


# HEAT SHRINK TUBING



Heat shrink tubing wraps snugly around wires and terminals to protect them from abrasion and keep them bundled. Photo courtesy Grayline Inc.

**Made of thermoplastic or elastomeric material, this tubing provides an extra layer of protection to wire harnesses.**

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Like a belt that is tightened, heat shrink tubing (HST) wraps snugly around wires and terminals to protect them from abrasion and keep them bundled. Harness manufacturers have used heat shrink tubing for decades to improve harness performance and maximize wear life for their OEM customers. For example, Caterpillar requires heat shrink tubing be applied to the harnesses used in its construction equipment.

HST also offers other important benefits, such as smoothing out rough surfaces, and providing thermal and electrical insulation. Adhesive-backed tubing provides a strong seal against moisture and chemicals that can corrode harness components.

Utility companies often use color tubing to color-code cables that are placed under ground. And the U.S. military regularly uses tubing for harness identification purposes only—having text and numbers printed on the tubing, but keeping it loose so the tubing can be easily moved up and down the harness.

## HOW IT'S MADE

Tubing is made using a four-step process. First, material is mixed and extruded using the conventional extrusion process. Next, tubing may be cross-linked through radiation exposure or a chemical reaction. Cross-linking helps the tubing maintain its shape before and after shrinking.

Third, heat and force are used to expand the diameter of the tubing. Finally, the tubing is cooled to room temperature while in the expanded state.

“If the tubing is later exposed to a sufficient amount of heat, it will shrink down to its original size—so long as it is not restrained from doing so,” says Joe Porter, applications engineer for Grayline Inc.

Tubing width can range from 1 millimeter to 9 inches. Its wall thickness can range from 10 thousandths to 0.25 inch. Most tubing material comes in several colors, and some tubing is available clear.

Once the tubing is made, suppliers flatten and cut it into 4-foot strips, custom lengths, or bulk amounts that are rolled onto large spools. Strips and custom-length tubing are placed



**CB-DWT polyolefin tubing resists moisture and corrosion and is frequently used in electrical applications. It is adhesive-lined and comes in 2-, 3-, and 4-to-1 ratios. Photo courtesy CYG USA**

in bags or boxes in amounts determined by the harness manufacturers.

Some suppliers offer tubing with an inner-liner adhesive, which is applied by machine after the tubing cools. The adhesive melts and flows at the same temperature at which the tubing shrinks.

David Levy, national accounts manager for Thermasleeve USA, says most harness manufacturers prefer buying tubing on master rolls and cutting it at their shops. He says that adhesive-backed tubing wider than 0.5 inch is typically sold in 4-foot sticks or short reel quantities (80 feet or less). This is because the wall thickness of adhesive tubing tends to stick together when the tubing is compressed tightly.

Tubing can also be printed on for harness identification. This is done by suppliers (during or after extrusion) or by harness manufacturers in their shops. Regardless of who does it, the tubing is fed through a marking device, most commonly an ink-jet or thermal transfer printer, hot stamp machine or print wheel.

Porter says ink-jet printers tend to be used for PVC tubing and thermal transfer printers for polyolefin tubing. Printed information can include serial and product numbers, safety warnings, instructions for use, date of manufacture and company name or logo.

## BE SPECIFIC

Three factors must be considered when specifying HST. The first is to know the electrical property requirements and operating environment of the application. Harness manufacturers must find out if their OEM customers' harnesses require electrical insulation and must be able to meet specific automotive or military specifications, such as UL, CSA, MIL and ASTM. The manufacturers must also know where the harness is to be used: outdoors or indoors, above or below ground, clear of chemicals or exposed to them and other corrosive fluids.

Thermosleeve USA makes a specialty elastomer HST called TS-25, which is specially designed to protect harnesses used in military applications as well as air and space travel. TS-25 meets SAE-MIL-23053 requirements for several tubing characteristics, including corrosion, properties after heat and fluid resistance, tensile and

dielectric strength, and minimum ultimate elongation percent.

The second factor is tubing dimensions, including shrink ratio, wall thickness, length and longitudinal shrinkage. Usually, HST has a shrink ratio of 2-, 3- or 4-to-1, although some suppliers make tubing with a shrink ratio as high as 6-to-1.

Shrink ratio is obtained by dividing the minimum expanded ID by the maximum recovered ID, says Tim Paczesny, president of CYG USA. The minimum expanded ID should be greater than the widest area of the harness, which is the terminal. The maximum recovered ID should be 20 percent less than the narrowest area of the harness, which is the wire.

CYG USA makes CB-DWT polyolefin tubing, which is adhesive-lined and comes in 2-, 3-, and 4-to-1 ratios. Because the tubing resists moisture and corrosion, it is frequently used in electrical applications such as back-end connector sealing and connector-to-cable transitions. CB-DWT 4-to-1 ratio tubing can be used to repair most damaged cable jackets without removing the connectors.

HST wall thickness is usually specified as the minimum thickness at the fully recovered stage. To obtain this number, the harness manufacturer must first determine the tubing's actual wall thickness after shrinking onto an underlying object.

When tubing length is a critical dimension, longitudinal shrinkage must be considered. Generally, shrinkage is about 5 percent to 15 percent of the original tubing length.

The third factor is choosing the appropriate heat shrink material. The most common tubing materials



**The Shrink oven heat shrinks tubing on harnesses up to several inches in diameter and 40 feet long. It can shrink all types of tubing except those with a shrink temperature above 350 F. Photo courtesy AMTI, a 7 Mile Solutions Co.**

are polyolefin, PVC, fluoropolymer, PTFE (Teflon) and PVDF (Kynar). Others include fluoroelastomer, neoprene and silicone rubber.

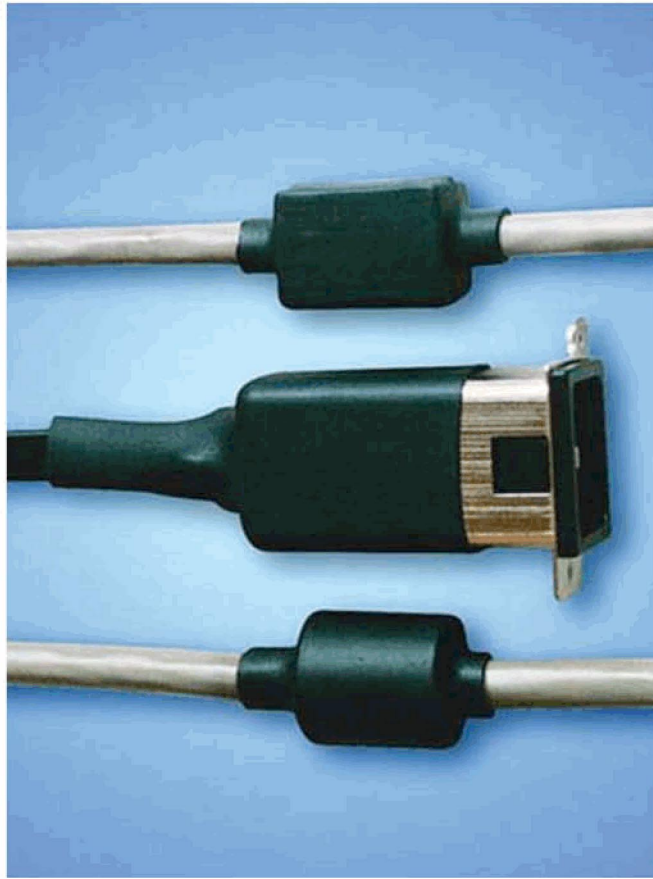
Polyolefin is the most common material because it is relatively inexpensive and has a good temperature rating of 125 to 135 C. Colored polyolefin tubing is flame retardant, but clear tubing is not.

PVC is frequently used because it is somewhat less expensive (10 percent to 60 percent) than polyolefin, comes in brighter colors and offers better clarity in its clear version. However, its temperature rating is only 105 C.

Fluoropolymer is the most expensive tubing because it has high flame resistance and a temperature rating of 200 C. PTFE tubing is often used in aerospace applications because of its extremely high temperature rating (260 C) and chemical resistance. Kynar tubing also offers excellent chemical and abrasion resistance, but its temperature rating is somewhat less at 175 C.

Suppliers such as Grayline can customize polyolefin and PVC tubing in small batches. GP-125 polyolefin and HS105C PVC tubing are available in custom sizes, wall thicknesses and colors. For instance, its GP-125 shrinks at 125 C and can be used for various commercial or industrial applications. The fluid-resistant tubing has a 2-to-1 shrink ratio and 5 percent longitudinal shrinkage. Because GP-125 doesn't use flame retardant additives, it can be produced in bright, bold colors.

HS105C is UL rated for electrical applications and is highly flame retardant. The lead-free PVC tubing has a 2-to-1 shrink ratio and 10 percent longitudinal shrinkage. Its operating temperature is -30 to 105 C. The tubing has excellent flame and chemical resistance.



Tubing needs to be wide enough to protect both wires and terminals.  
Photo courtesy Thermosleeve USA

#### THE HEAT IS ON

HST is typically placed manually on wire harnesses before being heated by a heat gun, a light source machine or flow-through oven. Shaped like a power tool, the heat gun can be used to apply tubing of any length. However, the gun is mostly used to shrink shorter tubing, such as those used on board-mounted harnesses.

Although the heat gun generates an extreme amount of heat—up to 900 F—the user does not need to wear a glove for hand protection. Typically, the gun shrinks tubing within 30 seconds. Then the tubing needs to cool for about 10 seconds.

“Proper use of the heat gun requires a lot of trial and error to get the right feel,” says Levy. “If the gun is too close, the tubing can melt or bubble rather than shrink. If it’s too far away, the tubing won’t shrink.”

Judco Manufacturing Inc. makes six models of light source

machines called the Focus-Lite series. A harness is conveyed inside the machine, which uses a 300-watt halogen light bulb to shrink all tubing within 3 seconds.

The Focus-Lite machines shrink tubing up to 1, 2.25, 8 or 15.5 inches long. They perform consistent shrinking and require low maintenance. Among the machines is the FLG3, which is hand held for use with board-mounted harnesses and tight spaces.

Flow-through ovens enable manufacturers to quickly shrink tubing on a large volume of harnesses. The ovens feature a conveyor belt (with prefeed area), a heater box and a control panel.

Users program the oven by inputting shrink temperature and conveyor speed. Then they turn on the oven, position the harnesses in the prefeed

area and activate the conveyor. As the harnesses move through the heater box, heated air (100 to 350 F) circulates evenly around the harnesses and shrinks all tubing.

AMTI, a 7 Mile Solutions Co., manufactures and markets The Shrink oven. Tom Hanlon, sales manager for AMTI, claims the machine can handle harnesses up to several inches in diameter and 40 feet long. He says the oven shrinks all types of tubing except those with a shrink temperature above 350 F.

The Shrink features a 52-inch-long heater box and 12-inch-wide Teflon or stainless steel conveyor. Conveyor speed is 1 to 100 inches per minute. The oven’s harness opening measures 12 by 6 inches, the in-feed area is 27 inches long, and the exit area is 13 inches long. For safety, the oven is timed to automatically shut off when the heaters are turned off. **A**