

**NOTICE: This is a DRAFT of a TAPPI Standard in ballot. Although available for public viewing, it is still under TAPPI's copyright and may not be reproduced or distributed without permission of TAPPI. This draft is NOT a currently published TAPPI Standard.**

WI \_\_\_\_\_ 180808.06 \_\_\_\_\_

T \_\_\_\_\_ 502 \_\_\_\_\_

DRAFT NO. \_\_\_\_\_ 03-SARG \_\_\_\_\_

DATE \_\_\_\_\_ May 18, 2021 \_\_\_\_\_

WORKING GROUP  
CHAIRMAN \_\_\_\_\_ Dennis Crawshaw \_\_\_\_\_

SUBJECT  
CATEGORY \_\_\_\_\_ Physical Properties \_\_\_\_\_

RELATED  
METHODS \_\_\_\_\_ See "Additional Information" \_\_\_\_\_

**CAUTION:**

This Test Method may include safety precautions which are believed to be appropriate at the time of publication of the method. The intent of these is to alert the user of the method to safety issues related to such use. The user is responsible for determining that the safety precautions are complete and are appropriate to their use of the method, and for ensuring that suitable safety practices have not changed since publication of the method. This method may require the use, disposal, or both, of chemicals which may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Material Safety Data Sheets which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this method, the user must determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, must follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

## **Equilibrium relative humidity of paper and paperboard (Reaffirmation of T 502 cm-07 as a Classical Method) (The ballot 2 reconfirmed this Standard as a Classical Method)**

### **1. Scope and significance**

1.1 This method describes procedures for determining the equilibrium relative humidity of paper and paperboard.

1.2 Paper which is dimensionally stable at a particular relative humidity and temperature will remain unchanged as long as this condition is maintained. Printers and paper converters can maintain a particular humidity and temperature condition more easily than they can regulate the moisture content of the paper to adjust for a change in its environment. Hence, for many purposes equilibrium relative humidity at a specified temperature is more significant than the moisture content of the paper.

## 2. Summary

The test is made by measuring the relative humidity and temperature surrounding the paper under test while the influence of the external atmosphere is excluded. The test apparatus and procedure required depend upon the form in which the paper is to be tested.

## 3. Definitions

3.1 *Equilibrium relative humidity* (Eq. RH), the ambient relative humidity (at a given temperature) at which exposure of the paper will not result in a net moisture absorption or desorption.

3.2 *Specification RH and specification temperature* are, respectively, the Eq. RH specified in the purchase order or other specification and the temperature at which it is measured; or, if not specified, TAPPI standard conditions of  $50 \pm 2\%$  RH and  $23 \pm 1^\circ\text{C}$ .

3.3 *Equivalent specification RH* is the Eq. RH that would exist with paper having the specified moisture condition when at a temperature different from that measured.

## 4. Apparatus

4.1 *Humidity and temperature sensing devices*<sup>1</sup> (see Appendix for performance requirements).

4.1.1 *For stacks of sheets*: probe or sword type device of such design that the sensors are isolated from the external atmosphere when the probe is inserted in a stack of paper.

4.1.2 *For rolls or stacks of sheets*: a device, such as a clamp or weighted plate, incorporating sensors and designed to isolate an area of the specimen, thus excluding the external atmosphere.

4.1.3 For special products (irregularly shaped paper products or corrugated board not adaptable to test by the above procedures): a container incorporating sensors designed to enclose the entire specimen and exclude the external atmosphere.

4.2 Indicator or recorder, connected to the sensors and readable within  $0.5^\circ\text{C}$  ( $1^\circ\text{F}$ ) and 1% RH.

## 5. Calibration

5.1 *Verification chamber*. Calibration of the humidity sensor requires a chamber free of any hygroscopic materials, such as paper, wood, fabric, etc., sealed from external moisture and either insulated from external temperature changes or used in a room maintained at constant temperature. The chamber must also be of small volume and designed to permit the humidity surrounding the test apparatus or its humidity sensor to be changed quickly from

---

<sup>1</sup>Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list, available as part of the CD or printed set of Standards, or on the TAPPI website general Standards page.

one relative humidity condition to another. A suitable chamber is available from manufacturers of humidity measuring equipment.

5.2 *Frequency of verification.* Completely calibrate the test instrument initially, and at least annually thereafter. Verify the accuracy of the humidity and temperature readings at least monthly at the specification or TAPPI standard conditions by the procedure described in the Appendix for both temperature and humidity accuracy and at two other humidities, also described in the Appendix.

## 6. Sampling and test specimens

6.1 *Important:* Do not unwrap or expose material to the atmosphere prior to testing time.

6.2 *For stacks of sheets.* Select the skids or packages to be tested in accordance with TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product.” Select the test positions so as to ensure representative results. The minimum sheet dimension is 600 mm (24 in.) in any direction.

6.3 *For rolls, sheets, and special products.* Select the rolls or packages to be tested in accordance with TAPPI T 400. The required specimen size depends on the free space of the clamp or container-type device, the hygroscopic absorptivity of the device and the sensors, and the difference between the initial condition of the test apparatus prior to insertion of the specimen and the final equilibrium condition. Use a specimen of sufficient size to limit the specimen loss or gain of Eq. RH to less than 0.5% RH for a change of 10% RH as indicated by the apparatus. This may be tested by withdrawing the original specimen from the test apparatus and immediately inserting an identical second specimen twice the size of the original. The resulting change in the indicated Eq. RH then should not exceed 0.5% RH.

**NOTE 1:** A change of 10% RH at TAPPI standard conditions involves an atmospheric moisture change of about 4.6 mg/1000 mL. Assuming the 0.5% RH limitation represents approximately 0.05% moisture content change in the paper, the minimum specimen size for a 100 mL (6.1 in.<sup>3</sup>) chamber would be 2.3 g.

## 7. Procedures

7.1 *For stacks of paper.* This procedure is limited to sheeted paper having a minimum dimension of 600 mm (24 in.) in any direction.

7.1.1 Precondition the probe to the temperature of the paper to be tested and as near as possible to the expected Eq. RH. Often this can be done simply by keeping the probe in the same room where the test measurements are to be made. If the paper has a different temperature than that of the test room, condition the probe by inserting it 150 mm (6 in.) or more into the skid at a point at least 20 mm (3/4 in.) above or below the position where the reading is to be taken, and allow it to remain for a minimum of 10 min. Note the temperature reading; if the temperature is still different or is still changing, remove the probe and reinsert it at a point within 20 mm (3/4 in.) of the original and allow it to remain for an additional 10 min or until the temperature reading remains constant for at least 2 min.

7.1.2 To make the test, quickly push the probe into the test position until the sensors are at least 150 mm (6 in.) from the edge of the paper. Record the temperature reading as soon as it remains constant for at least 2 min. Record the relative humidity after allowing sufficient time for the humidity sensor to reach equilibrium, i.e., when the humidity reading changes less than 0.5% RH in 5 min. If after 15 min elapsed time the sensor has not reached equilibrium as indicated by a greater change than 0.5% RH in 5 min, remove the probe and reinsert it at least 150 mm (6 in.) from the original position and wait another 15 min, or until the sensor has reached equilibrium. Then record the temperature and relative humidity. Leave a marker (a strip of paper) inserted at each place where the probe was inserted.

7.1.2.1 If the measured temperature varies by more than 3°C (5°F) from the specification temperature (defined in 3.2), use a conversion chart for the type of paper measured (Note 2) to convert the measured Eq. RH to the equivalent Eq. RH at the specification temperature and report both the measured and the equivalent values of the Eq. RH.

**NOTE 2:** To prepare a conversion chart, keep a specimen in the test clamp or a container with the temperature and humidity sensors until it reaches a stable temperature and note the Eq. RH. Do this for several temperatures. Plot Eq. RH versus temperature. Create a different conversion chart for grades of paper with ash content differences of 2% or greater.

7.1.3 At the completion of the tests, store the probe so that it will be protected from dust and mechanical damage.

7.2 For rolls, sheets, and special products. Important: Do not touch the test area of the specimen with the bare hands or any material that may change its moisture condition. Do not expose the specimen to the outside atmosphere for a longer time than absolutely necessary. Under no circumstances should this exposure exceed 5 s.

7.2.1 Precondition the test apparatus to the temperature of the specimen to be tested and as near as possible to the expected Eq. RH. If measurements are to be made in transit at a shipping dock, or in a warehouse where extreme temperatures may prevail, condition the apparatus to the same temperature before taking readings.

7.2.2 After first removing enough surface paper to ensure that the specimen is reasonably representative of the entire package or rolls, use the measuring device quickly to enclose or isolate the test area of the specimen with minimum exposure to room or outside air.

7.2.3 When using a clamp type device on a stack of paper, lay back the top 30-50 mm (1.25 - 2 in.) of paper and quickly clamp the six or eight sheets chosen for the test specimen. Mark the test location in the stack with a strip of paper.

7.2.4 When using a weighted plate device, place the device on the top of the stack after first laying back the top 30-50 mm (1.25 - 2 in.).

7.2.5 When taking a specimen from a roll, use a sharp knife to make a diagonal cut into at least 10 thicknesses of paper so as to make a triangular flap about 300 mm (1 ft) long. Fold back the top several thicknesses and quickly lift and clamp the next six or eight thicknesses. Cut or tear off the triangular piece (with the clamp in place).

7.2.6 If the difference between the initial and the final readings of the apparatus before and after insertion of the specimen is more than 10% RH or more, the test is invalid. In this case, precondition the apparatus by leaving the last specimen in place until a new specimen is taken and then inserted immediately. The time of exposure to the

atmosphere of both the new specimen and the apparatus' humidity sensor must not be more than 5 s. Record the temperature and relative humidity, as described in 7.1.2, being sure to allow sufficient time for the humidity sensor to reach equilibrium.

7.2.6.1 If the measured temperature varies by more than 3°C (5°F) from the specification temperature (defined in 3.2), use a conversion chart for the type of paper measured (Note 2) to convert the measured Eq. RH to the equivalent Eq. RH at the specification temperature. Report both the measured and the equivalent values of the Eq. RH.

## **8. Report**

Report as a test result the measured temperature and Eq. RH of each skid, roll, or package tested. Also report the equivalent Eq. RH at the specification temperature if determined.

## **9. Precision**

9.1 Repeatability (within laboratory): 1%.

9.2 Reproducibility (between laboratories): not known, in accordance with definitions of these terms in TAPPI T 1206 "Precision Statement for Test Methods."

9.3 Comparability (between materials): not known.

## **10. Keywords**

Paper, Paperboard, Humidity

## **11. Additional information**

11.1 Effective date of issue: To be assigned.

11.2 Voted as a Classical Method by the Physical Properties Committee, 1998. This method is seldom used. Most laboratories measure moisture content, and then calculate equilibrium relative humidity from the known relationship between moisture content and R.H. The method was reissued in 2007 with only minor editorial changes.

## Appendix A. Performance requirements for apparatus

A.1 *Humidity range.* Relative humidity range is to be at least 10% above and below the specification RH or the equivalent specification RH when the measurement is made at a temperature other than the specification temperature.

A.2 *Humidity accuracy.* Humidity is to be accurate within  $\pm 1.5\%$  RH between 20 and 25°C (68 and 77°F) and to within  $\pm 3\%$  RH at extreme of temperature range under the following three conditions:

A.2.1 The specification conditions  $\pm 1^\circ\text{C}$  (1.8°F) and  $\pm 3\%$  RH or, if not specified, the TAPPI standard conditions  $23 \pm 1^\circ\text{C}$  ( $73.4 \pm 1.8^\circ\text{F}$ ) and  $50 \pm 2\%$  RH.

A.2.2 The same temperature but at relative humidities at least 5% above and below the conditions of A.2.1 above.

A.2.3 The extreme temperatures likely to be encountered in use, but not less than 5°C (41°F) or more than 40°C (104°F) and for the equivalent relative humidity ( $\pm 5\%$  RH).

A.3 *Temperature range* (from A.2).

A.4 *Temperature accuracy.* Temperature is to be accurate within  $\pm 1^\circ\text{C}$  (1.8°F) under the following two conditions.

A.4.1 The specification conditions or, if not specified, the TAPPI standard conditions.

A.4.2 The extreme temperature likely to be encountered.

A.5 *Response.* The response must be verified as described under Calibration. Precondition the test apparatus in the verification chamber for at least 2 h at the specification conditions or, if not specified, at TAPPI standard conditions. Rapidly change the relative temperature by 5-10°C (10-18°F) from these initial conditions and record the indicated and actual relative humidities and temperatures at the end of 5 min. The apparatus must indicate within 1% RH and 1°C (1.8°F) of the end condition for both increasing and decreasing changes.

## References

1. Quinn, F. C., "Humidity/Moisture Considerations," American Instrument Company, 8030 Georgia Avenue, Silver Springs, MD 20910.
2. Wexler, A. E., "Humidity and Moisture: Measurement and Control in Science and Industry," Reinhold, New York, 1965.
3. Wexler, A., and Hyland, R. W., "The NBS Standard Hygrometer," NBS Monograph 73, National Bureau of Standards, Washington, DC, May 1, 1964.
4. Wexler, A., and Hasegawa, S., "Relative Humidity-Temperature Relationships of Some Saturated Salt Solutions in the Temperature Range of 0°C to 50°C," J. Research NBS 53: (19)1954.
5. Wink, W. A., and Sears, G. R., "Instrumentation Studies LVII. Equilibrium Relative Humidities Above Saturated Salt Solutions at Various Temperatures," *Tappi* **33** (9):96A (1950).

6. Wink, W. A., and Van den Akker, J. A., "Instrumentation Studies LVI, Development of a Method for the Measurement of Water-Vapor Permeability at Low Temperatures," *Tappi* **33** (8):84A (1950).

*Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Standards Department.* ■