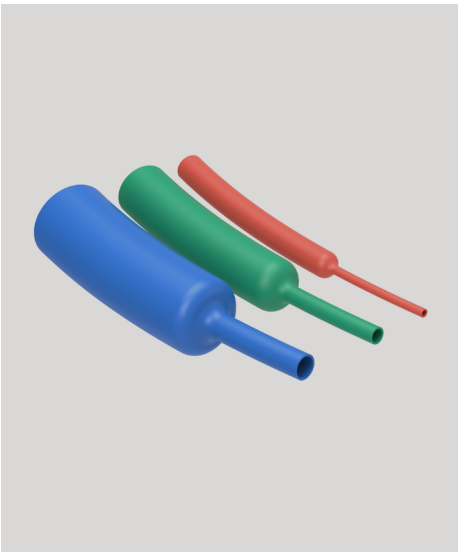


HEAT SHRINK TUBING SOLUTIONS

A GLOSSARY OF HEAT SHRINK TUBING ATTRIBUTES

CONTENTS

SPLITTING

Heat shrink tubing is a versatile product which can be used to cover and encapsulate many different substrates of varying size. One of the main features is the ability of the tubing to conform and adapt to form over complex shapes. It comes in a range of sizes, materials and with different shrink ratios to enable it to fit well and perform in the given environment.

When the tube is supplied it has inbuilt stresses which allow it to shrink when heat is applied. It is these stress's that create the heat shrink feature of the tube. The greater the shrink ratio the greater the stresses are. The shrink ratio is calculated by dividing the supplied internal diameter by the fully recovered internal diameter. Most heat shrink tubes have a 2:1 or 3:1 shrink ratio.

However, theses stresses can also cause problems if certain rules are not followed, and if not followed can cause the tube to split during installation.

GUIDELINES TO REDUCE THE LIKELIHOOD OF SPLITTING

- If the tube is cut to size it is important that the cut edge is clean (Fig. 1) and not ragged. A ragged edge promotes splitting (Fig.2)
- Use the biggest size tube that fits the application
- Use a tube with a lower shrink ratio
- Apply the heat during shrinking in an even and gentle way, avoiding overheating
- Avoid sharp edges and Burrs on the substrate if possible
- During shrinking over sharp edges on the substrate do not focus the heat on the edge
- Use a tube type that is not transparent (this is not always applicable, consult TE for more details)
- Avoid sudden and big changes in substrate diameter

Fig 1

Fig 2

QUICK TIP:
Do Not touch the tube with the heat gun

CUT LENGTH

Heat shrink tubing is normally supplied in long lengths on spools or for more rigid products in lengths of 1.2m (4 ft). Customers often need to cut the tubing prior to installation so that it fits a given application.

It is important that the cut edge is clean and is not at all ragged otherwise the ragged edge promotes splitting of the tube. Some tube types are more difficult to cut than others. The ease of cutting depends on the material of the tube, the size and wall thickness

If cutting tubing supplied on spools please allow maximum distance between the spool and the cutting device, this helps to counter the impact of spool set on the tubing.

Cutting devices are available from many suppliers and can be in the form of a guillotine type cutter or a rotating knife cutter, in all cases the blade must be extremely sharp.

Some heat shrink tubing is not suitable for cutting other than during its manufacture as it may be too hard or brittle.

Due to the influence of longitudinal change (see page 11 for section on longitudinal change) during installation the length of the tube when installed will be different than the cut length as supplied. The more the tube needs to shrink during installation the greater the influence of longitudinal change. It is for this reason that we recommend cut lengths are made in 5mm increments.

TE Connectivity can supply tubing pre-cut to the required length. However, each length has a cut length tolerance (Fig 3).
Please contact your TE Customer Care person if a cut length is required as TE has many cut length part numbers already available.

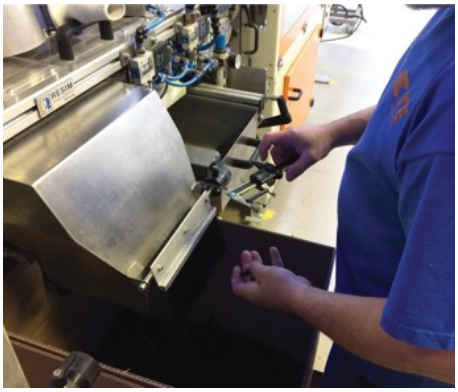


FIG. 3

Cut Length	Cut Length Tolerance
Up to 9.9mm	± 0.5mm
10 to 24.9mm	± 1.0mm
25 to 54.9mm	± 1.5mm
55 to 99.9mm	± 3.0mm
100 to 149.9mm	± 4.0mm
150 to 499.9mm	± 5.0mm
500mm and greater	± 12.5mm

DO NOT USE SCISSORS TO CUT THE TUBE.

QUICK TIP:
Always cut tubing with a very sharp knife, using one cut

APPEARANCE AND CONTAMINATION

The appearance of the tube often has little or no effect on how the tube handles during installation or how the tube performs in service. As heat shrink tubing can be made of many different materials which determine stiffness and flexibility the impact of this and the relative supplied wall thickness of the tube can influence what the product looks like.

ATTRIBUTES THAT MAY BE VISIBLE:

Crease Marks

Tubing supplied flat on spools is pressed flat before it is put onto the spool. The pressing causes crease lines at the side of the tube (Fig 5). As the tube shrinks the crease lines disappear (Fig 6). In some cases a faint witness mark of the crease may still remain.

Fig. 5

Fig. 6

Kinks

More rigid tubes when bent may show marks where the tube has bent even after it has been straightened manually. These kinks do not impact the functionality of the tube and disappear when the tube is recovered during the shrinking process.

Stress Whitening

Rigid tubes when bent may show marks in the form of ‘stress whitening’ (Fig. 7, 9). This is where the tube has been temporarily deformed past its yield point. When heated these ‘stress whitened’ areas disappear and the tube will perform as required (Fig. 8, 10).

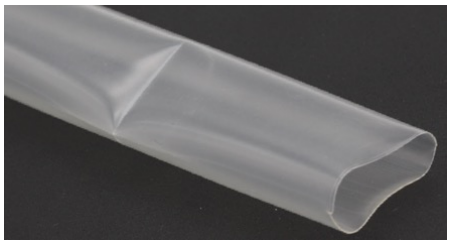


FIG. 7

FIG. 8

FIG. 9

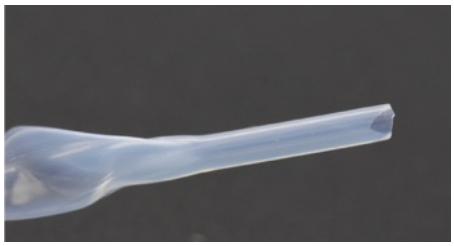


FIG. 10

QUICK TIP:
Many surface marks disappear when the tube is recovered

Inner Wall Contamination

In rare cases some clear tubes that are dual wall (with an adhesive liner) can show very small particles or black specs in an inner adhesive layer. The black specs do not affect the functionality of the tube to seal or perform as it should during installation and service (Fig. 11A).

Outer Wall Contamination

It is highly unlikely but should the outer wall of a tube be contaminated with a foreign body the tube should not be used and should be returned to the supplier for further investigation (Fig. 11B).

Heating tubing during installation can also bring about changes to the surface of the tube. Some tubes begin to 'sweat' when slightly overheated; this brings about a gloss appearance on the surface of the tube (Fig. 12). This gloss will not impact the performance of the tube. Some tubes when exposed to high temperatures for some time will discolor, this is most noticeable with some clear high operating temperature tubes. This discoloration does not mean the tube will not function correctly.

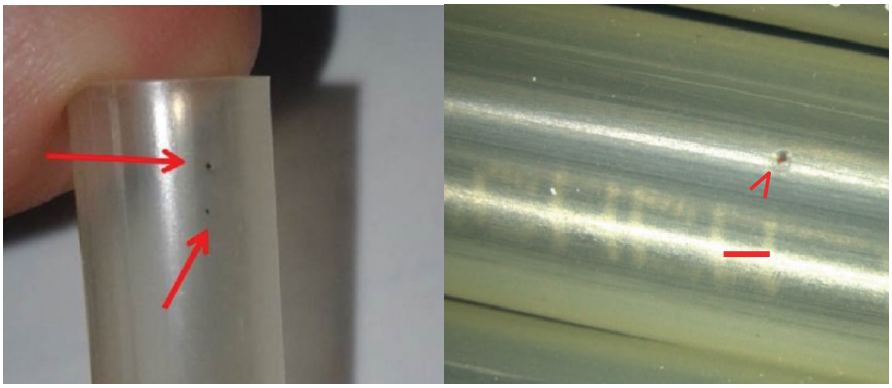


FIG. 11B

FIG. 12

TUBE COLORS

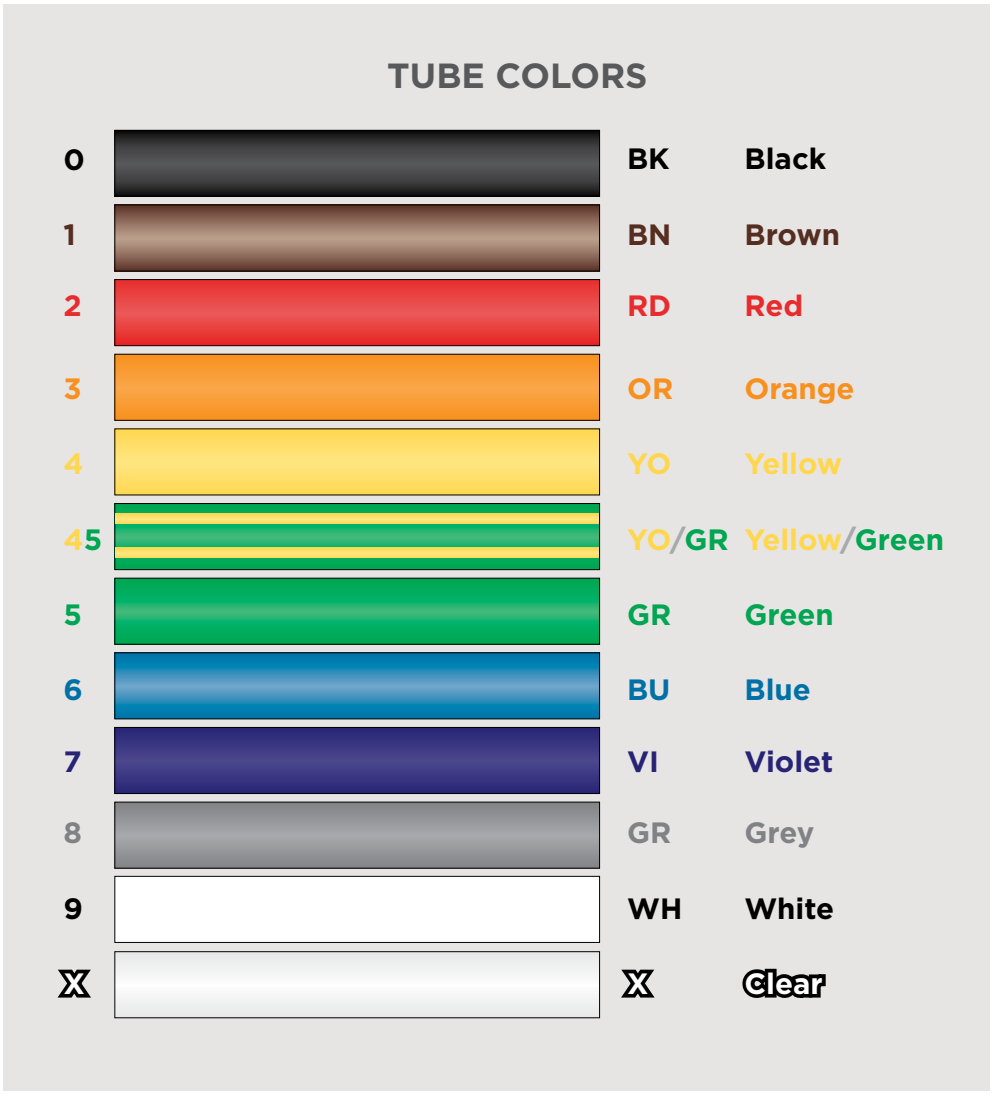
Most heat shrink tubing used is black in color, however colored tubing is also required and is used for color identification. A good example of this is tubing that is yellow and green striped, used for identifying electrical grounding applications.

To identify which color is required numbers or letters are used in product descriptions. As many applications for heat shrink tubing are electrical in nature it made sense to use the same color coding references used with electrical resistor components.

Where numbers are not used they can be replaced by letter abbreviations for the specific color.

Below you will see a cross reference for color numbers and latter abbreviations used by TE Connectivity. The color numbers follow the resistor color coding sequence.

Colors are graded on fully recovered tubing, the expanded tubing as supplied will have a lighter shade than the recovered tubing.



QUICK TIP:
Colors become more intense when the tube is recovered

ADHESION & SEALING

Heat shrink tubing used in combination with adhesives or sealants can create an environmentally sealed solution. This is normally achieved by using a dual wall heat shrink tube which has a meltable liner inside.

It is important to select the correct tube depending upon the function required and the details of the application. There are different types of dual wall heat shrink tubes, each designed with specific attributes to work in different situations and environments. The adhesives have been formulated to deliver different properties, some flow more easily than others, some work at higher operating temperatures and some have higher bond strengths, so it is important to pick the correct dual wall tube for the application.

Sealing multiple wires requires a tube where the adhesive flows easily; splice sealing tubes fall into this category (Fig. 13). The adhesive flows and fills the gaps between the wires to create a water tight seal. TE Connectivity has a range of splice sealing tubes such as RBK and ES tubes. For a higher operating version consider SCT tubing.

Sealing constructions with multiple wires can be tricky as there will be many voids between the wires and the wires can close up and seal off adhesive flow. The specialist products from TE Connectivity give details on the scope of the tubing and the number of wires that can be used. Other specialty products from TE such as RayBlock are capable of blocking larger number of wires. RayBlock uses profiled adhesive combs to encapsulate the wires (Figs. 17A-C).

Bonding to a single cable does not require an adhesive that flows but moreover one that bonds strongly to the cable jacket. Often also being required to bond to a connector or backshell, the tube often needs a high shrink ratio to accommodate the difference in diameter of the cable and the connector (Figs. 14-16). TE tubing ATUM and CGAT would be the ones to consider. For a higher operating temperature consider HTAT tubing.

For dual wall tubes to meet the requirements of Mil Spec use TAT-125 or ATUM tubing.

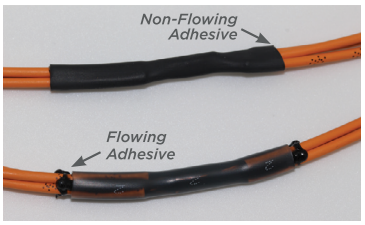


FIG. 13

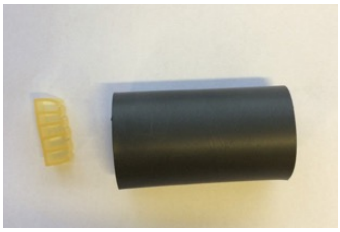


FIG. 17A

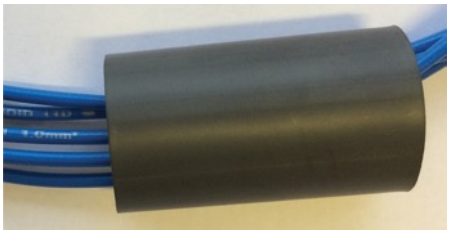


FIG. 17B

FIG. 17C

FIG. 14

FIG. 15

FIG. 16

Dual wall tubing is usually supplied as cut pieces or as Sticks (-STK). It can be supplied as spooled tubing however there is a risk that due to spooling the sides of the tube may stick together. In most cases if this occurs the tube will pop apart when squeezed.

NOTE: TE does not accept complaints for spooled tubing sticking together

QUICK TIP:
Always cut tubing with a very sharp knife, using one cut

CURVATURE OF TUBING

Heat shrink tubing is made from blends of polymers and elastomers with other added ingredients. As such these materials have inherent characteristics, one of which is to take on a 'shape set' as the tube is spooled.

Elastic deformation takes place as the round tube flattens and is effectively bent around the curved spool core. This deformation can be seen when the tube is taken from the spool.

Equally a further amount of deformation occurs as the tube is traversed across the spool from spool flange to spool flange. This deformation can be seen when the tube is taken from the spool (Fig 18).

This 'curvature' of the tubing can potentially cause some difficulties for customers who wish to print on or cut the tubing (Fig 19).

Some tubing supplied as sticks may also show some minor curvature from production processes.

FIG. 18

If printing or cutting the tube, problems due to spool set or curvature can be eased by increasing the distance between the spool and the machine feed rollers, in addition allow the spool to move sideways on an axle. This allows some of the tension to be relaxed and also moves some of the alignment forces to the spool rather than direct at the cutter (Fig. 20 & 21).

The use of product supplied in the Ribbon Spool format overcomes the curvature due to traversing between spool flanges, if curvature is a problem please consider the ribbon spool option (Fig. 22 & 23).

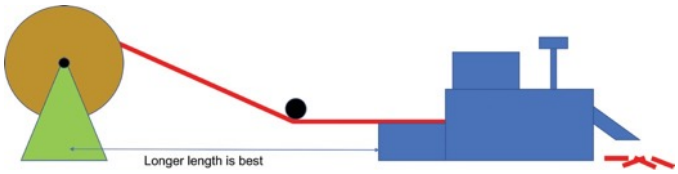


FIG. 20

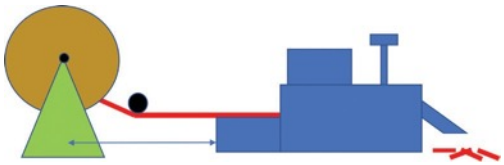


FIG. 21

FIG. 19

FIG. 22

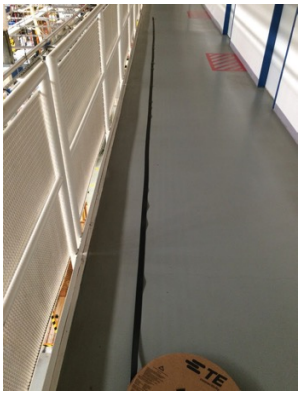


FIG. 23

QUICK TIP:
Use flat spooled tubing to minimize curvature

LONGITUDINAL CHANGE

Longitudinal change occurs in all heat shrink tubing. It is where the tube will also change in length when heated as well as a reduction in the tube diameter.

The maximum longitudinal change for a given heat shrink tube occurs at the point of full recovery in the diameter of the tube. This is the value given in specifications, in most cases the longitudinal change will be less than this specified value.

The amount of longitudinal change for a given product family (standard products) can be found in the TE specification for that family. Specifications can be found on te.com, please search by product family name or part number.

In most cases the longitudinal change will not impact the performance of the heat shrink tube. The exception to this is where the shrinking tube might expose bare conductor.

Longitudinal change is measured on unconstrained tubing and is calculated as:

Original length—Recovered length / Original length And expressed as a %

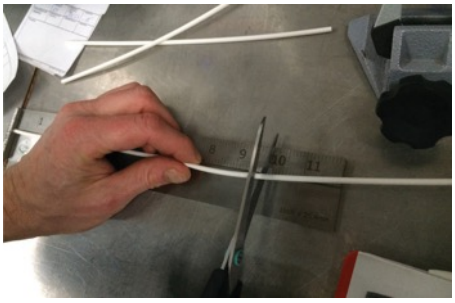


FIG. 24

FIG. 25

Please make allowance for longitudinal change when selecting a tube type for a particular cut length.

QUICK TIP:
Maximum long change is only reached at full tube recovery

TUBE DIMENSIONS

Heat shrink tubing is supplied in a range of sizes of which there are some important dimensions that are critical to the successful use of the tubing.

Expanded Internal Diameter (EID)

This is the diameter of the inside of the tube when it is supplied. This dimension con- trols whether the tube will fit over the substrate onto which it is being installed. In the majority of cases the EID is supplied as a minimum dimension which ensures it will fit over the specific dimension required. Some tubes may vary slightly in the EID but will always meet the minimum dimension. It is important that the given EID dimension is used for design purposes as sample dimensions vary.

Recovered Internal Diameter (RID)

This dimension refers to the inside dimension of the tube when it has been heated and has reduced in size to its minimum dimension, this shrinking must be made unrestricted to allow the tube to reach its smallest size. This dimension is referenced as a maximum size, this means it will always shrink to this dimension and in some cases it may even be a little smaller. Again, it is important that the given EID dimension is used for design purposes as sample dimensions vary.

Recovered Wall Thickness

The recovered wall thickness of the tube is the thickness of the tube after it has been fully recovered and allowed to reach its minimum size (see RID above). Wall thickness is measured using a pin micrometer (Figs. 29A & B).

How are the dimensions measured?

The diameters of the tube are measured using taper gauges (Figs. 26-28). Theses gauges allow the tube to fit around the taper avoiding any inaccurate measurement due to the shape of the tube as not all tubes are supplied in a fully round shape. Pin gauges can also be used (Figs. 30, 31).

If the supplied diameter of the tube (EID) is below the declare dimension it does not mean the tube is not usable, it is only not usable if it is too small to fit the application.

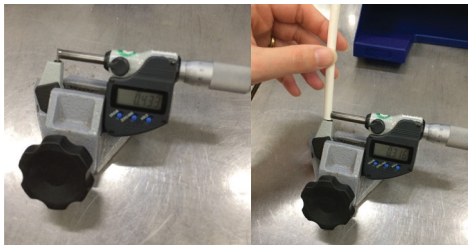


FIG. 29B

FIG. 26

FIG. 27

FIG. 28

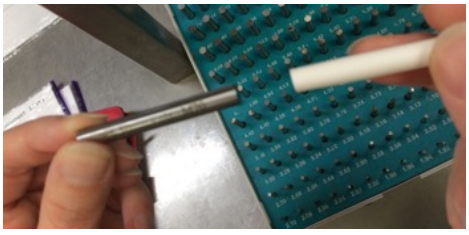


FIG. 30

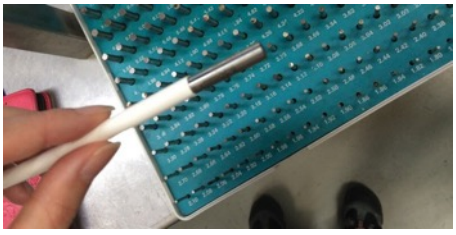


FIG. 31

QUICK TIP:
Only use samples as a check on fit, use design with published dimensions from data sheets and specifications.

TUBING SUPPLY FORMATS

Heat shrink tubing can be supplied in five product formats:

• Spools • Cut Pieces • Kits • Sticks • Mini Spools

Spools

Tubing supplied on cardboard spools is one of the most popular delivery formats. This means the user decides on what length of tubing is required for any particular application. The tubing is simply pulled from the spool and cut to length. When pulling the tubing from the spool the spool should be allowed to rotate freely, this is particularly important with small size tubes which can be stretched easily if the spool does not rotate (Fig. 32).

The tubing supplied on spools can be round or for some sizes it can be flat. The flat tubing only applies to a limited size range of single wall tubing. The advantage of flat tubing is it is easy to print on, more densely packed and does not suffer curvature issues (Fig. 33).

Spooled tubing may contain joins, so be aware that the spool quantity can be constructed of non continuous lengths. Spools with joins are indicated with an identifying mark on the spool label (Fig. 38).

Sticks

Sticks are lengths of 1.2m (4ft). Sticks are often used for rigid or semi-rigid tubing. They also make a convenient length where small pieces are required by the user (Fig. 34).

Cut Pieces

These are short lengths of tubing supplied by TE Connectivity at a specific length required by the user. Cut pieces are usually supplied in 5mm length increments (Fig. 35).

Mini Spools

Mini Spools are exactly like they sound, Smaller cardboard spools with just a few metres of tubing on them. This format is a very convenient way of carrying around a few handy packed metres of tubing from which small pieces can be cut (Fig. 36).

Kits

Some tubing is available in kits, these are a selection of different tube sizes from a tubing family. They may be in different lengths and colors. Again a useful and convenient way of having access to some heat shrink tubing (Fig. 37).

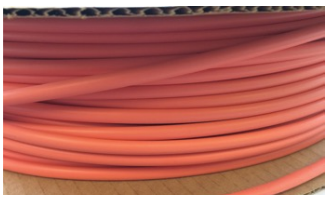


FIG. 32

FIG. 33

FIG. 34

FIG. 35

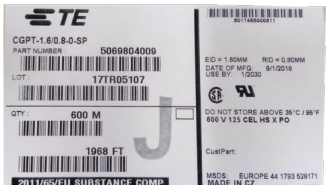


FIG. 36

FIG. 37

FIG. 38

QUICK TIP:

Think about what format is the most convenient for the user, conve- nience save time and time saves money

SHELF LIFE & STORAGE

As heat shrink tubing is made of polymeric materials there will be some degradation of the material over time. In addition with heat shrink tubing there is the added potential of 'loss of memory' where the tube does not shrink back to its specified dimensions when heated.

TE has issued a shelf life document describing the storage and transport conditions for heat shrink tubing. The shelf life is measured by the dimensional changes in the tubing over time.

The Tubing Shelf Life document is available on the TE.com website and is document 408-32191.

QUICK TIP:
Maximum long change is only reached at full tube recovery

SPLICES ON SPOOLS

Unless specifically requested, lengths of tubing may be spliced together to make up the complete spool length requirement. The splices are constructed in a way that is designed to allow air to move through the joint.

The splice joint process is described below.

1. Open end of tube.

2. One end of the tube is inserted into an open end.

3. Joint is taped with a colored tape

3. Product label is marked with a 'J' to identify that the tube on the spool has a joint.

QUICK TIP:
Cut the end of the tube nearest the spool core to allow air to escape when printing or cutting the tube

INSTALLATION GUIDELINES

- Remove all sharp edges, corners, burrs and poking wires
- Degrease using a suitable solvent
- Consider which would be the best installation tooling

Safety

- Use gloves when handling hot articles
- The shrinking process should be made in a ventilated area

Every application is different so it is impossible to provide precise instructions that will apply to every application. The following information is for guidance only. If you are unsure how to proceed please contact TE Connectivity and we will be delighted to assist you.

Heat shrink tubing will shrink in diameter when heated, it will also change in length to a lesser amount. In most cases the tube will reduce in length when heated (see the product specification for typical % change).

This change in length must be considered during installation.

Applications where one end of the tube is located in a critical position

In this situation it is recommended that the tube be positioned and the critical position be heated first. This will recover the end of the tube and 'anchor' it in place. For a dual wall tube it may be necessary to allow a cooling time for the adhesive to set before the rest of the tube is recovered.

Applications where the key substrate element will be in the center of the tube

Position the tube over the substrate so that the key element is towards the center of the tube, allowing enough tube either side to ensure total coverage when the tube is recovered. Shrink the tube from the center first, working outwards towards the ends of the tube. (not trapping air under the tube).

FIG. 43

FIG. 44

Using a Hot Air Gun

- Always keep the gun moving so that the hot air is not focused on just one point of the tube
- Rotate the gun to move the heat evenly around the tube such that the heat is distributed evenly, encouraging an even shrinking of the tube
- Don't touch the tube with the heat gun
- Use a reflector to get even heat distribution around the tube and a faster shrinking process (Fig. 43)

Using an Infrared Heater

- The temperature and time settings will need to different for each application, as heat sink and heat losses will be different in each application. Conditions will need to be established prior to serial production (Fig. 44)
- Normally for high volume usage

Using a Hot Air Oven

- Using a hot air oven will apply heat evenly across the assembly. This may present a challenge if the tube needs to be installed at a specific location at one end
- With applications that have a big heat sink oven heating may be the best method (Fig. 45).

Using a Conveyor Oven

- Consider that the first part of the appli- cation to enter the oven area will shrink first. This might be useful to 'anchor' one end of the tubing
- It is likely that air entrapment will not be an issue
- It may be possible to shrink more than one tube at a time.
- Fixtures may be made to support specific applications.

FIG. 45

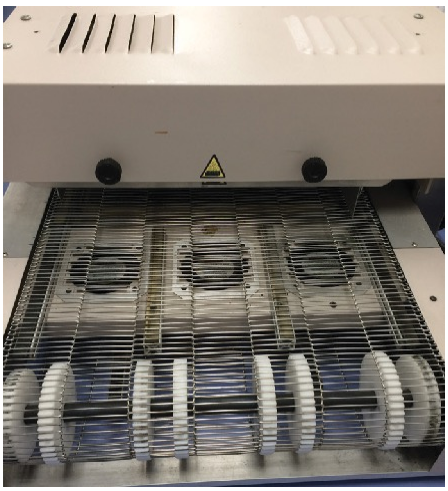


FIG. 46

QUICK TIP:
Use the biggest size tube that fits the application

GLOSSARY OF TERMS

Terminology	Explanation
Adhesive	A term for the inner layer of a dual wall tube
Adhesive Flow	The movement of the inner layer of a dual wall tube coming form the end of the tube when heated and recovered on to a substrate
Application	The purpose of the tubing being installed
Application Parameters	The temperature, speed, air flow, distance of tooling form the tube etc during installation
Application Tooling	The tools used to install the tube (hot air, infrared, conveyor oven etc.)
Batch Number	The unique number as shown on the product label that relates to the individual batch of product supplied
Beaming	The process of changing the molecular structure of the tube material to 'crosslink' it
Clarity	The ability to see through the wall of the tubing
Clog	A foreign body on the inside of the tube
Cold Spot	A sunken mark on the outside of a tube indicating insufficient heating during installation
Compound	The material made from several ingredients that is used to make the tubing
Concentricity	The difference between the smallest wall thickness and the largest wall thickness of any single tube. Expressed as a percentage.
Contamination	A foreign body visible on or in the tube material
Cracking	When the surface of the tube shows a surface defect that exposes the inner material from which the tube is made. (can occur not at the end of the tube)
Cross Linking	The process of changing the material structure of polymers so that they no longer melt
CSR	Customer Service Representative. The TE person as first point of contact
Curvature	As a plastic material the tubing will take on a set in the shape of the spool. It will also take on a set form the traversing of the product across the spool form one side and back again. This set is known as curvature.
Customer Care Agent	The same as Customer Care Representative
Cut Edge	The end of a piece of tube that has been supplied ready for use
Cut Length	The supplied length of the small piece of tubing
Cut Piece	Small piece of tubing
Cutting Angle	The angle of the end of a piece of tube that has been supplied ready for use
Deformation	The change in shape pf a product due to mechanical forces
Dimensions	The size of the tube (EID, RID, Recovered Wall Thickness, Cut Length)
Distribution Center	The TE warehouse where products are stored and shipped from
Drool	A foreign body attached to the outside of the tube
Dual Wall	A tube with two layers, the inner layer is usually meltable
EID	Expanded Internal Diameter, the internal size of the tube as supplied by TE
Excessive Shrinkage	The amount of longitudinal change beyond that allowed in the specification
Expansion	The process of increasing the diameter of a tube to the dimensions required according to the specification
Extrusion	The process of creating a tube form molten plastic
FAE	Field Application Engineer
Finishing	The process of formatting the expanded tube to a customer useable quantity. Involves supplying tubing on spools, as cut pieces and as sticks (1.22m or (4 ft) lengths
Flat Spool	Another name for a Ribbon Spool
Flat Width	The external width of the tube when made flat
GAM	Global Account Manager

GLOSSARY OF TERMS (CONTINUED)

Terminology	Explanation
Glue	A term for the inner layer of a dual wall tube
Irradiation	The process of delivering high energy electrons to cross link the tube material, also known as 'beaming'
License Tag	The outer box label used for recording and monitoring product movement in transportation and warehousing
Liner	A term for the inner layer of a dual wall tube
Long Change	The change in length of the tube when recovered freely to without restrictions to its smallest size.
Lot Number	The unique number as shown on the product label that relates to the individual batch of product supplied
Marking	The marks deliberately made on the surface of the tube to deliver data such as size or certification
Polyolefin	A group of ethylene-based plastic materials such as polyethylene and poly vinyl acetate
Printing	The marks deliberately made on the surface of the tube to deliver data such as size or certification
Production Label	The product label on the inner packaging defining the delivered product
PVDF	Poly Vinylidene Fluoride, an engineering thermoplastic used to make tubes with higher operating temperatures
RAM	Regional Account Manager
Recovered Product	Tubing that has been heated and shrinks fully onto a substrate
Ribbon Spool	A specific type of cardboard spool where the tube is only wound without transverse orientation
RID	Recovered Internal Diameter, the internal size of the tube after heating and being allowed to recover freely without restrictions to its smallest size.
Shelf Life	The storage and transportation life of the product before installation
Shrinking	The process of heating the tube so that it reduces in diameter during installation
Single Wall	A tube with made of only one layer
Splitting	When the tube wall separates, failing to maintain the tube fully around the article on which it has been recovered on to
Spool Set	Also known as curvature, As a plastic material the tubing will take on a set in the shape of the spool. It will also take on a set form the traversing of the product across the spool form one side and back again. This set is known as curvature.
Spooling	The process of putting the tube onto a round cardboard bobbin that is used to deliver the tubing to the user
Substrate	The article on or over which the tube is recovered
Surface Appearance	The interpretation of the visual outer layer of the tube
Tearing	A small split that has propagated down the tube
TECHS	The TE customer complaints system
Transparency	The ability to see through the wall of the tubing
Unresolved Recovery	The difference between the fully recovered internal diameter and that of the tube diameter when recovered onto a substrate
Wall Thickness	The thickness of the wall of the tube after being allowed to recover freely to the tube diameter when recovered onto a substrate
Warp	The fibers running along the length of a fabric tube
Weft	The fibers running across the tube at 90° to the warp.

This Glossary is based on the terms we come across everyday in the world of Heat Shrink tubing. We believe this Glossary will be useful to our customers when communicating about Heat Shrink tubing, its uses and applications.

USEFUL INFORMATION RELATING TO CUSTOMER COMPLAINTS

In the unusual event of heat shrink tubing from TE Connectivity not working as well as it should, the information below will help us to help our customers.

Due to the complexity and the breadth in the range of heat shrink tubing it is very important that when the tubing is not performing the way customers believe it should that samples are returned to TE Connectivity along with details of the complaint. With samples we can much better determine the cause and scope of the problem.

Without samples we cannot verify the complaint or take action. If samples are not provided, the compliant may not be upheld. Pho- tographs only provide a very small amount of information.

It is also extremely useful to know how the tubing is being installed and what it is being used for. Pictures of installation equipment and installation techniques really helps. Please supply a sample of the application if possible.

Include all product references (a photo of the product label is best) including the batch or lot number. Also please include the scope of the problem (is it one or two parts affected or an entire delivered quantity, or something in between).

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