Application Note AN-S

# RdF Surface Temperature Sensors



## I. Introduction

Surface temperature is a highly desired but difficult measurement. Unlike applications in which transducers in protective tubes are immersed in fluids under controlled or known circumstances, surface measurements require that sensors be outside of vessels where environmental conditions may affect results. In addition, factors such as conformance with surface contours and thermal as well as electrical paths between the sensors and the objects of measurement influence output signal integrity. Selection of sensors and mounting techniques influence measurement system performance. Surface temperature is of direct interest in many applications and is of value for assessing conditions at inaccessible locations in others. Various sensors and mounting techniques are available. Selection criteria include factors appropriate for any temperature measurements such as range, accuracy, ruggedness, and sensitivity to substances likely to contact the element. Additional considerations peculiar to surface applications include the thickness and flexibility of the units as well as heat exchanged with the object of measurement and the surroundings.

The two most important rules in the use of a surface sensor are:
**1)** The surface sensor must be mounted in a manner which permits maximum thermal contact and minimal mechanical strain. RdF Designs are easy to mount properly.
**2)** The surface sensor must be insulated or isolated to make its temperature as close to that of the surface as possible. This is controlled by the user.

To illustrate these points ***Figure I*** shows a typical surface sensor installation. The sensor in this case is mounted on a pipe which is carrying a fluid. The point closest to the fluid where a sensor can be measured practically is the outer wall of the pipe. If the fluid flow is adequate and the temperature fluctuations are not severe, the outer wall temperature will be very close to that of the fluid.

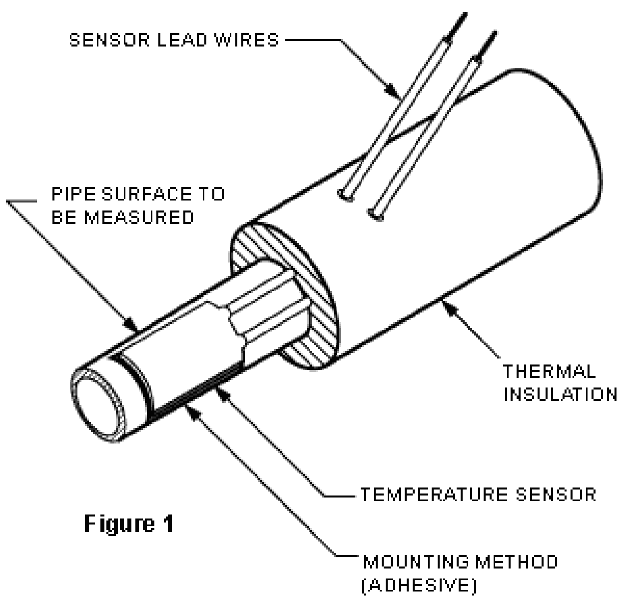


**Figure 1**

The surface sensor is only able to measure its own temperature and an

## C. Thermocouple Surface Sensors

### C. Flexible Foil Thermocouples

### E. Heavy Duty Sensors Models 22802

# III. Surface Sensor Selection Guide

| Sensor Style Model | Temperature Range | Sensor Type | Sensor Size (in.) | Carrier Material |
|---|---|---|---|---|
| Flexible Wire Strapon® RTD 22810 | –200°C to +232°C (–320°F to 450°F) | Resistance 100 Ω Platinum @ 0°C | 1.00 x 0.62 | Polyimide |
| Flexible Stikon® TC Sensor | –200°C to +260°C Short Term to 371°C (700°F) | Thermocouple Types K, E, T or J* | 0.32 x 0.75 | Polyimide/Glass |
| Flexible Foil TC Sensors | –200°C to 816°C (–320°F to 1500°F) | Thermocouple Types K, E, or T* Grounded or Ungrounded | 1.00 x 0.75 or 0.37 x 0.75 | Optional Polyimide |
| Heavy Duty Surface Mount RTD 22802 | –200°C to 480°C (–320°F to 900°F) | Resistance 100 Ω Platinum @0°C | 1.00 x 1.00 | 316 Stainless Steel - - |
| Heavy Duty Surface Mount TC 26881 | –200°C to +760°C (–320°F to +1400°F) Leads to 480°C (900°F) | Thermocouple Types K, E, T or J* Grounded or Ungrounded | 1.00 x 1.00 | 316 Stainless Steel |
| Strapon® RTD Sensors 22391, 22392 & 22393 | –200°C to +232°C as mounted, +260°C (500°F) short term clamped | Resistance 100 Ω or 1000 Ω Platinum @0°C | 1.00 x 1.00 | Stainless Steel overmolded with medium density polymide pad - |
| Strapon® TC Sensors 26391, 26392 & 22393 | –200°C to 232°C continuous as mounted, 260°C (500°F) short term clamped | Thermocouple Types K, E, T or J* Grounded or Ungrounded | 1.00 x 1.00 | Stainless Steel overmolded with medium density polymide pad |
| Miniature Flexible Platinum RTDs 29222, 29223 | –200°C to 260°C (–320°F to 500°F) | Thermocouple Types K, E, T or J* Grounded or Ungrounded | 0.14 x 0.40 or 0.19 x 0.40 | Polyimide |
| Surface Platinum RTD Capsules 29230, 29309 | –200°C to 260°C (–320°F to 500°F) | Resistance 100 Ω or 1000 Ω Platinum @0°C | 0.22 x 0.50 or 0.30 x 0.50 | Polyimide |
| Immersible Surface Platinum RTDs 29272 | –200°C to +232°C (–320°F to +450°F) | Resistance 100 Ω or 1000 Ω Platinum @0°C | 0.30 x 0.80 | Polymide |
| 29280 | –200°C to260°C (–320°F to +500°F) | | 0.25 x 0.50 or 0.30 x 0.50 | |

**K–Chromel/Alumel, E–Chromel/Constantan, T–Copper/Constantan, J–Iron/Constantan*

# IV. Mounting Considerations

## A. Flexible Sensors

The first step in installing a surface sensor is the determination of the mounting method. In the case of some sensors, mechanical mounting hardware is available and these will be described later, but in most cases an adhesive is required. In selecting an adhesive the following questions should be considered:

• Is the expected operating temperature range compatible with the adhesive under consideration?

• Are the coefficients of thermal expansion of sensor, surface and adhesive similar?

• Is the adhesive application compatible with the installation? eg. if the adhesive requires a cure at an elevated temperature, it may become a problem in a remote installation.

• Is the adhesive mounting intended for permanent or temporary installation?

There are several types of adhesives that are commonly used to mount sensors:

**1) Epoxies**

This type adhesive is available in a variety of forms including liquid, pastes, films, tapes and powders, but are usually found in two parts which must be mixed before applying. Cure times vary between 5 minutes at room temperature to several hours at elevated temperatures. Most epoxies have fillers added to the basic resin which make them ideal to fill gaps or over coat sensors.

**2) Cyanoacrylate Adhesives**

These adhesives are of the “super quick set” variety. They cure at room temperature in 10 to 60 seconds. There are temperature and humidity restrictions for their use. Because most cyanoacrylates either do not contain fillers or have limited capability to fill voids, parts must be in close contact.

**3) Silicone**

Silicone adhesives have the advantage of being rubbery and provide a resilient low stress bond between sensor and surface. They are available in single or two part paste or even as a double sided tape which can be instantly applied to sensor and surface. They have a very wide useful temperature range. The paste type silicones require a long cure time and are subject to possible reversion if not cured above the required service temperature.

**4) Polyimide Adhesives**

There are several families of polymer adhesives which provide excellent adhesion and high temperature stability. However, they must be cured under carefully controlled temperature and pressure requirements. This makes field installation very difficult.

# III. Surface Sensor Selection Guide

| Leads | Typical Applications | Data Sheet |
|---|---|---|
| #26 AWG Stranded, Teflon® Insulated Ribbon cable | Flat or curved surfaces such as plastic, metal or glass for industrial, laboratory, commercial or aerospace applications. | R-STK |
| #30 AWG Solid, PFA or Fiberglass Insulated | Flat or curved surfaces such as plastic, metal or glass for industrial, laboratory, commercial or aerospace applications. | T-STK |
| 0.001 x 0.03 T/C Ribbons or #30 AWG Solid, Fiberglass Insulated | Extremely low mass sensor for precise analytical or experimental measurements – fast response time. + | T-F |
| #22 AWG Stranded, Teflon® or Fiberglass Insulated | Heavy duty applications where the sensor can be mechanically mounted such as boiler tubes, flue stacks, refineries or plant applications where physical abuse is common. Bolt-on flange can also be welded or bonded. | R-HD |
| #22 AWG Stranded T/C Conductors, Fiberglass Insulated | Heavy duty high temperature applications where the sensor can be mechanically mounted such as boiler tubes, flue stacks, refineries or plant applications where physical abuse is common. Bolt-on Flange can be welded. | T-HD |
| 2 wire: 22 AWG, FEP, Twisted Cable<br>3 wire: 24 AWG, FEP, Twisted Cable<br>4 wire: 26 AWG, PFA, Ribbon Cable<br>Stranded, Teflon® Insulated Cable | Flexible sensors for immediate installation for permanent or temporary measurements of fluid lines for energy management systems, process plants, refineries, utilities or aerospace applications. Suitable for condensing or wet environments. | R-STR-LOW |
| #20 AWG Stranded, Fiberglass Insulated w/Fiberglass Overbraid + | Flexible sensors for immediate installation for permanent or temporary measurements of fluid lines for energy management systems, process plants, refineries, utilities or aerospace applications. | T-STR-LOW |
| #28 AWG Stranded,PFA Teflon® Ilnsulated Ribbon Cable | Flat or curved surfaces such as plastic, metal or glass for industrial, laboratory, commercial or aerospace applications. | R-MINI |
| #28 AWG Stranded, PFA Teflon® Insulated Ribbon Cable | Flat or curved surfaces such as plastic, metal or glass for industrial, laboratory, commercial or aerospace applications. | R-SCAP |
| Stranded lead cables;<br><br>#22/#24 AWG, FEP Teflon® Twisted<br>#26 AWG Stranded, PFA Teflon® Ribbon | Flat or curved surfaces such as plastic, metal or glass for industrial, laboratory, commercial or aerospace applications where condensation or shallow immersion occurs. | R-IMM |

**K–Chromel/Alumel, E–Chromel/Constantan, T–Copper/Constantan, J–Iron/Constantan*

**5) Ceramic Adhesives**
Ceramic adhesives or cements have the advantage of having the highest useful temperature. They are used in paste form with metal oxides used as fillers with an acid used as the binder. They often require a cure at elevated temperatures. After curing, ceramic cements are generally hard, brittle and hygroscopic.

**6) Solvent Release Adhesives**
There are a number of commonly available inexpensive adhesives which require the release of a solvent from the resin material to form the bond. It should be noted that if the sensor is impervious to the solvent, the adhesive will not cure properly. Caution should be used in selecting these adhesives. After the adhesive has been selected a procedure must be developed which can be used to consistently mount the sensor The following is a general guideline for a typical mounting procedure.

**7) Surface Preparation *(Figure 2)***
One of the most important steps in mounting a surface sensor is the proper preparation of both the sensor and mounting surfaces. Dirt, grit, oils, finger prints, etc. can act as a mold release, and affect the adhesion of the sensor to the surface. As a minimum, the sensor and surface should be solvent cleaned with a clean cloth wetted with alcohol, acetone, M MEK or toluol.

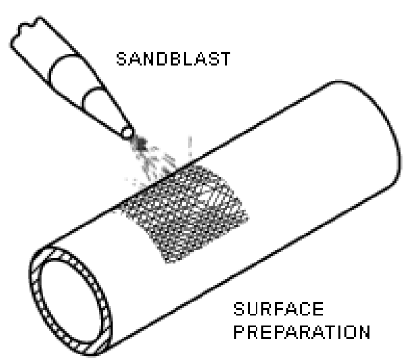


**Figure 2**

Caution: some surfaces may be adversely affected by some solvents and a pretest of the solvent on the surface is recommended. In the case of metal or shiny hard surfaces roughening of the finish is usually required to insure a better bond. This can be done by roughening the surface with a light sandblasting or manually applied abrasive. Clean air should be used to remove grit after roughening is complete, followed by a solvent cleaning as described above.

**8) Adhesive Preparation**

brazing, bolting or clamping. The purpose of the rigid sensor is to provide a

2. Mold Temperature Sensor ***(Figure 6)***

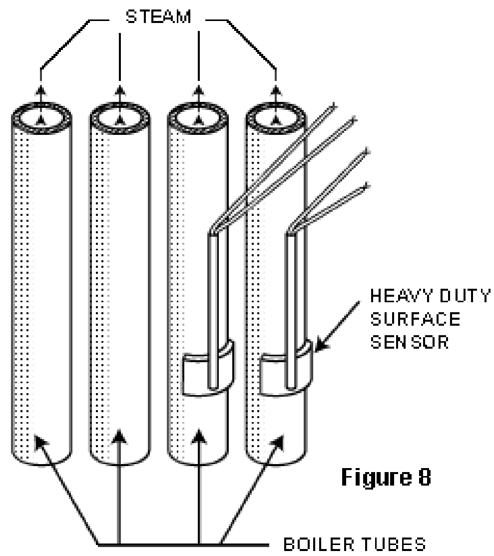


**Figure 8**

# VI. Surface Thermocouple Specifications

*Limits of error are new material interchangeability expressed in percentage of positive or negative Celsius temperature when greater than basic limit.
**Temperature range is for the small or stranded wires in surface TCs.

# VII. Platinum Resistance Ratio Table

**Temperature Coefficient 0.00385ohms/ohms/°C — Nominal IEC751 - Class B Interchangeability**

| °C | ±Class B | $R/R_0$ | °C | ±Class B | $R/R_0$ | °C | ±Class B | $R/R_0$ |
|---|---|---|---|---|---|---|---|---|
| -200 | | 0.185 | 50 | | 1.194 | 300 | ±1.8 | 2.120 |
| -190 | | 0.228 | 60 | ±0.6 | 1.232 | 310 | | 2.156 |
| -180 | ±1.2 | 0.271 | 70 | | 1.271 | 320 | | 2.191 |
| -170 | | 0.313 | 80 | | 1.309 | 330 | | 2.227 |
| -160 | | 0.355 | 90 | | 1.347 | 340 | ±2.0 | 2.262 |
| -150 | | 0.397 | 100 | ±0.8 | 1.385 | 350 | | 2.297 |
| -140 | ±1.0 | 0.439 | 110 | | 1.423 | 360 | | 2.332 |
| -130 | | 0.480 | 120 | | 1.461 | 370 | | 2.367 |
| -120 | | 0.521 | 130 | | 1.498 | 380 | ±2.2 | 2.402 |
| -110 | | 0.562 | 140 | ±1.0 | 1.536 | 390 | | 2.436 |
| -100 | ±0.8 | 0.603 | 150 | | 1.573 | 400 | | 2.471 |
| -90 | | 0.643 | 160 | | 1.610 | 410 | | 2.505 |
| -80 | | 0.683 | 170 | | 1.648 | 420 | ±2.4 | 2.540 |
| -70 | | 0.723 | 180 | ±1.2 | 1.685 | 430 | | 2.574 |
| -60 | ±0.6 | 0.763 | 190 | | 1.722 | 440 | | 2.608 |
| -50 | | 0.803 | 200 | | 1.759 | 450 | | 2.642 |
| -40 | ±0.5 | 0.843 | 210 | | 1.795 | 460 | ±2.6 | 2.676 |
| -30 | | 0.882 | 220 | ±1.4 | 1.832 | 470 | | 2.709 |
| -20 | | 0.922 | 230 | | 1.868 | 480 | | 2.743 |
| -10 | | 0.961 | 240 | | 1.905 | 490 | | 2.776 |
| 0 | ±0.3 | 1.000 | 250 | | 1.941 | 500 | ±2.8 | 2.810 |
| 10 | | 1.039 | 260 | ±1.6 | 1.977 | 510 | | 2.843 |
| 20 | | 1.078 | 270 | | 2.013 | 520 | | 2.876 |
| 30 | | 1.117 | 280 | | 2.049 | 530 | | 2.909 |
| 40 | ±0.5 | 1.155 | 290 | | 2.085 | 540 | ±3.0 | 2.942 |

# VIII. Useful Conversions

**Temperature:**

°C = 5/9 (°F – 32) °F = 9/5 (°C) + 32 °K = °C + 273.15 °R = °F + 459.67

**Heat Transfer Coefficient:**

| Multiply | By | To Obtain |
|---|---|---|
| BTU / (HR) ($FT^2$) (°F) | 0.0001356 | CAL / (SEC) ($CM^2$) (°C) |
| | $1.929 \times 10^{-6}$ | BTU / (SEC) ($IN^2$) (°F) |
| | 0.0005674 | WATTS / ($CM^2$) (°C) |

**Thermal Conductivity:**

| Multiply | By | To Obtain |
|---|---|---|
| BTU / (HR) ($FT^2$) (°F / FT) | 0.00413 | CAL / (SEC) ($CM^2$) (°C / CM) |
| | 12 | BTU / (SEC) ($F^2$) (°F/IN) |
| | 0.0173 | WATTS / ($CM^2$) (°C / CM) |

Specialists in Temperature Measurement

Proudly manufactured in USA

RdF Corporation • 23 Elm Ave, Hudson, NH 03051-0490
800.445.8367 / 603.882.5195 • sensor@rdfcorp.com • www.rdfcorp.com

AS9100 ISO 9001 CERTIFIED COMPANY