BRAZING Q&A

BY ALEXANDER E. SHAPIRO

Q: We want to braze a 1⁄16-in.-diameter tungsten rod into a quartz glass tube about 1½ in. in diameter. The rod will work as an electrode inside the glass tube. A similar device that we have used for many years looks like it was made using a glass solder. How do we select the correct glass solder? What is the soldering technique that is applicable for use in a university lab? In other words, how can we make a sealed joint between the quartz glass tube and the tungsten rod?

A: Brazing or soldering glass to metals has a long history of applications. Since ancient times, they were used for decoration of glassware, in jewelry, and later, in the manufacture of optical and chemical devices. There are many methods involved with preliminary metallization of the glass part followed by joining to a metal part using either tin- or lead-based solders or silver-based brazing filler metals. All these methods require appropriate operator skills and training. During the 20th century, some more productive and reliable techniques were developed for the electronics industry, such as brazing in a hydrogen furnace for joining metal electrodes with glass disks, tubes, and housings (Ref. 1).

However, if you want to manufacture only one or two assemblies, you'd better try one of the "old" techniques, for example, soldering with an intermediate soft-glass layer.

I recommend the use of alumino-borosilicate glass solder. The content of aluminum oxide in such glass solders is from 3 to 16 wt-% and boron oxide 12 to 20 wt-%. These solders have coefficients of thermal expansion intermediate between tungsten and quartz glass, and a softening point below that of quartz. The coefficients of thermal expansion are in the range of 2 to 3 × 10^{-6} °C^{-1}.

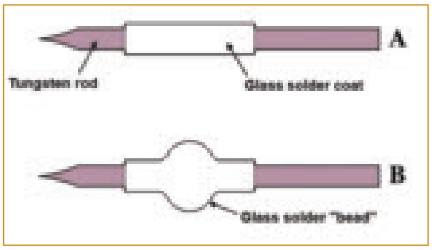


Fig. 1 — Sketches of the tungsten rod showing: A — Position of the glass solder coat; B — appearance of the glass solder bead.

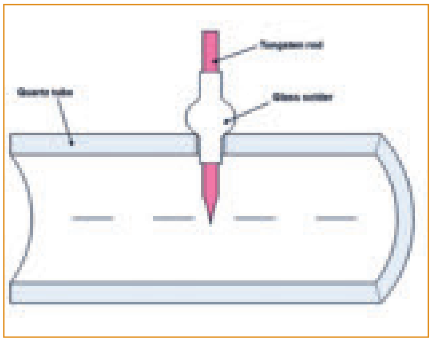


Fig. 2 — Cross section of the glass tube showing the position of the tungsten rod and glass bead prior to soldering in place.

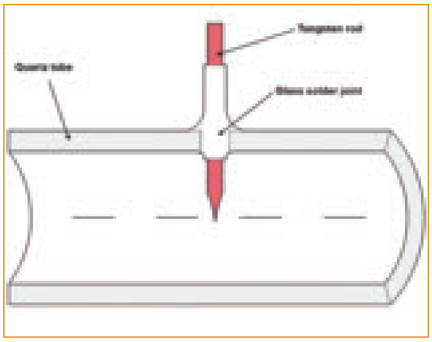


Fig. 3 — Cross-sectional view of the completed soldered assembly showing how the solder bead has melted to fill the gap between the tungsten rod and glass tube.

The diameter of the glass solder rod should be about 0.08 to 0.12 in. (2 to 3 mm). Your glass solder supply company will help you select the solder.

First, make a hole in the wall of the glass tube that is 0.020 to 0.030 in. (0.5 to 0.7 mm) larger than the tungsten rod diameter. Then, heat the tungsten rod using an oxyacetylene or acetylene-air torch.

The tungsten rod should be rotated in the horizontal position at the rate of about 100 rev/min using a drilling machine or Dremel® tool, and heated until it is white in color. Note: The heating is intensive and tungsten oxide scale may separate from the tungsten rod.

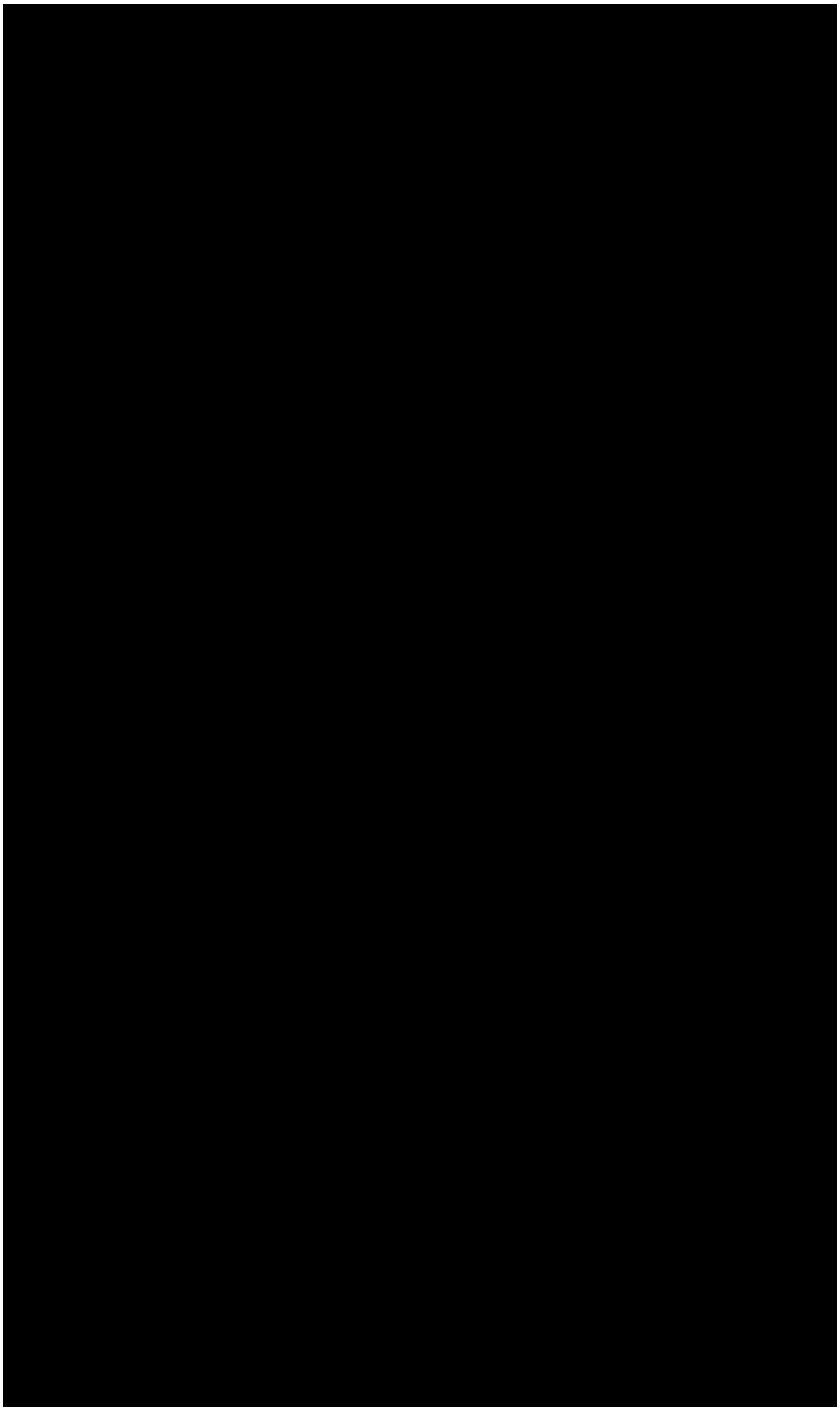
The length of the heated zone should be about ½ in. (12 to 15 mm) around the point to be joined with the glass tube.

Now, touch the glass solder rod to the tungsten rod and spread a thin layer of solder 0.01 to 0.02 in. (~0.2 to 0.5 mm) onto the rod. You may have to try this several times to develop your technique. After forming this glass coating (Fig. 1A), very gradually move the flame away from the rod. Keep the tungsten rod hot.

Next, it is necessary to form a so-called "solder bead" in the exact place where the tungsten rod will be joined with the glass tube wall — Fig. 1B.

To make the bead, just touch the glass solder rod to the rotating tungsten rod at one point for 2 to 3 s. The flame should be focused in the area targeted with your solder rod. The bead should have a smooth profile, without sharp angles.

Now, heat the glass tube around the hole, while keeping the tungsten rod hot. You can use a second torch for this purpose. Carefully insert the rod into the hole to contact the bead — Fig. 2. Then, heat this area intensively, and you will notice that the glass becomes softer and the solder bead flows into the hole to fill the gap. As soon as the joint is formed, as shown in Fig. 3, very gradually move the flame away from the joint area. I recommend you use a fixture to secure the glass tube and the tungsten rod during the operation.



Unfortunately, this is not the end of the story. There will be residual stresses in the glass that should be relieved by annealing. The annealing time and temperature depends on the type and composition of the glass. For the alumino-borosilicate glass solders discussed here, the temperature range is about 860°–1040°F (460°–560°C), with a holding time of 2 to 3 min (Ref. 1). Your distributor should provide you with the exact temperatures and holding times when you buy the glass solder. The upper temperature of this range is more important than the lower one because heating to the upper limit guarantees full stress relief in the glass. Heating, and especially the cooling, should be done very slowly. The cooling rate should be 2° to 4°F (1° to 2°C) per min. Annealing may be carried out in any furnace equipped with a controller.♦

Reference

1. *Joints of Glass with Metals*, 1951. Editor R. A. Nilender, Sovetskoe Radio, Moscow.

This column is written sequentially by TIM P. HIRTHE, ALEXANDER E. SHAPIRO, and DAN KAY. Hirthe and Shapiro are members of and Kay is an advisor to the C3 Committee on Brazing and Soldering. All three have contributed to the 5th edition of AWS Brazing Handbook.

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