules which state that you move up or down in current a specific amount each failure or success. The output of the analysis is a prediction of the all-fire current at the confidence level that can be assigned based on the number of units tested.

Additional Testing:

Tests that are usually run on ordnance (pyro) devices include shake-rattle-and –roll or vibration and shock testing, temperature and humidity, salt spray (corrosion resistance), altitude functioning, and acceleration. Since the units mass very little, most of the mechanical environments are passed easily. Sealing can be very problematical in re humidity, salt spray and altitude. In humidity and salt spray resistant designs, great attention is paid to the position on the Electro-chemical series of adjacent metals. If they are too separated in the series, they will tend to corrode in both humidity and salt spray testing. Pay attention to good naval practice, lots of experience along those lines there. As for altitude, a lack of seal may prevent an igniter or5 rocket motor from firing. Many compounds used are sensitive to “dP/dT” or the rate of change of pressure during operation. If a closure fails before full ignition is established, the rarefaction wave moving back through the motor or device may extinguish the propellant or compound.

Additional safety testing includes Electrostatic Discharge and exposure to high temperature or cook-off. Electrostatic discharge is easily passed by a device as described above, as there is no metal case to arc to and the leads are connected by a low resistance bridgewire, eliminating an arcing path between them. The “cook-off” temperature is used for reference only and is usually not a requirement.

Some typical Values:

For Vibration, about 2 g’s rms over a frequency range of 500 Hz to 20 kHz; Shock, 100 g’s for 10 msec; Temperature, fully functional between –65 and +165 F; Humidity, exposure to 60% to 80% with temperature cycling to create condensation; Salt Spray, not often tested, but is similar to a month at the beach with temperature cycling; Acceleration, about the same as the vehicle it will be placed in and for a similar duration (actually often the entire environmental history of a flight is used as a base line for environmental testing- logically); Altitude, again, just slightly more severe than the actual altitude at which the device will be functioned. As it may often ignite a much larger device, care is taken to simulate the initial volume of such a device.

Credits: Jonny Dyer for the basic construction of the Bridgewired Header
Steve Zwaska for the use of a wire wrap tool to speed the process up