



The Engineers of Heat Shrink Tubing – Script

Title Slide:

- Introduce yourself
- Welcome audience to presentation/meeting
- Introduce the medical business as follows:

“I represent the Medical business at TE. The focus of our group is on medical device solutions for advanced surgical, imaging and interventional medicine.”

Slide 2 // TE Medical & our legacy of innovation:

Today, the medical business at TE:

- Comprises over 4,000 employees of whom 450 are talented and experienced design engineers – we are experts in our field
- Has scale and velocity – we estimate that 120 patients are treated every minute with a medical device containing a TE technology
- Is proven. We are partners to more than 1,500 medical device companies across the globe – from the world's largest medical device companies to innovative emerging medical technology companies

TE's Medical business is built upon a legacy of leading and acquired brands:

- Creganna Medical, a world leading partner for minimally invasive and catheter-based technologies
- MicroGroup, a precision engineering partner for advanced surgical tubing
- AdvancedCath, an innovative catheter design and development company
- Measurement Specialities, a leading provider of advanced sensor solutions
- Precision Interconnect – a specialist in fine wire and medical cable assemblies
- AMP – a leader in high end connectors
- **Raychem – an innovator in material science and medical tubing and most recently,**
- **HSI – a leader in FEP tubing & FEP heat shrink for advanced minimally invasive applications**

Together we are the \$700M medical business unit of TE Connectivity.

Slide 3 // The Engineers of Heat Shrink Tubing

The Engineers of Heat Shrink Tubing – so what does that mean?

We don't just manufacture heat shrink tubing, we design it and optimize it for our customers and for use in the device solutions we develop for them. We are our own customers and we know the difference polymeric engineering can make to your complex catheter, electrosurgical device or laparoscopic instrument.

We're backed by over 60 years of polymeric science, we have 11 dedicated polymer scientists and engineers across 3 sites with significant manufacturing footprint. We manufacture our heat shrink tubing to ISO 10993 standards, ensuring biocompatibility so you don't have to. We have FDA master files for **select products (MT-LWA doesn't have a Master File)** meaning you don't have to worry about FDA clearance when qualifying our heat shrink tubing.



Slide 4 // Where it all began

In 1957, while studying at the Stanford Research Institute, electrical engineer Paul Cook discovered if you radiate certain polymers with an electron beam (cross-linking), you can change the molecular structure, increasing the crystalline melting point. This discovery led to the invention of heat shrink tubing and the foundation of Raychem, later TE Connectivity.

This process, as it relates to our polyolefin, PVDF & Pebax heat shrink, is known as cross-linking because the removal of the hydrogen atom from the polyethylene chain, creates cross-links between the carbon elements. **(Note: FEP isn't cross-linked)**

Slide 5 // What now?

So, Paul Cook invented heat shrink tubing more than 60 years ago, what does that mean for you today? Our product technology is based on specially-formulated thermoplastic polymer materials. Through our cost-effective manufacturing processes, we combine chemical additives with polymers to create optimized solutions for various medical applications. The compounds for these materials are designed, selected and customized by our own polymer engineering team. Sophisticated process controls employed during extrusion, cross-linking and expansion ensure uniform wall-thickness before and after recovery.

Not all heat shrink is created equal and so we have a wide range of customization options from raw material optimization to product design, custom material properties, finishing options and value add.

Our polymer engineers will partner with you to advise you on the best heat shrink tubing combination for your application – meaning you can stop wasting time on selecting materials and get back to innovating medical technology.

Slide 6 // Our material selection

For our heat shrink tubing, we work with 3 different types of polymers – fluoropolymers (PVDF & FEP) polyolefins (high-density polyethylene and low-density polyethylene), pebax and custom compounding.

Before we jump into these individually, here's what you may need to consider when selecting heat shrink tubing

Slide 7 // Considerations

- Do you need heat shrink as a process aid or a component of an end device?
 - Are you reflowing a catheter, or do you need a strain relief for a flexible electrosurgical device?
 - For catheter reflow; what is your finished OD?
 - Will the heat shrink be exposed to UV?
- Substrate material – what is the melting point? You'll need to know this, so you can choose a heat shrink with a suitable recovery temp
- Is your device rigid or flexible?
- Do you need to protect your device from abrasion or chemical exposure?
- What are your sterilization requirements?



Slide 8 // Application Guide

There's a lot of information in this deck and I understand you may not be interested in all of it right now, so we've created this quick application guide, advising you on two heat shrink options, by application. Again, these products can be customized.

(Note: FEP is good for abrasion protection too.)

Slide 9 // PVDF properties

PVDF offers excellent chemical and abrasion resistance, high dielectric strength and superior tensile strength. Its homogeneous structure (properties evenly distributed) contributes to its consistency and high performance.

Slide 10 // Our PVDF heat shrink tubing

We manufacture two different types of PVDF heat shrink tubing – MT1000 & MT3000 and the main difference here is that one is rigid, and one is flexible. For that reason, we recommend these products for slightly different applications. MT1000 is rigid and works very well for abrasion protection for rigid laparoscopic and in-vivo instruments. MT3000 is more flexible and works well for flexible surgical devices that require versatility in sterilization.

Slide 11 // Our FEP heat shrink tubing

FEP is the newest addition to our heat shrink tubing product offering, coming with the acquisition of Heat Shrink Innovations. **FEP is the industry gold-standard for reflowing catheter shafts**, and for good reason. FEP recovers at 410°F (210°C) - enough heat to reflow the substrate to the catheter but not so much heat that it damages the substrate. FEP has a great memory which helps with consistency – saving yield loss and time. It has a lower shrink ratio than other heat shrink tubing, $\leq 2:1$ – making it great for adding compressive forces to the catheter shaft. For our FEP, we offer consistent expanded IDs with a tolerance of ± 0.0015 ", half that of our competitors – from lot to lot, there will be minimal change, if any, in your reflow process due to your FEP heat shrink.

(Note: A shrink ratio of 2:1 for FEP is the upper limit, it's application specific and we prefer a shrink ratio of 1.6:1 – that is optimal, but 2:1 is possible. Kevin Wolfe can advise)

There is a lot to consider when selecting FEP for your reflow process, and we can help you make your decision but ask yourself this:

- If your compression ratios were consistent through your entire lot number – would that matter?
- If longitudinal growth could be controlled within $\pm 2\%$ - would that matter?
- If we could help you increase your yields from 75% to 90% - would that matter?

Slide 12 // Our polyolefin heat shrink tubing

We offer four polyolefin-based heat shrink tubing products – one high-density polyethylene and three different types of low-density polyethylene.

Our MT2000 is a high-density polyethylene (HDPE), it's semi-rigid and mechanically tough making it great for providing abrasion protection and insulation for electrosurgical devices



Low-density polyethylene (LDPE) is less insulating and more flexible than HDPE. Our MT5000 & MT5510 provide varying degrees of flexibility making them great for use as strain reliefs.

Our MT-LWA is a LDPE process aid. It's an excellent choice for reflowing catheters particularly when FEP shrink ratios are not suitable for your application. MT-LWA has a shrink ratio up to 4:1, is peelable with axial tear propagation and you can remove it while its warm. We offer customizable compression strengths too.

Slide 13 // Our PEBA heat shrink tubing (PEBAX)

Our MT-PBX is a PEBA based heat shrink tubing available in multiple options from flexible to semi-rigid, with dual layer options also available. Dual wall MT-PBX offers an inner reflowable layer with the outer layer acting as the outer jacket of the shaft. The outer layer will shrink and the inner layer will reflow to join the underlying braid to create a braided catheter shaft without the use of a removable heat shrink. This product is also great for ultra-thin guidewire jackets.

Single durometer.

Slide 14 // Solving your challenges with polymeric engineering

We've outlined a number of common heat shrink tubing challenges and how can help you solve these challenges.

1. The need for multiple different heat shrink tubing for tapered shafts or irregular shapes
 - a. Our low-density polyethylene offers varying degrees of flexibility, shrinks at a 4:1 ratio and conform easily to irregular shaped substrates eradicating the need for multiple different heat shrink for the one unit. We also offer a peelable low-density polyethylene-based heat shrink that maintains a shrink ratio of $\leq 4:1$.
2. The need for customized compression forces but limited by product design and manufacturing processes can be difficult
 - a. We offer many customisable options including customisable compression forces – we can do this in several ways -
3. Controlling longitudinal growth throughout your entire lot helps to reduce yield loss, saves time and cost. Controlled longitudinal growth also ensures a better fit of the reflowed substrates joints – no heels or gaps.
 - a. We can control longitudinal change within $\pm 2\%$ in our MT-FEP process aid solution

Slide 15 // The people who make it happen

Our teams and leaders. Here we have the minds and hands behind our heat shrink design, optimization, manufacturing and innovation. We have the breadth and depth of polymeric engineering and material science needed to partner with you for your heat shrink tubing needs.

Slide 16 // Premier Partner

TE specialize in the design and manufacturing of advanced surgical, imaging and interventional device solutions.

Within these areas, our further focus is on medical devices that enable physicians to visualize, access and delivery a therapy to a patient. We're confident in our heat shrink tubing capability because we use heat shrink tubing ourselves in the devices and sub-assemblies we supply to our customers.



Slide 17 // End presentation

Please use this slide at the end of your presentation. Open the floor to questions.

