Healthcare Solutions

DuPont™ Liveo™ Pharma TPE Tubing

Sterilizable, weldable TPE tubing for biopharmaceutical processing

With the launch of new DuPont™ Liveo™ Pharma TPE Tubing, DuPont is now offering a thermoplastic elastomer (TPE) option with high-purity benefits for fluid transport and single-use bioprocessing applications and is facilitating adoption and compatibility with leading competitive TPE tubing offerings.

This new product range complements our silicone-based Liveo™ Pharma Tubing and Overmolded Assemblies product lines and is produced under the same high-purity principles as the products our customers already know and trust.

Key features and benefits

- Improved heat-welding, both to itself and to competitive offerings
- High tensile strength and burst resistance before and after welding
- Low extractables
- Good chemical resistance
- Minimal spallation after 24 hours of pumping
- Good clarity; stable clarity after sterilization
- Manufactured in ISO Class 7 cleanroom
- Comprehensive data package to accelerate qualification and validation under the form of a qualification guide

Applications

- Fluid, media and solvent transport in biopharmaceutical processes and biotechnology
- Single-use assemblies
- Peristaltic pump applications
- Aseptic connection and disconnection without connectors (e.g., sampling)
- Applications where compatibility with industry benchmark TPE tubing is needed

Typical physical properties of Liveo™ Pharma TPE Tubing

Properties are based on Liveo™ Pharma TPE Tubing with an inner diameter (I.D.) of 3/8" (9.5 mm) and an outer diameter (O.D.) of 5/8" (15.9 mm).

Specification writers: These values are not intended for use in preparing specifications. Please contact DuPont prior to writing specifications on this product.

	Property	Test standard	Mean value
	Durometer hardness	ASTM D2240	65 Shore A
	Specific gravity	ASTM D792	0.900
	Property	**Test standard**	**Mean value**
Steam (121°C/30 minutes)	Maximum elongation	ASTM D412 Die C	1,134%
	Modulus at 200% elongation		2.7 MPa (392 psi)
	Maximum tensile strength		9.4 MPa (1,363 psi)
	Property	**Test standard**	**Mean value**
Gamma radiation (50 kGy)	Maximum elongation	ASTM D412 Die C	1,031%
	Modulus at 200% elongation		2.6 MPa (377 psi)
	Maximum tensile strength		7.4 MPa (1,073 psi)

Exacting purity data for Liveo™ Pharma TPE Tubing

- USP <85> (Endotoxins)
- USP <665> (Extractables and Leachables) with autoclave or gamma radiation sterilization methods
- USP <788> (Particulates)
- ISO 11737-1 (Bioburdens)

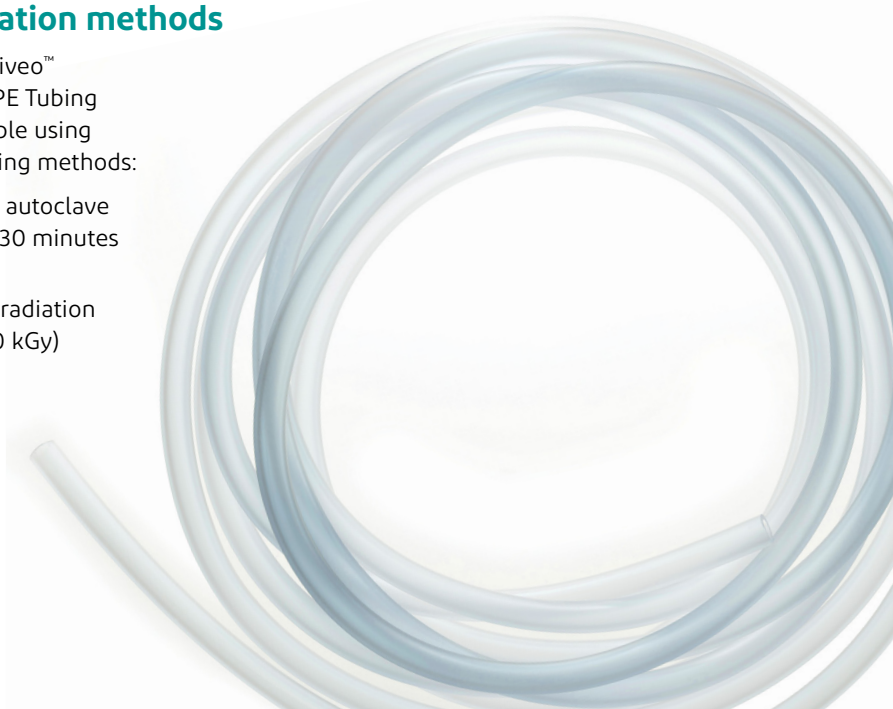
Regulatory data for Liveo™ Pharma TPE Tubing

- ISO 10993 Biocompatibility tests (5: Cytotoxicity, 6: Muscle Implantation, 11: Acute Systemic Toxicity, 23: Intracutaneous Irritation)
- USP Class VI (Intracutaneous Reactivity, Acute Systemic Injection, Intramuscular Implant)
- Pyrogenicity (USP <151>)
- Elemental Impurities

Sterilization methods

DuPont™ Liveo™ Pharma TPE Tubing is sterilizable using the following methods:

- Steam (1 autoclave cycle of 30 minutes at 121°C)
- Gamma radiation (up to 50 kGy)

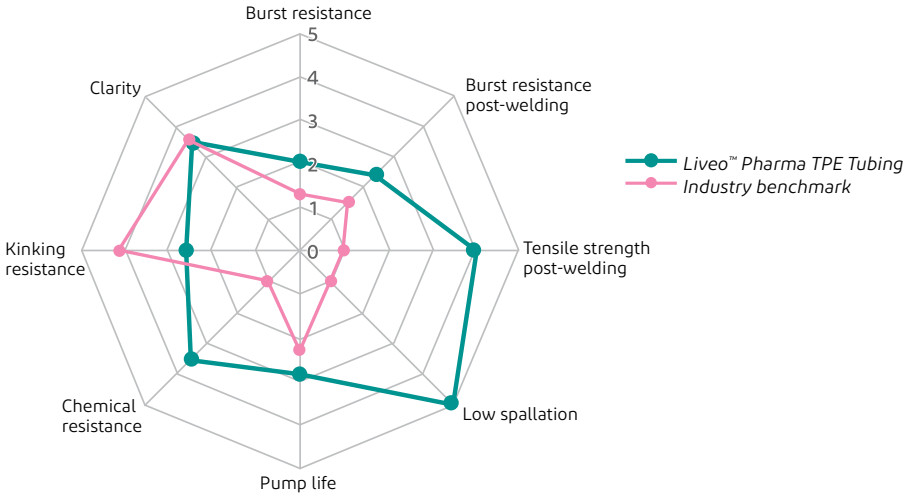


Performance data for DuPont™ Liveo™ Pharma TPE Tubing

Comprehensive studies were conducted on material in common sizes and using different sterilization methods, including steam and gamma radiation. The following is a review of analyses comparing Liveo™ Pharma TPE Tubing to industry benchmark tubing. Further testing data is available; please contact DuPont for more details depending on your application needs.

Benchmark analysis: Summary of typical performance

Test samples steam-sterilized (autoclaved 1 cycle of 30 minutes at 121°C); 0 = lowest performance; 5 = highest performance.



Liveo™ Pharma TPE Tubing showed better tensile strength after welding than the benchmark tubing.

Testing also revealed better welding strength and burst pressure resistance by Liveo™ Pharma TPE Tubing versus the benchmark tubing. Excellent welding strength and burst pressure resistance enable Liveo™ Pharma TPE Tubing to improve the safety margin during fluid transfer applications.

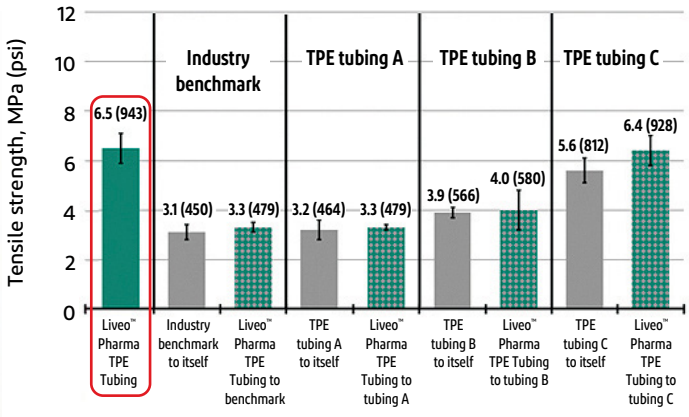
Testing protocol

- Weldability was assessed by sterilization of the samples prior to running specific testing to measure the ability of the welded section to withstand mechanical stress before failure was observed.
- The specimens were welded using the specific Biowelder® TC preprogrammed setting.
- Tensile strength of the welded section was determined from the average maximum tensile strength as measured on dumbbells cut out from the tubing using ASTM D412 Die C.
- Liveo™ Pharma TPE Tubing welded extremely well to itself and to the benchmark tubing using aseptic tubing welders/ standard recipes.
- Burst pressure resistance properties were determined according to ASTM D380 in a burst chamber apparatus by flowing water through the tubing and increasing the water pressure until ballooning and burst eventually were observed.

Benchmark analysis: Tensile strength after welding

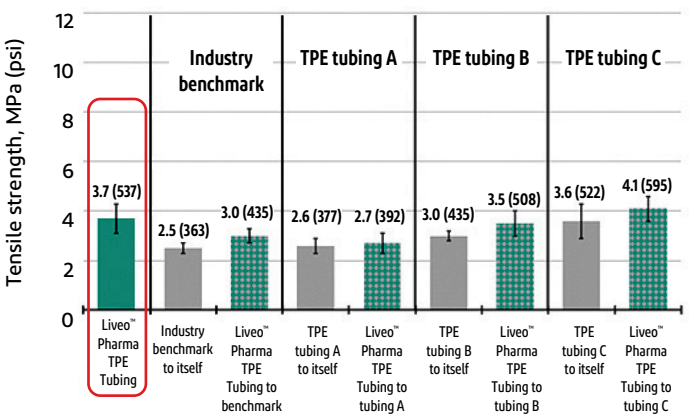
Test samples autoclaved (121°C/30 min).

Tensile strength after (co-)welding: Autoclaved, 3/8" x 5/8"



Test samples gamma-irradiated (50 kGy).

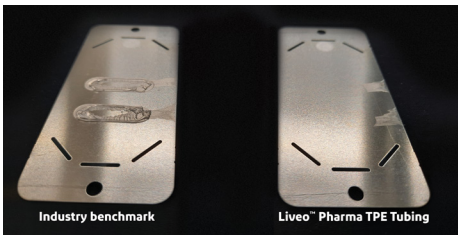
Tensile strength after (co-)welding: Gamma-irradiated, 3/8" x 5/8"



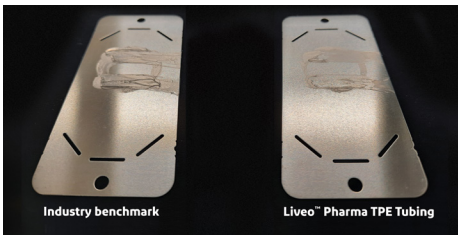
Regardless of the tubing dimensions, sterilized Liveo™ Pharma TPE Tubing exhibited superior tensile strength when welded to itself compared to other TPE tubing brands. Not only was Liveo™ Pharma TPE Tubing compatible with other TPE tubing brands, but it also improved the weld strength versus other kinds of TPE tubing welded to themselves.

Benchmark analysis: Tensile strength after welding *(continued)*

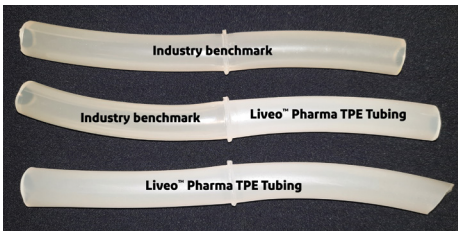
Use of the Cytiva™ Sterile Tube Fuser-Dry welding machine confirmed that DuPont™ Liveo™ Pharma TPE Tubing also could be welded successfully with the default settings. The TPE tubing material was tested and considered successfully welded when the weld was continuous and the material remained intact after it was pulled, twisted and pulled again by hand to assess the robustness of the weld, and eventually the lumen of the tubing remained opened after the welding step.



Difference in amount of residue left on back of blade



Difference in amount of residue left on front of blade



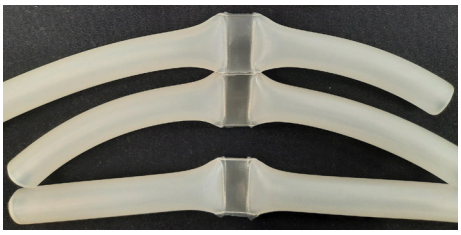
Unsterilized tubing welded then steam-sterilized for 30 minutes at 121°C

Sealing evaluation

A Cytiva™ Hot Lips Tube Sealer™ was used at predefined sealing settings.

Liveo™ Pharma TPE Tubing successfully sealed:

- No color change at the weld
- No air bubble/no defect at the seal/ no crack
- Cannot be broken by hand
- Within final thickness acceptance criteria
- Resists pressure leak test



Liveo™ Pharma TPE Tubing after sealing

Sealing tests demonstrated that Liveo™ Pharma TPE Tubing could be sealed with the use of the Cytiva™ Hot Lips Tube Sealer™ and the settings commonly used for other commercial TPE tubing.

Visual inspection and qualitative evaluation of the seal were carried out:

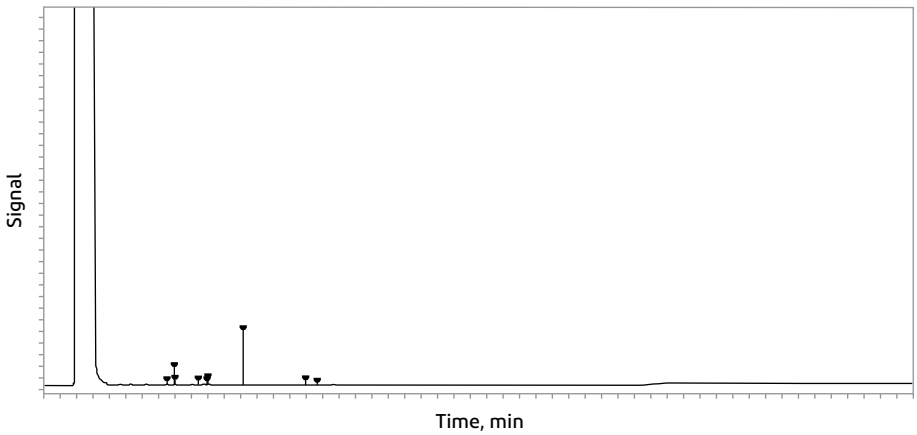
- Liveo™ Pharma TPE Tubing manually could be pulled, twisted and pulled again without breaking
- Liveo™ Pharma TPE Tubing did not exhibit any change of color at the seal
- No air bubbles, defects or cracks at the seal were observed

Low extractables

Establishing the extractables (release of chemical species during forced extraction under laboratory conditions) profile of single-use systems is critical. The goal of the extraction study is to identify and quantify material chemical constituents likely to be extracted from the tubing material in conditions as specified in the USP <665> protocol, which represent worst-case conditions. The results confirmed the high purity of Liveo™ Pharma TPE Tubing.

The figure below shows the GC-FID/MS chromatogram obtained with the original concentration of 50% aqueous ethanol extract collected from gamma-irradiated Liveo™ Pharma TPE Tubing. Despite its strong extraction power, the chromatogram obtained from the 50% aqueous ethanol extract remained particularly clear, highlighting the purity of Liveo™ Pharma TPE Tubing.

GC-FID chromatogram of gamma-irradiated Liveo™ Pharma TPE Tubing, extract 50% EtOH, original concentration



A concrete example of the high purity benefit is illustrated in upstream processing, which mainly is concerned with growing the cells that produce the therapeutic protein.

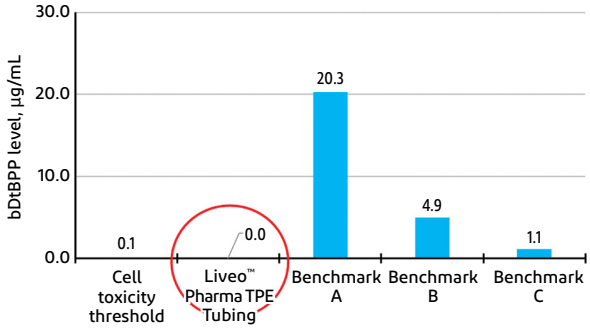
The more cells, the higher the amount of drug substance produced. Similarly, healthier cells lead to a better-quality product. The presence of contaminants within the culture media affects both the quality and the number of cells available to produce the protein.

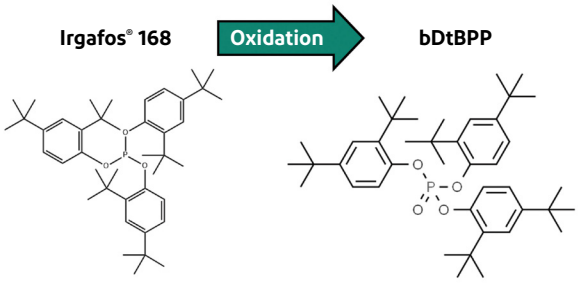
Tris(2,4-di-tert-butylphenyl) phosphite, usually known as Irgafos® 168 (its commercial name), is a common antioxidant found in TPE tubing material. It often is added to prevent severe molecular changes of the polymer during processing and sterilization. During these latter steps, Irgafos® 168 is likely to be oxidated into bis(2,4-di-tert-butylphenyl)phosphate (bDtBPP).

The presence of bDtBPP in single-use systems, and especially in tubing, can inhibit growth of cells such as Chinese Hamster Ovary (HMO) cells that are used widely during biopharmaceutical cell culture upstream processes.

Previously, the presence of bDtBPP was studied in existing TPE tubing readily available for the biopharmaceutical industry: No bDtBPP was found in Liveo™ Pharma TPE Tubing – unlike other TPE tubing brands, for which the bDtBPP level was above the cell toxicity threshold.

bDtBPP concentration on gamma-irradiated TPE tubing (50 kGy dose)





Purity testing

DuPont is committed to helping customers mitigate risk during the validation of single-use components by generating more data to substantiate the performance, quality and purity of our product solutions.

Based on industry standards, DuPont carries out testing to ensure our solutions meet the highest reliability. Below is an example of the bioburden, subvisible particulates and endotoxins measured for DuPont™ Liveo™ Pharma TPE Tubing:

ISO 11737-1: Determination of a population of microorganisms on products)
→ Bioburden counts 0.01 CFU (limit: ≤0.10 CFU/mL)
CFU = colony-forming unit

USP <788> Particulate Matter in Injections (Method 2)
≤3,000 for ≥10 µm particulate size → 0.10 particulate
≤300 for ≥25 µm particulate size → 0.01 particulate

USP <85> The Bacterial Endotoxins Test (BET)
→ All Liveo™ Pharma TPE Tubing: <0.125 EU/mL
(EMA limit: 0.250 EU/mL final drug)

Qualification guides

Comprehensive qualification guides are available to help ease the validation process and accelerate the qualification of Liveo™ Pharma TPE Tubing at your facility.

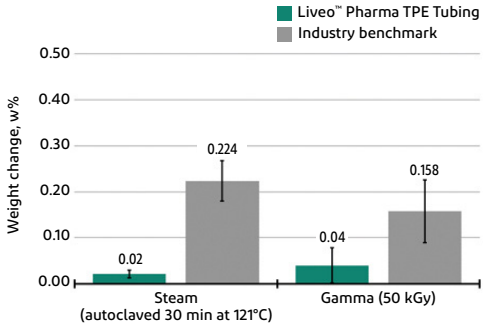
Data before & after sterilization:
- (Co-)welding and sealing (various welding/sealing machines)
- Mechanical, physical properties, and functional properties
- Purity and regulatory data

Good chemical resistance

With the production of vaccines based on mRNA (messenger ribonucleic acid) technology, low storage temperature and cryopreservation usually require the use of dimethyl sulfoxide solvent (DMSO) to ensure viability of the cells. DuPont™ Liveo™ Pharma TPE Tubing shows improvement in chemical resistance to DMSO, especially compared to industry benchmark TPE tubing.

DMSO is not the only solvent well compatible with this new TPE tubing material; other solvents typically employed by the biopharmaceutical processing industry, such as acid and alkaline aqueous solutions and alcohols, show similar compatibility with Liveo™ Pharma TPE Tubing.

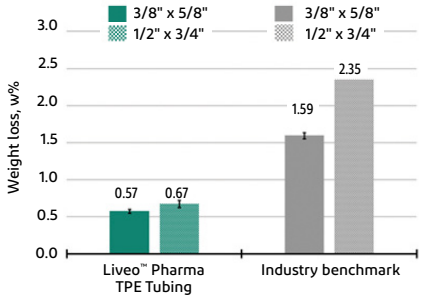
Weight change after 24 hr of 20 v% DMSO exposure



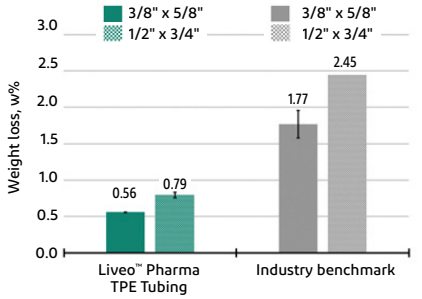
Gravimetric test:

- *Surface-to-volume ratio 4:1*
- *Room temperature for 24 hr*
- *Solvent exposed:*
  - *20% (v/v) DMSO*
  - *NaOH 5M*
  - *KOH 5M*
  - *HCl 5M*
  - *Propan-2-ol*
  - *Ethanol*

Total weight loss after 24 hr of solvent exposure (all solvents cumulated): Autoclaved (30 min at 121°C)



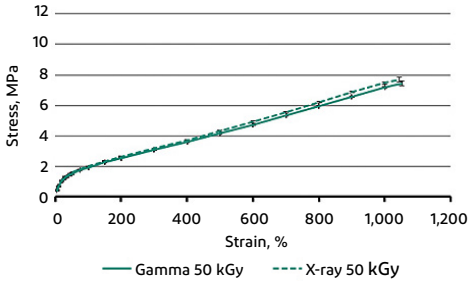
Total weight loss after 24 hr of solvent exposure (all solvents cumulated): Gamma-irradiated (50 kGy)



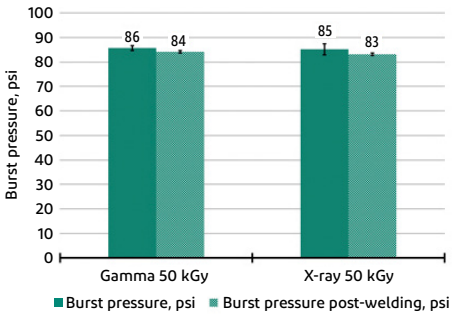
Equivalency between gamma and X-ray irradiation sterilization

Liveo™ Pharma TPE Tubing sterilized by gamma and X-ray irradiation (50 kGy dose).

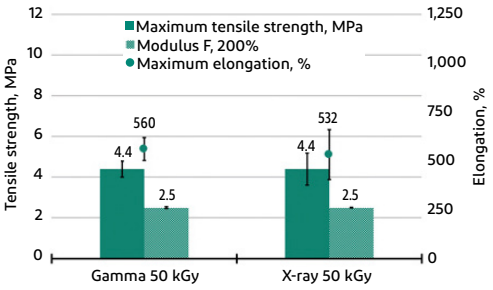
Stress-strain of Liveo™ Pharma TPE Tubing



Burst pressure resistance of Liveo™ Pharma TPE Tubing



Mechanical properties of Liveo™ Pharma TPE Tubing after welding



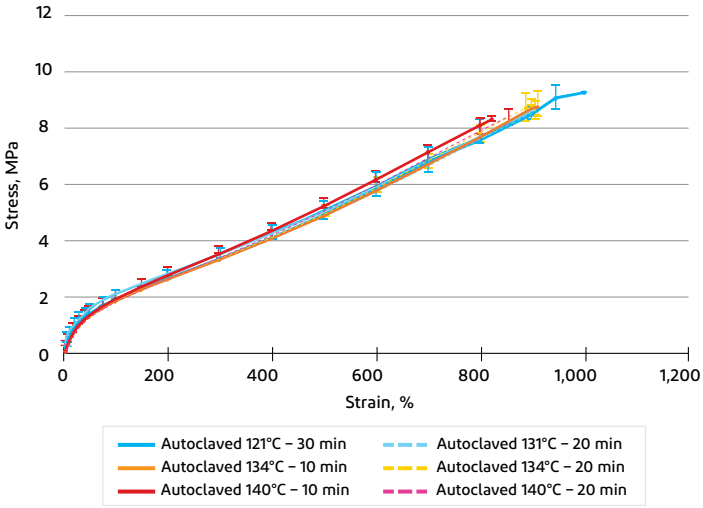
Liveo™ Pharma TPE Tubing demonstrates equivalency of gamma and X-ray irradiation through very similar viscoelastic, physical and functional properties.

Autoclaving resistance at high temperatures

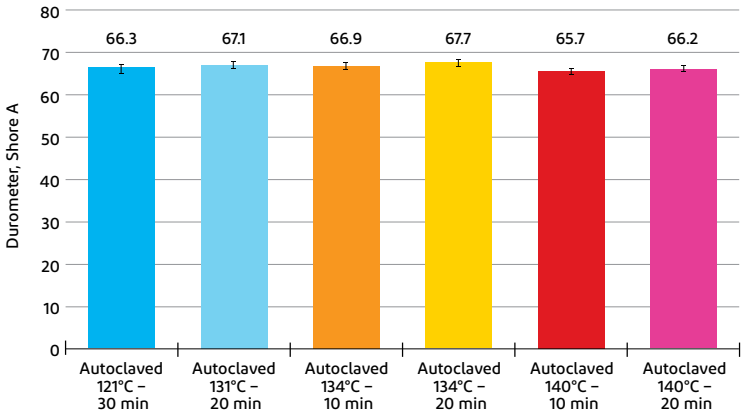
DuPont conducted evaluation of DuPont™ Liveo™ Pharma TPE Tubing to ensure that the tubing remained stable when exposed to a wide range of temperatures that potentially could be applied during an autoclave cycle.

Steam sterilization via autoclaving: From 121 to 140°C; from 10 to 30 min.

Stress-strain of autoclaved Liveo™ Pharma TPE Tubing, 3/8" x 5/8"



Durometer hardness of Liveo™ Pharma TPE Tubing following different autoclave conditions, 3/8" x 5/8"



Liveo™ Pharma TPE Tubing remained stable using autoclave cycles up to 140°C for 20 minutes:

- No deformation/color change
- No change of durometer
- No change of functional properties

Available dimensions

Available GMIDs for Liveo™ Pharma TPE Tubing include (but are not limited to):

Inner diameter (I.D.)		Outer diameter (O.D.)		Wall	
Inch	mm	Inch	mm	Inch	mm
1/8	3.2	1/4	6.4	1/16	1.6
1/4	6.4	7/16	11.1	3/32	2.4
3/8	9.5	9/16	14.3	3/32	2.4
3/8	9.5	5/8	15.9	1/8	3.2
1/2	12.7	3/4	19.1	1/8	3.2

Customization options

Liveo™ Pharma TPE Tubing is offered with a wide range of customization options to meet your processing needs, including custom sizes, marking, packaging, lengths, shapes, testing, tolerances and more. Each GMID can be customized to account for:

- Size
- Coil length
- I.D. x O.D.
- Multipack
- Marking
- Tolerances

For more information

For further details related to the performance of DuPont™ Liveo™ Pharma TPE Tubing, please contact your DuPont representative.

DUPONT™

To learn more about DuPont™ Liveo™ Healthcare Solutions, visit **liveo.dupont.com**.

LIVEO™

Smarter Healthcare.
Positive Patient Outcomes.

The information set forth herein is furnished free of charge and is based on technical data that DuPont believes to be reliable and falls within the normal range of properties. It is intended for use by persons having technical skill, at their own discretion and risk This data should not be used to establish specification limits nor used alone as the basis of design. Handling precaution information is given with the understanding that those using it will satisfy themselves that their particular conditions of use present no health or safety hazards. Since conditions of product use and disposal are outside our control, we make no warranties, express or implied, and assume no liability in connection with any use of this information. As with any product, evaluation under end use conditions prior to specification is essential. Nothing herein is to be taken as a license to operate or a recommendation to infringe on patents.

Caution: Do not use DuPont materials in medical applications involving implantation in the human body or contact with internal body fluids or tissues unless the material has been provided from DuPont under a written contract that is consistent with DuPont policy regarding medical applications and expressly acknowledges the contemplated use. The customer is solely responsible to determine whether DuPont products are suited for customer's intended purpose or application and may contact DuPont technical experts for more product details prior to sourcing products. DuPont disclaims liability for any incidental or consequential damages resulting from customer's use of DuPont products. For further information, please contact your DuPont representative. You may also request a copy of DuPont POLICY Regarding Medical Applications H-50103-4 and DuPont CAUTION Regarding Medical Applications H-50102-4.

Form No. 05-1060-01-AGP0522 #16932