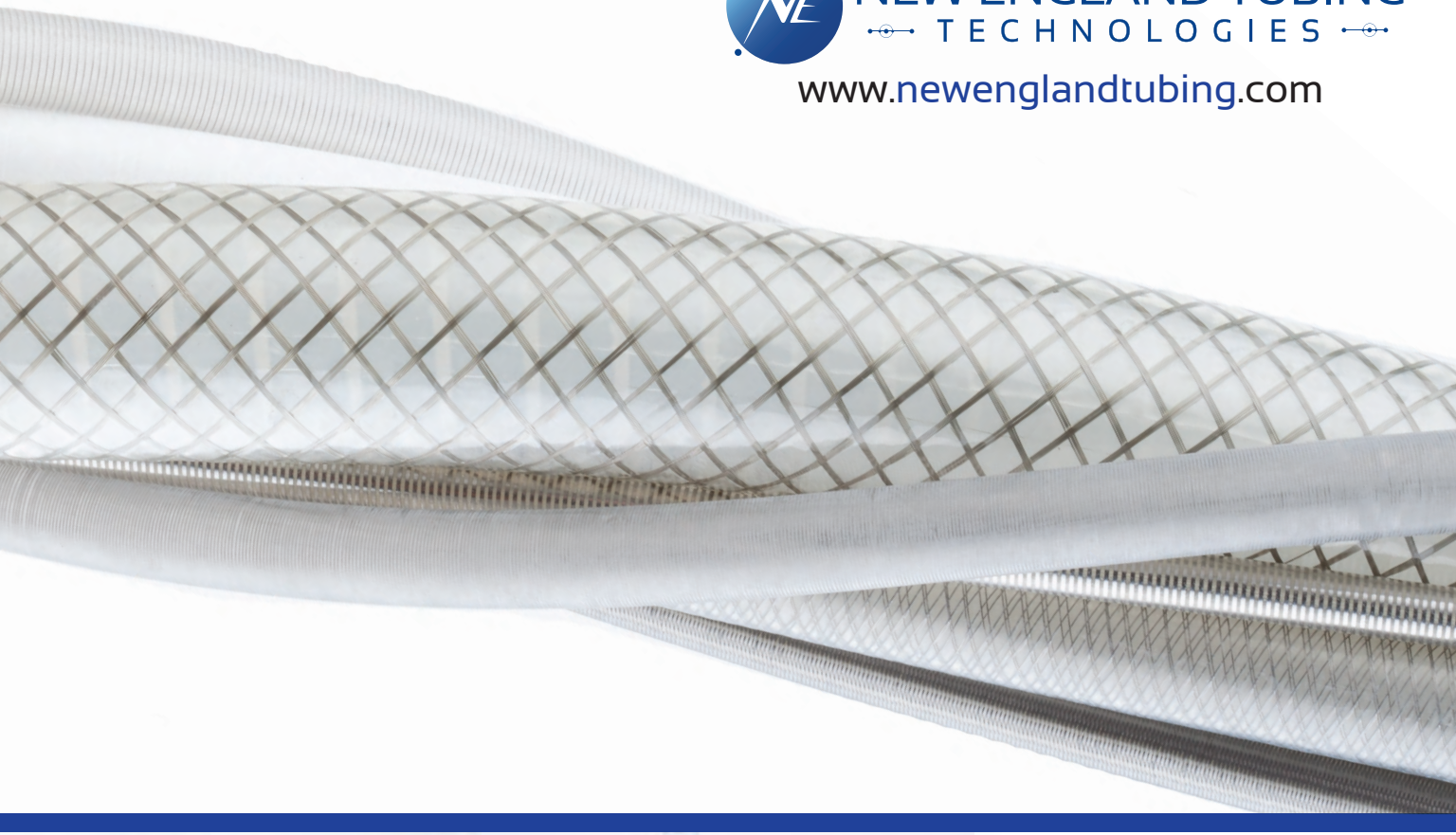
NEW ENGLAND TUBING
TECHNOLOGIES

www.newenglandtubing.com



PRODUCT & CAPABILITY GUIDE

WHO WE ARE

Incorporated in 2001 to serve the custom medical tubing and catheter industry, New England Tubing Technologies (NETT), constantly strives to provide innovative solutions to meet the ever changing needs of today's high-tech industries. Drawing on the unique combination of advanced extrusion expertise, extensive wire-processing experience, and vast custom manufacturing knowledge of our partner company, New England Wire Technologies, New England Tubing is well-versed in the specific requirements of numerous industries including medical, industrial manufacturing, military, and aerospace. Providing superior performance tubing is our passion; regardless of application. Our team of design engineers work closely with each customer to develop innovative, one-of-a-kind tubing solutions and custom OEM components, all designed to meet unique performance requirements. Through true vertical integration of manufacturing processes, we offer customers everything from accelerated prototyping and small quantity orders to full production and value-added services.

WHAT WE DO

New England Tubing Technologies provides an array of custom products including medical braids, spiral and braid reinforced tubing, lubricious lined catheter shafts, multi-lumen tubing, multi-durometer tubing, and hybrid constructions. We excel in thin-wall, tight tolerance tubing, bonding layers of thermoplastic to fluoropolymer, and braiding all types of round and flat wire. In addition to traditional tubing products we also offer eTubing® -- hybrid tubing configurations that include signal, coax, or other electrical components within the wall of the tube. A wide range of value-added and post-processing services such as tipping, hubbing/flaring, skiving, shaping/forming, and radiopaque striping are available to further enhance your design.

SERVICES WE OFFER

- **Design Assistance** – on-site engineering staff with extensive understanding of testing criteria, performance requirements, and material requirements
- **Development & Prototype Services** – small minimum order quantities with multiple variations per run
- **Custom Extrusions** – all products are designed and manufactured to your project's unique performance characteristics
- **Braid Reinforcement** – optimizes physical performance characteristics like torque response, bend radius, and tensile strength
- **Spiral (Coil) Reinforcement** – optimizes physical performance characteristics such as kink resistance and hoop strength
- **Multi-Lumen Geometries** – multiple lumens in all sizes and shapes for expanded capabilities
- **Multi-Durometer Designs** – varying hardness of plastic to alter flexibility over the length of the shaft
- **eTubing ® Configurations** – combines conductors in the wall of the tube for additional capabilities within the same cross-sectional area
- **Medical Braiding** – endoscope repair, reflow, catheter assembly
- **Value Added Services** – tipping, hubbing, flaring, thermal forming
- **Post Processing** – annealing, centerless grinding, precision cut to length
- **Extensive Modern Testing Facility** – wide range of standard and specialized test data
- **In-house Tool Making** – accelerated prototyping of custom designs

EXTRUDED TUBING

New England Tubing Technologies specializes in custom extrusions featuring small diameter, thin-wall, tight tolerance tubing. Building on more than 50 years of extrusion experience of our partner company, New England Wire Technologies, we utilize our comprehensive background in thermoplastic extrusion, in-house tool fabrication facility, and an extensive technical staff to effectively extrude a wide range of thermoplastic materials. This enables us to deliver quality, custom products to meet our customers' exact needs.

We provide custom configurations with outer diameters starting at .010" (.254mm) to >1/2" depending on design parameters.

Our years of experience within the medical market allows us to select the proper compounds to meet your requirements such as biocompatibility needs, radiopaque loadings, and sterilization methods. With 120 years of experience in other non-medical markets gained from our partner company, New England Wire, we can also meet your non-medical requirements for flame or low smoke needs, chemical compatibility, and temperature withstand. Our on-site color lab provides custom tubing in the ideal color required, with standard and custom color matches available.

Tubing is precision cut to length or can be supplied in bulk packaging, depending on the finished design.

Generally Acceptable Sterilization Methods

Material	Gamma	ETO	Autoclave	Cidex®	Sterrad®	Bleach (10%)	Isopropyl Alcohol wipe	Ethyl Alcohol wipe	Denatured Alcohol wipe	Virex® wipe	Virex® (Soak >= 10 min)	Sodium Hydroxide	Green soap tincture
PVC	A*	A	U	A+	B	A	A+	A+	A+	A	A	A	A
Polyethylene	A	A	U	A	A	A	A	A	A	-	-	A	-
Nylon	A*	A	U	-	A	U	-	A	-	-	-	A	-
Pellethane®	B	A	U	A	A	A	B+	B+	B+	-	-	B	-
Tecoflex®	B	A	U	-	A	B+	B+	B+	B+	-	U	-	-
ETFE	A	A	A	A	A	A	A	A	A	A	A	A	A
FEP & PFA	U	A	A	A	A	A	A	A	A	A	A	A	A
TPE's	A	A	A**	-	A	A	A	A	A	A	A	A	A
Elexar® & Kraton™	A	A	A**	A	-	A	-	-	-	-	-	-	-
Pebax®	A	A	-	-	-		-	-	-	-	-	-	-

Note: Specific sterilization methods and best practices may vary, it is the responsibility of the finished device manufacturer to select and verify the appropriate sterilization method for their device.

Chart Key

A = Generally Acceptable
B = Minor to Moderate effect (swelling, discoloration, surface clouding, cracking)
U = Unacceptable
* = Specific Grade required
+ = Short Term use only
- = Insufficient Data
** = Limited Cycle Use

Material	Durometer Range	Advantages	Considerations	Examples Where Used
PVC	Soft (70A-90A)	• Cost effective • Flexible	• Limited sterilization • Requires specific compounds for medical use	• Unreinforced tubing • Multi-lumen
HDPE	Hard (50D-70D)	• Cost effective alternative to PTFE liner • Good chemical resistance	• Low temp limit • High flexural modulus	• Unreinforced tubing • Liners
Polyurethane	Very Soft - Very Hard (80A - 75D)	• Great elasticity • Softens at body temperature • Flexible • Abrasion resistant • Easily compounded with additives	• Hygroscopic • Can be tacky	• Topcoat • Tie layer • Unreinforced tubing • Reinforced tubing
Nylon	Hard - Very Hard (40D - 90D)	• Wear resistant • Rigid	• Hygroscopic • High flexural modulus	• Topcoat • Unreinforced tubing • Reinforced tubing
PEBAX®	Soft - Hard (25D - 74D)	• Widely used in medical industry • Has great temperature stability • Relatively low coefficient of friction • Easily compounded with additives	• Cost • Softest grade is 25D	• Top coat • Tie layer • Multi-lumen • Unreinforced tubing • Reinforced tubing
FEP & PFA	Hard (55D - 60D)	• Low coefficient of friction • Cost effective alternative to PTFE liners	• Not suitable for gamma sterilization • Cost	• Liners • Multi-lumen • Reinforced tubing
ETFE	Very Hard (~75D)	• Suitable for gamma sterilization	• Rigid	• Liners
PEEK	Very Hard (~85D)	• Very rigid • Great chemical resistance	• Can be cost prohibitive • Opaque	• Unreinforced tubing • Multi-lumen
TPE	Very Soft - Soft (55A - 90A)	• Flexible • High elongation	• Low temperature rating • Limited sterilization	• Multi-lumen
Grilamid®	Hard	• Very optically clear	• Best used where high rigidity and high optical clarity are required	• Unreinforced tubing • Multi-lumen

MULTI-LUMEN

What is a "lumen"?

In simple terms, a lumen is the inside space of a tubular structure. In tubing, lumens are often used for air/fluid evacuation or delivery, or to provide separate access ports for other devices such as surgical scissors, stents, or cameras.

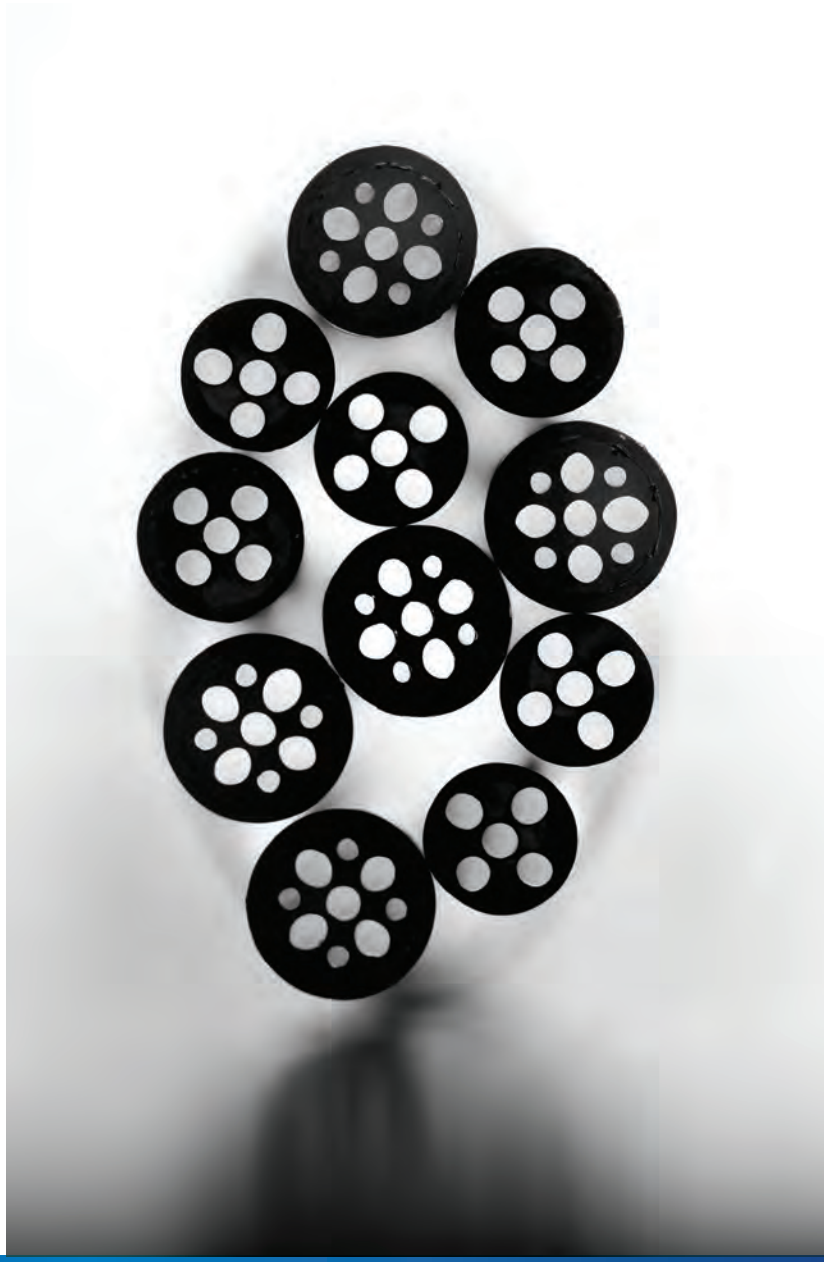
New England Tubing manufactures single and multi-lumen tubing in both reinforced and unreinforced configurations with a variety of custom lumen geometry options. Commonly requested multi-lumen profiles are for concentric circular, smaller satellite around larger lumens, the classic double D, oval, and "smiley face".

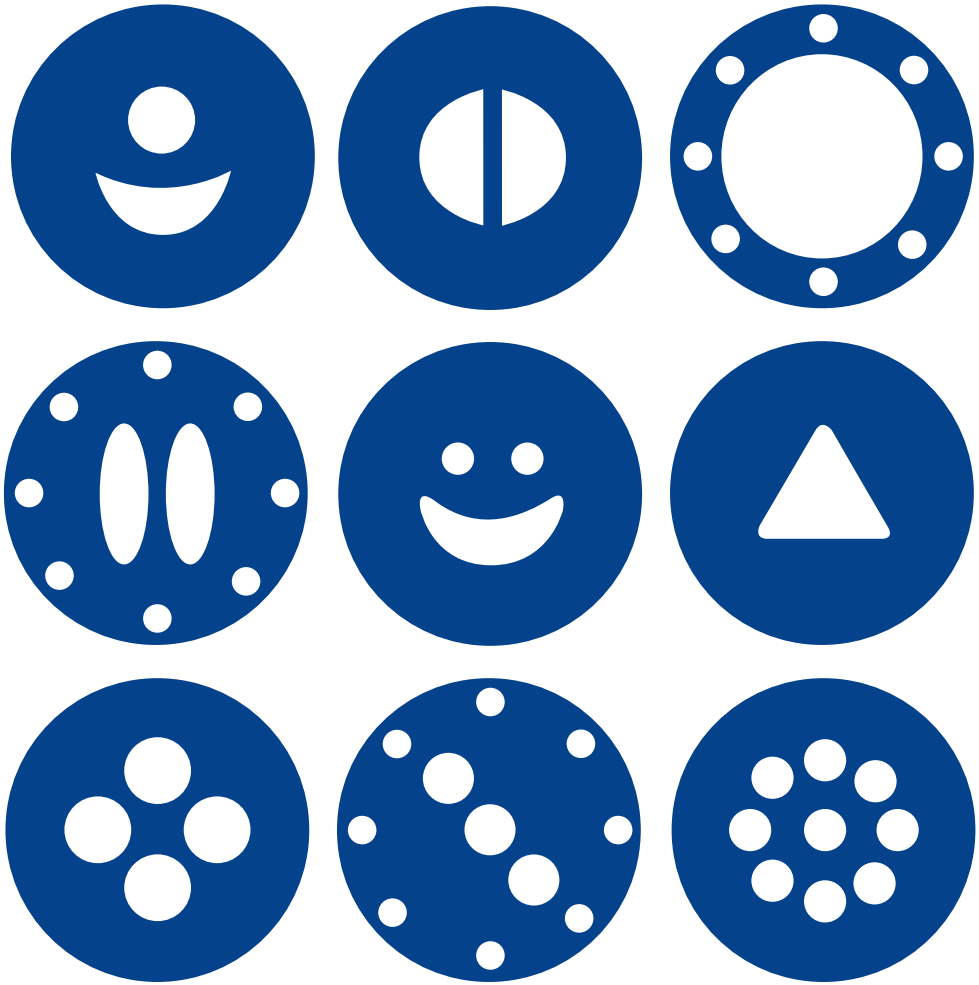
Usage & Benefits

- Air and/or fluid delivery or evacuation
- Flushing channel
- Vacuum channel
- Access ports for devices (stents, surgical scissors, cameras)

Applications

- Cardiology
- Urology
- Exploratory surgeries
- Endoscopy
- Borescopes
- Multi-functional devices





BRAID OR SPIRAL REINFORCED TUBING

New England Tubing Technologies has a variety of methods and materials at our disposal to reinforce your tubing. Constructions include spiral, braid, or longitudinal members as well as combinations and variations of each. Diverse reinforcing materials range from copper, copper alloys, and stainless steel, to textiles/ aramids and high strength polymers. We can reinforce most extruded tubing including single lumen, multi-lumen, thin wall, micro-bore, co-extrusions, unique profiles, and tubes with multi-layers of dissimilar materials.

Benefits of Reinforcement

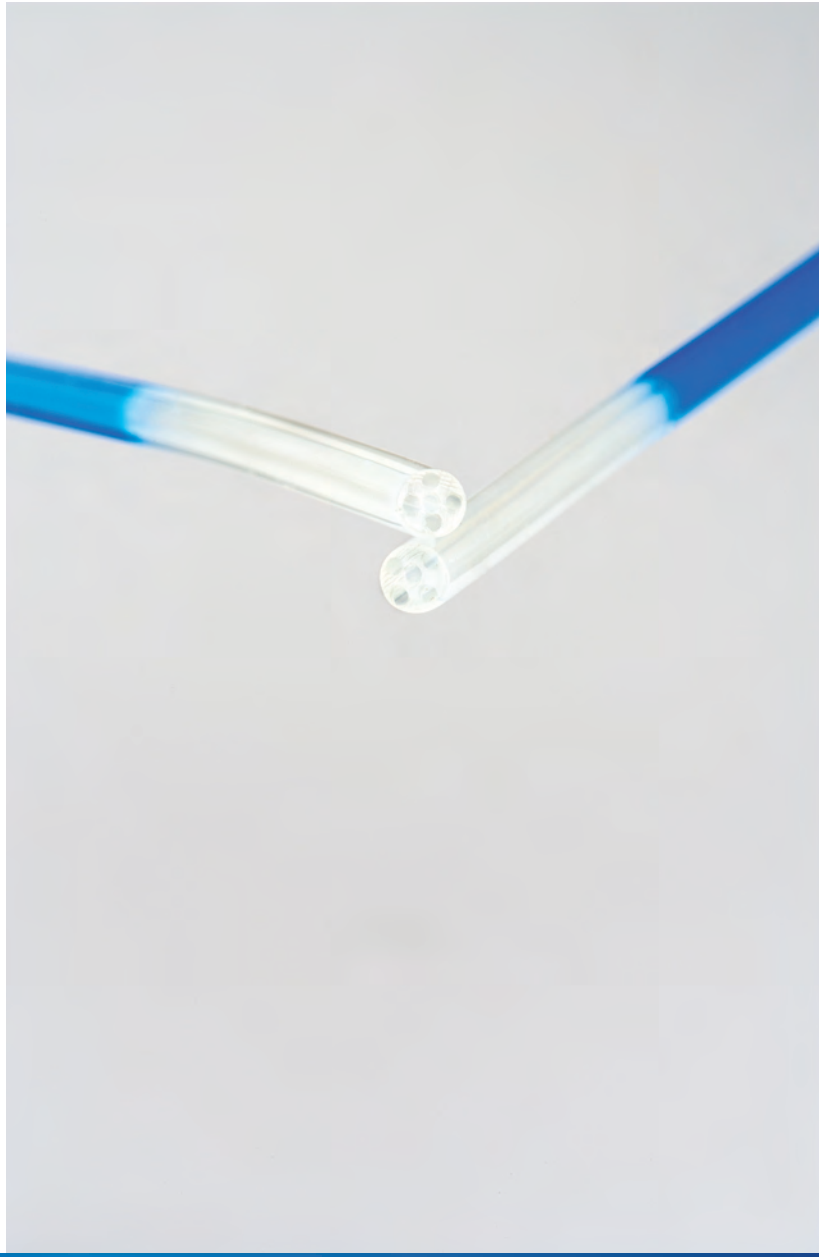
- Kink Resistance
- Variable Flexibility
- Improved Hoop (Crush) Strength
- Increased Column Strength
- Improved Tensile Strength
- Improved Torque Response
- Withstands High Pressure
- Adds Shape Memory
- Provides Armouring/Protection

Reinforcement Type	Benefits	Considerations
Spiral	• Hoop strength, which limits ovality when flexed • Thinner walls are achievable compared to braids	• Provides no benefit to torque
Braid	• Great for adding torque • Kink resistance and recovery	• Limited hoop strength gain compared to spiral
Linear Strength Member	• Provides great longitudinal tensile strength • Shape memory feature	• Potential negative impact on flexibility
Materials		
Stainless Steel Round Wire	• Hoop strength • Cost effective	• Typically builds more than flat wire
Stainless Steel Flat Wire	• Allows for thinner wall • Smoother surface finish	• Higher cost than round wire
Copper & Copper Alloys	• Great conductivity for eTubing	• Not as strong as stainless steel
Aramid	• Great for internal pressure • Longitudinal tensile strength • Light weight • Low elongation	• Not recommended for hoop strength, torque or kink resistance
High Strength Polymers	• Non magnetic for use in/near MRI applications	• Not as strong as steel • Can be cost prohibitive
Nitinol	• Superelastic material	• Can be cost prohibitive

MULTI-DUROMETER TUBING

Multi-durometer tubing allows for varying levels of flexibility over the length of one shaft. The proximal section of the tube can be made of a harder plastic to help with insertion and positioning while a more flexible distal section will allow your tube to better navigate challenging paths. This innovative process combined with reinforcement can produce a tube with varying flexibility while still maintaining important physical characteristics like torque transmission, kink resistance, and hoop strength.

Custom multi-durometer tubing can be designed in single or multi-lumen styles, with or without reinforcement. For multi-lumen constructions lumen patency is critical and is always maintained. Reinforced constructions generally have a continuous liner and reinforcement with varying durometers occurring on the outer most layer. Combining multi-durometer features with varying braid or spiral density can alter flexibility over the length of one shaft even further. Longitudinal members can also be added to increase tensile and column strength of your tube.



EXTRUSION MATERIALS - DETAILED

Material	Grade (Brand)	Shore Hardness	Tensile Strength (psi)	Flexural Modulus (psi)	Coefficient of Friction
PVC	Application Dependent	70-90A	2,500-3,200	-	-
PEEK	450G (Victrex®)	74D	14,500	595,000	.35-.50
	381G (Victrex®)	85D	12,200	550,000	.35-.50
PEBAX®	7433 (Pebax®)	73D	8,500	88,400	-
	7233 (Pebax®)	72D	8,120	75,000	0.21
	7033 (Pebax®)	69D	7,830	56,600	0.22
	6333 (Pebax®)	63D	7,685	42,100	0.26
	5533 (Pebax®)	55D	7,540	23,200	-
	4533 (Pebax®)	46D	6,100	12,500	-
	4033 (Pebax®)	42D	5,800	12,200	-
	3533 (Pebax®)	33D	5,650	3,630	0.61
	2533 (Pebax®)	25D	4,640	2,180	0.61
Nylon 11	Rilsan® Besno-TL	70D	-	164,000	-
Nylon 12	Rilsan® Aesno-TL	75D	-	171,000	-
	Vestamid® L2101F	-	6,500	200,000	-
	Grilamid® L25	74D	10,000	240,000	-
Polycarbonate	Application Dependent	-	~10,000	~350,000	-
Polyurethane	2363-80AE (Pellethane®)	83A	4,500	3,500	
	2363-90AE (Pellethane®)	90A	5,500	6,000	-
	2363-55DE (Pellethane®)	55D	6,200	10,000	-
	2363-65D (Pellethane®)	64D	6,800	19,000	-
	2363-75D (Pellethane®)	75D	6,800	220,000	-
	EG 85A (Tecoflex®)	77A	6,200	2,300	-
	EG 93A (Tecoflex®)	87A	7,700	3,200	-
	EG 100A (Tecoflex®)	94A	8,200	10,000	-
HDPE	Petrothene® LR 7320-01	67D	4,000	181,000	~.29
TPE	Santoprene® 8281-55MED	59A	667	-	-
	Santoprene® 8281-65MED	68A	856	-	-
	Versaflex® HC MT317	68A	870	-	-
	Versaflex® HC MT226	84A	1,600	-	-
Fluoropolymer	FEP	55D	2,760-3,190	78,000-92,000	~.20
	PFA	60D	4,000-5,000	94,000-99,000	~.20
	ETFE	75D	5,800-7,250	128,000-199,000	~.40

NOTE: These are typical values and should not be taken as specifications, values are provided from various sources

eTUBING® HYBRID CONFIGURATIONS

Combining our partner company, New England Wire Technologies, custom cable manufacturing expertise with our extruded tubing capabilities, we can customize your tube with added elements such as ultra-miniature coaxial cables, high frequency cables, thermocouples, and high strength/high flex alloys to provide more functionality in the same tubular cross-section – critical for today's minimally invasive surgeries. Our eTubing® designs can add analog and digital transmission of electrical signals for sensor capabilities, powering devices, and temperature/oxygen monitoring features by incorporating these customized wires or cables within the wall of the tube itself, while still providing additional device access for drugs or other needs.

Typical Elements for eTubing®

- Power supply
- Measuring/monitoring capabilities
- Signal carrying capabilities
- Strength members
- One or more lumen

Benefits

- More functionality in the same cross-section
- Return signal wire

Applications

- Handheld electrosurgical devices
- Cauterization
- Ultrasonic devices
- Monitoring devices
- Borescopes/endoscopes
- Power supply and cooling combinations

High Pressure Tubing

Whether your application needs specific pressure performance with a thin wall requirement or an ultimate pressure withstand of 30,000 psi or higher, New England Tubing Technologies can deliver the solution.

Extruded Parallel Tubing

Custom parallel tubing (paratubing) can be manufactured by New England Tubing in a wide range of thermoplastics, designs, and shapes. Paratubing provides you with two or more individual but connected tubes all of which can perform different tasks.

VALUE ADDED SERVICES

New England Tubing has a wide variety of additional services to help fulfill your finished tubing needs.

Tipping

Used to aid in the insertion and guidance of devices such as catheters and introducers. Tapered or atraumatic tips designed for unique customer applications—specific tip geometries, tapered ID or OD, rounded, or low-profile ends. This can involve shaping the end of the tube to provide a tip or attaching a tip made of a different material, most commonly a softer durometer than the main shaft. Often radiopaque additives are used in the tip material so they are visible under fluoroscopy.

Hubbing/Flaring

Used to expand the OD of the tube up to 1.4 times the beginning OD. This improves accessibility of the interior of the tubing to facilitate insertion of tools, stents, wire, fluids, etc. It expands the ID and OD of the tubing to create easier insertion, better access, or to fit a specific connector or device. The tube can be flared or we can bond on a flare depending on the requirements and tube construction. NETT can attach luer lock style fittings utilizing either thermal or adhesive methods.

Shaping/Forming

Used so the tube will hold a specific shape to aid in connecting with devices or accessing specific places within the anatomy. Depending on the construction and requirements we can attach a section that can be shaped or we can shape the tube itself.

Laminating

Used as a secondary process in multi-durometer constructions to provide varying flexibility over one length and/or improve the surface finish. Also used to manufacture parts too difficult for extrusion.

Centerless Grinding

Grinding of tubes can provide precise diameter control and smoothing of even the roughest extruded outer surface conditions.

We offer thru-feed grinding of the entire length of a tube, and in-feed grinding that creates a smooth surface and decreases the diameter on one section of tube, if required.

Extruded Tube Annealing

Annealing is a stress relieving cycle that straightens and minimizes internal stresses that result during manufacturing. Annealing is often performed to reduce casting of the tube caused by reel to reel processing, thereby straightening the tubes prior to shipment.

Precision Cut to Length

We utilize a variety of tube cutting methods to provide the precise cut and length required. Rotary cutters provide an accurate cut with a standard deviation of 0.5% of length. Our programmable machines monitor and store process information, providing repeatable results.

Radiopaque Striping

A co-extruded stripe encapsulating finely dispersed radiopaque material, such as barium sulfate, which has been compounded with the base plastic resin, can be added to the length of a tube. This enhances visibility and ensures proper tube placement when viewed using x-ray scan technology.

Fittings

Luer lock style connectors and custom fittings can be attached to our tubing utilizing several methods including press fit, adhesive, and thermal bonding techniques.

Laser Ablation (Cutting)

We are able to laser ablate certain extrusion materials. This enables us to create shaped holes to allow for fluid or gas passage or to provide access channels for wires or other devices in various applications. Additionally the laser can be used to ablate material to expose conductors for easy termination of our eTubing®.

MEDICAL BRAIDING

New England Tubing Technologies has access to over 100 braiders ranging from 8-carrier to 48-carrier configurations. We manufacture medical braids using all types of wire materials, tempers, and gauges. Various types of flat wire are often used to minimize the thickness of a tube while providing added strength. We also produce medical braids using textile products like high strength fibers and polymers, monofilaments or even a hybrid mix of materials.

Braid configurations often have angles from 20° to 70°, diameters up to 1.00", and coverage up to 96%, however designs are certainly not limited to these parameters. Braid densities can be varied throughout one length to provide changeable levels of flexibility.

General Usage

- Catheter tubing reinforcement
- Endoscopic assemblies
- Flexible fiber optic scopes
- Articulation sections
- Shielding
- Armour protection
- Organization of components

CUSTOM TUBING APPLICATIONS AND INDUSTRIES

- Endoscopy
- Borescope
- Cardiovascular
- Gastroenterology
- Urology
- Stent Delivery
- Monitoring Systems
- High Pressure Applications
- Fluid/Air Management and Delivery
- Robotics/Automation
- Custom Industrial Applications
- Armour / Protection

CUSTOM DESIGN ASSISTANCE

The key to providing the proper solution, regardless of application, is to start with an experienced team of engineers, armed with the latest design tools and technology. This knowledge and expertise, combined with state of the art manufacturing and testing facilities allows our engineers to provide innovative solutions and meet the ever changing needs of our customers.

Through endless hours of research and development along with vast amounts of testing, we have accumulated extensive data and information on the performance of various materials and constructions. This knowledge and experience gives us the ability to develop a custom design based on individual customer requirements. Customers can provide us with important characteristics (dimensions, torque, flexibility, etc.) and we can quickly and accurately develop a design to best fit their needs.

Contact us today to get started on your project!

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2022

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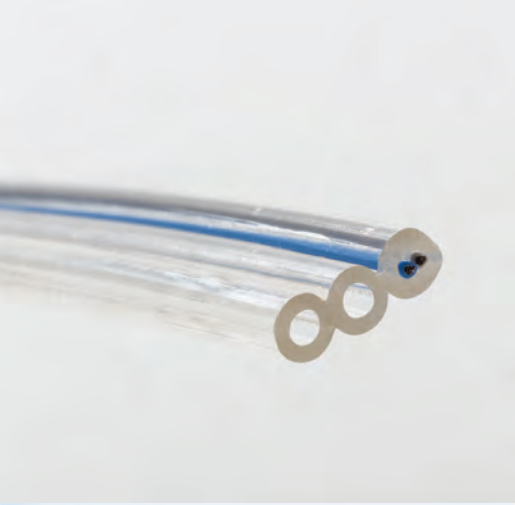


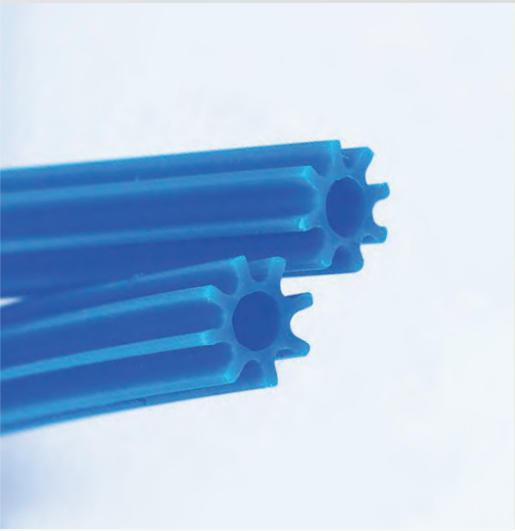
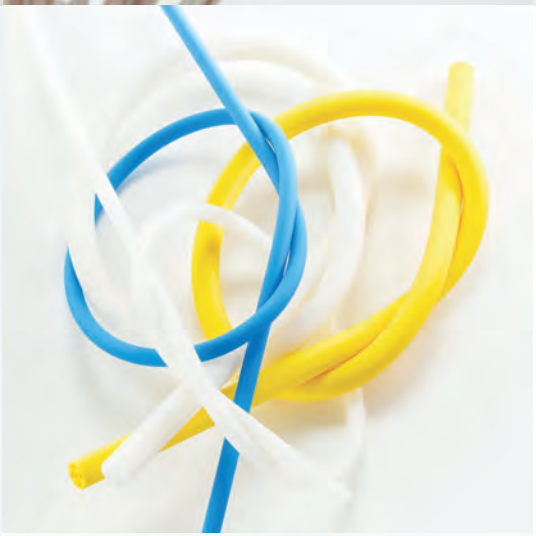



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