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Standard Guide for Selection of Permanent and Durable Offset and Book Papers[1]

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1. Scope

1.1 This guide covers offset and book papers, both coated and uncoated, used in the preparation of permanent records. Permanent records usually are expected to last several hundred years in a records repository, with little change in properties that affect readibility or handling, although some records are expected to have shorter lifetimes.

1.2 Acidic materials incorporated in paper during manufacture (for example, rosin-alum sizing) contribute to deterioration. It has been shown **(1, 2, 3, 4, 5)**[2] that the life expectancy of uncoated papers is an approximate function of the pH of an aqueous extract of the paper.

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 or can neutralize acidic materials formed in the aging of paper.

1.4 Three pH levels reflecting three levels of life expectancy are outlined in this guide. As one cannot rely on pH alone as an indicator of stability, minimum retentions of properties after accelerated aging at 90°C and 50 % relative humidity are suggested for the three levels of life expectancy.

1.5 In selecting papers for permanent records, papers with acceptable durability are evaluated for life expectancy through accelerated aging.

1.6 This guide should be used in the purchase of paper for permanent records.

1.7 This guide is based on the use of 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 X1.8) paper containing more than 1 % lignin may be employed for many other end uses in paper for records that are required to have a substantial life expectancy.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 585 Practice for Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, or Related Product[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 645/D 645M Test Method for Thickness of Paper and Paperboard[3]

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

D 689 Test Method for Internal Tearing Resistance of Paper[3]

D 774/D 774M Test Method for Bursting Strength of Paper[3]

D 828 Test Method for Tensile Breaking Strength of Paper and Paperboard[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 Method for Evaluating the Lightfastness and Weatherability of Printed Matter (Procedures 3 and 7)[4]

D 4714 Test Method for Determination of Effect of Moist Heat on Properties of Paper and Paperboard[3]

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

D 5625 Test Method for Measuring Length, Width and Squareness of Sheeted Paper and Paper Products[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 product[5]

[1] This guide is under the jurisdiction of ASTM Committee D06 on Paper and Paper Products and is the direct responsibility of Subcommittee D06.20 on Permanent Records Papers.

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

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

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

[5] Available from Technical Association of the Pulp and Paper Industry, Technology Park, Atlanta, PO Box 105113, Atlanta, GA 30348.

T 401 Fiber analysis of paper and paperboard[5]
T 403 Bursting strength of paper[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 and paperboard[5]
T 414 Internal tearing resistance of paper[5]
T 425 Opacity of paper (15°/diffuse illuminant A, 89 % reflectance backing and paper backing)[5]
T 452 Brightness of pulp, paper, and paperboard (directional reflectance at 456 nm)[5]
T 459 Surface strength of paper (wax pick test)[5]
T 479 Smoothness of paper (Bekk method)[5]
T 480 Specular gloss of paper and paperboard at 75 degrees[5]
T 494 Tensile breaking properties of paper and paperboard[5]
T 509 Hydrogen ion concentration (pH) of paper extracts (cold extraction method)[5]
T 511 Folding endurance of paper (M.I.T. tester)[5]
T 538 Smoothness of paper and board (Sheffield method)[5]

2.3 *ISO Standard:*

ISO 5630/1 Laboratory Aging of Paper—Aging in a Dry Oven at 105°C[6]
ISO 5630/3 Laboratory Aging of Paper—Aging in a Moist Oven at 80°C, 65 % Relative Humidity[6]
ISO 9706 Paper for Documents, Specifications for Permanence, Normative Annex—Special instructions for determining kappa number[6]

3. Terminology

3.1 *Definitions:*[7]

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 a paper that has resistance to aqueous-liquid 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 formed in the paper, or acidic gases sorbed from the atmosphere.

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 paper that has resistance to aqueous liquid penetration.

3.1.4 *book paper*, *n*—a general term for a group of uncoated or coated papers (exclusive of newsprint) suitable for the graphic arts.

3.1.4.1 *Discussion*—Grammage of book papers is usually in the range from 44 to 148 g/sq m (basis weight 30 to 100 lb, 25 × 38 in.—500 sheets). They are characterized by a wide variety of surface finishes (for example, antique, eggshell, machine, English, dull, matte, supercalendered, glossy, etc.), with good formation, printability and cleanliness.

3.1.5 *coating*, *n—of paper*, the layer of pigment and adhesive applied to the surface of paper or paperboard to create a new surface.

3.1.5.1 *Discussion*—Paper is coated to improve smoothness and the efficiency of printing. Although the kind and amount of coating are important, the purchaser is concerned with performance, that is, smoothness, resistance to pick, printability, etc.

3.1.6 *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 aqueous-liquid penetration.

3.1.7 *offset paper*, *n*—an uncoated or coated paper designed for use in offset lithography.

3.1.7.1 *Discussion*—The kind, type and combinations of pulps used in the manufacture of offset papers depend on the sheet qualities desired. Important qualities are good internal bonding, high surface strength, good dimensional stability, lack of curl, and freedom from fuzz and foreign surface material.

3.2 *Definitions of Terms Specific to Standards for Paper for Permanent Records:*

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 currency should be durable, but maximum permanence is not essential.

3.2.2 *life expectancy*, LE[8], *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 *life expectancy designation*, *n—for paper records*, a rating in years for the life expectancy of paper, when stored under prescribed conditions.

3.2.3.1 *maximum life expectancy, LE-1000, n—for paper*, a paper is expected to be usable for 1000 years when stored under prescribed conditions.

3.2.3.2 *high life expectancy, LE-100, n—for paper*, a paper is expected to be usable for 100 years when stored under prescribed conditions.

3.2.3.3 *medium life expectancy, LE-50, n—for paper*, a paper is expected to be usable for 50 years when stored under prescribed conditions.

3.2.4 *paper with a minimum pH value*, *n*—as the stability of paper is an approximate function of pH, one approach to describing a stable 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, and LE-50.

[6] Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

[7] See also the *Dictionary of Paper*, Tappi Press.

[8] Adapted from American National Standards Institute Committee IT9.1; approved December 1991.

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 increase life expectancy, and on the retention of selected properties after accelerated aging.

4.2 In this guide the suggested requirements are given in terms of the following:

4.2.1 Physical tests to identify potential durability in service,

4.2.2 A minimum percentage retention of selected properties after accelerated aging for 12 days at 90°C and 50 % relative humidity, and

4.2.3 Tests related to composition of the paper that are indicative of stability:

4.2.3.1 A pH test, for screening only.

4.2.3.2 For maximum life expectancy, the presence of an alkaline filler such as calcium carbonate, to serve as a buffering agent against attack by acidic contaminants from the atmosphere, and from the paper during aging.

4.2.3.3 Fiber analysis or a certificate from the supplier concerning fiber composition.

4.3 Although data from tests that may be performed in the laboratory do not correlate perfectly with use situations, several tests are available that should be useful to estimate the durability of paper. Examples of such tests, in approximate order of usefulness, are tearing force, tensile properties (tensile strength, elongation and tensile energy absorption), burst, and folding endurance. If possible, all of these tests should be used.

4.4 Papers buffered with a calcium carbonate filler, and with fiber composition in accordance with 7.1.2, are considered to have maximum life expectancy **(1, 4, 6)**.

4.4.1 It has been reported **(7)** that some coated papers lose folding endurance rapidly during accelerated aging, much more rapidly than the uncoated base paper.

4.4.2 Coated papers do not retain physical properties and brightness as well after accelerated aging as uncoated papers (see Table X1.3). The average for the retentions of tensile, TEA, tear, and burst after accelerated aging of 19 uncoated papers with pH values >7.0 is 91 %. The same average for 13 coated papers is 85 %.

4.4.3 More study is needed on the effect of coatings on the stability of paper, which is another reason why an accelerated aging procedure should be used in the evaluation of most papers for permanent records, especially coated papers.

4.5 Papers with a 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. Also, an acid paper may have been coated with a formulation containing calcium carbonate pigment. Therefore, an accelerated aging procedure is necessary to ensure the exclusion of such papers. If a paper is not coated with a calcium carbonate formulation, or if it is not surface sized with a sizing agent that contains calcium carbonate, the pH test should be valid.

4.6 In order to estimate the relative life expectancy of paper, it is necessary to develop a data base on the accelerated aging of several papers covering a spectrum of life expectancies. This information is available on the aging of 48 papers (see Note 1), and the aging of a collection of 13 papers (see Note 2). Retentions of selected physical properties after accelerated aging are used as indicators of probable longevity. Examples of tests that are useful for the purpose of estimating probable longevity include tearing force, tensile strength, elongation, tensile energy absorption (TEA), burst, and brightness.

NOTE 1—The 48 papers were supplied by manufacturers of book and offset papers, and are representative of papers that are available in the marketplace. See Table X1.1 and Table X1.2.

NOTE 2—The set of 13 papers was tested by the Institute for Paper Science and Technology (IPST) for the National Information Standards Organization (NISO), Subcommittee II, who made the data available to ASTM Committee D06. See Table X1.4.

4.7 Although arbitrary limits are suggested for various properties, these suggested limits are for guidance only. There are no limits to properties that can be measured in the laboratory above which a paper is acceptably durable or permanent, or both, and below which it is not acceptable. No paper has been tested that quite met all criteria in this guide for maximum stability. Selections must be made on the basis of the potential value of the records to be generated, resources, cost, and what is available in the marketplace.

4.8 Comparisons have been made between dry-oven aging at 100°C and natural aging for 36 years **(4)**. Correlations between dry-oven aging and natural aging are not perfect, but the data show that this approach is useful.

4.8.1 Comparisons have been made between dry-oven aging for 18 h at 105°C, and moist aging for 18 h at 65°C and 85 % relative humidity, of pulp samples with natural aging for 17 to 29 years **(8)**. Correlations of dry-oven aging and of moist aging with natural aging were good.

4.8.2 The parameters known to promote instability in paper also cause degradation in moist accelerated aging. Moist aging is a useful technique for comparing the relative stability of several papers. Paper usually degrades much faster during moist aging than during dry aging.

4.9 Coated papers present a special problem with respect to stability. Formulations for binders in coatings may be developed from a large number of polymeric materials. These formulations are proprietary and little is known about their stability.

5. Classification—Types

5.1 Three types of offset and book papers are described, according to life expectancy. These life expectancy levels are differentiated by pH and type of filler. One cannot rely on pH alone as an indicator of stability, but must also use accelerated aging in accordance with 8.3.

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

5.3 *Type II, High Life Expectancy*, LE-100—Neutral- or