Textile Conditioning – Is it Really Necessary? (Only When Your Testing is Important)

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The spectrometer and its associated software are the key elements in digital color communication. This technology has allowed companies around the world to design, specify, and produce in a repeatable manner to the same set of standards. An issue that is often neglected is that certain dyes shift in their color characteristics at different temperatures and moisture contents. A sample read in a New York laboratory at 21°C and 40% RH will show different color characteristics than the same sample being measured on a production floor in India at 28°C and 80% RH. To obtain accurate color measurement data, conditioning samples to a specified temperature and moisture content is critical.

To provide a standard condition for **textile conditioning** at 21.1°C and 65% RH, attention must be giving to the following three areas:

- **Control Constancy** – The ability of the conditioner and controller to maintain a constant control at the control sensor location
- **Uniformity** – stratification throughout the conditioned space caused by insufficient air flow, heat or moisture loads within the space, or leakage to or from an adjacent space
- **Sensor Accuracy** - calibration uncertainty of both the temperature and relative humidity sensors
- **Conditioning Time** – the amount of time a sample takes to come to equilibrium at the specified condition.

For example, consider a targeted condition of 21°C ±2°/65% RH ±5% where the display or recording device may indicate a relative humidity control of +2%. Instead of being well within the required specification, it is quite possible that the requirement is not being met when the uniformity and sensor accuracy factors are included with the control constancy. A more comprehensive determination of test conditions can be achieved by considering the following:

- The best solid-state relative humidity sensors on the market today have an accuracy of +1% (when properly calibrated). In most cases, ±2% is more realistic.
- Depending on airflow and heat load location within a room, a relative humidity gradient of +1% to +6% could be expected.
- Add the above to the previously indicated control cycle (±2%) and the net total uncertainty, at any location a test is being performed could be anywhere from **+4% to +9% or more.**

To obtain the true required conditions, a chamber or room must be designed with all three aspects of condition deviation in mind.

Single Point Constancy (control)

This is the amount of cycling or deviation from set point one would expect from the control sensor's location. Within this category, account must be taken for conditioner/controller cycling, day/night and seasonal cycling, and sudden load changes (machinery or lights turning on or off, door openings, etc.). This aspect is dependent on the capability of the conditioning equipment and its controls.

Short-term conditioner control can be assessed when there are no load changes within the controlled area. Conditioner cycling includes refrigeration, heaters, and humidity/dehumidification cycles. Day/night, seasonal, and load cycling all involve an increase or decrease in sensible and latent loads that affect the long-term stability of the conditioned area. Ambient-driven change can be minimized with appropriate insulation and an adequate vapor barrier.

A **conditioning system** must be designed to handle the maximum anticipated latent and sensible loads. The source of most latent loads comes from leakage, product, and door openings. Sensible loads come from lighting, equipment, leakage, and door openings. The system must be able to maintain control while the heat loads vary throughout daily and seasonal cycles.

Because relative humidity is temperature dependent, precise air temperature control is required for close relative humidity control. If moisture content stays constant at a 14.3°C dew point, but the air temperature is cycling ±1.0°C at 21°, the relative humidity is fluctuating between 61.5% and 69.5%. A small ±0.2°C air temperature cycle will cause a relative humidity cycle of more that 0.5% (ASHRAE 1993).

Uniformity

Uniformity deals with the point-to-point differences of temperature and humidity across an entire conditioned area. Some of the major influences affecting uniformity include: total heat load (sensible and latent), load location, control sensor location, air distribution, volume of air exchanged, and proper insulation and vapor barriers.

Total heat load (lights, equipment, people, and gain or loss through walls and ductwork) is the most important item affecting uniformity. If there were absolutely no load within the conditioned space, then uniformity would be easily handled, however this is not practical. For example: a 12' x 10' x 10' room (1,200 cubic feet) with equipment, moving 600 CFM (30 air changes per hour) and a 3,000 BTU (880 watts) load has a temperature difference from supply to return of 2.6°C. If air is supplied at 21°C/65% RH and assuming there is no change in moisture content, then air is returned at 23.6°C/56% RH. Increasing total airflow or decreasing load can reduce this difference.

Load placement is also an important factor. If possible, it is best to locate loads as close to a return duct as possible to avoid disturbing the rest of the conditioned space. Load location should also influence the placement of the control sensors. Control sensors should not be located down stream of major load producers or in the return duct(s).

Air distribution should be uniform across the conditioned space. Typically, ceiling supplies and returns that pick up near the floor and around the periphery of the conditioned space are recommended (TAPPI TIS 018-7 1982). A design with both ceiling supplies and returns should be avoided. In chambers, a uniform laminar flow across the chamber is required.

Sensor Accuracy

There are both temperature and humidity sensors employed that need to be considered. Temperature sensors are typically far more accurate and generally easier to calibrate than humidity sensors. Using standard practices, one can typically obtain a ±0.1°C accuracy for the temperature sensor. Humidity measurement therefore becomes the primary area of concern.

Most humidity sensors on the market today have a claimed accuracy of +1% throughout a slightly narrowed range (i.e.: 20-80%RH). This is the best that one could expect from a new sensor, operating under moderate conditions. When choosing a humidity sensor, the accuracy specification must be validated over the entire expected range of operation.

Relative humidity sensors must be calibrated regularly as they will drift over time. Calibration intervals will vary based on the type of sensor and the conditions of operation (temp. humidity range, cleanliness of atmosphere, concentration of various chemicals, etc). Typically, a one-year calibration interval is sufficient and should be considered the maximum. Specific intervals will be dictated by the application and it is best to start conservatively (i.e.: 6 months) and adjust later as appropriate. Confirm that the sensor calibration covers your operating range and is traceable to N.I.S.T. with supporting documentation on the calibration of the instrumentation.

Traceability means that the instrument has been calibrated against a primary or transfer standard. Most sensors are supplied with a calibration report (Certificate of Calibration) showing the accuracy at the time of manufacture, which does not truly reflect the way the instrument will perform in the field (Wiederhold 1997). The accuracy of the controller or adjustments made in the circuitry down stream of the sensor can affect the accuracy of the readout.

Conditioning Time

After making sure the proper condition is met, the proper conditioning time must be determined. Conditioning time is effected by several factors. These include:

- Weight of sample – the lighter the sample, the quicker it will condition.
- Type of fabric – synthetic material will condition quicker than more hygroscopic material like cotton.
- Temperature and moisture content of sample prior to conditioning – samples that have been stored in a comfort conditioned area are much easier to condition than samples right of the production roll.
- Recovery time of conditioner after samples are loaded – systems with fast recovery times after a door opening with condition more effectively.
- Velocity of air around or through the sample – the faster the air velocity over a sample the quicker the sample will condition. If air is pulled through a sample, the sample will condition most rapidly.

Proper conditioning time for a specific type of sample can be determined by performing a series of color measurements over various time increments. When the color measurement does not shift from one time increment to the other, temperature and moisture content equilibrium has be reached. It is important that this time increment be performed under a “worst case” situation. Samples should be tested when they are far from the targeted conditioned state (example, loaded in a hot/dry condition), chamber should be fully loaded with samples, and the heaviest hygroscopic material should be used.

Conclusion

Conditioning textile samples to a standard temperature and moisture content is critical prior to color measurement. Being aware of the parameters that affect the temperature and moisture content will insure that the sample is being conditioned properly. Some of the key points to remember are:

- Employ a conditioning system with tight single point control.
- Whatever system is obtained, make certain that it has the capacity to handle the internal and external heat load and has sufficient air handling capability to assist in enhancing uniformity.
- Use a relative humidity sensor suitable to your application; be sure that it is positioned properly and is calibrated routinely.
- Be mindful of the influences of heat loads on a conditioned space and try to minimize them.
- The conditioned space and ductwork must be well insulated with an uninterrupted vapor barrier.
- Determine the proper conditioning time.

If the above items are addressed, proper conditioning prior to color measurement can be achieved.

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References

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