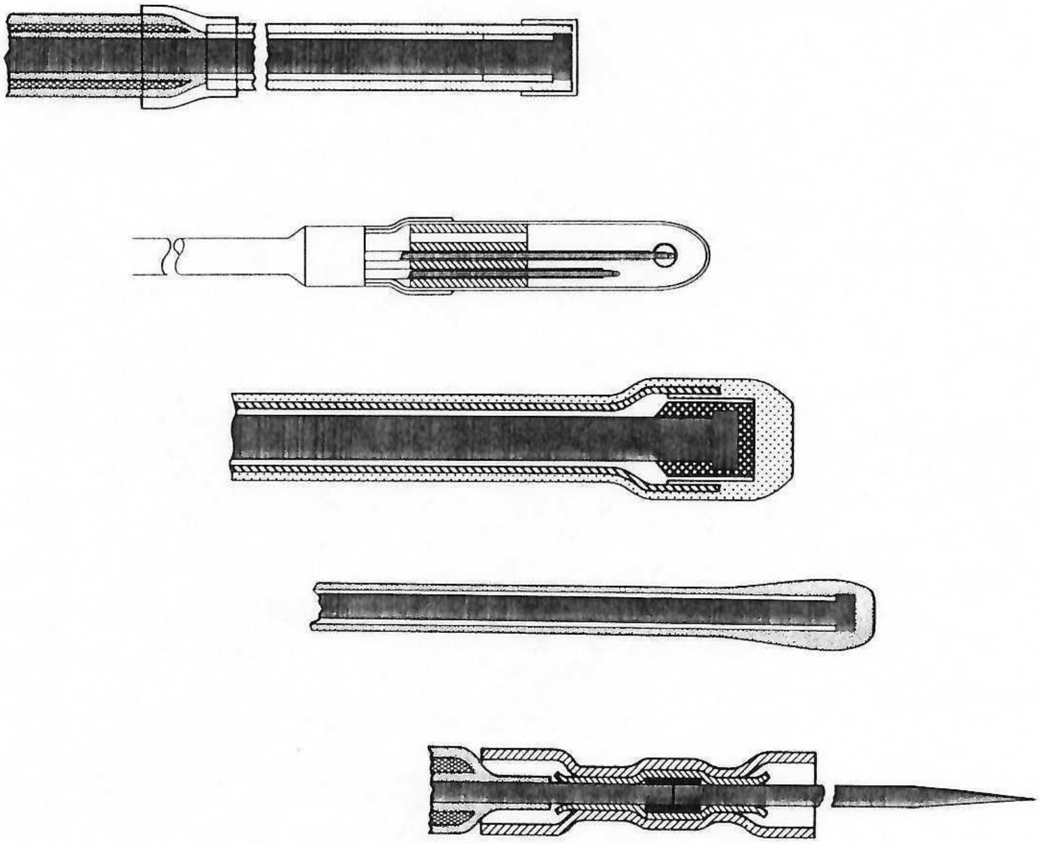
LUXTRON

Fiberoptic Probes and Accessories

for Model 790 Systems



Contents

Selection Guide

Product List

System and Sensor Technical Data

Easy Probe Selection

1. Refer to the Applications Chart on Page 2.
2. Locate your general application heading on the left. Below each heading are more specific application categories. Markers at the intersections of the application rows and the probe columns indicate appropriate probe types for that specific application. Dark markers indicate the best choice; outlined markers show probes that can be used, but may not be optimum.
3. Use the chart on Page 3 to verify the temperature range of the probe selected. The useful operating range for a probe is generally determined by the materials used in its construction. In some cases the best probe for an application may not have an adequate operating temperature range, and it may be necessary to select one with a wider range.

To Order a Probe or Fiberoptic Extension Cable

Detailed performance specifications for each probe or extension type appear on Pages 4 - 9. Specify the probe number, including the dash number suffix that indicates its length in meters.

Example: **SFF-5** is a Wide Range/Fast Response probe with a length of 5 meters.

Custom Probe Design

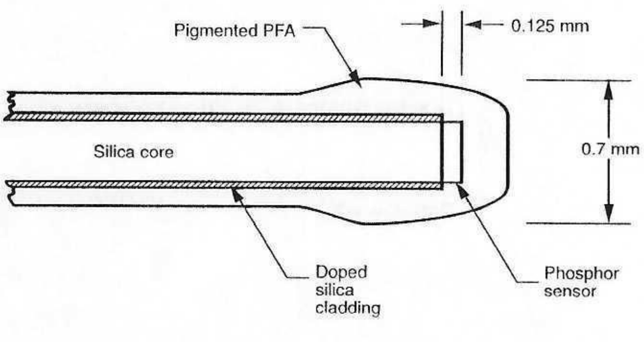
The probes shown in this catalog are suitable for most measurement applications. In some applications, however, it may be necessary to modify a standard probe configuration or length, or design a custom sensor. LUXTRON'S unique self-calibrating, fluorescent sensor lends itself very well to custom probe designs. To request a quotation on a custom probe, please include the following information with your request:

1. Brief description of the application
2. Temperature range
3. Sketch of the object or apparatus to be measured
4. Any special environmental constraints

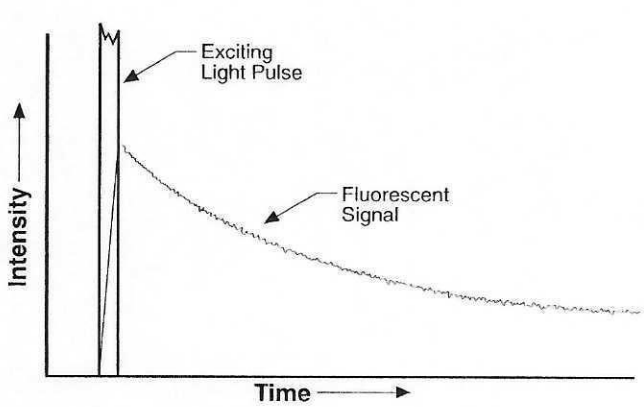
LUXTRON's Fiberoptic Temperature Measurement Technology

LUXTRON is the world's leading manufacturer of Fiberoptic Thermometry Systems. A wide variety of high performance fiberoptic thermometry systems are now in use worldwide for temperature sensing in hostile environments and are known for their quality and reliability.

LUXTRON's patented technology is based on a temperature-sensitive phosphor sensor attached to the end of an optical fiber, which is connected to the instrument. Blue-violet light pulses are sent down the fiber causing the phosphor to glow red. The decay of the fluorescence after each pulse varies precisely with temperature, providing the basis for accurate temperature measurement at the sensor, up to an absolute accuracy of ±0.1°C. The fluorescent decay time is measured by a multipoint digital integration of the decay curve. The same optical fiber transmits the excitation pulses and returns the fluorescent signal to the instrument.



Cross Section of Typical Probe Tip



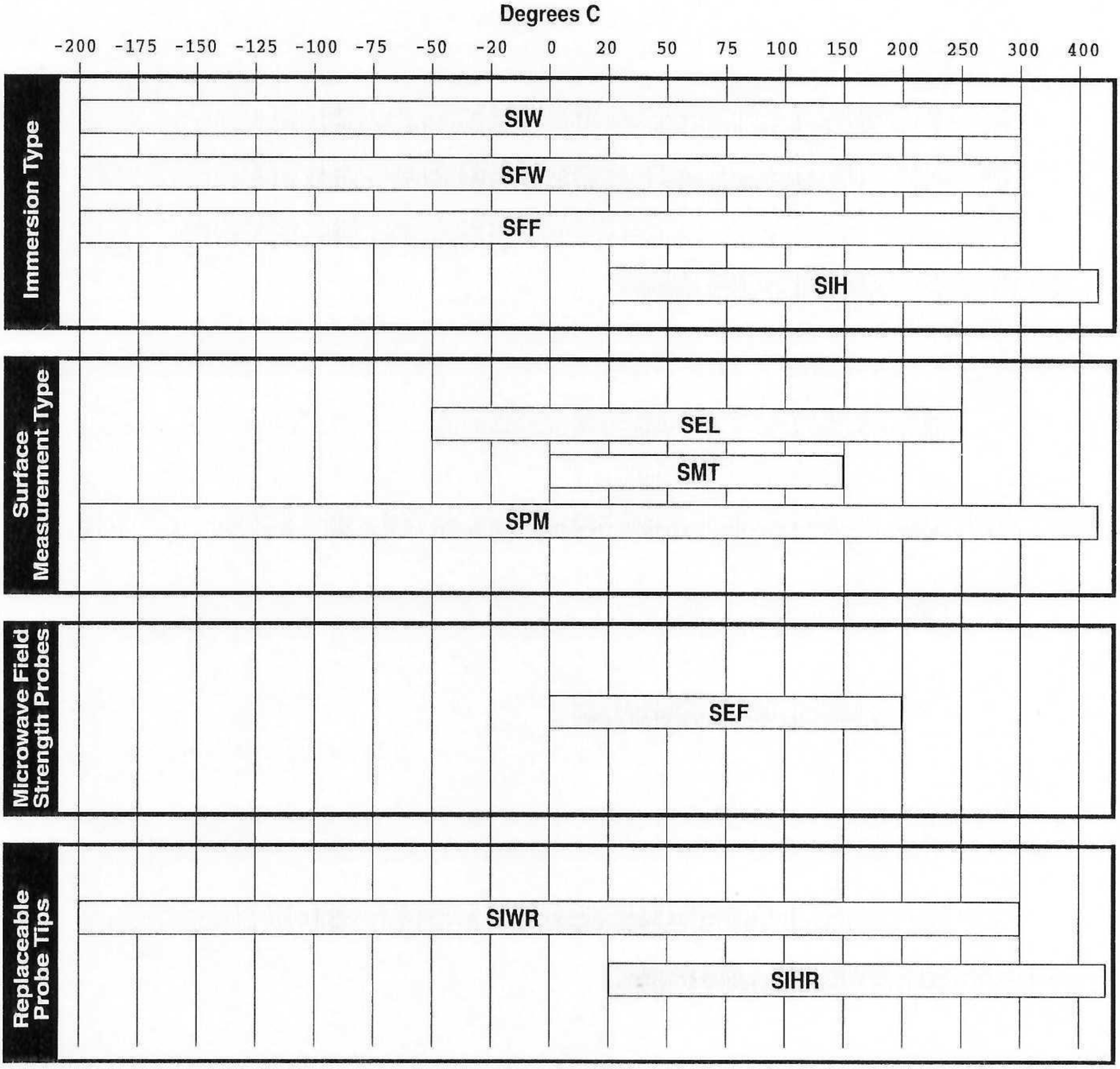
Decay Time. Digital curve fit technique.

790 PROBE APPLICATIONS

	Immersion/ Bulk Type Probes				Surface Measurement Type Probes			Microwave Field Strength Probes	Replaceable Probe Tips	
	SFW	SFF	SIW	SIH	SEL	SMT	SPM	SEF	SIWR	SIHR
Semiconductor										
Plasma Etch		●	●		●		●		●	
Deposition	○	○	○	●			●		○	●
Sputtering	○	○	○	●			●		○	●
CVD	○	○	○	●			●		○	●
Magnetic Field										
NMR/MRI	○	●	●		○				●	
Materials										
Materials Research	●	●	●	○	●	○	○	●	●	○
Composite Material Curing	○	●	●		○				○	
High Voltage										
High Voltage Components	○	●	●	○					○	○
High Voltage Lines	●	○	○						○	
Generators	●	●	●		●				●	
Electronic Technology										
Microelectronics Circuit Board Testing					●	●	●			
I.C. Package Design			○	○	●	○	●			
Hybrid Circuit Board Testing			○	○	●	○	●			
Junction/Case Temperature Measurement			○	○	●	●	●			
RF & Microwave										
Microwave Food Product Development	●	○	○	○				●	●	○
Packaging Material Development		●	●	○	○			●	●	○
Dielectric Heating	●	●	●	●	○			○	●	●
Microwave Digestion	●								●	
Special R & D										
* EMC (RF & Microwave Induced Current)							●			
* Radiation Exposure	●	●	●	●		○	○		○	○
* Hazardous Environment	●	●	●	●	○		○		○	○

● Recommended ○ Usable *Consult factory for recommendations

TEMPERATURE RANGE OF MODEL 790 PROBES

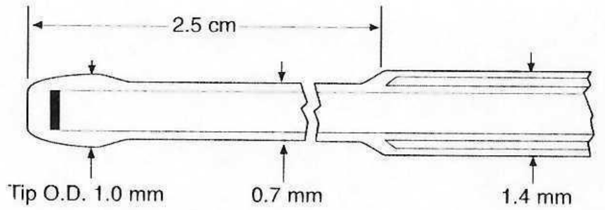


IMMERSION TYPE PROBES

SIW-XX

Wide Range

Last 2.5 cm of probe is not Kevlar® cabled. Recommended for use with long SEC-type fiberoptic extension cables.



Temperature Range
-195° to 300°C

Fiber Type
340 µm all-silica, double PFA Teflon® jacketed, Kevlar cabled fiber.

Available Lengths
2, 5, and 10 meters

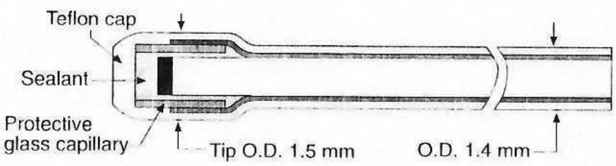
Response Time
2.0 seconds in still air.
0.4 seconds in stirred water.

Connector Type
SMA 905

SFW-XX

Wide Range/Chemical Resistant

Sensor is encapsulated with oil-resistant sealant. Probe is Kevlar cabled all the way to the sensor tip.
Not recommended for use with extension cables longer than 10 meters.



Temperature Range
-195° to 300°C (-30° to 200°C when used in chemical or oil immersion applications).

Fiber Type
200 µm all-silica, double PFA Teflon jacketed, Kevlar cabled fiber.

Available Lengths
2, 5, and 10 meters

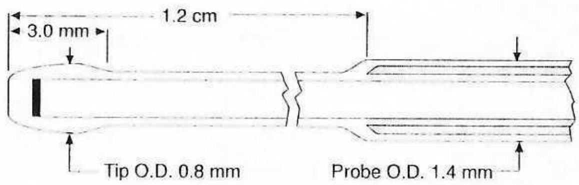
Response Time
5 seconds in still air.
0.7 seconds in stirred water.

Connector Type
SMA 905

SFF-XX

Wide Range/Fast Response

Last 1.2 cm of probe is not Kevlar cabled.
Not recommended for use with extension cables longer than 10 meters.



Temperature Range
-195° to 300°C

Fiber Type
200 µm all-silica, double PFA Teflon jacketed, Kevlar cabled fiber.

Available Lengths
2, 5, and 10 meters

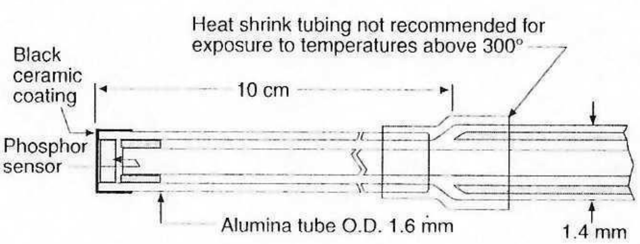
Response Time
1.25 seconds in still air.
250 milliseconds in stirred water.

Connector Type
SMA 905

SIH-XX

High Temperature Range

Sensor located at the tip of a 10 cm alumina ceramic tube.



Temperature Range
20° to 400°C (450°C intermittently for several minutes).

Fiber Type
340 µm all-silica, double PFA Teflon jacketed, Kevlar cabled fiber.

Available Lengths
2, 5, and 10 meters

Response Time
6 seconds in still air.
Not recommended for use in liquids (consult factory).

Connector Type
SMA 905

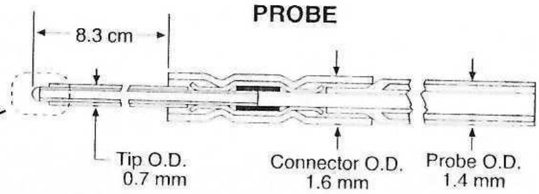
Suffix XX specifies probe length in meters. Example: SSP-10 is a 10-meter, remote-sensing, surface-temperature probe.

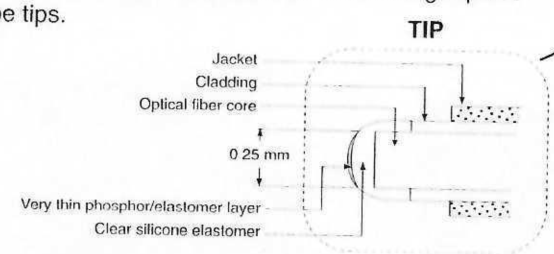
Surface Temperature Probes

SEL-XX

Surface Contact Temperature Probe

Includes Teflon slip connector and two 10 cm-long replaceable probe tips.





To order replacement probe tips for SEL Surface Temperature Probes, specify **SEL TIPS** which includes

- 8 replacement sensor tips
- 1 replacement slip connector
- 1 sensor cleaning kit

Temperature Range
-50° to 200°C (250°C intermittent)

Fiber Type
400 µm PCS, double PFA Teflon jacketed, Kevlar cabled fiber.

Available Probe Lengths
2 and 5 meters

Surface Contact Force
7 to 14 grams (0.25 to 0.5 oz)

Sensing Spot Size
0.25 mm (0.010 in)

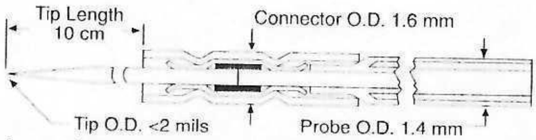
Response Time
25 milliseconds

Connector Type
SMA 905

SMT-XX

"Microtip" Surface Temperature Probe

Includes one SSC-2 probe body with two 12.5 cm-long SMT replaceable probe tips, 3-axis micropositioner and probe holder.



To order replacement probe tips for SMT Surface Temperature Probes, specify **SMT TIPS** which includes

- 4 replacement sensor tips
- 1 replacement slip connector
- 1 sensor cleaning kit

Temperature Range
0° to 150°C (200°C intermittent)

Fiber Type
340 µm all-silica, double PFA Teflon jacketed, Kevlar cabled fiber.

Available Probe Length
2 meters

Response Time
<25 milliseconds

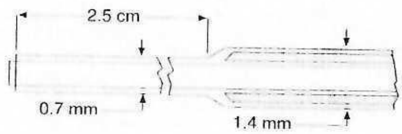
Sensing Spot Size
25 µm (0.001 in). Recommended for use with a microscope to ensure proper probe placement.

Connector Type
SMA 905

SSP-XX

Remote Sensing Probe

Fiber end is polished for remote phosphor sensing. Last 2.5 cm of probe is not Kevlar cabled.



Temperature Range
-195° to 300°C

Fiber Type
340 µm all-silica double PFA Teflon jacketed, Kevlar cabled fiber.

Available Probe Lengths
2, 5, and 10 meters

Connector Type
SMA 905

Use with P/N 01-11808-01 phosphor sensor and P/N 01-10921 binders.

SPM

Remote Phosphor Kit (P/N 00-11775-01)

With Remote Sensing Probe

Contains

- 1/2 gm MFG2 Phosphor sensor powder (01-11808-01)
- 1 ml 150°C Silicone binder (01-10921-01)
- 1 ml 250°C Silicone binder (01-10921-03)
- 1 ml 450°C Potassium silicate binder (01-10921-05)
- 1 SSP-2 Remote sensing probe
- 1 Instruction manual

Additional Materials

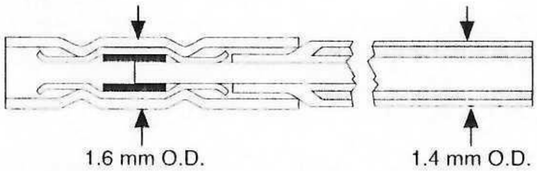
01-11808-01	1/2 gm MFG2 Phosphor sensor powder
01-11808-02	1 gm MFG2 Phosphor sensor powder
01-10921-01	1 ml 150°C Silicone binder
01-10921-03	1 ml 250°C Silicone binder
01-10921-05	1 ml 450°C Potassium silicate binder

Suffix XX specifies probe length in meters.

SSC-XX

Probe Body for Replaceable Tip Probes

Use with SIWR, SIHR, and SMT probe tips. Includes Teflon slip connector to accept replacement probe tips.



Temperature Range
-195° to 300°C

Available Lengths
2, 5, and 10 meters

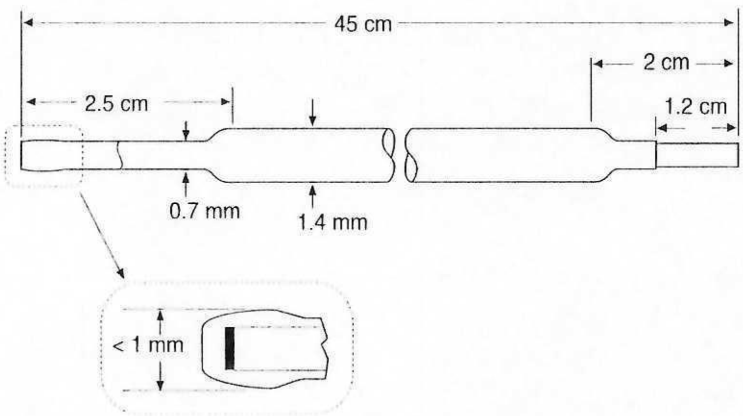
Fiber Type
340 µm all-silica, double PFA Teflon jacketed, Kevlar cabled fiber.

Connector Type
SMA 905

SIWR

Wide Range Replaceable Probe Tips

Use with SSC probe body.



To order, specify **SIWR TIPS** which includes four replaceable probe tips with slip connectors.

Temperature Range
-195°C to 300°C

Fiber Type
340 µm all-silica, double PFA Teflon jacketed, Kevlar cabled fiber.

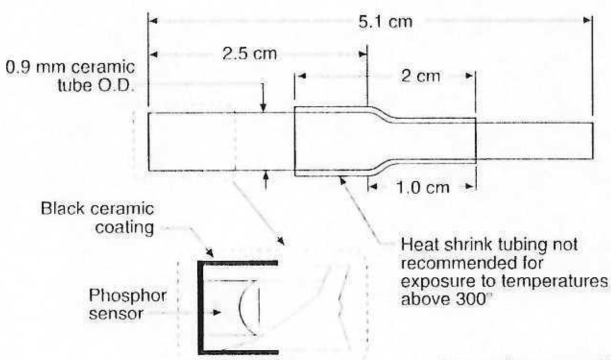
Length
45 cm

Response Time
2.0 seconds in still air
0.4 seconds in stirred liquid

SIHR

High Temperature Replaceable Probe Tips

Use with SSC probe body.



Temperature Range
20° to 400°C (450°C intermittent)

Fiber Type
340 µm all-silica, double PFA Teflon jacketed, Kevlar cabled fiber.

Length
5.1 cm

Response Time
4 seconds in still air
Not recommended for use in liquids (consult factory).

To order, specify **SIHR TIPS** which includes

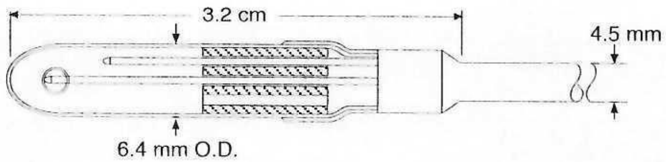
4 replaceable probe tips
1 replacement slip connector
1 sensor cleaning kit

Suffix XX specifies probe length in meters.

MICROWAVE E-FIELD/POWER DENSITY PROBE

SEF-XX

Microwave E-Field/Power Density Probe



Sensor Operating Temperature Range

-50° to 200°C

Accuracy

20% of reading

Isotropy

±15%

Cable Length

2 meters. PFA Teflon jacketed fibers with polyethylene outer sheath.

Sensor Response Time

20 seconds

Connector Type

SMA 905

Specifications at 2.45 GHz	SEF-1.5	SEF-2.0	SEF-3.0
Minimum measurable E-field with Model 790 (volts/meter)	1600	1200	900
Minimum measurable free-space equivalent power density with Model 790 (mW/cm2)	700	400	220
Maximum CW E-field (kV/meter)	50	36	24
Maximum CW power density (watts/cm2)	694	360	160

Select SEF-1.5, 2.0, or 3.0 for your specific power range and sensitivity requirements.

APPLICATIONS

- Local field measurements in high power environments
- Microwave applicator testing
- Near field antenna beam profiling
- Microwave food product and packaging materials development
- Microwave systems design
- Measurements in waveguides and cavity resonators
- Millimeter wave measurements and diagnostics
- On-line microwave process monitoring and control
- Inputs for computer models of microwave heating

DESCRIPTION

The patented* SEF Microwave E-field/Power Density probe consists of a minimally-perturbing resistive susceptor attached to a Fluoroptic® temperature sensor.

The temperature of the susceptor is measured continuously as microwave power ($|E|^2$) is absorbed causing the susceptor temperature to rise. A second Fluoroptic temperature sensor simultaneously measures the ambient temperature around the susceptor.

The temperature differential (ΔT) between the two sensors is calibrated at 2.45 GHz at various power levels in a waveguide to provide the necessary correlation between sensor ΔT and E-field strength.

PC compatible software included with the probe provides a direct reading of electric field strength and power density. The software also provides for data display and storage of up to two SEF probes.

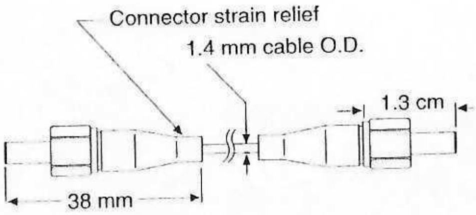
Unused instrument channels can be used for simultaneous temperature measurements.

US. Patent No. 4,816,634, licensed exclusively to LUXTRON.

Suffix XX specifies probe length in meters.

FIBEROPTIC EXTENSION CABLES

SEA-XX
General Purpose Extension Cable



Temperature Range Fiber
0 to 200°C

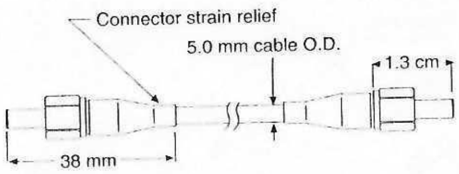
Connector
80° Maximum for continuous use.

Fiber Type
400 μm PCS, double PFA Teflon jacketed, Kevlar cabled fiber.

Available Lengths
2, 5, and 10 meters

Connector Type
SMA 905 on both ends. Includes one SMA connector receptacle.

SEC-XX
Heavy Duty Extension Cable



Temperature Range
0 to 80°C including connectors.

Fiber Type
600 μm PCS, triple PVC jacketed, Kevlar cabled fiber.

Connector Type
SMA 905 on both ends. Includes one SMA connector receptacle.

Available Lengths
5, 10, 30, 50, and 75 meters
Note
30, 50, and 75 meter extensions are not recommended for use with high vacuum feedthroughs, SFW or SFF probes.

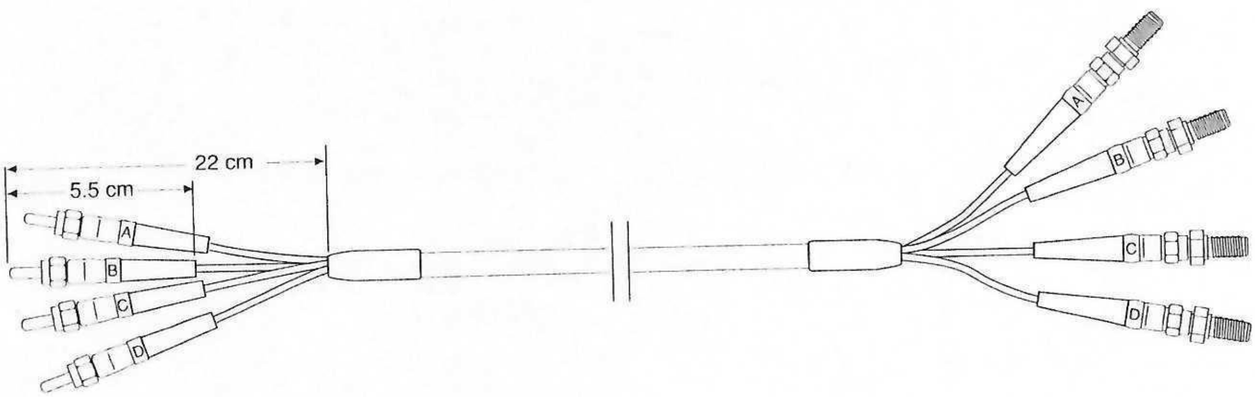
SET-XX
Heavy Duty Four Fiber Extension Cable

Temperature Range
0 to 80°C including connectors.

Fiber Type
400 μm PCS, bundled four fiber PVC jacketed Kevlar cabled fiber.

Available Lengths
5 and 10 meters

Connector Type
SMA 905's on both ends. Includes four SMA connector receptacles.

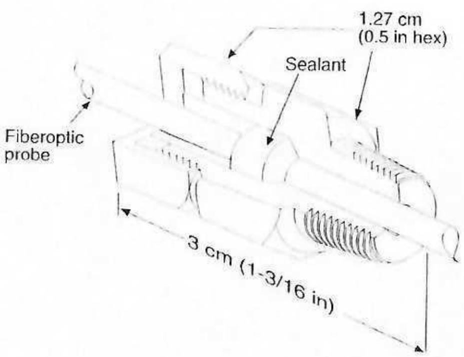


Suffix XX specifies probe length in meters.

Vacuum/Pressure Feedthroughs

Compression Gland Feedthrough

90-1462



Material
304 Stainless

Maximum Vacuum (torr)
5 ¥ 10^{-6}

Maximum Pressure
3,000 PSI

Sealing Gland
Viton

Temperature Range (Min/Max)
-20°C (-10°F) / 230°C (450°F)

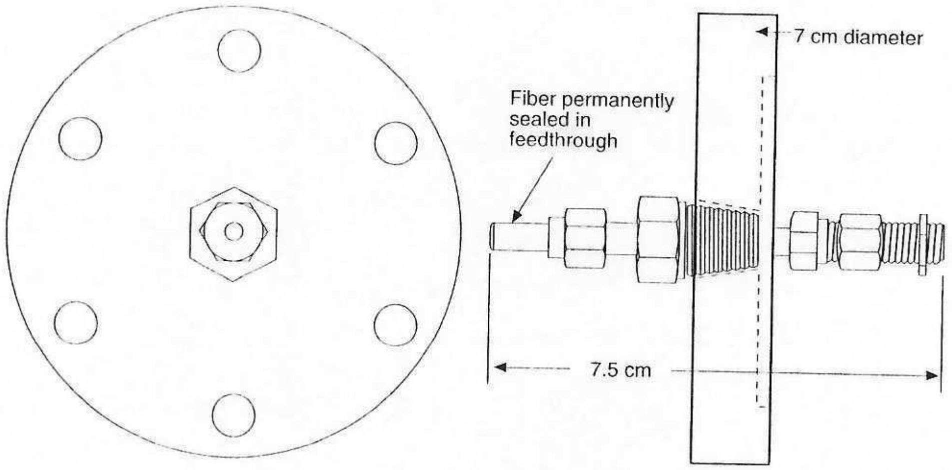
Fitting (Flange) Size
1/8 inch NPT

Compatible Probe Types
All Standard Model 790 Probes

Bulkhead High Vacuum Feedthrough

HVFTS

HVFTS Feedthroughs require an SEA or SEC type fiberoptic extension. Maximum recommended extension length is 10 meters.



HVFT Feedthrough Handling Precautions

1. Protect the flange knife edge of the HVFT feedthroughs as any damage will result in a poor vacuum seal.
2. To prevent deposition or damage to the vacuum end connector when a probe is not attached, cover the connector.

Material
304 Stainless

Maximum Vacuum (torr)
1 ¥ 10^{-10}

Connector Types Used
Stainless Steel SMA 905

Temperature Range (Min/ Max)
-20°C (-10°F) / 100°C @ 10^{-10} torr

Fitting (Flange) Size
2-3/4 in CONFLAT

Compatible Probe Types
SIW, SIH, SSP

Glossary of Terms

The LUXTRON Model 790 offers a unique way to make temperature measurements and is frequently used in applications where more conventional instruments perform poorly. LUXTRON uses the following terms to define the instrument's performance:

Resolution

The smallest temperature units that can be displayed or read by the system.

Precision

The reproducibility of a measurement as determined by the noise fluctuations observed in the output data.

Accuracy

How close the reading is to the true value. (A reading can be precise but inaccurate.)

Calibration

Means by which the accuracy of the system can be improved. This involves a correction based on a comparison with a standard temperature reference.

Sensitivity

The smallest change in temperature that can be detected. The ultimate sensitivity limit is set by the noise-equivalent-temperature difference (NETD) of the system. However, in practice the observable sensitivity limit may be set by the resolution or precision of the system.

Stability

Short-term stability is synonymous with precision. Long-term stability is determined by system drift.

Range

The temperature region over which meaningful measurements can be made. The limits may be set either by the sensor itself or by the materials used in the probe adjacent to the sensor.

Rating Model 790 Performance

Resolution

The system can display temperatures to 0.1°. It can also read out temperatures to 0.01°via its data ports, thus providing 0.01 degree (C or F) resolution.

Precision

If the Fluoroptic sensor is in a highly stable thermal environment, and if eight or more individual measurements are made before an average value is computed and a reading is displayed, the typical RMS precision of the system reading, using standard length probes, is approximately ±0.1° C. However, if individual (single-flash) measurements are displayed without averaging, the scatter from reading to reading is more typically ±0.25°C. Thus, precision can be increased by integration but with a decrease in output speed. Stated precision is $\pm.25/\sqrt{n}$°C, where n is the number of samples averaged. Precision will vary somewhat with the temperature being measured, since both the rate of change of decay time with temperature and the fluorescent signal level from the sensor vary with temperature. The stated precision is deliberately conservative to encompass temperature range and probe length variations, as well as other possible sources of signal loss.

Accuracy

Because the system determines temperature by measuring a single intrinsic property (the fluorescent decay time) of the phosphor sensor, its accuracy is only a function of the signal level available (versus noise), the timing accuracy of the system, and any conformity (compositional) variations from batch to batch of the sensing material. Allowing for such variations, the typical accuracy of a measurement made *without* calibration using a standard length probe is ≤ ±2°C. If higher accuracy is needed, it will be necessary to calibrate the system. By calibration against a standard reference bath whose temperature is known to ±0.1° C, system accuracy can be improved typically to ±0.2°C at the calibration temperature and to ±0.5° C or better over a range 50°C on either side of the calibration temperature.

Calibration

Calibration can be accomplished by first informing the system of the true temperature of a stable reference into which the sensor has been placed and then instructing the instrument to apply the observed difference between the known and measured temperature to future readings. Note that each probe must be calibrated. The calibration needs to be repeated if a probe is disconnected and reconnected.

Sensitivity

The true limit of sensitivity set by the noise-equivalent temperature difference of the instrument, is about 0.05°C under normal conditions.

Stability

As noted previously, *short-term stability* can be related to the noise fluctuations observed in the normal course of readings and is thus equivalent to precision. *Long-term stability* is related to system drift, and reflects gradual changes in signal levels or electrical component values such as might be produced by ambient temperature changes or by component aging. Long-term drift, though not specified, is typically of the order of ±0.1°C over one hour and not greater than 0.5°C over many days or weeks.

Range

Measurements can, in principle, be made from -200°C to +450°C with the standard sensor material. However, the rate of change of τ, the fluorescent decay time, with temperature is substantially reduced below about -180°C. The upper limit is set by the very rapid rate of decline of τ to less than 0.5 ms above 450°C, coupled with a rapid decrease of fluorescent intensity in the same range. Different probe types may operate over only a portion of the sensor range because of limitations of materials used in the fibers or probe tips.

Interchangeability of LUXTRON Sensors

The LUXTRON fluorescent decay time method of fiberoptic temperature measurement is independent of the sensor geometry. Many different types of sensors designed for specific applications are interchangeable when used with the Model 790 Fluoroptic Thermometer. Probe designs differ substantially in the types of optical fiber used, the shape and location of the sensor, and the various materials used as coatings, binders and adhesives.

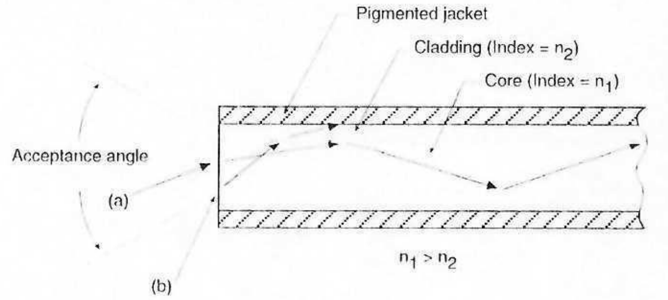
Optical Fibers

Optical fibers are wave guides for light. They operate by confining rays of light within a central "core". This fiber core is surrounded by another optical layer called the "cladding" which has a lower index of refraction (n_2) than that of the core (n_1) . Light rays striking the core-cladding interface from within the core are totally internally reflected, at least for a well-defined range of incident angles. The repeated reflection of such rays at the core-cladding interface enables the long-distance transmission of light.

The throughput of the fiber is dependent upon the range of angles for which internal reflection occurs and the losses with length for the wavelengths of interest. For short fibers and fast optics, the acceptance angle of the fiber is the dominant factor. The larger the difference in index of refraction between core and cladding, the larger the acceptance angle. The "numerical aperture" (NA) of the fiber, defined as

$$\sqrt{n_1^2 - n_2^2}$$

is generally used to quantify the angular acceptance of the fiber. The larger the numerical aperture, the larger the angle of acceptance (see below).



Section of an optical fiber. Light ray (a) falls within the acceptance angle and is transmitted by multiple reflections whereas ray (b) falls outside the acceptance angle, is refracted into the cladding and strikes the black-pigmented jacket where it is absorbed.

LUXTRON probes use fibers with relatively large diameters (200 to 400 micron cores), and large numerical apertures to maximize the transmitted flux of exciting and fluorescent radiation.

In addition, there are losses with length caused by absorption and by scattering at inhomogeneities within the fiber, these losses generally being greater at shorter wavelengths.

Fiber Bending Effects

Unlike a wire, an optical fiber changes its signal transmission when it is bent. This is partly due to the change in angle of incidence for certain light rays and partly to the change in relative indices of refraction of the core and cladding as the fiber is stressed by the bend. The result is a loss of higher angle rays (mode stripping). To make a useful sensor using an optical fiber, the measurement should be insensitive to such unavoidable transmission changes. The LUXTRON decay time method exhibits the critical immunity to bending loss. In addition, the Model 790's Automatic Gain Control (AGC) feature compensates for signal losses produced by bending.

Only if the fiber is flexed very rapidly during a measurement might an effect be observed. Typically, the stiffer all-quartz fibers and large core fibers show the most pronounced bending effects, while the highly flexible plastic fibers and small diameter fibers show the least.

Choice of Optical Fiber Materials

Optical fibers can be made from a variety of optically transmitting materials. The most common fibers are made of glass, fused silica (quartz) or plastic. Glass and quartz fibers are coated with an organic "buffer" layer to seal out moisture and to minimize surface oxidation which could lead to incipient fractures. The buffer layer is unnecessary for plastic fibers, while in plastic clad silica (PCS) and hard clad PCS, the cladding itself serves as a buffer. The all-quartz fibers used by LUXTRON have a thin polyimide buffer layer.

The fiber is typically covered by an outer plastic "jacket" to provide added strength and to act as a light shield. The jacket may be of single layer or multilayer construction and may include "cabling" of a reinforcing wrap such as Kevlar. The jacket may also contain a pigment to block out stray light.

The jacket on virtually all LUXTRON probes is of PFA, a high-melting (320°C) member of the Teflon family. Probes made of the PCS or all-quartz fibers are also fabricated in cabled form with a Kevlar fiber wrap between two PFA layers.

Since many applications involve electrically hostile environments, the specially formulated black pigment used in the jacket is electrically nonconducting, as are the rest of the probe materials. This minimizes both the hazard of electrical breakdown in high voltage environments and conductive heating artifacts when the probe is used in RF or microwave fields.

The Sensor and Associated Materials

The phospor used by LUXTRON is magnesium fluorogermanate activated with tetravalent manganese. This hardy material was originally developed as a color corrector for mercury vapor street lamps. It is prepared as a powder by solid state reaction involving firing in air at 1200°C. The resultant material is quite stable, fairly insoluble, and relatively benign from a biological standpoint.

Various binders and adhesives are used to form the sensor and attach it to the fiber tip, or to a surface. These are typically silicone resins, or for higher temperatures, potassium silicate, fired to produce a glassy matrix.

The sensor is supported in some probe designs by an elastomer which promotes good surface contact, and in others by a ceramic tube impervious to high temperatures. As with all other probe materials, these materials are selected for minimum electrical conductivity.

Connectors

Optical fiber connectors are made of plastic or metal. Stainless steel SMA type connectors are standard on LUXTRON Model 790 probes. Each connection butt-joins the polished fiber ends. This produces losses due to the following factors

- Imperfections of the end polish
- Small centerline misalignments
- Imperfect optical contact between the fiber ends

For LUXTRON probes in which two-way transmission of light occurs we typically observe a 2dB loss per connection. The number of connections should be minimized in order to maintain good signal levels.

Critical Materials Properties

The properties of primary importance in selecting probe materials are as follows

- Electrical conductivity
- Thermal behavior
- Transparency at wavelengths of interest
- Durability under protracted exposure to short wavelength irradiation

Secondary features of interest include

- Chemical inertness
- Magnetic field insensitivity
- Degree of sensitivity to ionizing radiation

All probe materials are selected for minimal electrical conductivity. This provides electrical safety when the probes are used in high voltage applications, and minimizes inductive heating when the probes are used in rf or microwave environments. (Note that all materials are heated to some extent by dielectric heating; however, the selected sensor materials are typically much less heated than the materials being measured.)

The silicone (and silicate) binders and adhesives are chosen for the following reasons

- Transparency
- High temperature stability
- Chemical inertness
- Resistance to blue or UV light
- Ease of forming and curing

The low thermal conductivity of the probe materials is also important. This minimizes heat flow to and from the sensor and thermal perturbation of the temperature being measured.

The sensor is insensitive to high magnetic fields, with tests indicating no observable change in calibration in fields up to 12 Tesla (120,000 Gauss).

All fibers experience color center formation at sufficiently high levels of exposure to ionizing radiation. The plastic fibers are the most sensitive while the high purity quartz fibers are least affected. Fortunately, the radiation-induced absorption in quartz fibers is quite low in the excitation (420 nm) and emission (650 nm) regions, although it is much stronger in the mid-visible and UV regions.

LUXTRON probes of moderate length quartz core fibers can be used under accumulated radiation doses of 10^7 to 10^8 rads of γ radiation from a Co^{60} source.

Fiber Type	Fiber Core Material	Fiber Core Diameter (microns)	Fiber Cladding Material	Cladding/Buffer Diameter (microns)	Jacket Material	1st Jacket Diameter (mm)	Outer Jacket Diameter (mm)	Kevlar Cabling For Strength	Minimum Bend Radius (cm) Mechanical Limit	Minimum Bend Radius (cm) Optical Limit	Temperature Range °C	Probe Types Used On
320 Micron all silica	Silica	320	Silica	420	PFA Teflon	0.7	1.4	Yes	1.5	3.0	-200 to 300	SIW SIH SSP SSC SMT SIWR SIT
200 Micron all silica	Silica	200	Silica	240	PFA Teflon	0.5	1.4	Yes	1.0	1.5	-200 to 300	SFW SFF SFT
400 Micron plastic clad silica	Silica	400	Silox-ane	550	PFA Teflon	0.7	1.4	Yes	1.0	1.0	0 to 200	SEL SEF SEA
600 Micron plastic clad silica	Silica	600	Silox-ane	700	Poly-ureth-ane	0.82	5.5	Yes	5.0	5.0	0 to 80	SEC

Materials Used in LUXTRON Probes

	Specific Heat, C_p J/Kg °K	Thermal Conductivity, k W/m °K	Dielectric Constant	Density g/cm^3
Quartz (high purity silica)	0.8	9	3.7 - 4.1	2.65
Teflon PFA	1.05	0.27	2.1	2 - 2.3
Polysiloxane (cladding on PCS fiber)	1 - 2	0.2 - 0.4	2.9	1.0
PMMA (plastic fiber)	1.39	0.19	2.8	1.2
MFG phosphor sensor	.21	.81	—	2.1

General Properties of Fiber Materials

HANDLING AND USE OF LUXTRON PROBES

There are some precautions worth observing in handling fiberoptic probes. Handled properly, probes will last indefinitely. Below are some guidelines that should be followed when using LUXTRON probes.

Probe Flexibility

Each probe is made from a single strand of silica fiber or PCS fiber. These fibers exhibit varying degrees of flexibility, based in part on the diameter of the fiber and the type of jacketing material used. However, any fiber may be damaged or broken if it is bent too sharply.

Cabling the probe with Kevlar (such as with the SIW, SFW, SFF and SIH probes) strengthens the probes significantly. It is recommended that probes are not bent to a radius of less than two centimeters.

Note that all-quartz fiber probes (such as the SIW, SIC, SIH probes) are stiffer and more susceptible to signal losses due to sharp bending than other fibers.

Probe Temperature Range

Probe life is also dependent on application. Using probes outside their intended temperature range or chemical environments may shorten their life span. Operation of the probes at higher temperatures than they are designed for is limited by the plastics used in the jacket and cladding. The cladding of the PCS fiber (used in SEL probes) will oxidize and deteriorate if exposed to air at temperatures above 200°C for an extended period. The PFA jacket on most probe types melts at 320°C. The lower limit of operation of each probe type is set primarily by the optical transmission of the fiber used. Only the all-silica fiber has acceptable transmission at very low temperatures.

Care of the Probe When It Is Not in Use

Each probe is supplied with a red cap over the connector. Replacing this cap when the probe is not in use will prevent dirt from accumulating on the open fiber end. A dirty fiber will have reduced transmission and performance. If the polished fiber end in the center of the connector should need cleaning, wipe it with a cotton swab moistened with spectrograde methanol or isopropanol.

Probe Length

Signal level at the instrument detector decreases with increasing fiber length, and the losses experienced depend on the fiber type. The use of multiple connectors and extensions will also reduce the signal level. A good rule of thumb is you will experience a factor-of-two loss in signal for each additional connection.

The lower the signal, the lower the signal-to-noise ratio. This increases the number of samples per measurement needed to achieve a given level of precision. Increasing the number of samples per measurement will improve the precision and accuracy of the reading because more samples are averaged together to obtain a measurement. However, if the signal levels are too low, the probe may be out of the normal operating range of the instrument.

Please consult the factory for assistance in applications involving long probes, extension cables, or feedthroughs.

WARRANTY

LUXTRON Corporation warrants each Fluoroptic Thermometer to be free from defects in material and workmanship under normal use and service for the period of one year from date of shipment. This warranty extends only to the original purchaser. It does not apply to fuses, lamps, or probes, nor any products or parts that have been subject to misuse, neglect, accident or abnormal conditions of operation.

In the event of failure of the instrument covered by this warranty, LUXTRON Corporation will repair and calibrate the instrument if it is returned to LUXTRON within one year of the original shipment, provided LUXTRON's examination discloses that the product is defective. LUXTRON may, at its option, replace the unit in lieu of repair. The repairs or replacement will be made without charge if the instrument is returned within one year of the original shipment date.

If the fault has been caused by misuse, neglect, accident or abnormal conditions of operation, repairs will be billed at current service rates. In such case, a purchase order number is required prior to the start of any repair. If requested, an estimate of the service charges will be given prior to the start of any repair.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. LUXTRON CORPORATION SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

THE COMPANY

LUXTRON Corporation was founded in 1978. Corporate headquarters, including manufacturing facilities, are in a 37,000 square foot building in Santa Clara, California. An additional facility is located in Beaverton, Oregon.
LUXTRON develops, manufactures and markets unique sensors and instrumentation, based on optical and heat flow technologies, for a wide range of industrial, medical and R&D applications.

MAJOR PRODUCT LINES

Luxtron brand Fiberoptic Temperature Sensors and Instruments using patented Fluoroptic sensors which are intrinsically safe and immune to EM interference (-200°C to +450°C).
Accufiber brand Fiberoptic Temperature Sensors and Instruments that use infrared and blackbody technology. They are intrinsically safe and immune to EM interference (+200°C to +4000°C).
Xinix brand Semiconductor and LCD Panel Process Controllers using noncontacting, optical sensor in plasma (dry) etch, wet etch and resist develop processing equipment to determine precisely when a process is completed.
Transmet brand Non-Contact Temperature Systems that are applied to moving objects in industrial processes such as in wire and optical fiber production (+10°C to +300°C).

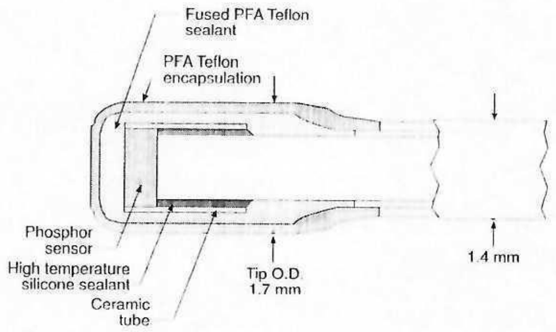
LUXTRON

IMMERSION TYPE PROBES

SIC

Wide Range/Chemical & Oil Resistant

Sensor is encapsulated with oil-resistant sealant. Probe is Kevlar cabled all the way to the sensor tip.



Temperature Range

-195° to 300°C

Fiber Type

340 µm all-silica, double PFA Teflon jacketed, Kevlar cabled fiber.

Available Lengths

2, 5 and 10 meters

Response Time

5 seconds in still air.
0.7 seconds in stirred water.

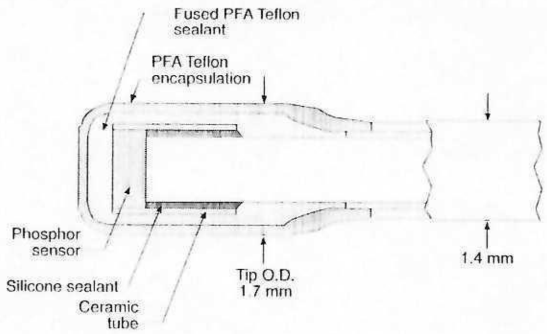
Connector Type

SMA 905

SIA

General Purpose/Industrial

Rugged PCS Fiber. Probe is Kevlar cabled all the way to the sensor tip.



Temperature Range

0° to 200°C

Fiber Type

400 µm PCS, double PFA Teflon jacketed, Kevlar cabled fiber.

Available Lengths

2, 5 and 10 meters

Response Time

5 seconds in still air.
0.7 seconds in stirred water.

Connector Type

SMA 905

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