PRODUCT MANUAL

Press-Fit 3 MM Cavity Temperature Sensor

TS-PF03-K

Training and Technology for Injection Molding

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PRODUCT MANUAL

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INTRODUCTION

Read, understand, and comply with all following instructions. This guide must be kept available for reference at all times.

DISCLAIMER

Inasmuch as RJG, Inc. has no control over the use to which others may put this material, it does not guarantee that the same results as those described herein will be obtained. Nor does RJG, Inc. guarantee the effectiveness or safety of any possible or suggested design for articles of manufacture as illustrated herein by any photographs, technical drawings, and the like. Each user of the material or design or both should make his own tests to determine the suitability of the material or any material for the design as well as the suitability of the material, process, and/or design for his own particular use. Statements concerning possible or suggested uses of the material or designs described herein are not to be construed as constituting a license under any RJG, Inc. patent covering such use or as recommendations for use of such material or designs in the infringement of any patent.

PRIVACY

ALERTS

The following three alert types are used as needed to further clarify or highlight information presented in the manual:

DEFINITION *A definition or clarification of a term or terms used in the text.*

NOTE *A note provides additional information about a discussion topic.*

CAUTION *A caution is used to make the operator aware of conditions that can cause damage to equipment and/or injury to personnel.*

ABBREVIATIONS

DIA	diameter
MIN	minimum
MAX	maximum
R.	radius

NOTES

PRODUCT DESCRIPTION

The press-fit 3 mm cavity temperature sensor TS-PF03-K is made out of a plug of steel 3 mm in diameter and 4.5 mm in length, with 6 feet of 30 gage, type K thermocouple wire extending out of the back.

The steel of the sensor body is an H-13 with a hardness of 42-46 Rc. The sensor withstands cavity pressures up to 30,000 psi. The Teflon wire coating allows the sensors to work in molds up to 400 °F (204 °C). The sensor responds to the arrival of the flow front in 2–4 milliseconds.

APPLICATIONS

PRESS-FIT CAVITY TEMPERATURE SENSORS

The press-fit 3 mm cavity temperature sensor TS-PF03-K analyzes temperature variation inside the mold cavity, and is made of hardened steel which is then contoured, angled, and/or textured to match the cavity in which it is installed. Once installed and textured, the witness mark should be less than that of an ejector pin or flush-mount sensor.

- Locate the sensors near areas where short shots, dimensional errors, or warp are likely to occur.
- Placing sensors in different areas of the part can show problems with non-uniform cooling.

FOUR-CHANNEL SENSOR SYSTEM

The TS-PF03-K is designed for use with RJG, Inc.'s Lynx™ Quad Temperature Module LS-QTTB-K—which receives input from up to four thermocouples—and the eDART® or CoPilot® systems.

OPERATION

MELT AND MOLD TEMPERATURES

In injection molding, both the melt temperature and mold temperature are two of the four "Plastics Variables" that determine how the part is formed. These temperatures are commonly monitored occasionally, rather than on every shot, often because mold temperature controllers and barrel temperature controls on the machine appear to be stable. In addition, many part characteristics are easily correlated to pressure in the cavity rather than temperature.

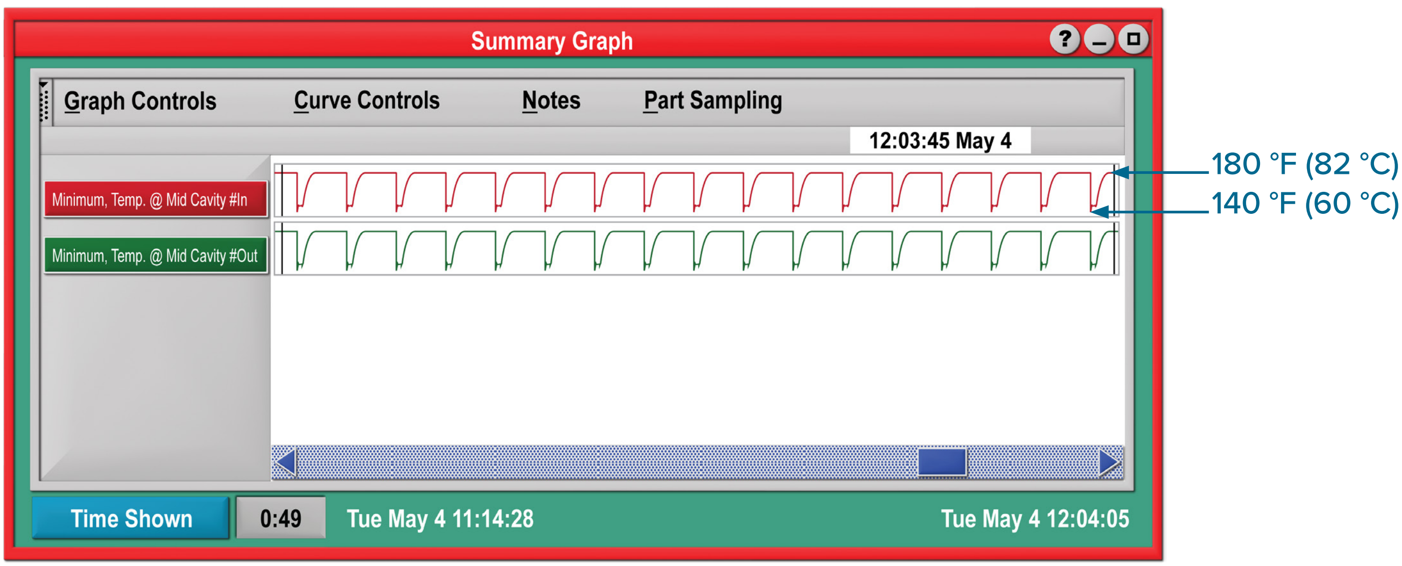
Regardless, temperature is critical in many parts—especially parts made with semi-crystalline materials and/or parts requiring tight dimensional tolerances. Furthermore, any changes in cycle time, or breaks in cycle, dramatically affect thermodynamic stability in injection molding. Achieving proper temperatures after a cycle break can take many cycles, so monitoring the temperature inside the cavity helps with problem diagnosis, and can be used to prevent parts made at the wrong temperature from being shipped.

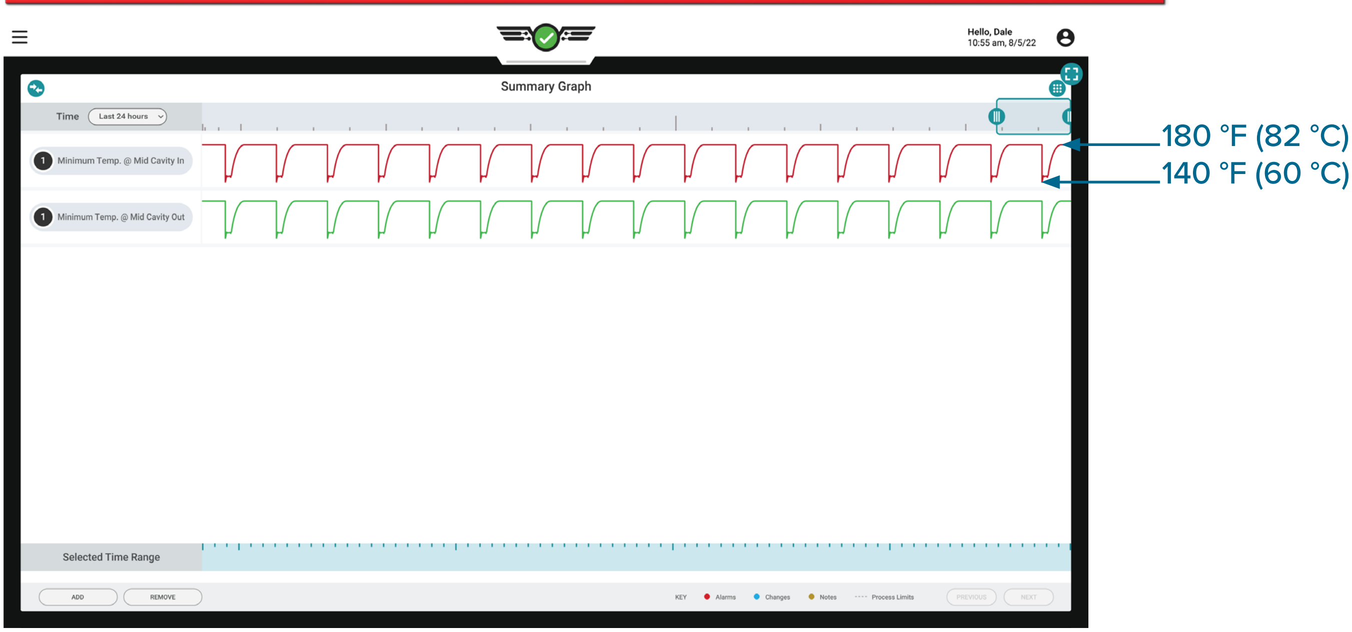
TEMPERATURE COMPUTATIONS

1. Minimum Temperature

The eDART and CoPilot systems compute a “Minimum” at each cavity temperature sensor. The minimum is the mold surface temperature at that point; watch for oscillations and time to reach stabilization. The following graph illustrates how the minimum (mold surface) drops in temperature and then returns over several shots as the mold warms up.

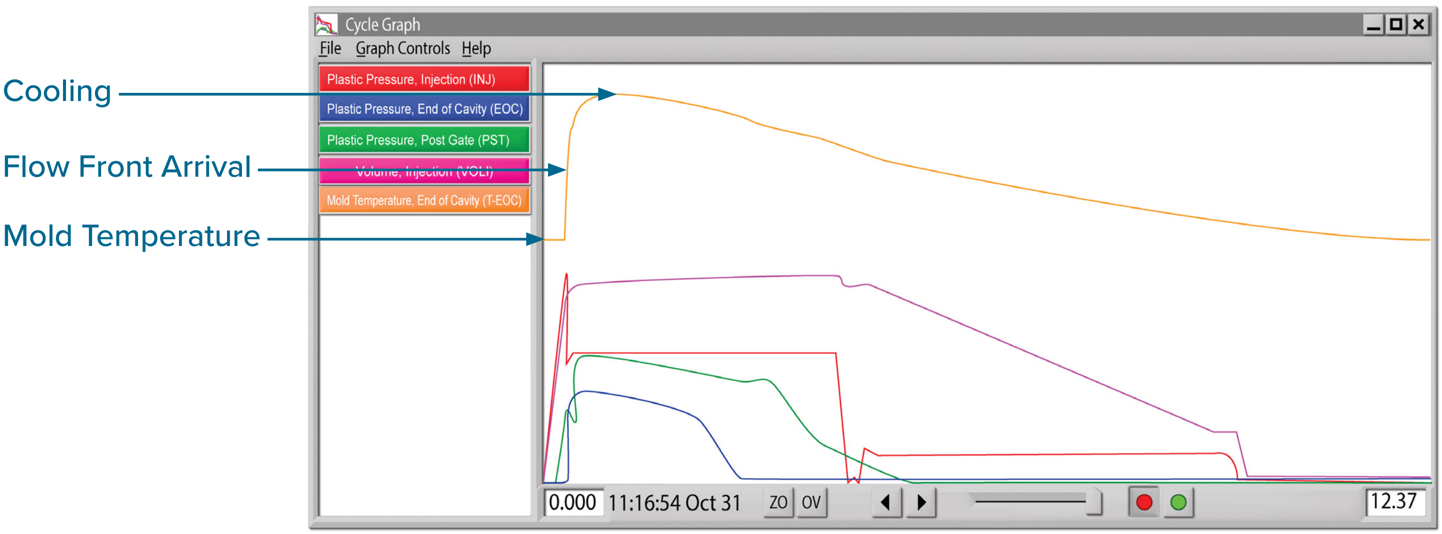
Below, it can be seen on the eDART system Summary Graph and the CoPilot system Summary Graph that the cycle break allows the mold surface to cool to 140 °F (60 °C), and several shots are required to re-heat the mold surface to 180 °F (82 °C).





The time to reach stability is often longer than anticipated, so the concept of identifying mold temperature stability is important when preparing a process for “lights out” operation, or before parts are sampled for measurement.

A typical, stable cycle on the eDART system and CoPilot system Cycle Graphs are shown below. As depicted in the graph, the Minimum / Temp. @ End of Cavity is the temperature to which the mold cools just before the flow front arrives; this is the plastic variable “Mold Temperature”. The temperature rises quickly as the hot material touches the sensor face. The peak temperature shown is never near the actual melt temperature, because the skin cools and is insulated quickly as the heat is pulled away by the sensor and surrounding steel. Then, the back slope depicts the cooling of the steel; as the part cools, the skin thickens, and less and less heat flows out.



2. Effective Melt Temperature

The eDART and CoPilot systems compute a relative value that shows changes in melt temperature called "Effective Melt Temperature" (similar to "Effective Viscosity"). Several poorly defined constants in the equation make it impossible to measure the actual melt temperature in degrees. Still, using the temperature curves, the eDART and CoPilot systems can estimate how much heat was removed from the mold. The systems can compute a value that shows changes in melt temperature using the "cold" temperature (minimum). Much of the process (e.g. cycle time) must remain constant for this value to be of use.

3. Range

The eDART and CoPilot systems also compute a "Range" for each sensor, which is the difference between peak and minimum. This correlates very roughly with changes in melt temperature, though the changes in "Range" are minuscule. If everything else is constant, a change in a "Range" number may indicate a heating or hot runner control problem.

4. Process Time and Temperature @ X

The eDART and CoPilot systems compute the time from start of fill until the melt arrives at the sensor. This is called "Process Time", "Temp. @ X" where X is the location of the sensor. The arrival time of the flow front can be observed to determine actual in-cavity flow or balance of flow.

PROCESS CONTROL WITH TEMPERATURE SENSORS

Temperature-based process control is suitable for applications where pressures are too low at flow front arrival when a control decision must be made to utilize cavity pressure sensors. The best use of temperature sensors for control is with valve gates, and works particularly well when there is little or no pressure at the point where a gate must be actuated. For example, sudden rise in temperature indicates the arrival of the flow front; a gate can be opened when the flow front just passes by the gate if a temperature sensor is placed there.

The temperature sensor “close” control on the eDART or CoPilot systems’ Valve Gate control can be set to close vents at the arrival of the flow front. Use the close control on vents for structural foam, or for large molds that need large vents; this also works to close overflow gates.

In coining operations, the eDART or CoPilot system can be used to clamp the machine when the material has reached a known position.

Temperature sensors can also be used to control gas pins at the arrival of the flow front at a certain position.

In all of the above control scenarios, install the sensor slightly upstream to allow for some adjustment using the “Open on Temperature Rise” method; if selected, the valve gate will open at the user-entered temperature rise of the selected sensor plus an additional volume.

MACHINE TRANSFER WITH TEMPERATURE SENSORS

Machine transfer on temperature does not control pressure well. While transfer of the machine at the flow front arrival can be done, it does not directly control pack pressure. However, temperature transfer may work very well in high speed, thin-wall applications requiring a DECOUPLED MOLDING® control method. Many of these processes build high pressures quickly at the gate with none at the end of fill by the time the machine needs to transfer. Using DECOUPLED MOLDING, the material can be driven to a known point in the cavity and then, when the eDART or CoPilot system detects a temperature rise, transfer the machine. Accumulated runner pressure will fill and pack the part.

In a DECOUPLED MOLDING III process, temperature-controlled transfer can stabilize pack pressures better than a DECOUPLED MOLDING II process—position transfer—when viscosity changes. But during steady state (no viscosity change) the “normal” pressure variation is greater than a DECOUPLED MOLDING II process.

CONTAINMENT WITH TEMPERATURE SENSORS

Part containment can be achieved using temperature sensors by setting alarms on either the eDART or CoPilot system.

1. Reject Parts on Startup

To reject parts on startup until the mold surface reaches a specified temperature, set alarms on minimum temperature at each sensor to ensure that the mold temperature is within required limits.

2. Detect Short Shots

To detect short shots, place the sensor at or very close to the point where a short occurs, set alarms on the “Process Time / Temp @…” value at each sensor. This value is the most sensitive to shorts but depends on a constant flow rate.

The “range” value can also be used for detecting short shots. A low “range” (i.e. temperature rise) indicates that the material did not arrive at that point. Of course if the short shot occurs at different places depending on the flow then “range” will not catch all short shots. There is not yet a technique for picking the best lower level for range.

3. Detect Flash

To detect flash outside of the cavity, such as in the parting line or around an insert, an alarm set on “range” could detect hot material entering an area in which it should not be through temperature rise.

4. Detect Changes in Flow

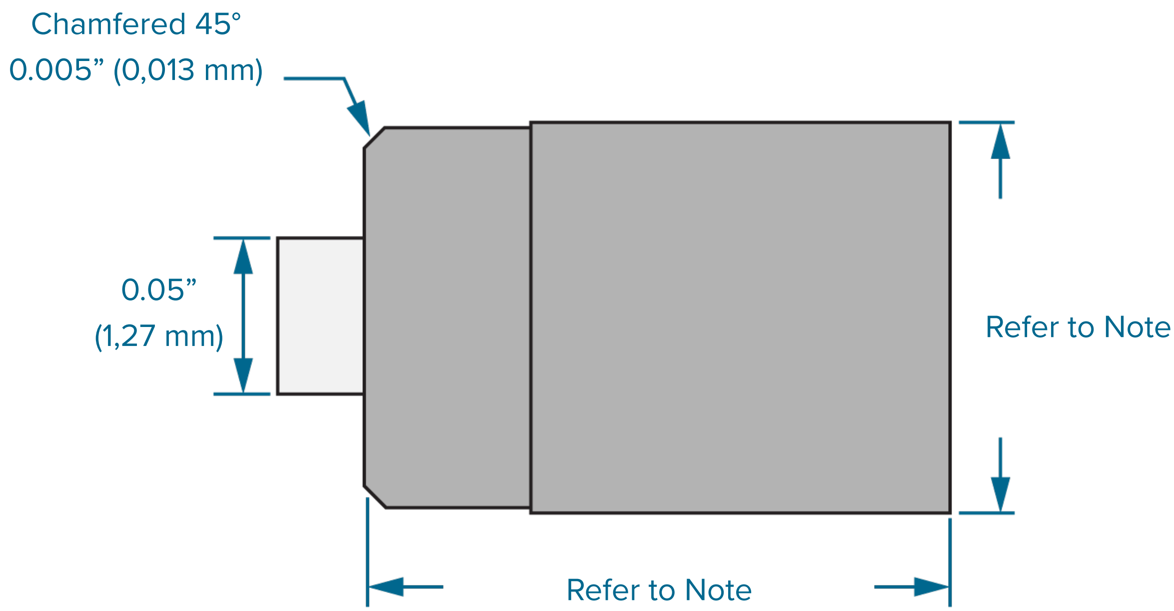
To detect changes in flow, set alarms on “Process Time” / “Temp. @…”; this can help with sorting out bad parts that are flow sensitive (e.g. textured parts etc.) or detecting improper process setups.

5. Detect Changes in Melt Temperature

To detect changes in melt temperature, set alarms on “Effective Melt Temperature”. The “range” value can also be used to divert parts, though “Effective Melt Temperature” is much more sensitive.

DIMENSIONS

SENSOR



ⓘ **NOTE** *The sensor is press fit. Gauge each sensor body, then cut each sensor pocket diameter: Refer to “Sensor Head Pocket” on page 10.*

SENSOR CABLE LENGTH

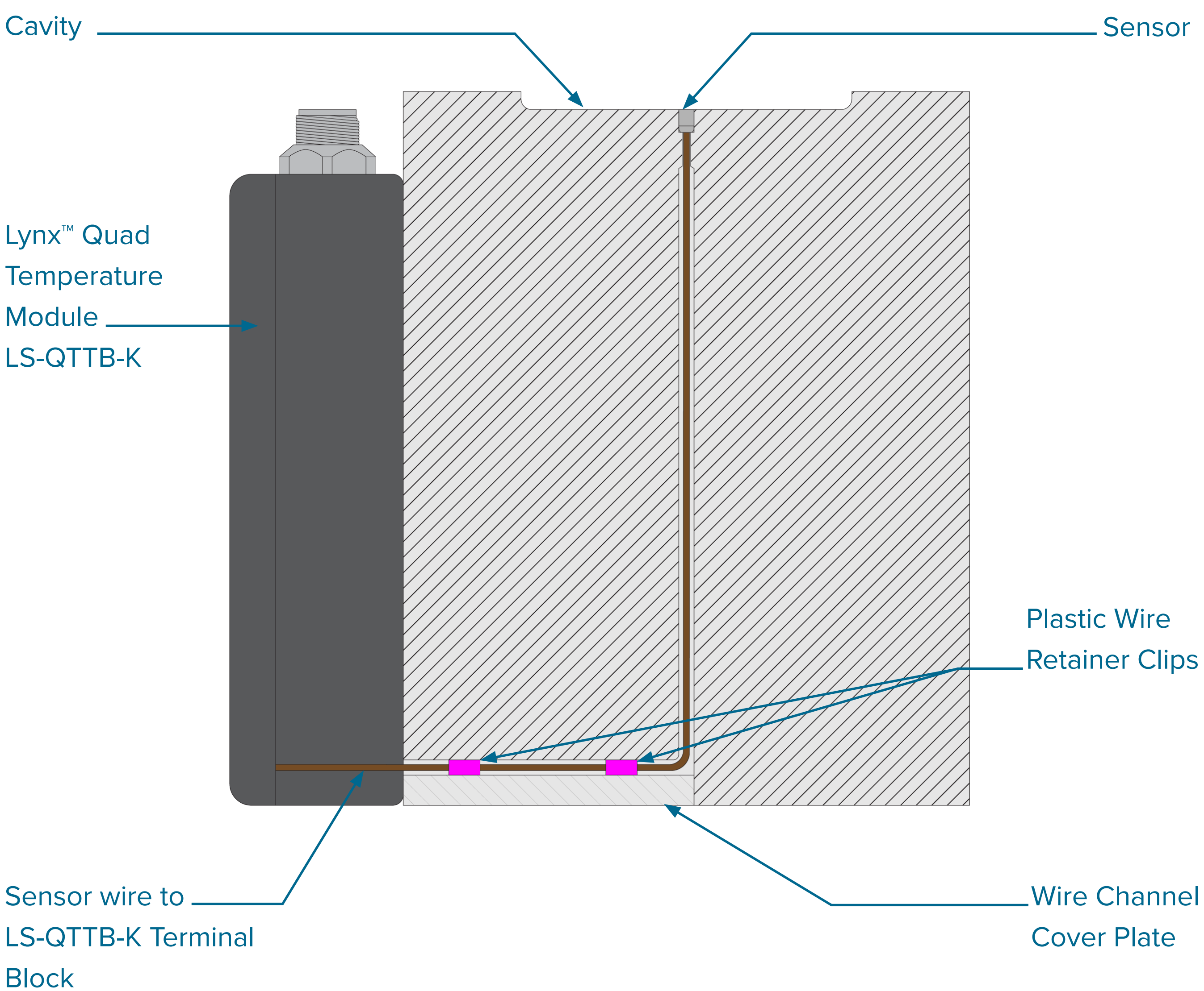
The TS-PF03-K sensor wire is 6 ft (1,83 m) in length, and can be shortened or lengthened appropriately for each application. Length must be longer than needed to assure proper installation without tension on the lead wire.

Gage	30
Length	6 ft (1,83 m)

NOTES

INSTALLATION OVERVIEW

A small hole is machined for the sensor cable, then a flat-bottomed pocket with the tolerance necessary to press fit the sensor in from the cavity face is milled. The sensor is pressed into the cavity, and the sensor face is surface and/or contoured to match the cavity surface.



INSTALLATION SPECIFICATIONS

CAUTION *Once installed, a sensor CANNOT **be removed.** Attempts to remove sensor will result in destruction of sensor.*

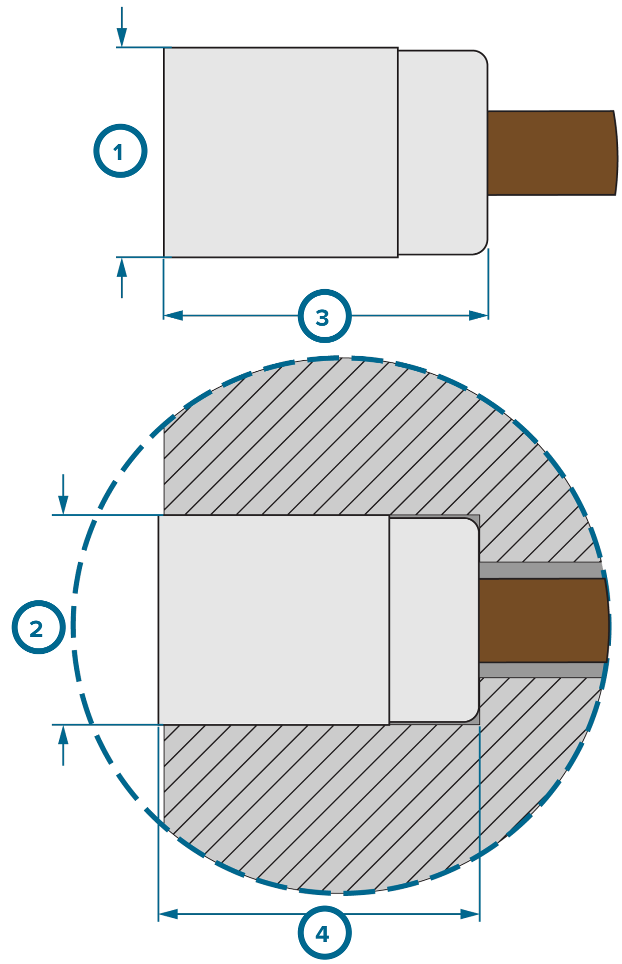
SENSOR HEAD POCKET

The sensor is press fit. Gauge each sensor body diameter (1 at right), then cut each sensor pocket diameter (2 at right): 0.0005” (0,013 mm) less than body measurement for installation in steel or 0.001” (0,03 mm) less than body measurement for installation in aluminum.

Gauge the sensor length (3 at right), then cut the pocket depth (4 at right) to allow 0.001” (0,03 mm) of the sensor steel to be exposed for later finishing.

CAUTION *The finished sensor length may not be less than 0.177” (4,496 mm).*

1	Gauge sensor diameter before cutting sensor pocket
2	Sensor DIA - 0.0005” (0,013 mm) for installation in steel ***OR*** Sensor DIA - 0.001” (0,03 mm) for installation in aluminum
3	Gauge sensor length before cutting sensor pocket: ***The finished sensor length may not be less than 0.177” (4,496 mm)***.
4	Sensor length + 0.001 (0,03 mm) ***exposed in the cavity for later finishing***



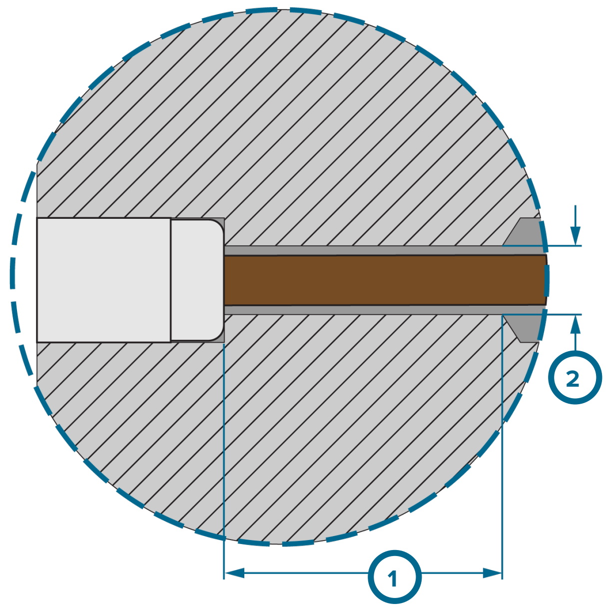
SENSOR CABLE CHANNEL

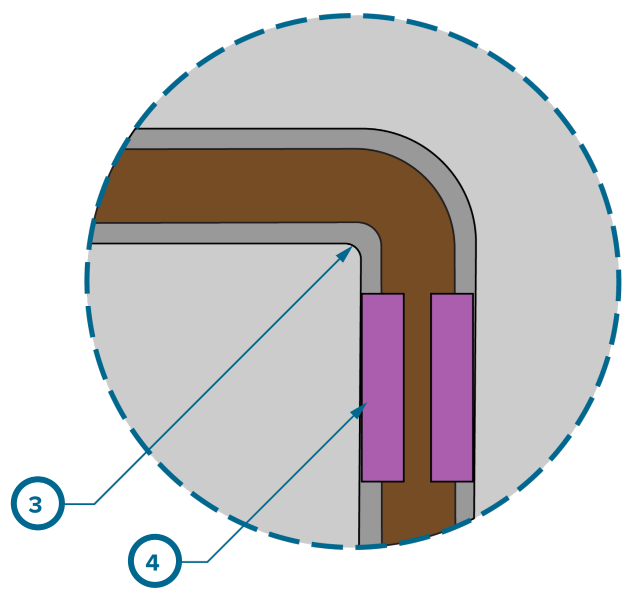
Provide a channel for the sensor cable 0.066” (1,68 mm [1 at right]) MAX DIA from the back of the sensor for 0.25” (6,4 mm [2 at right]) MIN. The sensor cable channel diameter and length are specified to ensure support for the sensor body under pressure while allowing clearance for the 0.050” (1,27 mm) x 0.030” (0,76 mm) wire. *The channel does not need to be enlarged as shown.*

CAUTION *DO NOT pull on sensor cable with greater than 6 lbs of force. DO NOT lay sensor cable in hot runner power channels. Failure to comply will result in damage to equipment.*

- Round cable pocket corners to prevent cutting wire. Minimum wire bend radius is 0.125” (3,18 mm [3 at right]).
- Use plastic cable retainers [4 at right] to hold the wire in channel to prevent pinching.

1	0.066” (1,68 mm) MAX DIA
2	0.25” (6,4 mm) MIN
3	0.125” (3,18 mm) MIN R.
4	plastic cable retainer





SENSOR WIRING

1. Remove cover.

Remove screws (1) from LS-QTTB-K, then remove cover plate.

2. Remove shield plate.

- Remove screws (2) from shield plate(3), then remove shield plate(3).

3. Insert thermocouple wire.

- Feed thermocouple wire (4) through the mounting gasket and wire slot (5) in bottom of module.

4. Connect negative (-) lead.

- Connect red wire (6) to the negative terminal.

5. Connect positive lead (+).

- Connect yellow wire (7) to positive terminal.

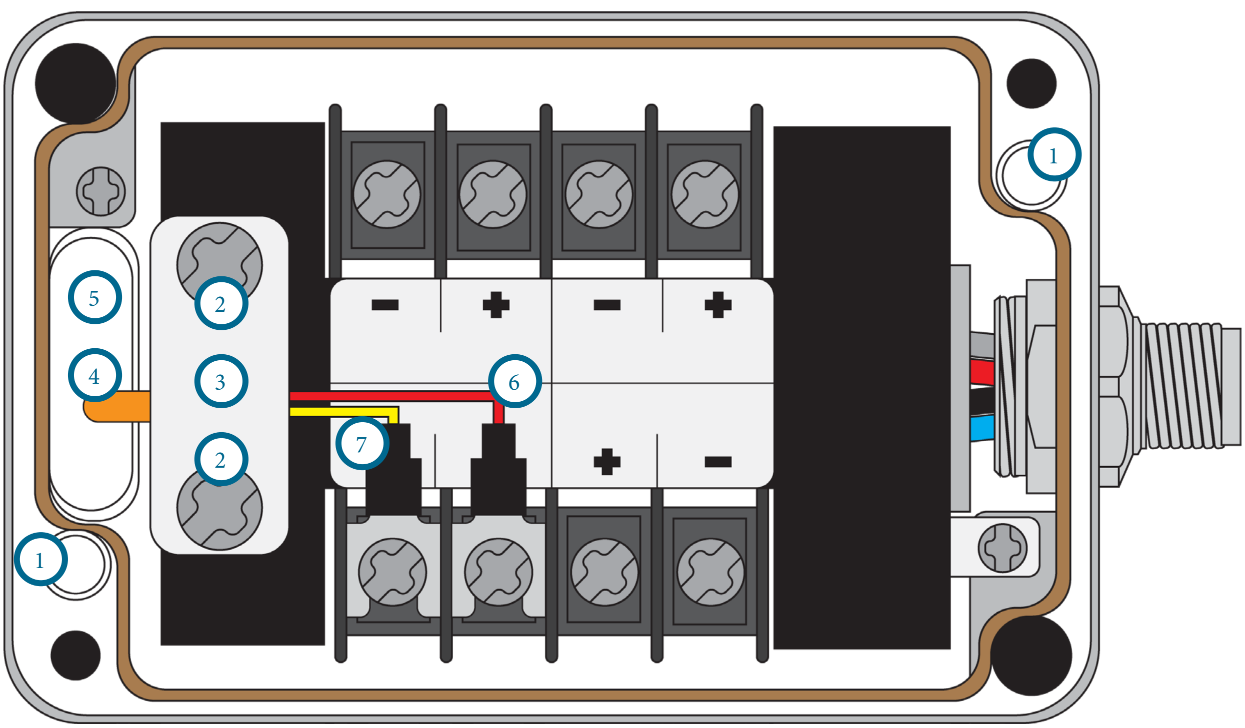
6. Install shield plate.

- Install shield plate (3) over the thermocouple wire with screws (2)—ensure the plate contacts the shield.

CAUTION *Do not over-tighten the plate; failure to comply will result in damage to equipment.*

7. Install cover plate.

- Install LS-QTTB-K cover plate with screws (1).



THERMOCOUPLE TYPE	THERMOCOUPLE WIRE COLORS	
Type K	Positive (+)	yellow
	Negative (-)	red

PRESS FIT SENSOR

After machining the sensor and cable pockets, feed the sensor cable through the pocket from the cavity face. Ensure the wire does not become damaged when the mold is turned on its side. When the sensor cable is routed, feed sensor head into the sensor pocket. Press the sensor head into the pocket using a pin with a larger diameter than the sensor head to prevent cracking the weld.

Once installed, the only way to remove a sensor is to drill it from the front, or punch it from the back, thus destroying it.

CAUTION ***Once installed, a sensor CANNOT be removed.*** *Attempts to remove sensor will result in destruction of sensor.*

CONTOURING OR SURFACING

Material can be removed from the sensor face for texturing or contouring; **the finished sensor length may not be less than 0.177" (4,496 mm)**. A maximum angle of 5° is acceptable *if one side is left at full height*. Failure to comply will result in damage to the thermocouple junction.

Improved response times can be achieved by removing the extra material from the sensor face; even in flat cavity surfaces, removal of material can improve the sensor response time.

TESTING

Test the sensor cable wire resistance with an ohmmeter during installation to confirm the proper resistance.

Negative (-)	Red	~1.8 Ω/ft
Positive (+)	Yellow	~4.6 Ω/ft

The red (-) wire should be ~1.8 Ω/ft. and the yellow ~4.6 Ω/ft. from between each lead stripped bare and the sensor face. Clip the millivoltmeter positive lead to the yellow sensor wire and negative to the red wire. Heat the face of the sensor slightly with a torch. The voltage reading on the meter should increase by 0.016 millivolts/ °F (0.03 millivolts / °C). The sensor temperature should raise to 64 °F to cause a +1 mV change, without any damage to the mold steel.

NOTES

MAINTENANCE

The TS-PF03-K temperature sensor requires little maintenance.

CLEANING

Keep sensor pocket, cable channel, and sensor components free from oil, dirt, grime, and grease.

TESTING & CALIBRATION

Thermocouples are known to have drift in calibration dependent upon time and temperature. To test calibration, check the thermocouple output against the thermocouple rating and electromagnetic field (EMF) tables in a known temperature source.

WARRANTY

RJG, Inc. is confident in the quality and robustness of the TS-PF03-K sensors, and so are offering a three-year warranty. RJG's cavity temperature sensors are guaranteed against defects in material and workmanship for three years from the ship date. The warranty is void if it is determined that the sensor was subjected to abuse or neglect beyond the normal wear and tear of field use, or in the event the sensor has been opened by the customer.

PRODUCT DISCLAIMER

RJG, Inc. is not responsible for the improper installation of this equipment, or any other equipment RJG manufactures.

Proper RJG equipment installation does not interfere with original equipment safety features of the machine. Safety mechanisms on all machines should never be removed.

NOTES

TROUBLESHOOTING

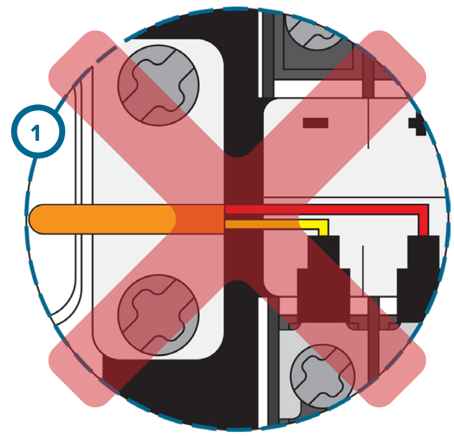
MEASUREMENT ERRORS

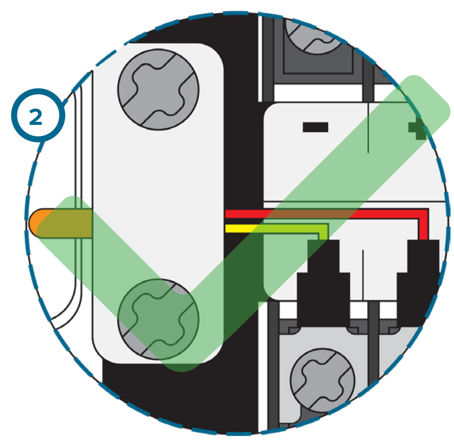
Errors in measurement can result from connection problems, lead resistance issues, or electrical noise.

CONNECTION PROBLEMS

Connections must be clean and free from oil, dirt, grime, and grease.

If shielded wire is used, the wire must run under the LS-QTTB-K shield plate (1 & 2 at right). The shield plate should be tightened and have good contact with the shielded thermocouple wire to reduce radio-frequency (RF) interference susceptibility.





WIRE EXTENSIONS

Thermocouple wires are typically thin, and have a high resistance, making them sensitive to noise. If extra wire is needed, use thermocouple extension wire between the thermocouple and measurement instrument. Thermocouple wire is much thicker and thus has a lower resistance.

NOISE

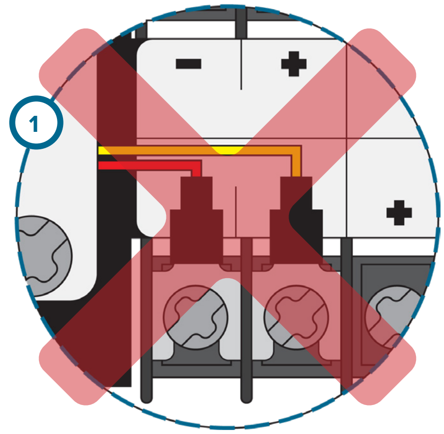
Electromagnetic interference (EMI), or RF, is caused by electric devices such as motors, and can result in measurement reading errors. If noise is suspected, turn off all equipment that is suspect while monitoring the reading to determine the source.

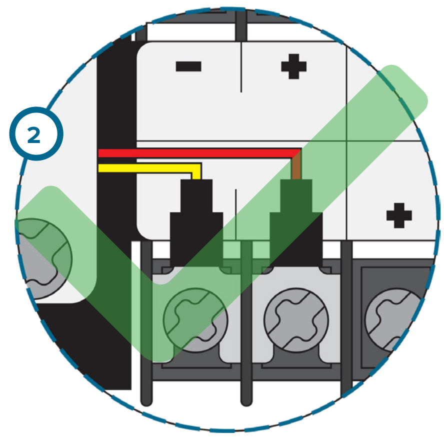
Thermocouples and wiring can short or open circuit causing error in signals. Check the thermocouple with a standard volt meter across the positive and negative leads to determine if the circuit is functioning correctly.

INSTALLATION ERRORS

REVERSED CONNECTIONS

Connections must not be reversed (1 & 2 at right). Reversed leads will provide a reading which will vary in the opposite direction relative to ambient temperature.





LOOSE CONNECTIONS

Ensure connections are firmly in place, but are no over-tightened. Over-tightening may crush the wires.

RELATED PRODUCTS

COMPATIBLE PRODUCTS

The TS-PF03-K temperature sensor is compatible with other RJG, Inc. products for use with the eDART or CoPilot process control and monitoring systems.

LYNX QUAD TEMPERATURE TERMINAL—TYPE K LS-QTTB-K

The Lynx quad temperature module LS-QTTB-K (1 at right) connects up to four TS-FM01-K temperature sensors to the eDART or CoPilot process control and monitoring systems in order to track barrel zone, mold, and mold coolant temperatures.

1

SIMILAR PRODUCTS

RJG, Inc. offers the following additional temperature sensors for flush-mount and cavity temperature applications.

SPRING-LOADED 1.5 MM TEMPERATURE SENSOR TS-SL01.5-K

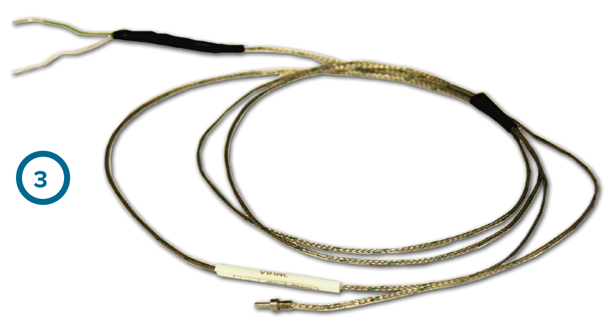
The TS-SL01.5-K 1.5 mm spring-loaded temperature sensor (2 at right) analyzes temperature variations inside the mold cavity when used with the Lynx quad temperature module LS-QTTB-K and the eDART or CoPilot systems.

2

FLUSH-MOUNT 1 MM CAVITY TEMPERATURE SENSOR TS-FM01-K

The flush-mount 1 mm cavity temperature sensor TS-FM01-K (3 at right) analyzes temperature variation inside the mold cavity. The TS-FM01-K is designed for use with RJG, Inc.'s Lynx™ Quad Temperature Module LS-QTTB-K—which receives input from up to four thermocouples—and the eDART or CoPilot system.

3



NOTES

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