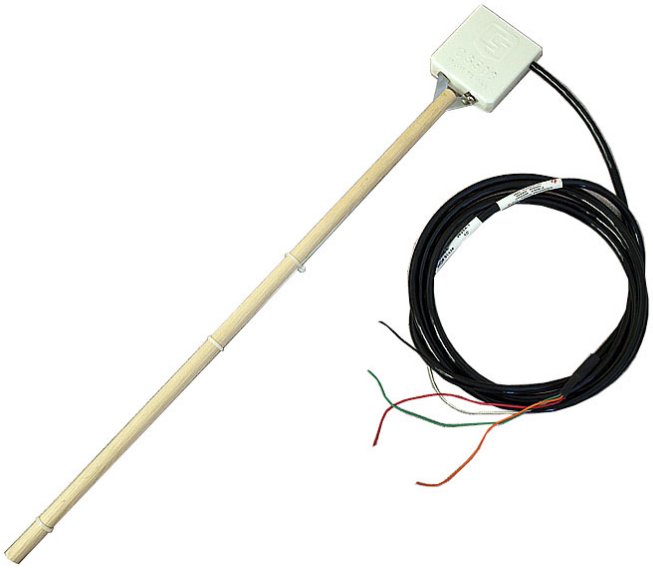
INSTRUCTION MANUAL

CS506 Fuel Moisture Sensor

Revision: 7/15



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Logan, Utah 84321-1784

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General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

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CS506 Fuel Moisture Sensor

1. Introduction

The CS506 fuel moisture sensor measures the moisture content of the 26601 10-hour fuel moisture stick. The 26601 emulates the moisture content of similarly sized twigs on the forest floor. The CS506/26601 combination is used to assess forest fire fuel and is often incorporated in our prewired or custom fire-weather stations.

NOTE This manual provides information only for CRBasic dataloggers. It is also compatible with our retired Edlog dataloggers. For Edlog datalogger support, see an older manual at *www.campbellsci.com/old-manuals* or contact a Campbell Scientific application engineer for assistance.

2. Cautionary Statements

- READ AND UNDERSTAND the *Precautions* section at the front of this manual.
- Avoid touching the dowel of the 26601 fuel moisture stick with your bare hands. Your hands can contaminate the dowel with oils and dirt that can affect the measurements.

3. Initial Inspection

- Upon receipt of the CS506 and 26601, inspect the packaging and contents for damage. File damage claims with the shipping company.
- The model number and cable length are printed on a label at the connection end of the cable. Check this information against the shipping documents to ensure the expected product and cable length are received.

4. Overview

Traditionally, the standard fuel moisture stick consists of a rack of four 0.5 inch diameter ponderosa pine dowels. The resulting rack is about 20 inches long with an oven-dry weight of 100 grams. The characteristic time constant of the rack is 10 hours. The rack is mounted 12 inches or about 30 centimeters above the forest floor. The rack is left outside continually exposed to the same conditions as forest fuels. The rack absorbs and desorbs moisture from its surroundings. As the rack transfers moisture, its weight changes. Periodic weighing of the rack determines changes in moisture content and provides an indication of moisture changes in forest fuels.

A disadvantage of the traditional weighing racks is that you cannot remotely monitor the changing fuel conditions. Campbell Scientific's CS506/26601 combination supports this while providing similar measurements.

The CS506 consists of a printed circuit board encapsulated in a waterproof epoxy housing. A shielded four-conductor cable is connected to the circuit board to supply power, enable the electronics, and monitor the signal output.

The 26601 10-hour fuel moisture stick includes two stainless steel strips pressed into grooves carved in a carefully selected USFS standard ponderosa dowel. Nylon tie wraps secure the dowel to the stainless-steel strips. The 26601 connects to the CS506 with two Phillips head screws. Because the complete dowel surface is accessible for moisture exchange, the response of the CS506 is similar to that of the traditional weighing rack.

4.1 Dowel Selection

The 26601 Fuel Moisture Stick uses the same dowel as used by the traditional weighing fuel moisture racks. No artificial materials such as epoxy sealant are added to the dowel that would adversely influence its natural characteristics.

To optimize stick-to-stick repeatability and to allow stick interchangeability without individual calibration, two additional sorts are performed on the dowels before they are selected to be used as a 26601 fuel moisture stick. First, the dowels are sorted dry by density to improve accuracy in the dry range of 0 to 15%. Second, the dowels are sorted after a 50-minute soak by weight to reduce probe-to-probe time response variation and minimize variability in the wet range of 20 to 50%.

Even after careful selection and sorting is performed to choose the most representative dowels, the majority of measurement error is due to the variability of wood. Wood's ability to transfer moisture is dependent on many variables, primarily cell structure and wood resin content. These variables change over time and after repeated wetting and drying cycles. Only a small amount of overall measurement error is due to the electronic circuitry.

4.2 CS506 Measurement Technique

High speed electronic components on the circuit board are configured to oscillate when power is applied. The output of the circuit is connected to the 26601 fuel moisture stick which acts as a wave guide. The oscillation frequency and therefore output signal of the circuit is dependent on the dielectric constant of the media surrounding the stainless steel strips. The dielectric constant is predominantly dependent on the water content of the wood. Digital circuitry scales the oscillation frequency to an appropriate range that our dataloggers can measure.

The CS506 output is essentially a square wave with an amplitude of ±0.7 Vdc. The frequency of the square wave output ranges from approximately 31 to 58 kHz. Its output period ranges from 17 to 32 μs.

5. Specifications

Features:

- Companion product to CS205/107 fuel temperature sensor; can be mounted on the same stake
- Can automatically monitor changing fuel conditions without having to visit the measurement site
- Compatible telemetry options include spread spectrum radios, narrow-band radios, cellular phones, and satellite transmitters
- Compatible with Campbell Scientific CRBasic dataloggers: CR6, CR800, CR850, CR1000, CR3000, and CR5000

***Fuel moisture accuracy:**
(with a new stick)

range	90% of all measurements	rms error
0 to 10%	±1.25%	±0.74%
10 to 20%	±2.00%	±0.90%
20 to 30%	±3.40%	±1.94%
30 to 50%	±4.11%	±2.27%

Range: 0 to 50%

Power Supply: 5 Vdc minimum to 18 Vdc maximum

Enable voltage: off at 0 V (<1 Vdc)
on at 5 V (>4 Vdc maximum 18 Vdc)

Current usage: 65 mA active/ 45 µA quiescent

Output signal: ±0.7 V square wave with an output frequency of approximately 31 to 58 kHz.

Weight: <0.5 kg (<1 lb)

Dimensions
Dowel: 1.3 cm (0.5 in) diameter, 50.8 cm (20 in) long
Electronics: 10.2 x 6.4 x 1.9 cm (4 x 2.5 x 0.75 in)

*The above accuracy is a static accuracy derived at slow changing conditions with experimental data for the CS505.

6. Installation

6.1 26817 Mounting Kit

The CS506/26601 is typically mounted with the CS205/107 using the 26817 Mounting Kit (FIGURE 6-1 and FIGURE 6-2). The kit's bracket places the probes in a horizontal position.

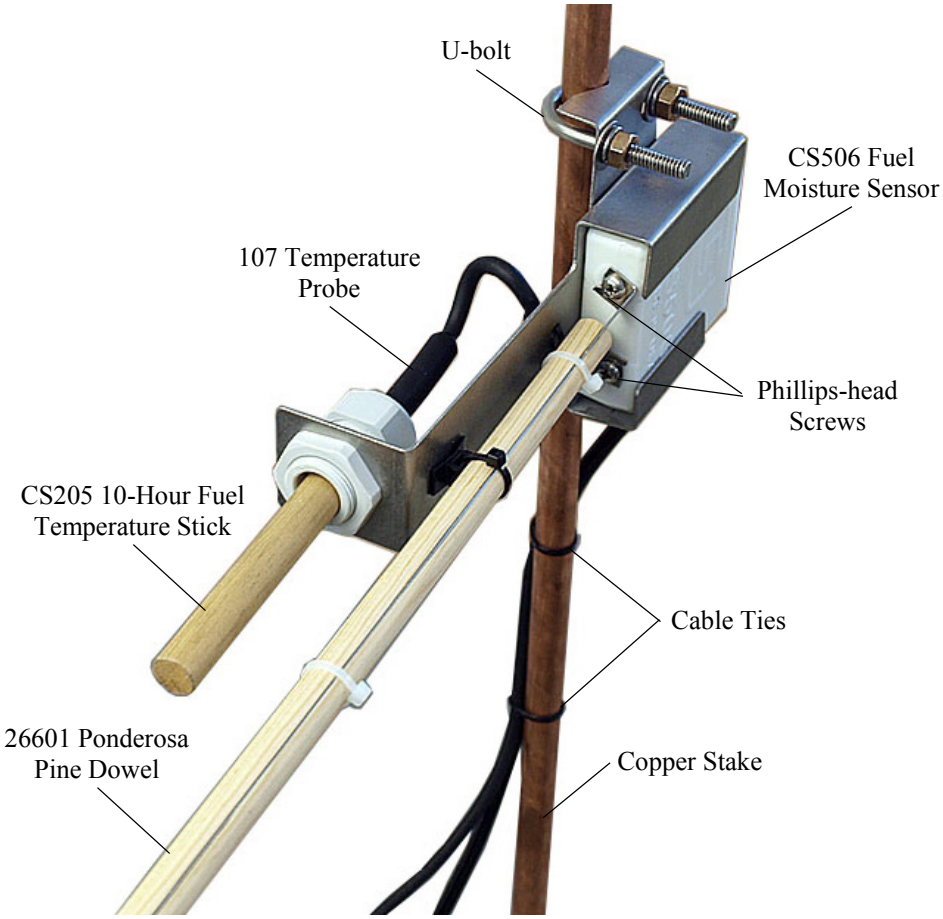

FIGURE 6-1. Front view of the 26817 fuel moisture/temperature mounting stake

1. Choose a site that is representative of the forest-floor duff layer.
2. Carefully hammer the copper stake into the ground so that it is secure and vertical.
3. Place the mounting bracket on the copper stake so that the probes will be approximately 30 cm (12 in) above the ground and pointing south (northern hemisphere) or north (southern hemisphere).
4. Tighten the nuts on the U-bolts.
5. Insert the CS506 electronics into the bracket.
6. Secure the 26601 10-hour fuel moisture stick to the CS506 using the Phillips screws.

CAUTION Wear gloves to avoid touching the dowel with your bare hands. Your hands can contaminate the dowel with oils and dirt that can affect the measurements.

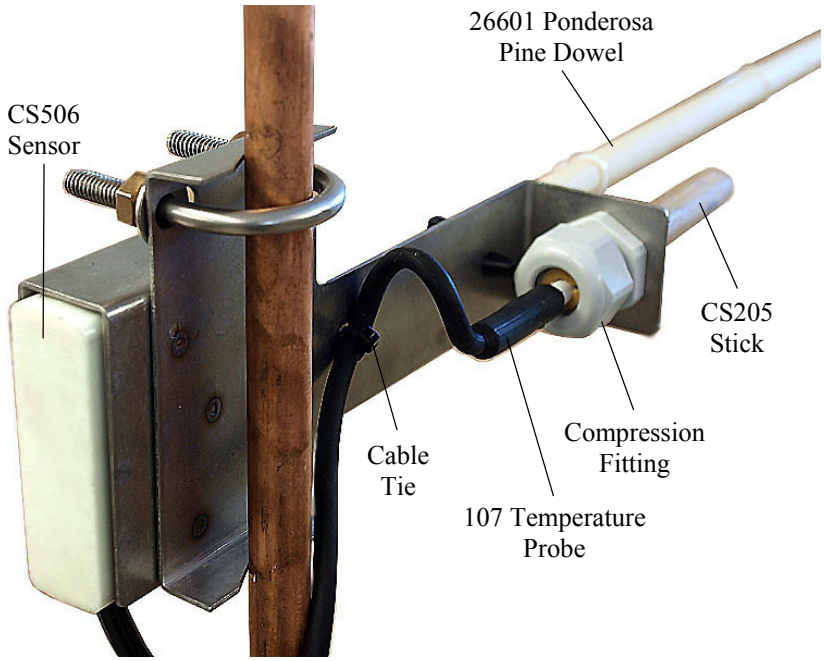

FIGURE 6-2. Back view of the 26817 fuel moisture/temperature mounting stake

7. Insert the CS205 fuel temperature stick into the mounting stake's compression fitting.

8. Insert the 107 temperature probe into the CS205 stick.

9. Tighten the compression fitting so that it compresses the split wood and snugly holds the 107 probe.

10. Use the ultraviolet light resistant cable ties included in the 26817 mounting kit to secure the cables. One cable tie passes through the two slots in the bracket to loosely secure the cable of the CS205/107 (FIGURE 6-2). The other two cable ties secure both cables to the copper stake (FIGURE 6-1).

6.2 Wiring

Connections to Campbell Scientific dataloggers are given in TABLE 6-1.

TABLE 6-1. CS506 Wiring

Color	Description	CR800, CR1000, CR3000, CR5000	CR6
Red	Power	12 V	12 V
Black	Ground	G	G
Green	Signal	Single-Ended Channel	Universal Channel
Orange	Enable	Control Port	Control Port
Clear	Ground	⏚	⏚

6.3 Datalogger Programming

The CS506 has a built-in enable circuit. When voltage on the enable lead is less than 1 Vdc, the sensor is off. When a voltage greater than 4 Vdc, commonly 5 Vdc, is applied to the enable lead, the sensor is on. The output signal is a ±0.7 volt square wave. The CRBasic instruction **PeriodAvg()** is used to measure the period of the output signal in microseconds on a single-ended analog input channel.

Since fuel moisture does not change very rapidly, the sensor is typically measured only once per hour.

After the period of the output signal in microseconds is measured, it is converted to percent water content using one of two equations:

$$\theta(\tau \leq 17.7) = 7.6298\tau - 130.0904$$

$$\theta(\tau > 17.7) = 0.0406\tau^2 + 3.7685\tau - 73.7974$$

Where θ is the percent of water by weight in the fuel moisture stick and τ is period average in microseconds.

There is a slight disconnect in the two equations at 17.7 µs where the linear equation gives a water content of 4.98% while the quadratic equation gives 5.68%. A sudden small increase or decrease in the measured water content near 5% is to be expected as the datalogger changes from one equation to the other.

A complete CR1000 program can be found in Appendix A, *Example Program* *(p. A-1)*. Programming basics and programming examples for Edlog dataloggers are provided at *www.campbellsci.com\old-manuals.*

7. Maintenance

Replace the 26601 Fuel Moisture Stick each spring; more frequent replacements may be required in some environments. The more wet/dry cycles the dowel experiences, the more frequently it will need to be replaced.

To change the 26601 Fuel Moisture Stick, loosen the Phillips-head screws and remove the old fuel moisture stick. Replace it with the new 26601 Fuel Moisture Stick and tighten the screws.

CAUTION Wear gloves to avoid touching the dowel of the 26601 fuel moisture stick with your bare hands. Your hands can contaminate the dowel with oils and dirt that can affect the measurements.

Appendix A. Example Program

A.1 CR1000 Programming

The following program measures a CS506 fuel moisture sensor using the CRBasic **PeriodAvg()** instruction.

```
'CR1000

'CR1000 Program for CS506

'Declare Variables and Units
Public FuelM
Public PA_uS

Units FuelM=%
Units PA_uS=uSec

'Define Data Tables
DataTable(Table1,True,-1)
  DataInterval(0,60,Min,10)
  Sample(1,FuelM,FP2)
  Sample(1,PA_uS,FP2)
EndTable

'Main Program
BeginProg
  Scan(10,Sec,1,0)
    'CS506 Fuel Moisture Sensor measurement FuelM and PA_uS:
    If IfTime(0,1,Hr) Then
      PortSet (1,1)
      PeriodAvg(PA_uS,1,mV250,1,0,0,100,10,1,0)
      PortSet (1,0)
      If PA_uS <= 17.7 Then
        FuelM = 7.6298* PA_uS - 130.0904
      Else
        FuelM= 0.0406* PA_uS ^2 + 3.7685 * PA_uS -73.7974
      EndIf
    EndIf
    'Call Data Tables and Store Data
    CallTable(Table1)
  NextScan
EndProg
```

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