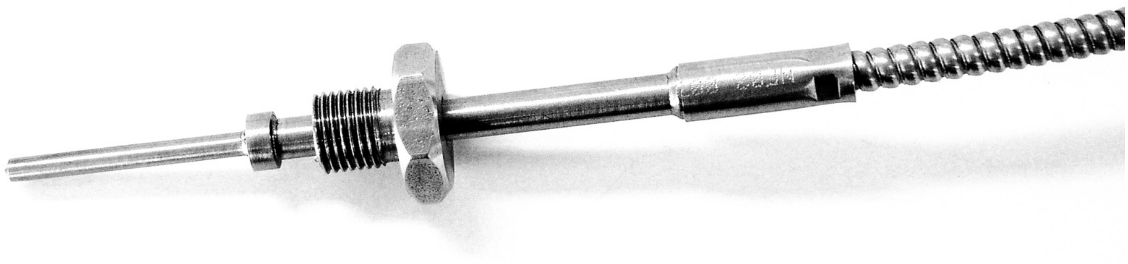
Hukseflux
Thermal Sensors

# USER MANUAL **NF02**

## Miniature needle type heat flux and temperature sensor



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# Warning statements

⚠ Follow the installation instructions of this manual. It contains safety notes, rated operating conditions, recommendations on installation and shielding, and requirements for maintenance.

⚠ We recommend use of NF02 in a decision-supporting role only, and not to use measurements of NF02 as the sole or main source of information supporting decision making or judgements on safety.

⚠ The measurement accuracy of NF02 depends on the quality of its thermal contact to its environment.

⚠ Putting more than 12 Volt across the sensor wiring can lead to permanent damage to the sensor.

⚠ Do not use "open circuit detection" when measuring the sensor output.

# Contents

# List of symbols

| Quantities | Symbol | Unit |
|---|---|---|
| Heat flux | $\Phi$ | W/m² |
| Voltage output | U | V |
| Sensitivity | S | V·m/K |
| Temperature | T | °C |
| Temperature difference | $\Delta T$ | °C |
| Resistance | R | Ω |
| Thermal conductivity | $\lambda$ | W/(m·K) |
| Temperature coefficient | $C_1$ | V·m/K |
| Temperature coefficient | $C_2$ | V·m/$K^2$ |
| Temperature coefficient | $C_3$ | V·m/$K^3$ |
| Temperature coefficient | $D_1$ | W/(m·K) |
| Temperature coefficient | $D_2$ | W/(m·$K^2$) |
| Temperature coefficient | $D_3$ | W/(m·$K^3$) |

**Subscripts**

N/A

# Introduction

NF02 measures temperature and heat fluxes. It is a small version of NF01, and is typically used in (injection) moulds. Measuring heat flux as well as temperature with one sensor is much more accurate and practical than using distributed temperature measurements. See the chapter on sensor theory for a detailed explanation. The same technology is used to manufacture heat flux sensors for different applications.

NF02's suggested use is in studies of energy balance of industrial processes and in studies of the energy balance in moulds. We recommend use of NF02 in a decision-supporting role only, and not to use measurements of NF02 as the main or sole source of information for judging safety.

The sensors inside NF02, a thermopile and a thermocouple, are protected by fully sealed stainless steel "needle" body. The part of the cabling closest to the sensor is a special high temperature metal sheathed cable, with an interlocked spiral stainless steel armour. The sensor as well as the high temperature cable and armour withstand temperatures up to 450 °C. The low temperature extension cable is made of PTFE. The sensor outputs are heat flux, an analogue voltage signal in the millivolt range, and temperature using a thermocouple type K. The user must know the thermal conductivity of the surrounding material to calculate the heat flux.

Using NF02 is easy. It can be connected directly to commonly used data logging systems. The heat flux Φ in $W/m^2$ is calculated by dividing the NF02 output, a small voltage U, by the sensitivity S and correcting for the thermal conductivity λ of the environment. The sensitivity S is provided with NF02 on its calibration certificate.

The measurement function of NF02 is:

$$\Phi = U \cdot \lambda / S \qquad \text{(Formula 0.1)}$$

The sensitivity S in V·m/K is temperature T dependent.

$$S = C_1 + C_2 \cdot T + C_3 T^2 \qquad \text{(Formula 0.2)}$$

The constants C are supplied on NF02's product certificate.

To work with NF02 the user must know the thermal conductivity of its environment as a function of temperature.

$$\lambda = D_1 + D_2 \cdot T + D_3 T^2 \qquad \text{(Formula 0.3)}$$

NF02's standard diameter is $3 \times 10^{-3}$ m and its standard temperature range is 450 °C. NF02 design is user-specific; needle diameter, needle length and temperature range are designed in cooperation with the user for the specific application. Optionally the sensor and cable temperature range can be extended to 700 °C.

Common options are:

- longer cable (specify total cable length in m for both cable types L2 and L3)
- needle lengths (specify L1)
- needle rated operating temperature range up to 700 °C (no spring)
- connector at NF02 cable end

For installation the user needs to drill a hole for the needle and tap a thread for the MF10 x 1 bolt.

See also:

- view our complete product range of heat flux sensors
- our industrial sensors
- NF01 needle type heat flux and temperature sensor (large version of NF02)

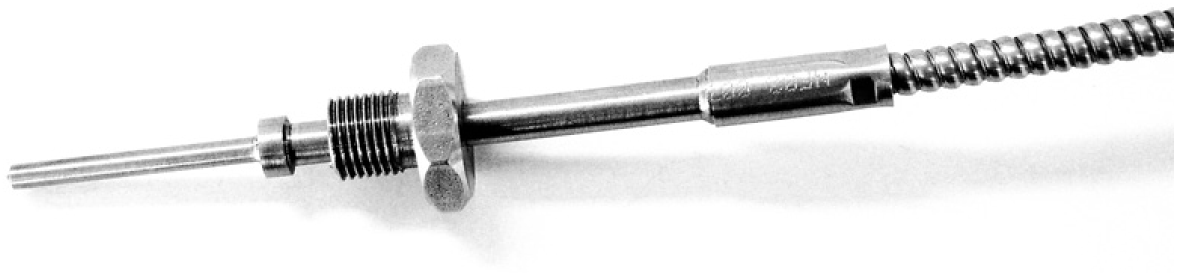

**Figure 0.1** *NF02, standard 3 x 10$^{-3}$ m diameter model, with spring loaded M10 x 1 coupling and high temperature cable. Not shown: low temperature extension cable.*

## 1.1 Ordering NF02

The standard configuration of NF02 is 30 x $10^{-3}$ m long with 0.1 m high temperature cable and 2.5 m low temperature extension cable. Every needle is supplied with a spring-loaded bolt coupling. The wiring colour code is according to IEC, with the thermocouple wires green and white.

For every needle the most important considerations are

- needle length
- cable lengths

Common options are:

- longer cable (specify total cable length in m  for both cable types L2 and L3)
- needle lengths (specify L1)
- needle rated operating temperature range up to 700 °C (no spring)

Less common options are:

- needle rated operating temperature range up to 1000 °C
- EC type examination certificate (ATEX) II 2 G EEx d IIC T6

For installation the user typically needs couplings and a set of tools:

- 3.2 mm diameter drills for the standard 3 x $10^{-3}$ m diameter NF02. For other models take a drill diameter of 5 to 6 % higher than the needle diameter. NF02 drills must be adapted to needle length
- drill and tap for the MF10 x 1 spring loaded bolt coupling

Optionally added parts are:

- connector at NF02 cable end
- low temperature extension cable with 2 connectors, matching cable connector and chassis connector
- chassis connector with internal wiring
  (colour code of wiring identical to cable colour code)

## 1.2 Included items

Arriving at the customer, the delivery should include:

- heat flux and temperature sensor NF02
- including cables of the lengths as ordered
- product certificate matching the instrument serial number

Upon arrival check at least the above including needle and cable lengths against the order. Perform a functionality check.

## 1.3 Quick instrument functionality check

A quick test of the instrument can be done by connecting it to a multimeter.

1 Check the electrical resistance of the heat flux sensor between the black [-] and red [+] wires and the thermocouple between the green [+] and white [-] wires. Use a multimeter at the 100 Ω range. Measure the sensor resistance first with one polarity, then reverse the polarity. Take the average value. Typical resistance should be the nominal sensor resistance of 5 Ω for the thermopile sensor at standard cable lengths, plus for additional low temperature extension cable 0.2 Ω/m (resistance per meter cable) for the total resistance of two wires (back and forth added), for high temperature cable 13 Ω/m. For the thermocouple work with 10 Ω at standard cable lengths, plus additional low temperature extension cable 3 Ω/m resistance per meter cable ), for high temperature cable 28 Ω/m. Infinite resistance indicates a broken circuit; zero or a lower than 1 Ω resistance indicates a short circuit.
2. Check if the heat flux sensor reacts to heat: put the multimeter at its most sensitive range of DC voltage measurement, typically the 100 x $10^{-3}$ VDC range or lower. Expose the sensor to heat, for instance exposing the tip to the flame of a lighter. The signal should read > 0.1 x $10^{-3}$ V now. Also look at the reaction of the thermocouple to heat.
3. Inspect the instrument for any damage.
4. Check the sensor serial number engraved on the transition piece between sensor and cable, against the certificate provided with the sensor.

# 2 Instrument principle and theory

NF02 is a sensor that measures heat flux and temperature. It is mainly used to measure heat flux in moulds at high heat flux levels. The heat flux sensor inside NF02 is a thermopile which measures a temperature difference along the axis of the NF02 needle. The user must know the thermal conductivity of the surrounding material to calculate the heat flux. The sensor outputs are heat flux, an analogue voltage signal in the millivolt range, and temperature using a thermocouple type K.

Using NF02 is easy. It can be connected directly to commonly used data logging systems. The heat flux Φ in W/$m^2$ is calculated by dividing the NF02 output, a small voltage U, by the sensitivity S and correcting for the thermal conductivity λ of the environment. The sensitivity S is provided with NF02 on its calibration certificate.

The measurement function of NF02 is:

$$\Phi = U \cdot \lambda / S \qquad \text{(Formula 0.1)}$$

The sensitivity S is temperature T dependent:

$$S = C_1 + C_2 \cdot T + C_3 T^2 \qquad \text{(Formula 0.2)}$$

For the standard geometry NF02:

$$S = (1.239\,069\,347\,319\,4 - 0.000\,258\,111\,888\,1\ T + 0.000\,000\,791\,608\,4\ T^2) \qquad \text{(Formula 2.1)}$$

The constants C are supplied on NF02’s calibration certificate.

To work with NF02 the user must know the thermal conductivity of its environment as a function of temperature.

$$\lambda = D_1 + D_2 \cdot T + D_3 T^2 \qquad \text{(Formula 0.3)}$$

The measurement accuracy of NF02 depends on the quality of the thermal contact to its environment. The hole in which NF02 is inserted must have a tight fit around the sensor.

For a reliable heat flux measurement, NF02 performs significantly better than a network of distributed individual temperature sensors:

- NF02 creates a single temperature difference signal. This is much more accurate than calculating a heat flux by subtracting two individual temperature measurements. If a heat flux is calculated from two temperature measurements, you subtract two large values with large uncertainties to calculate a small difference, which then has a similarly large uncertainty.
- NF02 sensors can be quickly installed; contrary to spatially distributed temperature sensors, the relative position of the sensors used for the temperature difference measurement is already determined during manufacturing. The exact depth of insertion is not a critical factor determining the accuracy of this relative position. Installation can be done quickly with little training.
- NF02 sensors are fully exchangeable. Contrary to spatially distributed temperature sensors, the sensors in the NF02 are "matched pairs". This is essential to attain the best possible temperature difference measurement.
- NF02 has a fast heat flux response time: the high accuracy makes it possible to measure a temperature difference over a small distance.

NF02's standard diameter is 3 x $10^{-3}$ m and its standard temperature range is 450 °C. NF02 design is user-specific; needle diameter, needle length and temperature range are designed in cooperation with the user for the specific application.

# 3 Specifications of NF02

## 3.1 Specifications of NF02

NF02 measures heat flux and temperature. The heat flux sensor inside NF02 is a thermopile which measures a temperature difference along the axis of the NF02 needle. The measurement accuracy of NF02 relies on good thermal contact to its environment. You must know the thermal conductivity of the surrounding material to calculate the heat flux. The sensor outputs are heat flux, an analogue voltage signal in the millivolt range, and temperature using a thermocouple type K. NF02 is a passive sensor; it does not need power. It can only be used in combination with a suitable measuring system. The sensor should be used in accordance with the recommended practices this manual.

**Table 3.1** *Specifications of NF02 (continued on next pages)*

| **NF02 SPECIFICATIONS** | |
|---|---|
| Sensor type | miniature needle type heat flux and temperature sensor |
| Heat flux sensor | thermopile |
| Measurand | heat flux |
| Measurand in SI units | heat flux density in W/m$^2$ |
| Rated measurement range | 0.05 to 50 x 10$^3$ W/m$^2$ (typical) |
| Temperature sensor | thermocouple type KX |
| Temperature sensor specification | ANSI MC96.1-1982 / EN 60584 |
| Measurand | temperature |
| Measurand in SI units | temperature in °C |
| Measurement range | -30 to 450 °C |
| Rated operating temperature range<br>sensor and high temperature cable<br>sensor optional (no spring)<br>low temperature extension cable | <br>-30 to +450 °C<br>-30 to +700 °C<br>-30 to +240 °C |
| Measurement function / required programming | $\Phi = U \cdot \lambda / S$<br>$S = C_1 + C_2 \cdot T + C_3 T^2$<br>$\lambda = D_1 + D_2 \cdot T + D_3 T^2$ |
| Sensitivity for standard geometry | S = (1.239 069 347 319 4 – 0.000 258 111 888 1 T + 0.000 000 791 608 4 T$^2$) |
| Required input to the measurement equation | thermal conductivity of the material surrounding the needle as a function of temperature<br>$\lambda = D_1 + D_2 \cdot T + D_3 T^2$ |
| Recommended number of sensors | 2 per measurement location |
| Sensitivity (nominal) | 1.2 x 10$^{-6}$ V·m/K |
| Response time (95 %) | depends on surrounding material |
| Expected voltage output | depends on heat flux and measurement environment typically 5 x 10$^{-3}$ V |
| Required readout | heat flux sensor: 1 x differential voltage channel or 1 x single ended voltage channel<br>temperature sensor: 1 x Type K differential thermocouple channel or 1 x Type K single ended thermocouple channel<br>both with input resistance > 10$^6$ Ω |
| IP protection class<br>Needle and high temperatiur ecable<br>Low temperature extension cable | <br>IP68<br>IP64 |

**Table 3.1** *Specifications of NF02 (started on previous page, continued on the next page)*

| | |
|---|---|
| High temperature cable type | metal sheathed mineral insulated cable |
| Low temperature extension cable type | PTFE signal cable with shield |
| Rated operating relative humidity range | 0 to 100 % |
| Required sensor power | zero (passive sensors) |
| Needle length | specified by the user |
| Standard needle length | 30 x $10^{-3}$ m |
| Needle diameter | 3 x $10^{-3}$ m |
| Standard cable lengths<br>High temperature cable<br>Low temperature extension cable | <br>0.1 m (see options)<br>2.5 m (see options) |
| Heat flux sensor resistance (nominal) | 5 Ω (standard cable length) |
| Low temperature extension cable: heat flux sensor cable resistance | 0.2 Ω/m (nominal) |
| High temperature cable: heat flux sensor cable resistance | 13 Ω/m (nominal) |
| Thermocouple resistance (nominal) | 10 Ω (standard cable length) |
| Low temperature extension cable: temperature sensor cable resistance | 3 Ω/m (nominal) |
| High temperature cable: temperature sensor cable resistance | 28 Ω/m (nominal) |
| High temperature metal interlocked spiral armour diameter | 5 x $10^{-3}$ m |
| Low temperature extension cable diameter | 4 x $10^{-3}$ m |
| Transition piece diameter | 10 x $10^{-3}$ m |
| Marking | 1 x engraving on the needle to cable transition piece, showing serial number<br>1 x sticker at cable end, showing serial number |
| Net weight | approx. 0.5 kg (standard version) |
| Equipment status according to directive 2014/34 EU | NF02 is a passive sensor which does not have its own source of ignition. It becomes equipment in the sense of Article 2 of the directive only when operating in combination with other equipment. |
| **GENERAL INSTALLATION AND USE** | |
| Location | see recommendations in this user manual |
| Installation | see recommendations in this user manual<br>The measurement accuracy of NF02 depends on the quality of its thermal contact to its environment. Make sure there is good thermal contact. |
| Cable extension | see options: longer cable, extension cable and connectors |
| **MEASUREMENT TRACEABILITY** | |
| Traceability | to ITS90 and distance |
| Product certificate | included (showing traceability and dimensional verification during production) |
| On-site testing | Is possible by comparison to a reference sensor of the same type, mounted side by side under similar conditions. |
| Temperature sensor tolerance class | IEC Tolerance class EN60584-2: Type KX, class 2 |
| Temperature sensor error limits | ASTM E230-ANSI MC96.1: Type KX, standard limits |
| **MEASUREMENT ACCURACY** | |
| Uncertainty of the measurement | statements about the overall measurement uncertainty can only be made on an individual basis. |

**Table 3.1** *Specifications of NF02 (started on previous 2 pages)*

| | |
|---|---|
| **VERSIONS / OPTIONS** | |
| Sensor design | NF02 design is user-specific; needle diameter, needle length and temperature range are designed in cooperation with the user for the specific application |
| Order code | NF02/L1/L2/L3<br>L1 to L3 in x $10^{-3}$ m |
| Standard version | NF02/30/100/2500 |
| Option | needle and high temperature cable temperature range to 700 °C (no spring) |
| Option | longer cable (specify total cable length for both cable types L2 and L3) |
| Option | needle length (specify L1) |
| Option | EC type examination certificate (ATEX) II 2 G EEx d IIC T6 |
| **ACCESORIES** | |
| Connector | connector at NF02 cable end |
| Extension cable | low temperature extension cable with 2 connectors with 2 connectors matching cable connector and chassis connector (specify cable length in m) |
| Chassis connector | chassis connector with internal wiring<br>(colour code of wiring identical to cable colour code) |

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## 3.2 Dimensions of NF02

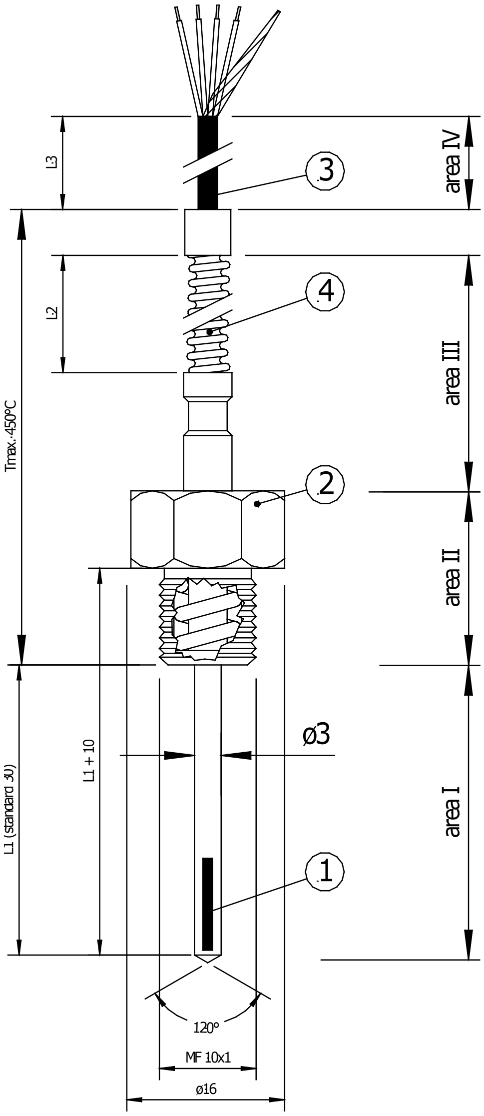


**Figure 3.2.1** *NF02 miniature needle type heat flux and temperature sensor is used for high temperature applications: (1) heat flux sensor & thermocouple location, (2) spring loaded bolt (MF10 x 1), (3) low temperature extension cable, (4) high temperature cable with metal interlocked spiral armour. Dimensions in x* $10^{-3}$ *m*

# 4 Installation of NF02

## 4.1 Electrical connection

A heat flux sensor should be connected to a measuring system, typically a so-called datalogger. NF02 is a passive sensor that does not need any power, neither for the heat flux sensor, nor for the temperature sensor. Cables may act as a source of distortion, by picking up capacitive noise. We recommend keeping the distance between a datalogger or amplifier and the sensor as short as possible.

**Table 4.1.1** *The electrical connection of NF02. Standard IEC colour code; the IEC code for thermocouple K is green / white.*

| WIRE | |
|---|---|
| Red | heat flux signal [+] |
| Black | heat flux signal [−] |
| Green | thermocouple type K [+] |
| White | thermocouple type K [−] |
| Blank | shield |

## 4.2 Installation

**Table 4.2.1** *General recommendations for use of NF02 heat flux sensors*

| | |
|---|---|
| Location | NF02 sensors are located at carefully selected locations.<br><br>The measurement accuracy of NF02 depends on the quality of its thermal contact to its environment. Make sure there is good thermal contact for example by using thermal paste. |
| Performing a representative measurement | we recommend using > 2 sensors per measurement location.<br><br>this redundancy also improves the assessment of the measurement accuracy |
| Signal amplification | ask the manufacturer for recommendations for signal amplification / conversion |

**Table 4.2.2** *Recommendations for installation of NF02 heat flux sensors*

| | |
|---|---|
| 1 | drill and tap for the MF10 x 1 spring loaded bolt |
| 2 | drill using a standard 3.2 mm drill (for the standard 3 x $10^{-3}$ m diameter needle, adapted diameter for other needle diameters. The drill diameter should be close to the needle diameter to ensure good thermal contact. |
| 3 | screw the NF02 spring loaded bolt on the tapped hole.<br>if possible use locally approved thermal paste to promote thermal contact between the hole and the needle for example using thermal paste |

# 5 Recommended practices for use

## 5.1 Short user guide

**Table 5.1** *Recommended practices for use*

| **NF02 RECOMMENDED PRACTICES FOR USE** | | |
|---|---|---|
| 1 | Read the full manual | |
| 2 | Determine options | choose needle length, cable lengths, needle temperature range, connectors |
| 3 | Design mounting and amplification | see the chapter on electrical connection and installation |
| 4 | Determine mounting and tooling requirements | drills, use of locally approved thermal paste |
| 5 | Ordering | |
| 6 | Unpack NF02 | check shipment contents (see paragraph on included items) against the order |
| 7 | Check sensor functionality | see the paragraph on the functionality test |
| 8 | Install | see the directions on installation |
| 9 | Check performance | verify by comparing measured heat flux to a reference measurement at a spot where sensors of the same type can be mounted side by side |
| 10 | Check inspection / maintenance / verification procedures | check the maintenance schedule |

# 6 Maintenance and trouble shooting

## 6.1 Recommended maintenance and quality assurance

NF02 measures reliably at a low level of maintenance, but does require frequent inspection. Unreliable measurement results are detected by scientific judgement, for example by looking for unreasonably large or small measured values. The preferred way to obtain a reliable measurement is a regular critical review of the measured data, preferably checking against other (nearby) measurements.

**Table 6.1.1** *Recommended maintenance of NF02. If possible the data analysis is done on a daily basis.*

| **MINIMUM RECOMMENDED HEAT FLUX SENSOR MAINTENANCE** | | | |
|---|---|---|---|
| | INTERVAL | SUBJECT | ACTION |
| 1 | 1 week | data analysis and inspection | compare measured data to the maximum possible or maximum expected heat flux and to other measurements for example from nearby or redundant instruments. Historical records can be used as a source for expected values. Look for any patterns and events that deviate from what is normal or expected. Compare to acceptance intervals |
| 2 | 6 months | inspection | inspect, inspect cable quality, inspect mounting, inspect location of installation |
| 3 | 2 years | on-site check | check the sensor in the field, see following paragraphs |
| 4 | | lifetime assessment | judge if the instrument will be reliable for another 2 years, or if it should be replaced |

## 6.2 Trouble shooting

**Table 6.2.1** *Trouble shooting for NF02*

| | |
|---|---|
| General | Inspect the sensor for any damage. Inspect the quality of mounting / installation.<br>Inspect if the wires are properly attached to the data logger.<br>Check the condition of the cable.<br>Inspect the connection of the shield (typically connected at the datalogger side).<br>Check the datalogger program in particular if the right sensitivity is entered.<br>NF02's sensor serial number is engraved on the transition piece between sensor and cable. The sensitivity can be found on the calibration certificate.<br>Check if the right thermal conductivity of the environment is entered.<br><br>Check the electrical resistance of the heat flux sensor between the black [-] and red [+] wires and the thermocouple between the green [+] and white [-] wires. Use a multimeter at the 100 Ω range. Measure the sensor resistance first with one polarity, then reverse the polarity. Take the average value. Typical resistance should be the nominal sensor resistance of 5 Ω for the thermopile sensor at standard cable lengths, plus for additional low temperature extension cable 0.2 Ω/m (resistance per meter cable ) for the total resistance of two wires (back and forth added), for high temperature cable 13 Ω/m. For the thermocouple work with 10 Ω at standard cable lengths, plus additional low temperature extension cable 3 Ω/m resistance per meter cable ), for high temperature cable 28 Ω/m. Infinite resistance indicates a broken circuit; zero or a lower than 1 Ω resistance indicates a short circuit. |
| The sensor does not give any signal | Check if the heat flux sensor reacts to heat: put the multimeter at its most sensitive range of DC voltage measurement, typically the 100 x $10^{-3}$ VDC range or lower. Expose the sensor to heat, for instance exposing the tip to the flame of a lighter. The signal should read > 0.1 x $10^{-3}$ V now.<br>Check the reaction of the thermocouple sensor to heat.<br>Check the data acquisition by replacing the sensor with a spare unit. |
| The sensor signal is unrealistically high or low | Check the cable condition looking for cable breaks.<br><br>Compare data to data coning from nearby sensors, for example sensor mounted at the same location but at a different depth.<br><br>Check the data acquisition by applying a 1 x $10^{-6}$ V source to it in the 1 x $10^{-6}$ V range. Look at the measurement result. Check if it is as expected.<br>Check the data acquisition by short circuiting the data acquisition input with a 10 Ω resistor. Look at the output. Check if the output is close to 0 W/m$^2$. |
| The sensor signal shows unexpected variations | Check the presence of strong sources of electromagnetic radiation (radar, radio).<br>Check the condition and connection of the shield.<br>Check the condition of the sensor cable.<br>Check if the cable is not moving during the measurement. |

## 6.3 NF02 diagnostics

The following tables are use for checking and trouble shooting NF02.

**Table 6.3.1** *Resistance checks for diagnostics of NF02 with IEC wire cladding colour*

| WIRE | WIRE | RESISTANCE ACCEPTANCE INTERVAL |
|---|---|---|
| Red | Black | 5 Ω at standard cable length, 0.2 Ω/m for low temperature extension cable, 13 Ω/m for high temperature cable |
| Red | Green | several Ω |
| Red | Body | infinite (> $10^6$ Ω) |
| Green | White | 10 Ω at standard cable length, 3 Ω/m for low temperature extension cable, 28 Ω/m for high temperature cable |
| Green | Body | infinite (> $10^6$ Ω) |
| Blank shield/ drain wire | Body | infinite (> $10^6$ Ω) |

## 6.4 Checks in the field

On-site field check is possible by comparison to a reference sensor, temporarily mounted side by side.

Hukseflux main recommendations for field checks are:

1) to compare to a new sensor
2) use high heat flux levels

# 7 Appendices

## 7.1 Example calculations

For Steel HII, a typical shell / mantle material, one might use (accuracy relative to the literature value within ± 2 % from 50 to 500 ° C):

$\lambda = 51.508 - 0.0082\ T - 0.000003\ T^2$ (Formula 7.1.1)

Formula 0.1 now becomes:

$\Phi = U\ (51.508 - 0.0082T - 0.000003\ T^2) / (1.239\ 069\ 347\ 319\ 4 - 0.000\ 258\ 111\ 888\ 1\ T + 0.000\ 000\ 791\ 608\ 4\ T^2)$ (Formula 7.1.2)

with $\Phi$ in $W/m^2$ and U in x $10^{-6}$ V

## 7.2 EU declaration of conformity

| | |
|---|---|
| We, | Hukseflux Thermal Sensors B.V.<br>Delftechpark 31<br>2628 XJ Delft<br>The Netherlands |

in accordance with the requirements of the following directive:

| | |
|---|---|
| 2014/30/EU | The Electromagnetic Compatibility Directive |

hereby declare under our sole responsibility that:

| | |
|---|---|
| Product model: | NF02 |
| Product type: | Miniature needle type heat flux and temperature sensor |

has been designed to comply and is in conformity with the relevant sections and applicable requirements of the following standards:

| | |
|---|---|
| Emission: | EN 61326-1: 2013 |
| Immunity: | EN 61326-1: 2013 |

Eric HOEKSEMA
Director
Delft
March 01, 2016