

FABRICATION OF SEMPAK[®]

The fabrication of wire, crushable ceramics and sheath tubing into SEMPAK[®] is achieved with quality components, careful control of contaminants and great attention to detail. To provide an understanding of the process steps and sequence involved, the following step-by-step description gives a simplified version of the manufacture of SEMPAK[®].

Wire Preparation – Step 1

Bright, clean, pre-inspected, calibrated wire is removed from the controlled storage cabinets. The wire is straightened, cut to length and cleaned.

Ceramic Preparation – Step 2

Crushable mineral oxide preforms that have been previously checked for dimensional accuracy, grain size and density are removed from controlled storage. They are furnace fired in oxygen at 1800°F to burn off any organic impurity that might be present. After firing they are placed in desiccators, evacuated and backfilled with inert gas. The insulators are stored in this manner and from this point on, they are handled only with hand protection to prevent contamination by body contact. Maintaining insulator purity is important and it is carefully controlled throughout the entire assembly operation.

Sub-Assembly of Wire and Ceramics – Step 3

The ceramics are carefully hand beaded onto the pre-cleaned wire. Great care is taken to prevent contamination of the insulators during this operation. At Semco, this assembly step takes place on a 100-foot long stainless steel table in an environmentally controlled room. In this clean facility, dehumidified air is supplied through absolute filters to prevent contamination of the insulator and maintain product cleanliness.

Ceramics, such as BeO, that are used for high temperature applications or have toxicity or special handling precautions associated with them are moved through an air lock into a glove box assembly line. This 20-foot line is completely equipped to assemble SEMPAK[®] products in inert gas atmospheres. In this glove box line, argon is recirculated and continuously purified to maintain oxygen and moisture content to less than 2 PPM. Complete assembly of high-temperature, high-reliability sensors can be accomplished in this chamber. This includes welding of the measuring junction and sealing the cold junction end of the thermocouple.

Tube Preparation – Step 4

Tubes that have been inspected for dimensional accuracy, cleanliness and specification compliance are removed from the controlled storage area. They are uncapped and the internal cleanliness is verified. Where required, the tube is flushed internally with a hot acid wash and then flushed and neutralized with pure distilled water. To achieve high insulation resistance, it is important that the tube I.D. is clean and free of drawing compounds, carbon, dust or other contaminants.

Assembly of Tube and Ceramics – Step 5

The metal sheath tubing, cleaned to surgical standards, is slipped over the wire and insulator sub-assembly. This process takes place in Semco's 135 foot long, controlled atmosphere room. The ceramic size, bulk density, and the sheath tube dimensions are calculated so that minimum wire reduction, optimum ceramic pack density and specified sheath wall thickness all occur during the swaging process.

Pre-Swage Vacuum Drying Process – Step 6

This optional intermediate step prior to swaging is used in certain products to insure that the ceramic insulators are completely dry and oxygen free. The tube and ceramic assembly are placed in Semco's 56 foot long vacuum furnace, evacuated and heated to completely remove all traces of moisture, carbon dioxide and oxygen. They are then backfilled and cooled in argon gas.

Compacting SEMPAK® - Step 7

Single pass swaging is used to compact the assembly to a predetermined size. In this process, dies rotate and impact the sheath, working it to a smaller diameter. By careful control of die angle and configuration, a sequence of events occur that first reduces the sheath diameter, powders the ceramic preform, and then re-compacts the powder around the wire to a density of 90-95%. With proper ceramic preform dimensions, the wire is not significantly deformed or reduced in diameter in this compacting process. Single pass swaging is normally used for SEMPAK® materials in the size range from 0.500 inch diameter to 0.032 inch diameter. Below 0.032 inch diameter, a drawing process is utilized, in steps, with intermediate anneals. Dual wire SEMPAK®, as small as 0.007 inch diameter, has been produced by this successive drawing process.

Annealing SEMPAK® - Step 8

Because the mechanical reduction work hardens the sheath (and the wire very slightly), an annealing step is introduced into the assembly sequence. Depending on the materials processed, a time-temperature cycle is programmed into an electric furnace through which the material is moved at a predetermined rate. Because the annealing takes place at high temperature, a protective gas atmosphere is provided.

The preselected gas atmosphere around the SEMPAK® material is contained in furnace muffles and cooling chambers through which the material passes.

By proper annealing, the thermocouple wire retains the original accuracy and the sheath regains ductility.

Inspection – Step 9

Inspection follows production of SEMPAK®. All material receives physical checks for insulation compaction, sheath ductility and integrity. Electrical checks insure that accuracy, resistivity and dielectric strength are maintained.

Inspection after the high temperature anneal is important because the annealing process accelerates the degradation of insulation quality. Small amounts of contamination that are not detectable in unannealed material cause low insulation resistance readings after the material has been heated in the annealing process.

To meet specific customer requirements, inspection can also include voltage breakdown tests, loop resistance and capacitance measurements, and high temperature insulation resistance tests. Time response measurements and radiographs of finished junctions can be furnished. Helium leak testing, dye penetrant inspection and metallographic examination of the sheathing are furnished when requested.

At completion, the exposed ends of the SEMPAK® are sealed against moisture, part numbered, then stocked or shipped.