WI 120808.14

T 402

DRAFT NO. 2

DATE April 2013

WORKING GROUP CHAIRMAN Janice Trotter

SUBJECT Process and Product Quality
CATEGORY General

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.

# Standard conditioning and testing atmospheres for paper, board, pulp handsheets, and related products (Revision of T 402 sp-08)

## (underscores and strikeouts indicate changes from Draft 1)

### 1. Scope

1.1 This standard practice defines the standard atmospheres for normal preconditioning, conditioning, and testing of paper and paper products, paperboard, fiberboard, and containers made from them. It also specifies procedures for handling these materials in order that they may reach equilibrium with the respective atmosphere.

1.2 This standard practice is also applicable to standard pulp test handsheets, except that the preconditioning procedure is omitted, that is, the sheets are not dried to conditions below those obtained by exposure to the standard conditioning and testing atmospheres. (See TAPPI T 205 "Forming Handsheets for Physical Tests of Pulp.")

1.3 This standard practice does not include special conditioning and testing atmospheres, such as those that attempt to simulate tropical or arctic environments.

## 2. Significance

2.1 The physical properties of a sample at 50% RH depend on whether the sample was brought to 50% from higher or lower relative humidities; this "humidity hysteresis effect" is 5-25% of the test value for many physical properties. For example, a hysteresis effect of 1% moisture content (or 16% of the test value of 6% moisture content) is typical. Preconditioning on the dry side within the range specified will avoid most of the hysteresis effect and result in the moisture content of a given sample being established within 0.15% when the sample is later conditioned to 50% RH and 23°C. Conditioning *down* to 50% gives most papers a moisture content very nearly the same as conditioning *up* to 60%.

2.2 Both temperature and relative humidity have significant effects on the physical properties of paper and board (*1*, *2*). For some properties of paper and board (e.g., MD tensile and CD stretch) a change of 1°C may have nearly as much effect as a change of 2% RH. For synthetic fibers and plastic laminates, the temperature effect may be greater than the RH effect.

## 3. Standard atmospheres

3.1 *Preconditioning atmosphere*, 10-35% RH and 22-40°C (72-104°F) (see Appendix).

3.2 *Conditioning atmosphere*, 50.0% ± 2.0% RH and 23.0 ± 1.0°C (73.4 ± 1.8°F.)

3.3 *Testing atmosphere*, same as for conditioning.

**NOTE 1:** It is important to distinguish between the overall limits of the temperatures within which conditioning and testing may be carried out and the limits within which the temperature must be maintained in order to maintain the specified relative humidity limits; i.e., the close temperature tolerance of ±1°C required in 3.2 and 3.3 will not in itself ensure the close relative humidity requirement of ± 2% RH, as a sudden change of 1°C when at 23°C and 50% RH will change the RH about 3%.

## 4. Apparatus

4.1 *Preconditioning chamber*[1], a room or cabinet in which sample sheets or specimens may be individually exposed to circulating air at the preconditioning relative humidity and temperature.

**NOTE 2:** For smaller sheets or specimens, the required preconditioning may be achieved easily with a simple cabinet, if no other means are available. If this cabinet is operated in a room maintained at 50% RH and 23°C and so designed that room air is drawn through it, and if the air entering and in the cabinet is heated to a temperature of 39 ± 1°C (102.2 ± 1.8°F), the relative humidity in the cabinet will be at or about 20% RH, which is within the allowed range of 10-30% RH. Commercially available forced-ventilation "ovens" should prove satisfactory. Input air to the oven should be drawn from the standard room, output should be vented outside of the standard room.

[1] 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.

4.1.1 For many papers and boards, approximately the same preconditioning moisture content obtained by the above procedure may be achieved by using a sealed cabinet operated in a room maintained at 23 ± 1°C and using a saturated solution of lithium chloride (LiCl) to obtain a relative humidity of about 12-13%. For larger rooms needed for preconditioning sealed containers and large sheets, the required low relative humidity may be achieved by drawing air over a refrigerator expansion coil operating at a few degrees above freezing temperature.

4.2 *Conditioning and testing chamber*, one or more rooms or cabinets in which sample sheets or specimens may be individually exposed to circulating air at the conditioning relative humidity and temperature and then tested under the same conditions.

**NOTE 3:** The required relative humidity (50.0 ± 2.0%) and temperature (23.0 ± 1.0°C) are not easy to achieve, and therefore careful attention must be given to the design, evaluation, and maintenance of the "standard room." A separate procedure, TAPPI TIP 808-04, has been prepared for this.

4.3 *Hygrometer*, any instrument that can indicate directly or indirectly the relative humidity of the air with a calibrated accuracy of ± 1.0% RH at 23°C and 50% RH.

4.4 *Thermometer*, either the dry bulb of a psychrometer (i.e., a hygrometer of the wet- and dry-bulb type) or a separate thermometer of any convenient design. If a separate thermometer, it should be graduated to 0.2°C (0.5°F) or closer with scale errors not exceeding these values. (Psychrometer thermometers must be graduated and correct to 0.05°C or closer and carefully matched to each other to give the required accuracy and repeatability in the measurement of relative humidity.) Wet-dry bulb psychrometry requires close attention to technique sources of error, purity of water, cleanliness of wick, proper air flow, and in particular the tightness of the wick on the temperature sensor.

## 5. Procedure

5.1 Obtain and preserve the sample in accordance with TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product.” In particular, avoid exposure of the sample to direct sunlight, to extremes of temperature, and to relative humidities above 65% ~~58%~~ (see Appendix A.1). If the sample is to be held for some time before testing, preserve it at a temperature below 25°C (77°F) and relative humidity below 65% ~~58%~~, but not below 10% as the paper may curl or cockle and change in other respects. If low temperature storage is used, the sample should be protected against condensation.

5.2 *Specimen preparation*

5.2.1 Cut specimens from a sample where critical dimensions are involved only after conditioning the sample. Where there are no critical dimensions, specimens may be cut before preconditioning or conditioning.

5.2.2 If shipping containers are to be sealed with aqueous adhesives, make the seal prior to preconditioning.

5.3 Expose the sample sheets or specimens to the preconditioning atmosphere so that both surfaces of single sheets and exterior surfaces of laminated products or sealed containers are freely exposed. This is best achieved by

suspending them from overhead or supporting them on a wire grid or rack.

5.4 Precondition the sample sheets or specimens by exposing them as specified above (5.3) to the preconditioning atmosphere. Precondition for a minimum of 24 h, unless a lesser time has been found to give satisfactory results through careful experimentation. If the sample is to be stored for a time after preconditioning, store at a temperature below 25°C (77°F) and a relative humidity below 40%, but not below 10%.

**NOTE 4:** ~~The~~ From anecdotal experience, the following preconditioning times have usually been found satisfactory for a preconditioning apparatus of ample capacity and air circulation: paper of ordinary weight and composition, less than 1 h; boards (i.e., linerboard, corrugating medium, chipboard, boxboard), 1-2 h; corrugated and solid fiberboard in sheet form, 5-10 h; sealed boxes (including shipping containers), 12-16 h; boards of heavy substances and specially treated water vapor resistant papers and boards, 24 h or more.

5.5 Condition the sample sheets or specimens by exposing them as specified in 5.3 to the standard conditioning atmosphere for a sufficient time for them to come into equilibrium with the atmosphere. Pulp handsheets (see T 205, Note 8) should be conditioned in the drying rings to the standard conditioned atmosphere. Determine that equilibrium has been obtained by weighing the sheets or specimens at time intervals which increase roughly geometrically. Plot the weight against log time (i.e., on semilogarithmic paper); the desired equilibrium exists when the plotted curve becomes essentially parallel to the time axis.

**NOTE 5:** ~~The~~ From anecdotal experience, the following conditioning times have usually been found satisfactory for a conditioning apparatus of ample capacity and air circulation: paper of ordinary weight and composition, 4 h; boards (i.e., linerboard, corrugating medium, chipboard, boxboard) and unsealed boxes, 5-8 h; sealed boxes (including shipping containers), 16 h; and much longer periods for boards of heavy substances and specially treated water-vapor-resistant papers and boards and wax-treated containers a minimum of 72 h.

5.6 Handle preconditioned and conditioned sheets or specimens as little as possible; especially avoid touching or breathing on test areas.

5.7 Test the specimens in the standard testing atmosphere.

## 6. Report

6.1 Report the temperature, relative humidity, and total time of:

6.1.1 Preconditioning.

6.1.2 Conditioning before testing.

6.2 Report the minimum and maximum temperature and relative humidity during testing.

6.3 Report any variations in procedure from this method.

## 7. Keywords

Temperature control, Test facilities, Humidity rooms, Test conditions, Conditioning, Atmosphere, Controlled atmospheres, Paper, Paperboard, Handsheets, Fiber boards, Container boards

## 8. Additional information

8.1 Effective date of issue: to be assigned.

8.2 In the ~~this~~ 2008 revision, the method was modified to clarify wording in Note 2, to make the wording in Note 4 and Note 5 more consistent, ~~to change the % high relative humidity from 58% to 65% in Appendix A.1,~~ to reflect more accurately the information published by Wink (*1*), and to add identifiers to the graph. Also in 2013, the method was supposed to have been revised to change the % high relative humidities in the Appendix and Section 5.1. However, the five-year review of the 2008 document revealed that the percentages had been changed in the Appendix, but not in Section 5.1, so this correction was made in the 2013 edition. Also in the 2013 edition, a Reference section was added.

8.3 Related methods: ASTM D 685, ISO 187, Australian Standard AS/NZ 1301.414 and AS/NZ 1301.415s: 1998, SCAN P2-75, DIN 50014 & 53112, Canadian PAPTAC A.4.

8.4 This method was corrected or revised in 1934, 1936, 1941, 1944, 1949, 1970, 1993, 1998, and 2008. The 2008 edition changed the wording of Notes 4 and 5 to make them consistent, changed 58% to 65 % relative humidity in A.1 based on the paper by Wink (*1*), and added identifiers to Figure 1.

## Appendix A: Importance of preconditioning

A.1 For the sake of obtaining close interlaboratory agreement, especially on physical properties, a specified preconditioning procedure is necessary but not always sufficient. While preconditioning practically eliminates the hysteresis effect, it has little influence on strain relaxation effects. The latter depend on the entire previous moisture history of the sample, especially on the conditions of initial drying and tension, and on the duration and degrees of subsequent excursions to high relative humidity (i.e., above about 65% RH). Consequently, for very close interlaboratory agreement a procedure for handling the sample from manufacture to testing is required. See Fig. 1 for a graph showing typical moisture isotherms for pulp and paper (*1*).

A.2 For mill control and similar within-one-laboratory purposes, the preconditioning step may often be eliminated. In rare instances, especially when the paper or board has been dried to a moisture content below its level in equilibrium with 50% RH, for some properties and materials, preconditioning may not be necessary, either because the hysteresis effect may produce only a very small difference in moisture content or because the test performed requires less accuracy.

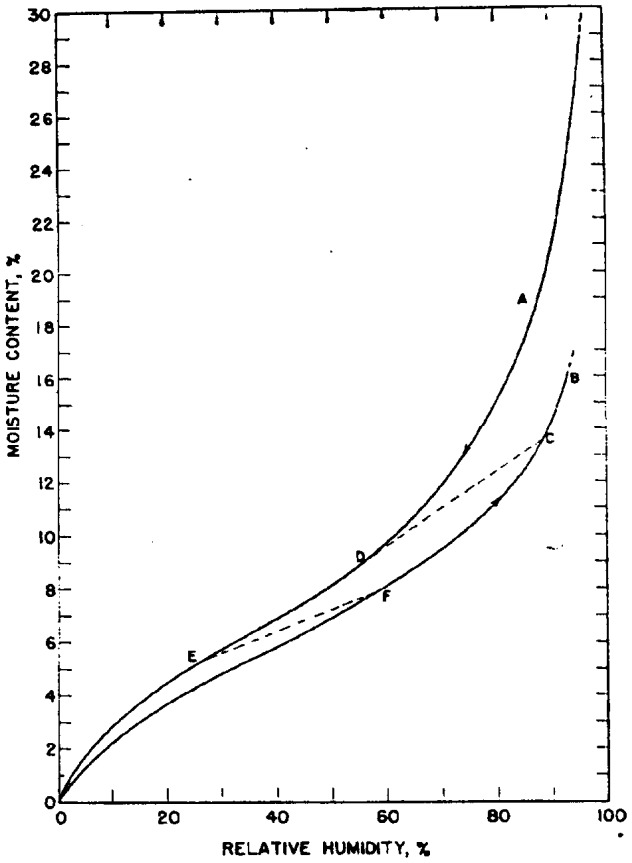


**Fig. 1.** Typical moisture sorption isotherms for pulp and paper. A = desorption curve; B = absorption curve; C = partial adsorption; CD = C followed by desorption to point D; E = partial desorption; EF = E followed by adsorption to point F.

## Literature cited

1. Wink, W. A., *Tappi* **44** (6): 171A (1961).
2. Crook, D. M., and Bennett, W. E., *Brit. Paper & Board Industry Research Association*, Report RA/T/90, Feb. 1962.

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Fellers, C., and Brange, A., "The impact of water sorption on the compressive strength of papers," Proceedings of the 8th Fundamental Research Symposium, Fundamental Research Society, Lancashire, England, pp. 497-509, 1985, http://www.ppfrs.org/

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

WI 120808.14

T 402

DRAFT NO. 1

DATE October 23, 2012

WORKING GROUP CHAIRMAN to be determined

SUBJECT Process and Product Quality
CATEGORY General

RELATED METHODS See "Additional Information"

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# Standard conditioning and testing atmospheres for paper, board, pulp handsheets, and related products (Five-year review of T 402 sp-08)

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1.1 This standard practice defines the standard atmospheres for normal preconditioning, conditioning, and testing of paper and paper products, paperboard, fiberboard, and containers made from them. It also specifies procedures for handling these materials in order that they may reach equilibrium with the respective atmosphere.

1.2 This standard practice is also applicable to standard pulp test handsheets, except that the preconditioning procedure is omitted, that is, the sheets are not dried to conditions below those obtained by exposure to the standard conditioning and testing atmospheres. (See TAPPI T 205 "Forming Handsheets for Physical Tests of Pulp.")

1.3 This standard practice does not include special conditioning and testing atmospheres, such as those that attempt to simulate tropical or arctic environments.

## 2. Significance

2.1 The physical properties of a sample at 50% RH depend on whether the sample was brought to 50% from higher or lower relative humidities; this "humidity hysteresis effect" is 5-25% of the test value for many physical properties. For example, a hysteresis effect of 1% moisture content (or 16% of the test value of 6% moisture content) is typical. Preconditioning on the dry side within the range specified will avoid most of the hysteresis effect and result in the moisture content of a given sample being established within 0.15% when the sample is later conditioned to 50% RH and 23°C. Conditioning *down* to 50% gives most papers a moisture content very nearly the same as conditioning *up* to 60%.

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**NOTE 4:** The following preconditioning times have usually been found satisfactory for a preconditioning apparatus of ample capacity and air circulation: paper of ordinary weight and composition, less than 1 h; boards (i.e., linerboard, corrugating medium, chipboard, boxboard), 1-2 h; corrugated and solid fiberboard in sheet form, 5-10 h; sealed boxes (including shipping containers), 12-16 h; boards of heavy substances and specially treated water vapor resistant papers and boards, 24 h or more.

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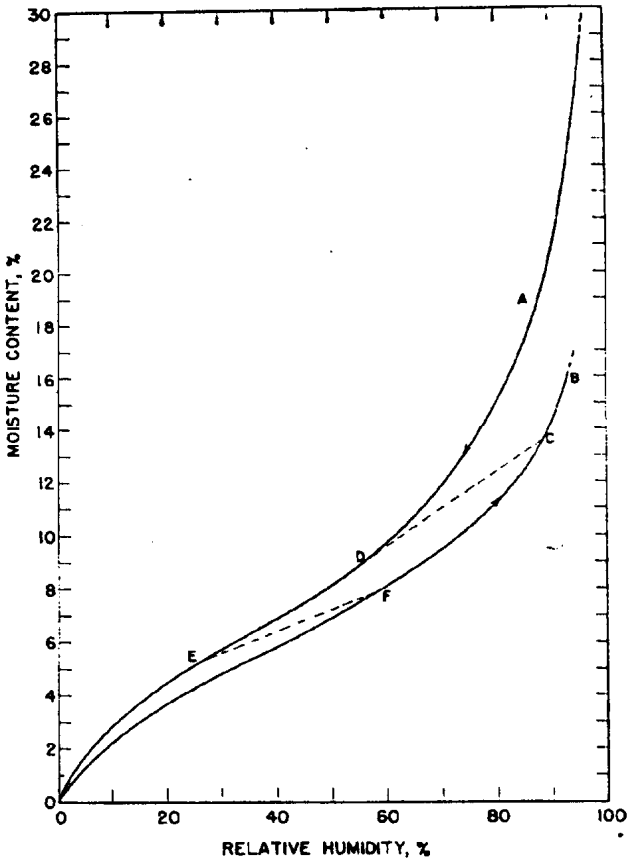


**Fig. 1.** Typical moisture sorption isotherms for pulp and paper. A = desorption curve; B = absorption curve; C = partial adsorption; CD = C followed by desorption to point D; E = partial desorption; EF = E followed by adsorption to point F.

## Literature cited

1. Wink, W. A., *Tappi* **44** (6): 171A (1961).
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