Cooperation Centre for Scientific Research Relative to Tobacco

TSNA in Air-Cured and Fire-Cured Tobacco Sub-Group

CORESTA Guide N° 23

Placement of Data Loggers in Air-cured Barns and Data Logger Maintenance

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Author:
Colin Fisher, University of Kentucky, U.S.A.
Co-Author:
Andy Bailey, University of Kentucky, U.S.A.

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Technical Guide for the Placement of Data Loggers in Air-cured Barns
and Data Logger Maintenance

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1. Introduction

This document is a guide that describes the placement of data loggers in air-curing barns to monitor humidity and temperature during curing. These data are useful in studies relating aspects of leaf chemistry, such as tobacco-specific nitrosamines and leaf quality, to the barn environment.

2. Recommendations for Placement of Data Loggers to Measure Environmental Conditions during Air- and Fire-Curing

- A minimum of two data loggers should be used per barn or curing structure.
  - These loggers should be placed near the center of the barn, equidistant from the perimeter of the barn. This is particularly important in fire-cured barns that tend to be hotter in the center than near end doors.
  - For multiple tiers, data loggers should be placed in the top and bottom tiers of structure.
- When tobacco is not all housed in the barn at the same time, data loggers should be placed in the freshly harvested tobacco at each time of housing.
- Data loggers should be placed within, but not in direct contact with the tobacco.
  - Hang data logger from center of stick at the same level as that at which the sample is to be collected.
  - Suggested to hang near 4^{th} leaf from top of plant where sampling will occur.

The accuracy of the data loggers should be checked before using them to record critical experimental data.

3. Relative Humidity and Data Loggers Maintenance in TSNA-related Work

Temperature and relative humidity are both factors that affect accumulation of tobacco-specific nitrosamines (TSNAs) during air curing and storage of tobacco leaf. Monitoring these environmental parameters is important for both quality control and research, and, therefore, care should be taken to ensure that the environmental data collected are accurate.

Relative humidity is one of the most difficult environmental parameters to measure accurately over time. The most accurate method uses single manual readings with a dew point mirror, but this method is not suited to continuous measurements. Data loggers are now affordable and convenient to collect data in research on TSNA accumulation.

The three major components of a data logger are the temperature and relative humidity sensors and the circuitry, including the data chip. There are several types of relative humidity sensors, each of which has its own peculiar characteristics.

3.1 Capacitive humidity sensors

The most commonly used in industrial, commercial, and weather telemetry applications are capacitive sensors. These consist of a glass, ceramic, or silicon substrate coated with a thin film of polymer or metal oxide between two conductive electrodes. This sensing surface is protected from contamination and exposure to condensation by a porous metal electrode coating. Water vapour absorbed into the sensor alters the electrical current between the electrodes and this is recorded as relative humidity. Capacitive sensors can function at temperatures up to 200 °C and, very conveniently, the recorded humidity is not affected by the temperature. This sensor type can fully recover from condensation, and have a reasonable resistance to chemical vapours. The response time to changes in relative humidity is typically 30 to 60 seconds. The less expensive capacitive sensors have an accuracy of no more than ±2 % of the true humidity but this is reduced to ±1 % for the more expensive high-end sensors.

3.2 Logger accuracy

The accuracy of temperature data is rarely a problem, and is usually within 1 °C. There are, however, two factors that affect the accuracy of the humidity data recorded by capacitive sensors.

3.2.1 Drift

The most insidious cause of inaccuracy is sensor drift over time. Most sensor specification sheets will state the expected rate of accuracy drift, usually 1 to 2 % per year (Fig. 1).

3.2.2 Sensor contamination

The sensors must be in contact with the ambient air to be able to absorb the water vapour into the sensor substrate. This exposes the sensors to contaminants such as dust, smoke and chemicals, including fumes from paint and adhesives, which can coat the sensor's surface and interfere with the absorbance of water vapour and lead to erroneous humidity readings (Fig. 2). Manufacturers warn that even the adhesive of the tape used for packaging could contaminate the sensors. Erroneous readings can also be caused by moisture condensation on the sensor, although this can be rectified by ensuring that the sensor is dried properly. Most applications for humidity loggers are in homes, office blocks, museums and libraries which are clean, with little dust or other airborne contaminants. In the tobacco industry, loggers are used in warehouses and curing barns which are considered "harsh" environments by the manufacturers of the sensors because of potential for dust and other contaminants in the air. This applies especially to monitoring humidity in the smoke environment of fire-cured barns.

For these two reasons, the accuracy of the loggers must be checked regularly, as often as every few months if they are used for critical applications.

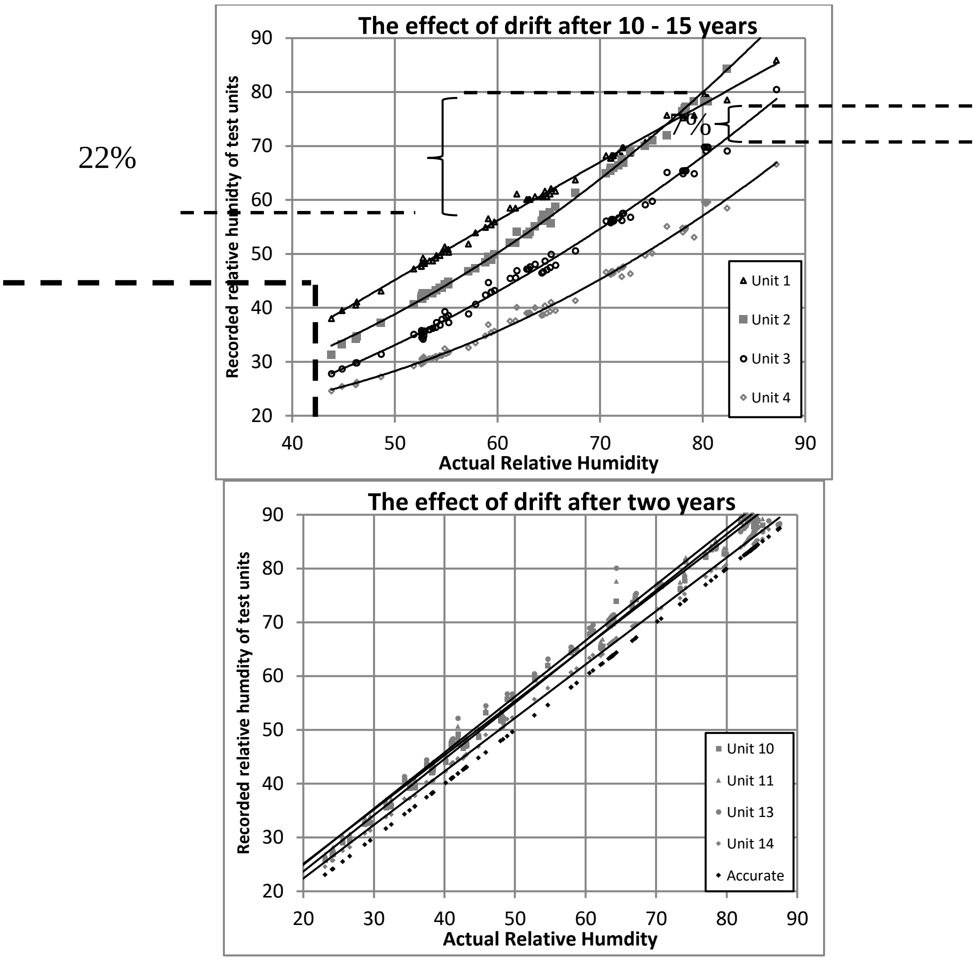

Fig. 1. Accuracy drift of relative humidity sensors with time. A. Data from four data loggers over 10 years old varied by more than 20 % humidity between them and by as much as 25 % below the true humidity. B. Even after two years, there was at least a 5 % difference between loggers, and all were recording higher values than the actual humidity.

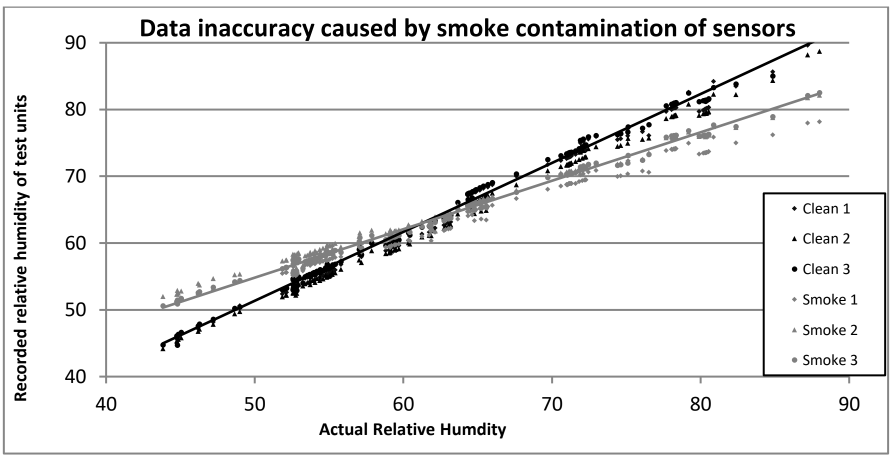

Fig. 2. Smoke contamination of the sensors in loggers used in a fire-cured barn caused severe distortion of the recorded data.

3.3 Suggested methods to reduce inaccuracies

Depending on the facilities available and budget, the following are suggestions on how to achieve the most accurate humidity data.

3.3.1 Data logger or sensor replacement

Apart from purchasing new data loggers each year, the sensors in many models can be replaced. The manufacturer of the data logger may offer this as a service, or may supply service kits.

3.3.2 Recalibration

It may be possible to recalibrate some models, but this requires sophisticated equipment, requiring either:

a. chemically pure salt solutions, or
b. various forms of chamber in which known ratios of saturated and dry air are mixed, or
c. dew point mirror.

3.3.3 Rejuvenation

Heating capacitive sensors at 100 – 105 °C for 10 hours followed by rehydration at about 75 % relative humidity for 12 hours can reduce the amount of drift by baking volatile substances off the sensor (Fig. 3).

3.3.4 Calibration in humidity chamber

Many leaf analytical laboratories have humidity chambers for equilibrating the moisture content of cut rag or test cigarettes. Assuming that these chambers are calibrated correctly, they could be used to test the accuracy of data loggers. Alternatively, data loggers with new sensors should be included with the loggers being tested.

1. Set the chamber at a low humidity (20 – 40 %).
2. Launch all data loggers, including at least two new ones, to start recording at the same time and at the same recording interval (e.g. 15 minutes).
3. Once the loggers are in the chamber, allow them to record several data points at the set humidity.
4. Increase the humidity in the chamber to between 50 and 70 %. Allow sufficient time for the loggers to record several data points after the chamber has equilibrated.
5. Increase the humidity in the chamber to between 80 and 90 %. Allow sufficient time for the loggers to record several data points after the chamber has equilibrated.
6. Repeat steps 4 & 5, but decreasing the humidity through the same range of humidities.
7. After downloading the data, calculate the regression of the actual humidity from the new loggers against that of the old loggers, and use these equations to correct the data (Fig. 4).

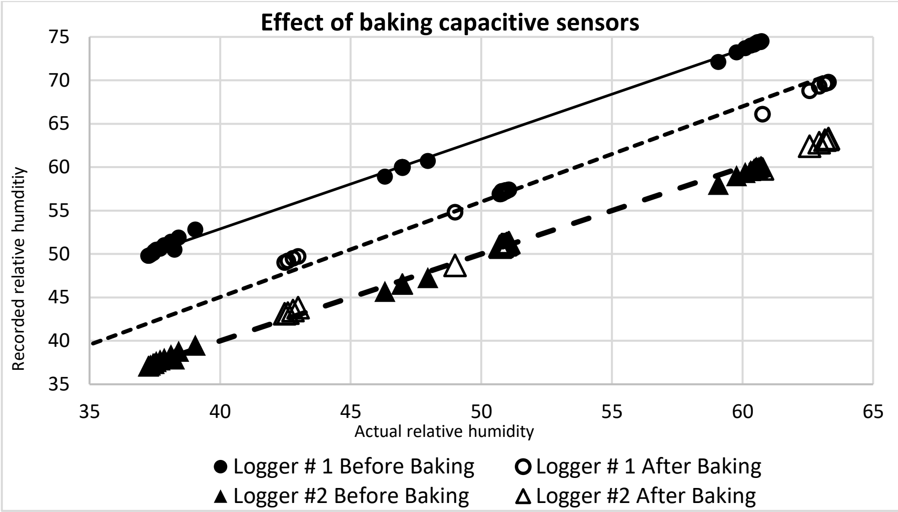

Fig. 3. Baking capacitive sensors can decrease inaccuracy: Baking reduced the drift of logger # 1 from 13 % down to 6 %. It made no difference to Logger # 2 that was accurate to begin with.

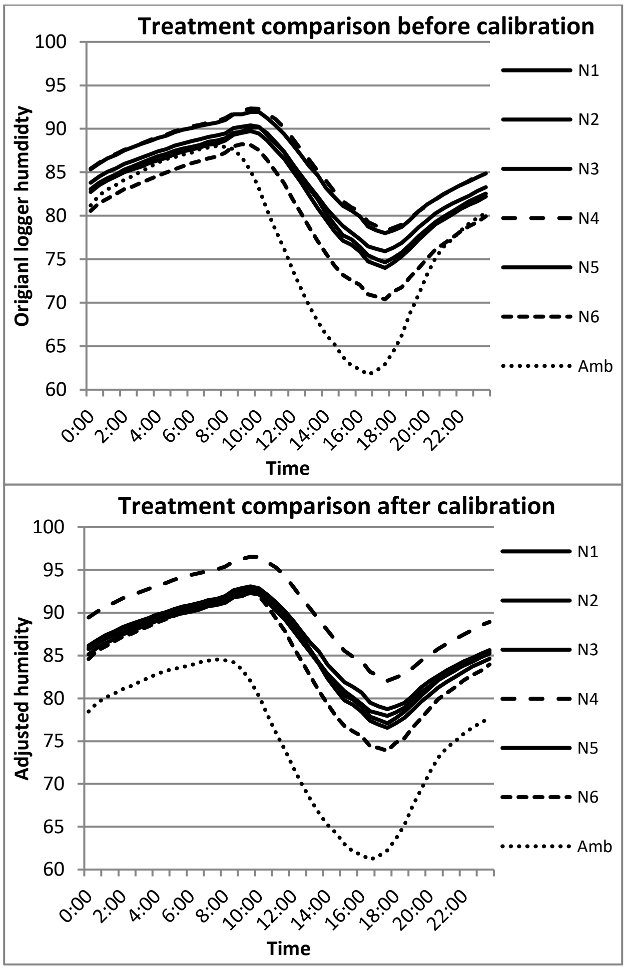

Fig. 4. Twenty-four hour time plot of the mean humidity at various locations (N1 – N6) in a commercial barn over the duration of a cure of air-cured tobacco. A. Without adjusting for sensor accuracy drift. B. After logger calibration and adjustment for drift. Note especially the difference between the data for positions N4, N6 and Ambient.

3.3.5 Calibration over salt solutions

In the absence of any convenient equipment in which to test the loggers, some idea of discrepancy between logger data can be ascertained by using a series of home-made saturated salt solutions, although humidities generated by these home-made solutions will not be accurate enough to calibrate the loggers.

1. Use the smallest airtight container that the data loggers will fit into.

   Gently warm aliquots of 100 mL of distilled or deionized water to above room temperature.

2. Dissolve the requisite amount of salt (Table 1) and add slightly more until no more dissolves.

3. Allow the solution to cool to room temperature; some salt should precipitate out of solution.

4. Suspend the data loggers over the saturated solution for several hours.
   Note that the saturated salt solution kits mentioned in method 1. above are chemically pure salts which will produce known humidities and are more expensive than those obtainable at general stores.

Table 1. Commonly available salts that can be used for a home-made saturated salt solution test series.

Salt	Approx. RH	Solubility
Calcium chloride	32	91 g/100 mL at 20 °C; 115 g/100 mL at 40 °C
Calcium nitrate	55	127 g/100 mL at 20 °C; 271 g/100 mL at 40 °C
Sodium chloride	75	36 g/100 mL at 20 °C and 40 °C

3.3.6 Simple accuracy check

If none of the four previous methods are options, then at least place the loggers in environments likely to be at different humidities. These could be in a bathroom with a tub containing hot water; in a room with central air conditioning that dries the room air, whether it is through cooling in summer or heating in winter.

In general, it is unlikely that an accuracy of less than 2 % humidity is feasible in most TSNA work. An accuracy of within 5 % is more realistic.

Additional information may be found at:
http://www2.ca.uky.edu/agcomm/pubs/aen/aen87/aen87.pdf