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Standard Specification for Bond and Ledger Papers for Permanent Records[1]

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1. Scope

1.1 This specification covers bond and ledger papers used in the preparation of records and documents that are expected to have maximum, or substantial, life expectancy.

1.2 It has been shown **(1, 2, 3, 4, 5)**[2] that life expectancy is at least an approximate function of the pH of an aqueous extract of the paper. Three pH levels, reflecting three levels of life expectancy, are specified.

1.3 The following would be expected to contribute significantly to the life expectancy of books and documents: the use of papers with controlled acidity, or of papers manufactured under neutral or alkaline conditions, especially papers with a calcium carbonate filler that absorbs acidic gases from the atmosphere and can neutralize acidic materials formed in the aging of paper.

1.4 This specification is based on fiber sources used in the production of paper that contains no more than 1 % lignin, for papers used in archives, libraries, and other permanent records. However, under proper conditions, (see X1.5), paper containing more than 1 % lignin may be employed for other end uses in paper for records that are required to have a substantial life expectancy.

1.5 As indicated in Appendix X1.4 and X1.5, this specification may be used as a guide.

2. Referenced Documents

2.1 *ASTM Standards:*

D 585 Practice for Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, or Related Products[3]

D 589 Test Method for Opacity of Paper[3]

D 644 Test Method for Moisture Content of Paper and Paperboard by Oven Drying[3]

D 646 Test Method for Grammage of Paper and Paperboard (Weight per Unit Area)[3]

D 1030 Test Method for Fiber Analysis of Paper and Paperboard[3]

D 1968 Terminology Relating to Paper and Paper Products[3]

D 2176 Test Method for Folding Endurance of Paper by the M.I.T. Tester[3]

D 3424 Test Methods for Evaluating the Lightfastness and Weatherability of Printed Matter[4]

D 4714 Test Method for Determination of Effect of Moist Heat (50 % Relative Humidity and 90°C) on Properties of Paper and Board[3]

D 4988 Test Method for Determination of Calcium Carbonate Content (Alkaline Reserve of Paper)[3]

D 5625 Test Method for Measuring Length, Width, and Squareness of Sheeted Paper and Paper Products[3]

D 5634 Guide for the Selection of Permanent and Durable Offset and Book Papers[3]

2.2 *TAPPI Standards:*

T 236 Kappa Number of Pulp[5]

T 400 Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, or Related Products[5]

T 401 Fiber Analysis of Paper and Paperboard[5]

T 410 Grammage of Paper and Paperboard (Weight per Unit Area)[5]

T 411 Thickness (Caliper) of Paper and Paperboard[5]

T 412 Moisture in Paper[5]

T 414 Internal Tearing Resistance of Paper[5]

T 425 Opacity of Paper (15°/Diffuse Illuminant A)[5]

T 452 Brightness of Pulp, Paper, and Paperboard (Directional Reflectance at 457 nm)[5]

T 509 Hydrogen Ion Concentration (pH) of Paper Extracts—Cold Extraction Method[5]

T 511 Folding Endurance of Paper (MIT Tester)[5]

T 544 Effect of Moist Heat on Properties of Paper and Board[5]

2.3 *ISO Standards:*

ISO 9706 Paper for Documents. Specifications for Permanence. Normative Annex—Special instructions for determining kappa number.[6]

3. Terminology

3.1 *Definitions*—Terms used in this specification are defined

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[2] The boldface numbers in parentheses refer to the list of references at the end of this specification.

[3] *Annual Book of ASTM Standards*, Vol 15.09.

[4] *Annual Book of ASTM Standards*, Vol 06.02.

[5] Available from The Technical Association of The Pulp and Paper Industry, P.O. Box 105113, Atlanta, GA 30348.

[6] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

in accordance with Terminology D 1968.

3.1.1 *acid-sized paper*, *n*—paper that has been manufactured using a procedure or process at pH values below 7 (usually 4.0 to 6.5) that results in paper that has resistance to water penetration.

3.1.2 *alkaline-filled paper*, *n*—a paper containing an alkaline filler, such as calcium carbonate having a pH value in excess of 7 (extract pH usually in the range from 7.5 to 10.0), and containing a reserve buffering capacity that can neutralize acidic materials in the paper or acidic gases sorbed from the atmosphere.

3.1.2.1 *Discussion*—Such a paper is alkaline (extract pH usually in the range 7.5 to 10.0) and contains a reserve buffering capacity that can neutralize acidic gases sorbed from the atmosphere, or from the paper during degradation.

3.1.3 *alkaline-sized paper*, *n*—paper that has been manufactured using a procedure or process at a pH value above 7 (usually 7.5 to 10.0) that results in a paper that has resistance to liquid penetration.

3.1.4 *base paper*, *n*—the fiber network existent prior to the application of any material onto the surface of that fiber network.

3.1.4.1 *Discussion*—An example is paper, internally sized in preparation for a coating or surface sizing operation.

3.1.5 *bond paper*, *n*—one of many grades of paper covering a wide range of quality, from grades requiring superior performance, strength and durability to applications where permanence and durability are less important, but in all cases requiring good printing properties, color fidelity, erasability and cleanliness.

3.1.6 *ledger paper*, *n*—a paper characterized by strength, high tearing resistance, erasability, water resistance, ink receptivity, uniformity of surface, and smoothness.

3.1.6.1 *Discussion*—Originally, ledger paper was used especially for pen and ink records. Most ledger papers are surface sized, frequently subjected to appreciable wear, and must have a high degree of permanence and durability.

3.1.7 *neutral sized paper*, *n*—paper that has been manufactured using a procedure or process at a pH value of 7 (with a normal range of 6.5 to 7.5) that results in a paper that has resistance to water penetration.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *durability*, *n—of paper*, the capacity of paper or paperboard to resist the effects of wear in performance situations.

3.2.1.1 *Discussion*—Durability should not be used interchangeably with permanence. For example, paper money should be durable, but maximum permanence is not essential.

3.2.2 *high referral*, *adj—in paper*, descriptive of any grade of paper designed for use in situations involving frequent handling.

3.2.3 *life expectancy (LE)*, *n—for paper*, length of time a product can be expected to maintain its functional (that is, physical, chemical, appearance and so forth) characteristics when stored under prescribed conditions.

3.2.3.1 *LE designation*, *n—for paper records*, a rating in years for the life expectancy of paper, under prescribed conditions, primarily for records.

3.2.3.2 *maximum life expectancy (LE-1000)*, *n—for paper*, the document is expected to be usable for 1000 years under prescribed conditions.

3.2.3.3 *high life expectancy (LE-100)*, *n—for paper*, the document is expected to be usable for 100 years under prescribed conditions.

3.2.3.4 *medium life expectancy (LE-50)*, *n—for paper*, the document is expected to be usable for 50 years under prescribed conditions.

3.2.4 *paper with a minimum pH value*, *n*—as the life expectancy of paper is an approximate function of pH, one approach to describing a permanent paper is to specify a minimum pH value, for example, 5.5; this value can be achieved with a rosin-alum sizing system.

3.2.5 *permanence*, *n—of paper*, the tendency to resist changes in any or all of its properties with the passage of time.

3.2.5.1 *Discussion*—It is expected that the terms maximum, high, and medium permanence eventually will be replaced with maximum, high and medium life expectancy, or with the LE designations LE-1000, LE-100, LE-50.

4. Significance and Use

4.1 The only completely valid way to check the life expectancy of paper is to store it under the relevant conditions for the expected lifetime of the document, perhaps several hundred years. As this is not feasible, one must rely on observations made on historical documents, and on our current knowledge of factors, in terms of paper properties and paper composition, that increases life expectancy. Accelerated aging also may be used.

4.2 In this specification, requirements are given in terms of the following:

4.2.1 Physical tests to identify potential durability in service,

4.2.2 Tests related to composition of the paper that are indicative of stability,

4.2.2.1 For maximum life expectancy, the presence of an alkaline filler, such as calcium carbonate, to serve as a buffering agent,

4.2.2.2 Fiber analysis, or a certificate from the supplier concerning fiber composition, and

4.2.2.3 A test for pH, within the limits described in 7.2.4.

4.3 Papers with neutral or alkaline pH without a calcium carbonate filler may, or may not, have the expected life expectancy. An acid paper may have been treated with a surface size containing enough calcium carbonate to give an alkaline extract pH. An acid paper may be coated with a formulation containing calcium carbonate, although bond and ledger papers seldom are coated. In cases of uncertainty, the supplier should provide an affidavit concerning the extract pH of the base paper.

4.4 An optional accelerated aging procedure is described in X1.3.

5. Classification—Types

5.1 Three types of bond and ledger papers are described, according to life expectancy level. These life expectancy levels are differentiated by pH and type of filler or sizing, or both. For situations where the records will be handled frequently, the

grade is described as "high referral." A higher tearing resistance is specified for this category, a folding endurance requirement is optional, and the purchaser may wish to specify all or part cotton or linen.

5.2 *Type I, Maximum Life Expectancy, LE-1000*—Neutral or alkaline sized paper made with a calcium carbonate filler, which will give an extract pH usually in the range 7.5 to 10.0.

5.2.1 *Grade 1*—Ordinary use.

5.2.2 *Grade 2*—High referral.

5.3 *Type II, High Life Expectancy, LE-100*—Neutral or alkaline sized paper with an extract pH usually in the range 6.5 to 7.5.

5.3.1 *Grade 1*—Ordinary use.

5.3.2 *Grade 2*—High referral.

5.4 *Type III, Medium Life Expectancy, LE-50*—Paper with a minimum extract pH of 5.5

5.4.1 *Grade 1*—Ordinary use.

5.4.2 *Grade 2*—High referral.

6. Ordering Information

6.1 Orders shall specify type and grade, dimensions, color, and, if necessary, paper stock and printing requirements.

7. Composition and Chemical Requirements

7.1 *Fiber Analysis (see Test Method D 1030)*—The paper shall be made from cotton, linen, or fully bleached chemical pulp. Virgin or recycled fiber may be used in any proportion as agreed upon between the buyer and the seller at the time of purchase, as long as the paper meets the requirements of this specification. The kappa number (from ISO 9706) shall not exceed five.

7.2 *Hydrogen Ion Concentration (pH) Cold Extraction*—See TAPPI T 509.

7.2.1 *Type I, Maximum Life Expectancy, LE-1000*—7.5 to 10.0.

7.2.2 *Type II, High Life Expectancy, LE-100*—6.5 to 7.5.

7.2.3 *Type III, Medium Life Expectancy, LE-50*—Minimum 5.5.

7.2.4 Some papers may have been given an alkaline surface size or an alkaline coating. The base paper of these papers may be acid and of questionable stability, but would exhibit an alkaline extract pH. *There is no known procedure for measuring the extract pH of the base paper of a paper to which an alkaline surface size or alkaline coating has been applied.* The manufacturer should furnish an affidavit that the pH of the base paper conforms to the limits set forth. The pH test is valid if the analyst can be ensured that the paper does not have an alkaline surface size or an alkaline coating. The accelerated aging procedure, as described in X1.3 may be used as an indicator of stability.

7.3 *Filler*—Type I paper shall contain an alkaline filler such as calcium carbonate. The minimum shall be 2 %, calculated as calcium carbonate and based on the oven-dry weight of the finished paper. Test for the presence and amount of carbonate in accordance with Test Method D 4988.

8. Physical Properties

8.1 *Grammage (Weight per Unit Area)*— Use Test Method D 646 or TAPPI T 410. The average weight in grams per square metre shall be within the ranges from 57 to 63, 71 to 79, 85 to 95, and 114 to 126 as specified, but the variation of the test unit averages within a shipment (or lot) shall be not more than 5 % above or below the lot sample average value. These groups of papers are the nominal 60, 75, 90, and 120 g/m^2, respectively. The equivalent weights in pounds, ($17 \times 22\,500$) are 16, 20, 24, and 32, respectively.

8.2 *Thickness*—Use TAPPI T 411. Thickness shall be expressed as micrometres (1×10^{-6} m) or as mils (1×10^{-3} in.). The average thickness normally will be within the ranges given in Table 1 for papers of different nominal weights. The variation of test unit averages within a shipment (or lot) shall be not more than 5 % above or below the average value. Otherwise, thickness is as agreed upon between the buyer and the seller.

8.3 *Internal Tearing Resistance*—Use TAPPI T 414. The average internal tearing resistance in each direction shall be not less than that given in Table 1 for different weights of bond and ledger papers.

8.4 *Directional Reflectance (Brightness)*—Use Test Method D 985 or TAPPI T 452. For white papers, the average brightness shall be not less than 75 %. Optical brighteners are not excluded, unless specifically stated at the time of purchase. The brightness requirement does not apply to colored papers.

8.5 *Opacity*—Use Test Method D 589 or TAPPI T 425. The minimum values of opacity for the several nominal weights per unit area are given in Table 1.

8.6 *Color*—The paper shall be white or colored and the hue shall be as specified at the time of purchase.

TABLE 1 Requirements for Thickness, Internal Tearing Resistance, and Opacity for Bond and Ledger Papers

Nominal Weight per Unit Area, g/m^2 (lb)[A]	Thickness, µm (mil)	Internal Tearing Resistance, min, g		Opacity, %
		Ordinary Use	High Referral	
Bond				
50 (13)	61 to 81 (2.4 to 3.2)	22	35	73
60 (16)	76 to 102 (3.0 to 4.0)	40	50	80
75 (20)	89 to 122 (3.5 to 4.8)	50	60	83
90 (24)	112 to 145 (4.4 to 5.7)	60	70	85
Ledger				
90 (24)	97 to 132 (3.8 to 5.2)	60	70	85
105 (28)	114 to 152 (4.5 to 6.0)	75	90	87
120 (32)	132 to 173 (5.2 to 6.8)	90	110	90
135 (36)	140 to 178 (5.5 to 7.0)	100	130	92

[A] lb = $17 \times 22\,500$.

9. Dimensions, Trim, and Grain

9.1 *Dimensions and Trim*—The paper shall be furnished in the size or sizes specified at the time of purchase. The paper shall not be undersize, shall not be more than 1/16-in. (1.6-mm) oversize in either direction, and shall be trimmed square. If squareness is especially important, tolerances shall be specified by the purchaser. Dimensions and trim shall be measured by Test Method D 5625.

9.2 *Grain*—The paper shall be supplied grain long or grain short at the option of the seller, unless otherwise specified by the purchaser.

10. Additional Requirements

10.1 *Sizing*—The paper shall be internally sized and surface sized so that is shall be suitable for the intended purpose, as indicated by the purchaser.

10.2 *Printing Properties*—If the paper is to be used in a printing process, a stipulation that the paper be suitable for this purpose shall be included in the requirements.

10.3 *Erasing Quality*—If erasing quality is of importance to the buyer, the testing of this characteristic shall be agreed upon between the buyer and the seller.

10.3.1 Visible feathering shall not be apparent after the paper has been written on with aqueous ink, erased, and written on again in the erased area with aqueous ink.

10.4 *Folding Endurance*—Use Test Method D 2176 or TAPPI T 511. Folding endurance traditionally is considered to be a measure of the durability of paper, but opinion is divided. Therefore, it is suggested that a folding endurance requirement, if specified, be a subject of negotiation between the buyer and the seller.

10.5 *Lightfastness*—If lightfastness is of concern to the purchaser, use Test Method D 3424, Procedures 3 and 7, as agreed upon between the buyer and the seller.

11. Sampling

11.1 The paper shall be sampled in accordance with Practice D 585 or TAPPI T 400.

12. Inspection

12.1 Inspection of the paper shall be agreed upon between the purchaser and the seller as part of the purchase contract.

13. Certification

13.1 Upon request of the buyer, a manufacturer's certification that the paper was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment.

13.2 Test results obtained by both the buyer and the seller shall be made available upon request to either party.

13.3 As the extract pH of a paper would be influenced by an alkaline surface size, or by an alkaline coating, it is desirable to request an affidavit from the manufacturer that the extract pH of the base paper conforms to the limits specified in 7.2.

14. Packaging and Marking

14.1 The paper shall be packaged in 500 or 1000-sheet quantities. These shall be wrapped and securely sealed, or packaged in boxes or cartons, in order to provide adequate protection during shipment and storage. Each package shall be marked to show the type of paper, quantity, color, size, basis weight (weight per unit area), and the name of the manufacturer.

14.2 Packaging in exterior containers for shipment shall be adequate to avoid damage during shipment and storage.

15. Keywords

15.1 bond paper; ledger paper; life expectancy; maximum life expectancy; permanent bond paper; permanent ledger paper

APPENDIX

(Nonmandatory Information)

X1. ADDITIONAL INFORMATION

X1.1 As there are many variables in the manufacture of paper and in the use and storage of records, it is impossible to place definitive values on the number of years that various categories of records will endure. It has been established that the rates of both natural and accelerated aging are approximate functions of the pH of the paper. The following information may be used as guidance.

X1.1.1 *Type I Papers, Maximum Life Expectancy, LE-1000*—Machine-made papers with an alkaline filler have existed, apparently with little change, for 100 years. Handmade papers containing an alkaline filler have survived for almost 400 years **(6)**. Acid papers have survived this long, but their condition is, comparatively speaking, not as good and is a function of acidity.

X1.1.2 *Type II Papers, High Life Expectancy, LE-100*—The probable life expectancy of these papers should lie somewhere between the life expectancy of Type I and Type III papers.

X1.1.3 *Type III Papers, Medium Life Expectancy, LE-50*—The relative condition of paper in old books and documents has been correlated with pH. Barrow **(1)** has shown that the condition of naturally aged paper definitely is a function of pH. Manifold papers in U.S. Government files with pH values as low as 4.2 have survived over 60 years **(5)**, and the physical properties of these papers are an approximate function of pH. A minimum pH of 5.5 should ensure longevity of 50 years or more.

X1.2 Papers containing cotton or linen, or both, are considered to be more durable than wood pulp papers. As both rag and wood pulp papers may cover a broad spectrum of life expectancy and durability, generalizations on the basis of fiber

content alone are not useful. Cotton linters are not as strong as cotton fiber.

X1.3 During the development of Guide D 5634, and during the development of a National Information Standards Organization (NISO) standard for permanent paper, about 60 papers were aged for 12 days at 90°C and 50 % relative humidity (Test Method D 4714, TAPPI T 544). The selection of percent retention values after aging for various levels of life expectancy is subjective, but enough information is available to make this approach attractive. The retention of tensile energy absorption, and of tearing strength, after aging for 12 days at 90°C and 50 % relative humidity should be 90 % or higher for maximum life expectancy, about 80 % or higher for high life expectancy, and about 70 % or higher for medium life expectancy.

X1.4 Paper may be procured on the basis of a standard sample, on the basis of requirements other than those listed in this specification, or one or more of the requirements may be waived. In order to obtain the degree of life expectancy required, it is very important that the pH requirements of this specification, or the aging requirement in X1.3, be met for the type and grade of paper purchased.

X1.5 Historically, specifications for paper for permanent records have limited fiber sources to those that would result in no more than 1 % lignin in the papers. The use of alkaline papermaking technologies, including the use of alkaline sizing and alkaline fillers, may change the situation for some applications. Although yellowing occurs during light exposure and dark storage, laboratory data indicate that the strength properties of papers containing substantial quantities of lignin do not change appreciably during accelerated aging in a moist atmosphere.

X1.5.1 There are many other end uses where alkaline papers with alkaline size and containing an alkaline filler and substantial quantities of lignin, would be suitable for long-term use and, for economic reasons, desirable. The user would decide whether yellowing during light exposure or long-term storage, or both, would be acceptable. These needs should be agreed upon between the buyer and the seller and written into standards intended for the purpose.

X1.6 Appearance properties, such as color and reflectance (brightness, whiteness, etc.) that might be affected by light and by dark aging may be important to the user. The traditional use of bleached chemical wood or cotton fiber has been recognized as a way to preserve appearance properties.

X1.6.1 As fiber sources are less uniform than in the past, it is desirable to measure the effect of light and dark storage on the appearance properties of paper.

X1.6.2 Test Method D 3424, Procedures 3 and 7, may be used for evaluating fading properties.

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