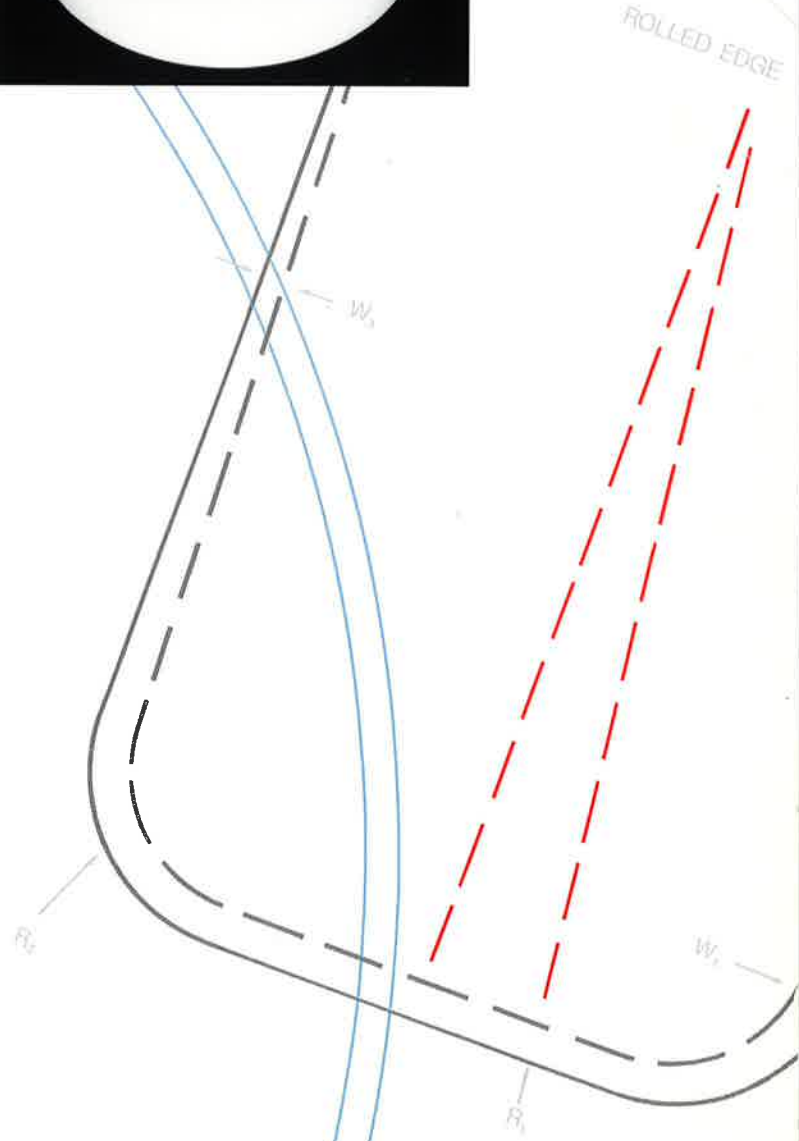
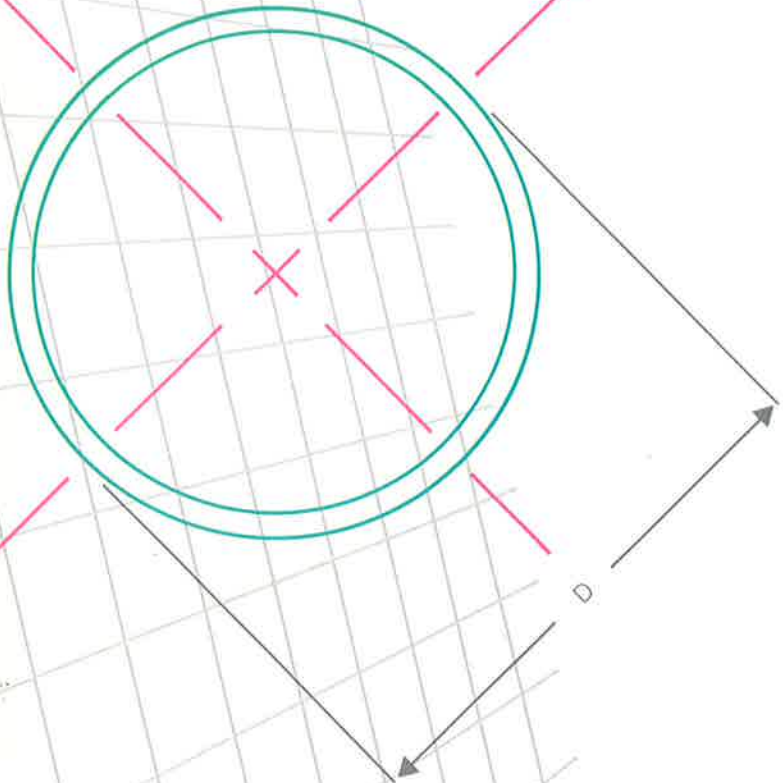
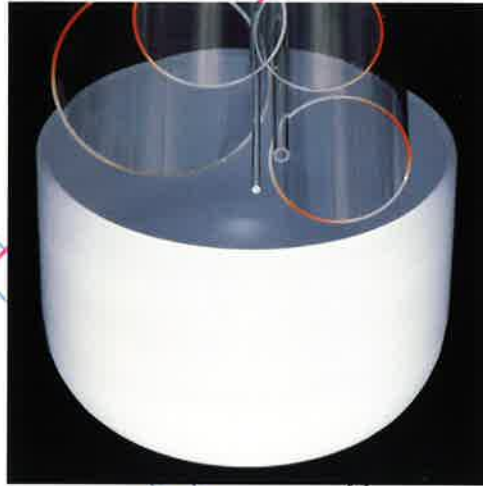


# Fused Quartz

$$K = \frac{E}{3(1 - 2\nu)}$$



**SYLVANIA** Emissive Products

**GTE**



# Introduction

Is there a component more ubiquitous today than the computer on a chip? Is there a manufacturing technology more demanding than semiconductors? It's hard to think of one. In a few short years the products that have resulted from the semiconductor industry reach every corner of the globe . . . and touch all facets of our lives. Indeed, scarcely any other human endeavour has ever achieved so much so quickly . . . or allowed so many other industries to flourish—and advance.

It's not been an easy task. Constant product evolution. More power in less space. More sophistication in simpler solutions. More capacity. Larger wafers. Market supply. User demand. Competitive proliferation. Quality. Quantity. Service.

GTE/Sylvania knows your industry, and the forces that are shaping it. We keep pace with changes—evolutionary and revolutionary—that make you the cutting edge of tomorrow's technology. We have to.

We supply superior fused quartz products for semiconductor fabrication. Like you, we are constantly pushing ourselves and our technologies to produce more, better, at higher quality. Improving processes by applying stringent statistical process controls. Deepening our engineering support. Expanding our distribution. Increasing the value of our products for you.

GTE/Sylvania is a reliable source of superior fused quartz crucibles, tubing and rod at a very competitive price. Our commitment to you? Deliver the flexibility you need to stay on top. This brochure is intended to do just that.



A || 52/M || 1

G || 27 + 11

# GTE Makes What You're Looking For

**At a GTE facility in Ipswich, Massachusetts, an industry-unique single-draw process is used to manufacture quartz tubing. Only GTE does it this way. This ten-inch tubing has no resize ridges and offers uncompromising tolerances. Statistical process controls ensure dimensional accuracy and product purity.**

When people who know silica glass see GTE fused quartz products for the first time, it's not uncommon for them to say, "I've never seen anything as flawless as this." Not surprising. GTE's expertise with fused quartz goes back a long way, back to the first envelopes for high temperature lighting over 30 years ago.

The difference in the clarity and purity of GTE fused quartz products is immediately apparent. It reflects the care we take during each step of the manufacturing process. Raw materials. Melting. Forming. Process control. Each step is vital, just as yours are to you. Yield is defined by performance to customer requirements, i.e. quality. Quality is never compromised by demand.

GTE delivers. Clarity that's obviously better—thanks to proprietary manufacturing processes. Strict process controls. National distribution. And the range of standard products and custom sizes you need to compete.

GTE understands your requirements: a pure, quality product delivered on time, and on spec.

These are what you look for in fused quartz products... but don't always see. These are what you find at GTE.

## GTE Fused Quartz

GTE fused quartz processes continually evolve. Our design engineers stay close to our processes and our customers to insure the products we manufacture meet market requirements. Suggestions from the floor and from our customers result in increased process control... and superior products.

### *Manufacturing:*

GTE fused quartz products reflect the quality of the raw material they come from. We start with carefully selected and analyzed SiO<sub>2</sub>. To ensure a completely effective match to the demands of wafer manufacturing, this sand is put through a highly stringent, GTE proprietary purification process. Only then is it ready to be turned into high purity fused quartz.

We manufacture tubing using a single draw process, drawing them directly to the size you need. Only GTE does it this way.

Other suppliers use a resize process, drawing tubes in only one diameter, then stretching them to larger sizes. The clear result: superior dimensional tolerances, fewer striations and no resize ridges on the surface of GTE tubes.

More important, the GTE tubing process minimizes hydroxyl (OH) content, resulting in low tube sag at the high temperatures of wafer production. No special coatings are ever required. And no extra handling steps.

Crucibles are manufactured with an equally demanding attention to detail. Process control charts are kept to back each crucible—from start to finish—and are available with the final shipped product. A complete history of specifications and verification of performance at your fingertips.

### *Quality*

Statistical process control is integral to manufacturing at GTE. This real time, critical tracking of process variables helps us guarantee to you a consistent, uniform product.

While a fused quartz product is being formed, dimensional accuracy is confirmed. At intervals, infrared spectrophotometry establishes product purity. Just as with defective chips, every small, hidden flaw must be uncovered. When it is, the product is rejected, and the process is fine-tuned. Our ultimate goal is to eliminate your need for incoming material inspection.

### *Distribution*

It doesn't matter how good a product is if it's out of stock. Or, if it doesn't come in the size you need. Or, isn't delivered on time. GTE delivers.

GTE supplies tubing and rod directly to IC manufacturers or to quartzware fabricators of diffusion tubes and wafer carriers. We also supply crucibles to both merchant and captive wafer growers. And with the increasing demand for wafers, you can count on GTE.

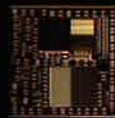
Local inventory is available for immediate delivery from GTE Distribution Centers in Phoenix, AZ; Teterboro, NJ; Burlingame, CA; Dallas, TX; and Exeter, NH. To help you plan ahead, we send you updated fused quartz inventory lists on a regular basis.

$$\frac{E}{2(1 + \nu)}$$

$$\nu = \frac{E}{2G} - 1$$

$W_a$

$$\nu = \frac{E}{2G} - 1$$

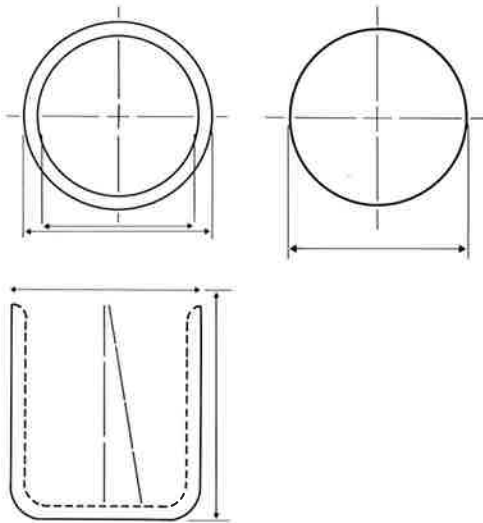


**GTE's comprehensive range of quartz products includes tubing, rod, and crucibles. The standard product offering continually evolves, and today includes larger tubing for six-inch and larger wafers, and flat bottomed crucibles for state-of-the-art silicon growth processes. For customers with special needs, we welcome custom orders.**

GTE/Sylvania makes a full range of tubes, rods, and crucibles in standard and custom sizes. Type SG25SC fused quartz tubes are available in diameters from 3mm to 290mm ID, in standard lengths up to ten feet. We welcome custom orders on nonstandard sizes.

Rod sizes range from 4mm to 19mm OD.

Crucibles range in size from 10" OD and up, with either round, semi-flat or our patent-pending flat bottoms. Your GTE representative will be glad to discuss custom sizes with you.



## Standard Sizes

### Tubing

Diameter Range (mm)	Standard Lengths (feet)
up to 5.9	4
6-35	4
35.1-79.9	4, 5, or 6
80-150	5, 6, or 7
150	6, 7, 8, or 9
190 up	6, 7, 8, 9, or 10

### Rod

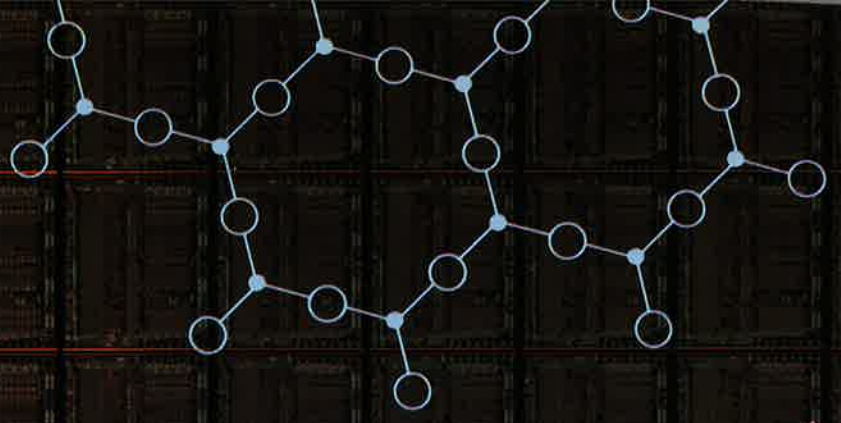
Diameter Range (mm)	Standard Length (feet)
4.0 to 7.0	4
8.0 to 19.0	4

### Crucibles

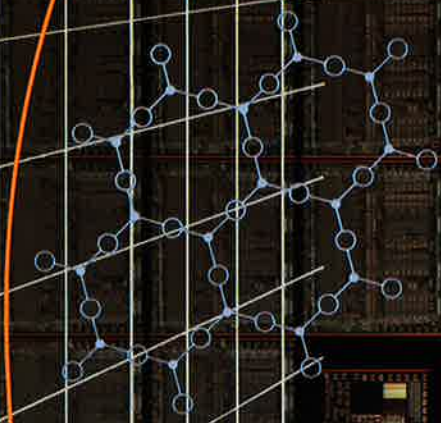
Diameter	Height
10"	7.500
12" Thin	7.500
12" Thick	9.000
13" Thin	10.236
13" Thick	9.500
14" Thin	11.000
14" Thick	12.000
16"	12.000
18"	14.000

Radius can be altered to customer specifications.

Tubing, rods, and crucibles can be ordered to desired custom sizes.



$$\nu = \frac{1}{2\pi} \sqrt{\frac{F}{m}}$$



$$G = \frac{E}{2(1 + \nu)}$$

$$\eta = \frac{9L^2}{241\nu} \left[ M + \frac{PAI}{16} \right]$$



**In a clean room at a GTE research laboratory, a technician loads a quartz wafer carrier. GTE knows that today's research leads to tomorrow's products. And GTE's commitment to the future of integrated circuit technology will ensure our customers have the fused quartz their technical advances require.**

With fused quartz, as with so many products, you can choose a manufacturer on the basis of specifications and technical data. Or on how the final product looks and works in your hands. GTE fused quartzware looks superior on paper and in reality. So the choice is clear.

#### **As Impressive on Paper as it is in Your Hand**

The amazing purity and clarity of GTE fused quartz speaks volumes about its high quality. The following graphs and charts express this quality in hard numbers.

##### *Chemical Analysis*

Impurities mean devitrification (the reformation of crystals in the quartz), which lowers tube life and performance. The semiconductor industry needs the highest possible purity, and the lowest possible hydroxyl content: GTE delivers. The chart below shows how far we go to keep impurities low.

#### **Typical Chemical Analysis, Tubing and Rod**

Element	ppm, by weight*
Aluminum	20.0
Calcium	1.3
Iron	1.0
Potassium	1.4
Lithium	0.7
Magnesium	0.2
Manganese	0.25
Sodium	1.2
Titanium	1.3
Zirconium	2.0
Boron	2.0
Phosphorous	0.2

\*Combined AA and ICP analysis

#### **Typical Chemical Analysis, Crucibles**

Element	ppm*
Aluminum	15.0
Calcium	5.0
Copper	0.5
Iron	2.5
Magnesium	0.5
Sodium	5.0
Lithium	0.5
Boron	not detected
Phosphorous	not detected

\*Measured by spectrographic qualitative analysis

### Tolerances

GTE has no tolerance for imperfections. The charts indicate the fine tolerances achieved.

GTE's commitment to on-going product refinement has resulted in the revised tolerances indicated below.

### Crucible Tolerances

Diameter	Diameter	Height	Wall 1	Major Radius	Minor Radius
<b>10"</b>	<b>10.000</b> ± 0.075	<b>7.500</b> ± 0.075	<b>0.170</b> ± 0.075	<b>14.000</b> ± 0.060	<b>2.000</b> REF
<b>12" Thin</b>	<b>12.000</b> ± 0.075	<b>7.500</b> ± 0.075	<b>0.200</b> ± 0.075	<b>14.000</b> ± 0.060	<b>2.000</b> REF
<b>12" Thick</b>	<b>12.000</b> ± 0.075	<b>9.000</b> ± 0.075	<b>0.325</b> ± 0.075	<b>14.000</b> ± 0.060	<b>2.000</b> REF
<b>13" Thin</b>	<b>13.000</b> ± 0.100	<b>10.236</b> ± 0.075	<b>0.240</b> ± 0.100	<b>12.000</b> ± 0.060	<b>3.000</b> REF
<b>13" Thick</b>	<b>13.000</b> ± 0.100	<b>9.500</b> ± 0.075	<b>0.320</b> ± 0.100	<b>12.000</b> ± 0.060	<b>3.000</b> REF
<b>14" Thin</b>	<b>14.000</b> ± 0.125	<b>11.000</b> ± 0.075	<b>0.275</b> ± 0.100	<b>15.000</b> ± 0.060	<b>3.500</b> REF
<b>14" Thick</b>	<b>14.000</b> ± 0.125	<b>12.000</b> ± 0.075	<b>0.400</b> ± 0.100	<b>15.000</b> ± 0.060	<b>3.500</b> REF
<b>16"</b>	<b>16.000</b> ± 0.125	<b>12.000</b> ± 0.075	<b>0.400</b> ± 0.100	<b>16.000</b> ± 0.120	<b>3.500</b> REF
<b>18"</b>	<b>18.000</b> ± 0.125	<b>14.000</b> ± 0.075	<b>0.400</b> ± 0.100	<b>18.750</b> ± 0.120	<b>3.250</b> REF

- 1) Crucibles can be ordered to desired height.
- 2) Radius can be altered to customer specifications

### Tubing Tolerances

Diameter Range mm	Diameter Ref.	Diameter Nom. %	Out of Rnd % of OD, Max	Wall Thickness	Siding Max % Wall	Bow, Max mm/M	Length mm
<b>UP to 3.7 ID</b>	<b>OD</b>	± 3.0%	2.0%	± 10%	10%	1.0	± 3.2
<b>3.8 ID to 35.0 OD</b>	<b>ID</b>	± 2.5%	2.0%	± 10%	10%	1.0	± 3.2
<b>35.1 to 79.9</b>	<b>OD</b>	± 2.5%	2.0%	± 13%	13%	1.0	± 3.2
<b>80 to 149.9</b>	<b>OD</b>	± 2.0%	1.0%	± 15%	15%	1.0	± 6.4
<b>150 to 200</b>	<b>OD</b>	± 2.0%	1.0%	± 15%	15%	1.0	± 9.5
<b>OVER 200</b>	<b>OD</b>	± 1.5%	1.0%	± 20%	20%	1.0	± 12.7

### Rod Tolerances

Diameter Range (mm)	Diameter Tolerance	Standard Lengths
<b>4.0 to 7.0</b>	± 5%	<b>4 feet</b>
<b>8.0 to 19.0</b>	± 4%	<b>4 feet</b>

Siding (Max. Wall—Min. Wall)  
Nominal Wall

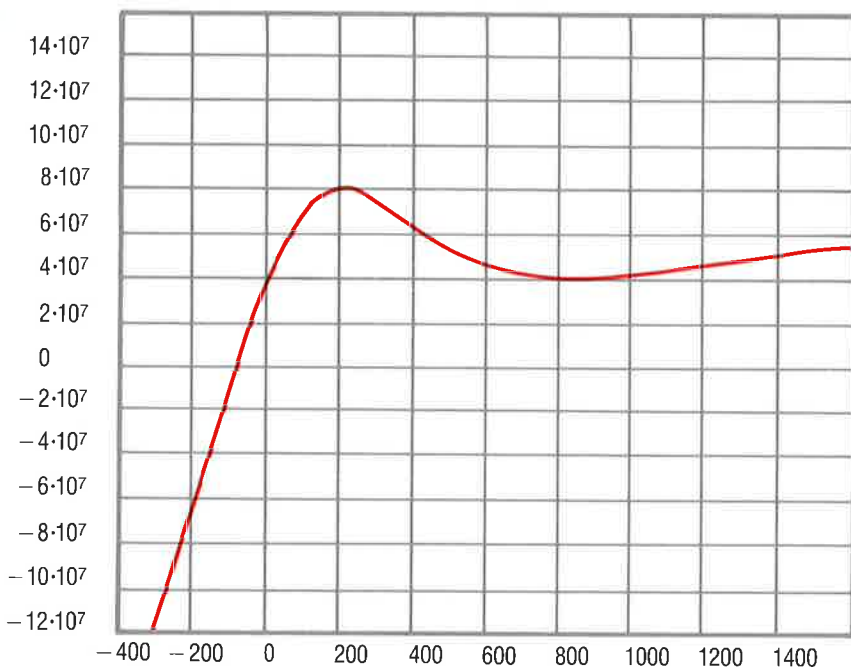
*Physical Properties*

GTE quartz features excellent mechanical strength, resistance to sagging and thermal shock, stability over a wide temperature range, and a low thermal expansion coefficient.

*Thermal Properties*

The very low coefficient of thermal expansion of GTE fused quartz products make it ideal for the high temperatures and rapid heating/cooling cycles found in semiconductor manufacture. At  $0.55 \times 10^{-6} \text{cm/cm}^\circ\text{C}$  (0–300°C), this coefficient makes GTE fused quartz ideal for the semiconductor industry. It can withstand tremendous thermal shock, exhibiting almost no movement and complete integrity from  $-80^\circ\text{C}$  to  $1000^\circ\text{C}$ .

**Coefficient of Expansion**  
cm/cm°C

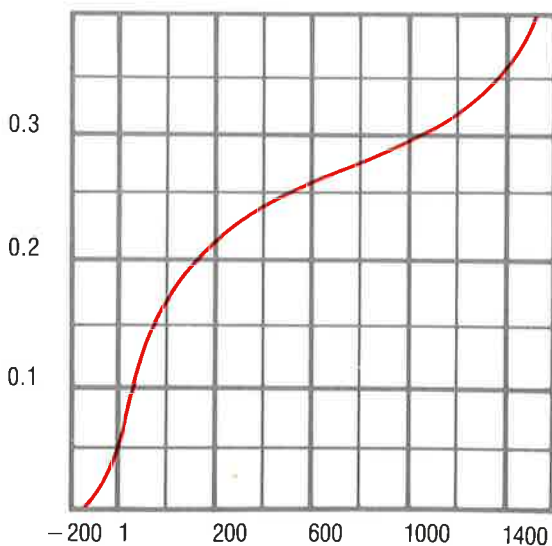


**Temperature, Degrees C** Representative values of the coefficient of expansion of silica glass.

**Physical Properties**

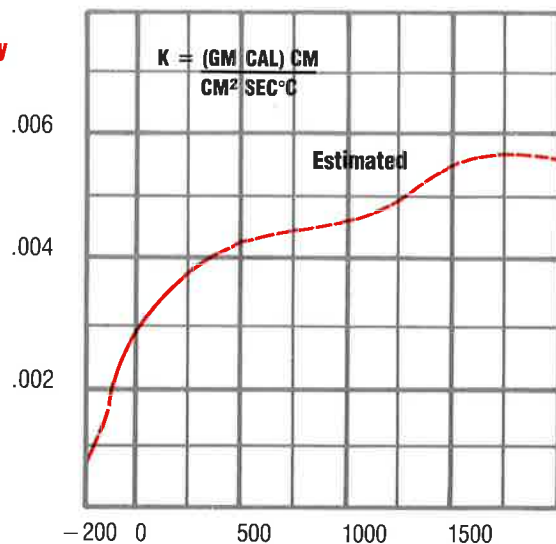
Density	2.2 grams/cm <sup>3</sup>
Tensile Strength	48 x 10 <sup>6</sup> Pa
Compressive Strength	1.1 x 10 <sup>9</sup> Pa
Bulk Modulus	37 x 10 <sup>9</sup> Pa
Rigidity Modulus	31 x 10 <sup>9</sup> Pa
Young's Modulus	72 x 10 <sup>9</sup> Pa
Poisson's Ratio	.16
Softening Point	1943°K/1670°C
Annealing Point	1493°K/1220°C
Strain Point	1392°K/1119°C
Coefficient of Thermal Expansion	.55 x 10 <sup>-6</sup> cm/cm°C (0°C–300°C)
Thermal Conductivity	1.4 W/m · K (290°K)
Specific Heat	750 J/kg · K
Electrical Resistivity	30 x 10 <sup>-6</sup> Ωm

**Heat Capacity**  
CAL/GM°C



**Temperature, Degrees C**

**Thermal Conductivity**



**Temperature, Degrees C**

*Viscosity*

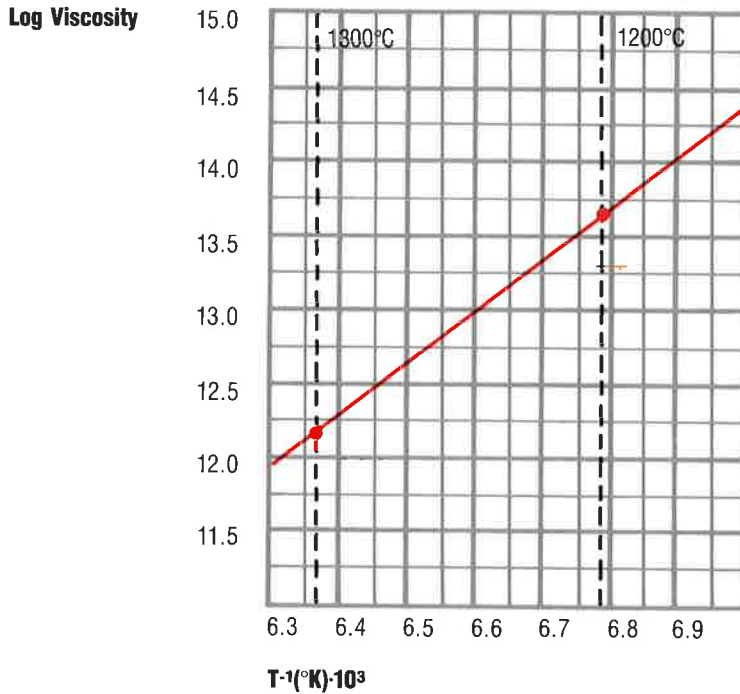
Like all glasses, fused quartz is a solid at room temperature. It does not have a distinct melting point, but softens over a broad temperature range, accompanied by a continuous change in viscosity as the temperature rises. Viscosity, the measure of a material's resistance to flow under shear stress, exhibits a wide range in fused quartz. Therefore, as in the chart below, viscosity is expressed logarithmically.

The graph below shows the temperature dependencies of these properties.

*Electrical Properties*

The excellent insulation and low-loss dielectric properties of fused quartz are a result of its ionic electrical conductivity, and the fact that alkali ions are found in trace amounts. GTE fused quartz exhibits these characteristics even at very high temperatures and over a wide frequency range.

**Fused Quartz Viscosity Test**



**Typical Values**

<b>Electrical Resistance</b>	<b>7(10<sup>9</sup>) ohm-cm at 350°C</b>
<b>Dielectric Loss Factor</b>	<b>.0004 at 20°C 1 Mc</b>
<b>Dielectric Constant</b>	<b>3.75 at 20°C 1 Mc</b>
<b>Specific Resistivity</b>	<b>10<sup>18</sup> ohms/cm<sup>3</sup> at 20°C</b>
<b>Dissipation Factor</b>	<b>.0001 at 20°C 1 Mc</b>

**Log Viscosity**

1200°C = 13.62  
1300°C = 12.19

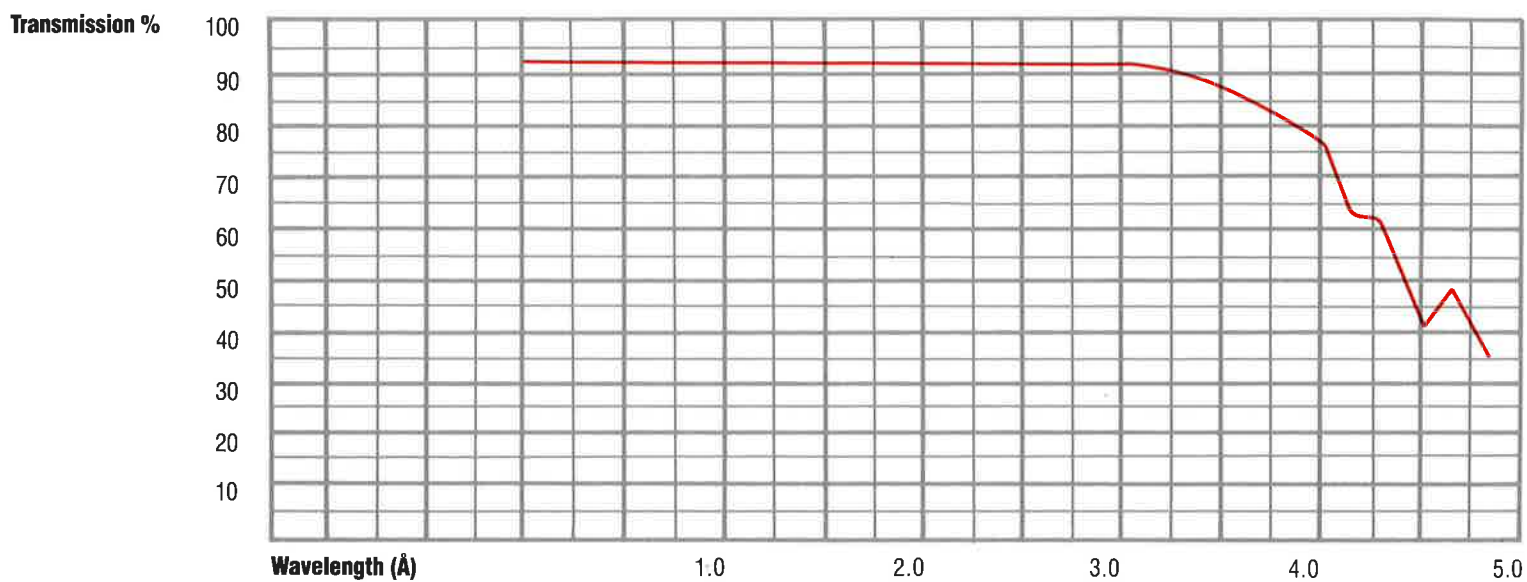
Anneal. Point = 1220°C  
Strain Point = 1119°C

<b>Temp</b>		<b>Visc.</b>
°C	°K	Log
1310	1583	12.05
1300	1573	12.19
1290	1563	12.33
1280	1553	12.48
1270	1543	12.62
1260	1533	12.77
1250	1523	12.91
1240	1513	13.04
1230	1503	13.19
1220	1493	13.33
1210	1483	13.47
1200	1473	13.62

*Average Transmittance Curves, Tubing and Rod*  
 The degree of transparency exhibited by various types of vitreous silica indicates purity and manufacturing technique.

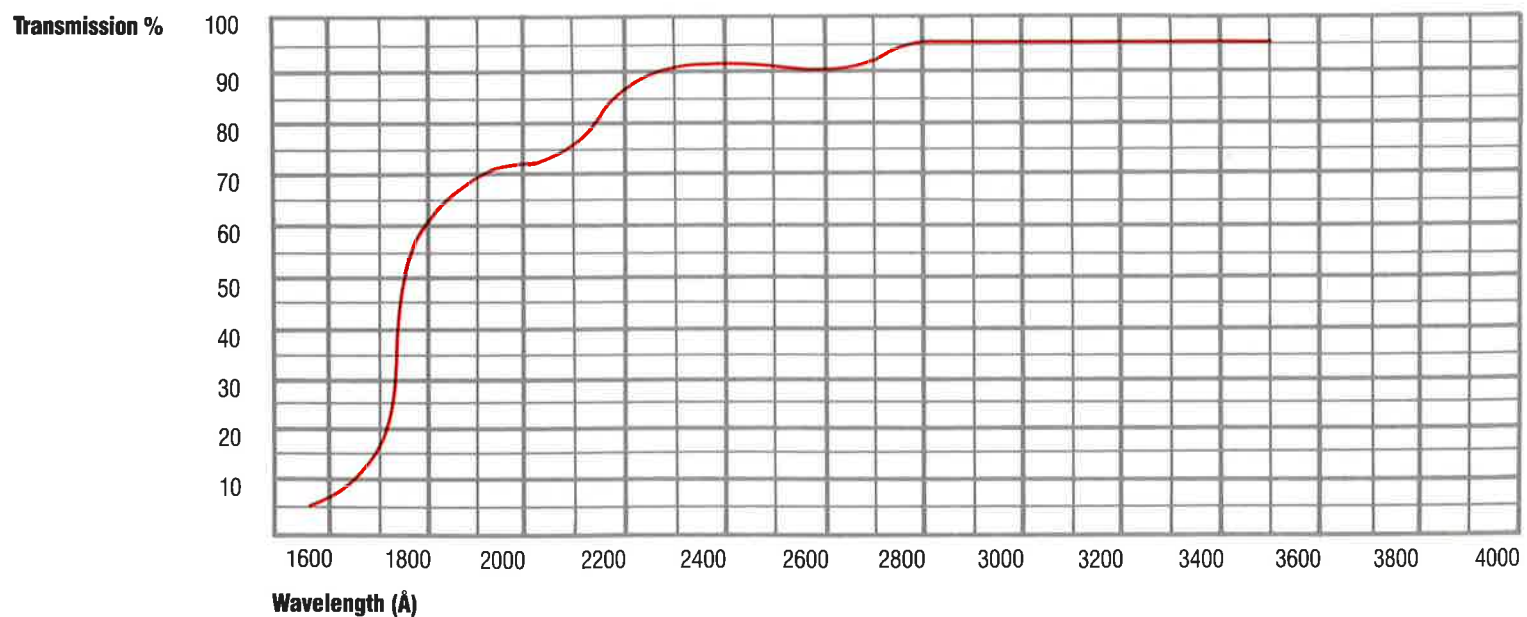
**Wavelength vs Infrared Transmission (1 mm Thickness)**

**SG25SC Fused Quartz**



**Wavelength vs Ultraviolet Transmission (1 mm Thickness)**

**SG25SC Fused Quartz**



### **Handling, Cleaning and Storage**

GTE takes great care in cleaning and packing our quartz products as you do with your chips.

Careful handling at your end will help you get the most out of them.

#### *Handling*

Fused quartz should be touched only with clean cotton gloves (the slightest contamination may cause rapid devitrification).

#### *Storage*

Store quartz in original shipping cartons for as long as possible in a clean, dry environment.

#### *Cleaning*

GTE quartz tubing should be washed in hot, DI water with a degreasing agent added.

Dip tubes in a 10 percent (by volume) hydrofluoric solution for a maximum of five minutes. The acid will etch the tube surface and help remove contaminants.

Follow this with several rinses of hot, circulating water (DI or distilled).

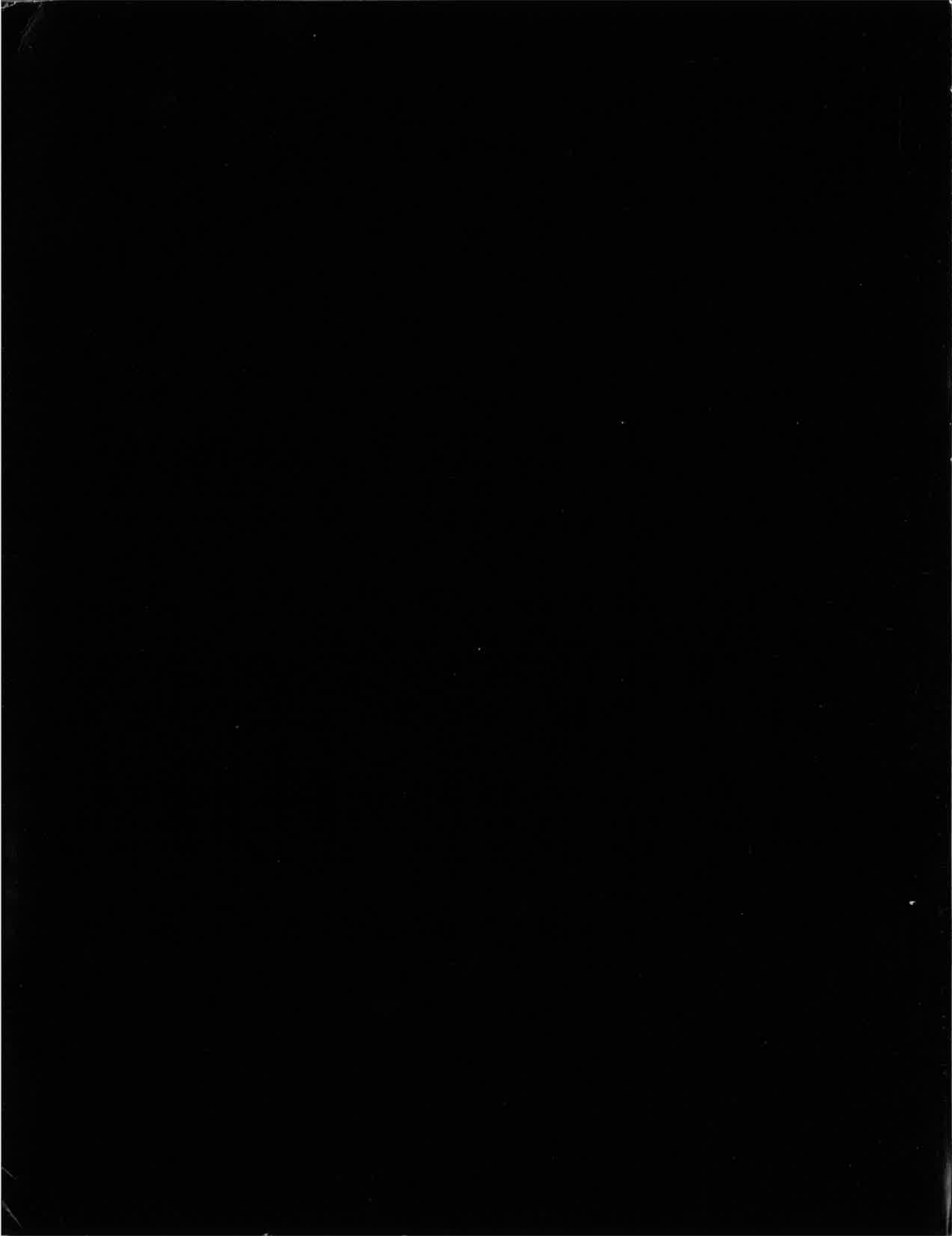
Rapid drying in filtered, heated air will minimize the possibility of water spotting (which may lead to rapid devitrification). Wrap and store in a clean, dry environment.

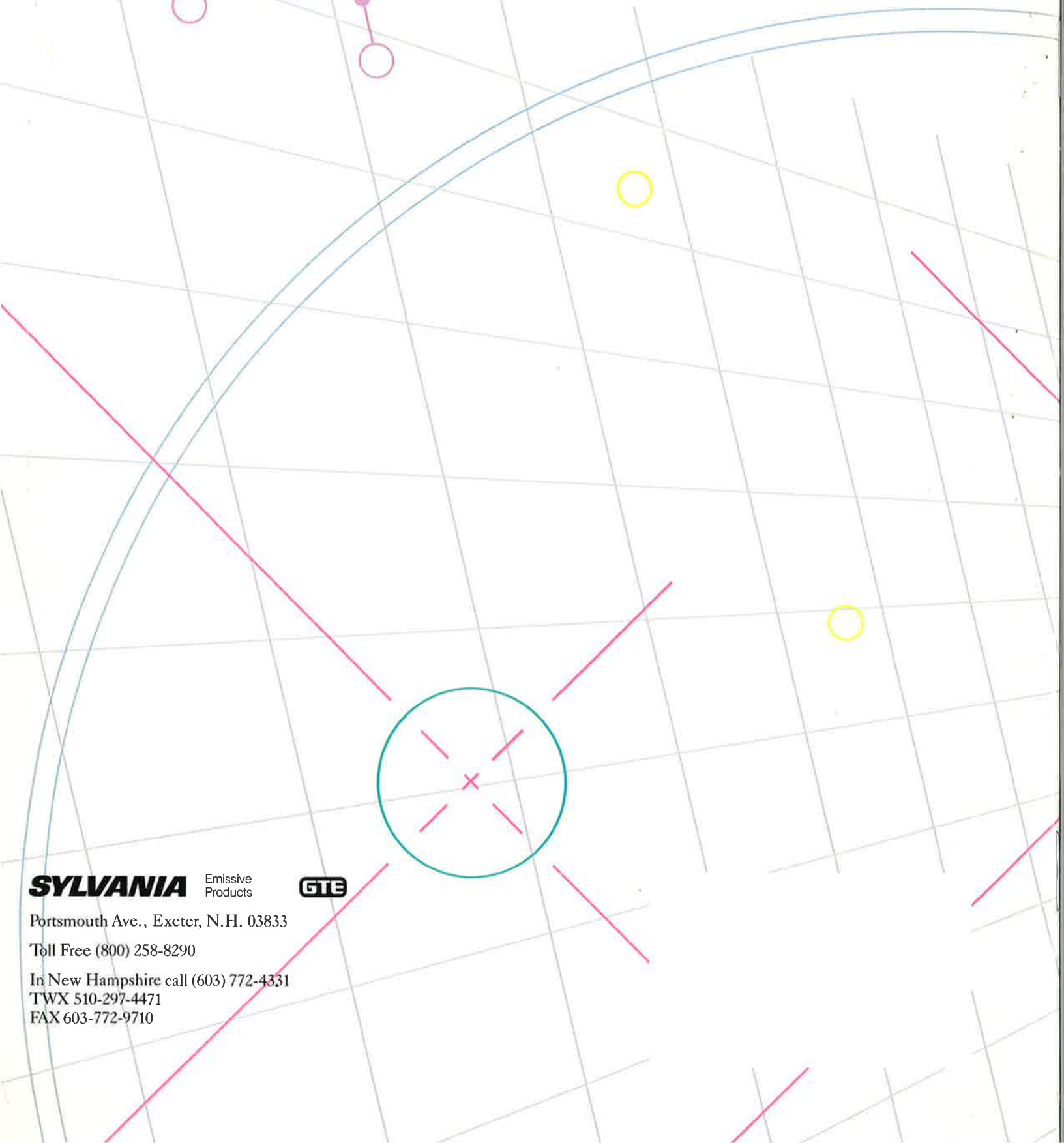
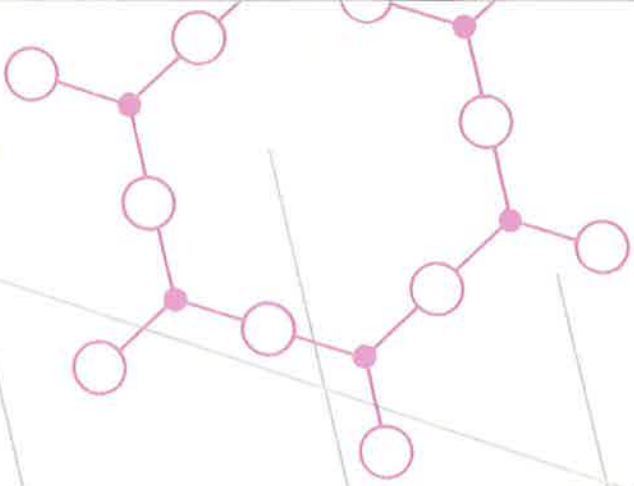
### **For ordering or technical information, contact:**

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Emissive Products  
Portsmouth Ave., Exeter, N.H. 03833

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In New Hampshire call (603) 772-4331  
TWX 510-297-4471  
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