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Standard Test Method for Apparent Tack of Printing Inks and Vehicles by a Three-Roller Tackmeter[1]

This standard is issued under the fixed designation D 4361; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the procedure for determining the apparent tack of printing inks using a mechanical or electronic model of a three-roller tackmeter.

1.2 This test method is applicable to paste-type printing inks and vehicles that are essentially nonvolatile under ordinary room conditions.

1.3 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *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. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *tack, n*—a function of the force required to split a thin fluid film of a printing ink or vehicle between two rapidly separating surfaces; it is a rheological parameter indicative of internal cohesion of the fluid.

2.1.1.1 *Discussion*—Tack of a printing ink or vehicle is not a fixed number but varies with operating conditions, primarily separation velocity, splitting area, and film thickness. Tack also varies with changes in the rheological properties of the ink or vehicle due to time, temperature, and interactions with the separating surfaces. In practice, one or more of these surfaces usually consist of rubber-like rollers that differ in composition and geometry and whose properties tend to change with age, nature of previously run fluids, type of wash-up solvent, and mechanical flaws. On laboratory instruments, tack readings are also sensitive to the calibration and zero accuracy of the tackmeter employed.

2.1.2 *apparent tack, n*—a tack reading obtained at a specific set of conditions.

2.1.3 *flying, n*—the tendency of a printing ink or vehicle to be ejected as large globules from a roller distribution system.

2.1.3.1 *Discussion*—Flying is generally most severe during rapid roller acceleration such as occurs when switching immediately from zero or a slow speed to a high operating speed.

2.1.4 *misting, n*—the tendency of a printing ink or vehicle to be ejected as a fine aerosol from a roller distribution system.

2.1.4.1 *Discussion*—Misting is generally most severe at high operating speeds and with fluids that produce long filaments.

3. Summary of Test Method

3.1 A thin film of the test printing ink or vehicle is applied to the three-roller distribution system of the tackmeter, which operates at speeds comparable to those on production printing presses. Measurement of the frictional torque induced by drag forces in the splitting film provides an arbitrary value for apparent tack. On mechanical models, the torque is determined with a manually balanced lever arm, a direct-reading attachment, or a recorder; on electronic models, with a digital readout, recorder, or printer. Readings are in units of gram-meters (g-m).

3.2 The procedure in this test method is designed to give a single value for apparent tack at a specific set of instrument conditions. Typical conditions are as follows: a cooling water temperature of 90°F (32.2°C); a volume of 1.32 mL (film thickness 12.3 µm) of the test printing ink or vehicle applied to the rollers; an operating speed of 400 r/min for vehicles, 800 r/min for sheet-fed offset inks, and 1200 r/min for web-fed inks; and a reading after 1 min of operation. Alternative conditions may be used by agreement between the supplier and the customer.

3.3 Instructions are also given for calibration of the Inkometer and for minimizing effects of interactions among the rollers, test fluids, and wash-up solvents.

4. Significance and Use

4.1 Tack of printing inks controls their high-speed transfer properties, as manifested by throughput in roll milling, picking of paper during printing, and wet trapping in multicolor printing. Although an apparent tack measurement does not completely predict the transfer performance of an ink or a vehicle, it provides a meaningful parameter for quality control,

[1] This test method is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.56 on Printing Inks. Subcommittee D01.37 on Ink Vehicles assisted in the development of the vehicle portion of this test method.

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development, and research.

4.2 A given tackmeter will produce repeatable results on a day-to-day basis only if proper attention is paid to calibration and maintenance procedures and to control of experimental variables referred to in 2.1.1.1.

4.3 Two or more instruments may not produce identical apparent tack readings, but if each gives repeatable results, they may be mathematically correlated.

NOTE 1—A number of three-roller tackmeters are available which differ in design features such as roller weight, geometry, and composition of the distribution system. It cannot be presumed that test results from these other types of tackmeters will either agree or correlate with those from the tackmeters specified in 6.1 and 6.2 of this test method.

5. Interferences

5.1 *Tackmeter Squeal*—A high pitched whine or squeal may be noted when running high tack fluids or at high rotating speeds, or both. Squeal may result in instability of the balance beam or direct reading attachment of mechanical models, or fluctuation of the digital readout of electronic models, making definite readings difficult.

6. Apparatus

6.1 *Three-Roller Tackmeter*—Models differ in available speeds and type of readout as follows:

6.1.1 *Mechanical Models*, operate three or four fixed speeds selected from among 400, 800, 1200, and 2000 r/min. A direct reading attachment or a recorder is recommended to supplement the manually operated balance beam.

6.1.2 *Electronic Models*, operate at variable speeds ranging from 100 to 2000 or 3000 r/min. A recorder or printer, or both, are recommended to supplement the digital readout.

NOTE 2—To convert to units of linear speed, multiply revolutions per minute by 0.785 to obtain feet per minute or by 0.004 to obtain metres per second.

6.2 *Tackmeter Rollers*, of suitable composition, preferably one set for each major system to be evaluated (see 10.3.1.) A set consists of a top (measuring) roller 3⅛ in. (79 mm) in diameter and 6⅛ in. (155 mm) in length, and a vibrator 2.0 in. (51 mm) in diameter and 7¼ in. (184 mm) in length. Together with the fixed brass roller, the total surface area of the distribution system is 166 in.^{2} (0.107 m^2). The measuring roller weighs 9.2 lb (4.2 kg) on mechanical models and 9.6 lb (4.4 kg) on electronic models.

6.3 *Ink Pipet*, consisting of a metal cylinder and a metal or TFE-fluorocarbon plunger. Suitable pipets include fixed-volume pipets, 1.32-mL capacity; and variable volume micropipets, 2-mL capacity, accurate to 0.01 mL.

6.4 *Stopwatch or Timer*, accurate to 1 s.

6.5 *Ink Knife*, small, free from nicks and rough edges.

6.6 *Manufacturer's Calibration Apparatus*, for the specific model tackmeter.

7. Reagents and Materials

7.1 *Wash-Up Solvent*, compatible with the test system, fast evaporating, and having minimal effect on the rollers; it should be acceptable environmentally. Hydrocarbon solvents with an initial boiling range of 250 to 350°F (120 to 177°C), a final boiling range of 300 to 400°F (150 to 205°C), a Kauri-Butanol value of 30 to 40 and less than 1 % benzene content are appropriate for many sheet-fed and heat-set systems. Specific solvents may be required for unique systems.

7.2 *Rags or Wipers*, clean, soft, absorbent, lint-free.

7.3 *Manufacturer's Current Manual*, for the specific model tackmeter.

8. Hazards

8.1 Never let an ink or a vehicle dry completely on the rollers of the tackmeter. (**Warning—**Never turn the ZERO button except during the calibration process (see 12.2.1)).

8.2 Take care not to damage the rollers during the cleaning process or by leaving them in contact when the instrument is not in use.

8.3 Do not disengage the balance beam of a mechanical model except when taking a reading.

9. Sampling and Test Specimen

9.1 Carefully select a sample that is free of skin and other contamination and representative of the lot being evaluated. A minimum of 3 to 4 mL is sufficient for two specimens. Transfer to a clean container, protect with skin paper, close, and seal.

9.2 When ready to make a run (see 12.3), fill the ink pipet as follows: Transfer 1.5 to 2 mL of sample to a clean glass plate; close and reseal the container. Gently work up with an ink knife but do not aerate. Fill the ink pipet with 1.32 mL of the worked sample (or with a smaller volume (0.5 to 1.0 mL) if a thinner film thickness is desired). Use the ink knife to force the specimen into the cylinder while slowly pulling back the ram. Wipe excess material off the top of the pipet.

NOTE 3—A specimen volume of 1.32 mL, divided by the roller surface area of 0.010 ft^2 (0.107 m^2), gives an initial film thickness of 12.3 µm when distributed uniformly on the roller system. However, the occurrence of appreciable flying or misting will result in loss of specimen from the rollers. Hence, operating film thickness is unknown.

10. Preparation and Conditioning of the Tackmeter

10.1 Locate the tackmeter on a sturdy bench in a draft-free temperature-controlled environment, preferably 73.5 ± 3.5°F (23 ± 2°C). Humidity control is necessary for test samples that are moisture-sensitive or prone to misting.

10.2 Set the water bath at 90.0 ± 0.2°F (32.2 ± 0.1°C). All tests are to be run at this temperature. (See also A1.3.)

10.3 Prior to use, ascertain the nature of the test sample for the following reasons:

10.3.1 *Roller conditioning*—Use only an instrument having rollers well broken in for the type of test system. The break-in procedure is given in A1.2. A separate set of broken-in rollers is mandatory for radiation curing systems. The necessity for separate sets of broken-in rollers, or for extensive reconditioning when switching among different types of conventional test systems shall be determined in each laboratory.

10.3.2 *Operating speed*—Vehicles are most commonly run at 400 r/min, alternatively at 800 r/min; sheet-fed inks at 800 r/min, alternatively at 400 or 1200 r/min; and web-fed inks at 1200 r/min, alternatively at 800 or 2000 r/min. (The conversion to linear speed is given in Note 2.)

10.4 Prior to the first use of the day, equilibrate the tackmeter as follows:

10.4.1 Warm up the instrument by activating the water cooling system. Engage the two composition rollers and run at the lowest available speed for about 30 min.

10.4.2 Make a conditioning run with a specimen representative of the system to be evaluated. Apply 1 to 1.5 mL of the ink or vehicle, and run for 5 to 10 min at the specified test speed (see 10.3.2). Clean up as directed in Section 13.

11. Calibration of the Tackmeter

11.1 Calibrate the tackmeter before initial use and periodically as needed. First, conduct the necessary steps in 10.3 and 10.4.

11.2 Using the manufacturer's calibration apparatus, follow the directions in the instrument manual.

11.2.1 *Mechanical Models*—Zero and calibrate the balance beam (and direct reading attachment or recorder, if they are to be used) at the test speed specified in 10.3.2.

11.2.2 *Electronic Models*—Zero and calibrate the digital readout (and recorder, if it is to be used) at 1000 r/min. When calibration is completed, check the dry reading at the specified test speed (see 10.3.2).

NOTE 4—Three-roller tackmeters can be calibrated at only one speed.

11.3 After each calibration or at regular periods, make a test run with a standard ink or vehicle. (See A1.5.)

12. Procedure for Tack Evaluation

12.1 If necessary, make preparations as in 10.3 and 10.4, and calibrate as in Section 11. If using an electronic model, make sure the motor is preset to the test speed specified in 10.3.2 and the drive is in the LOW mode.

12.2 Engage the rollers and run at the specified test speed. If the dry reading differs from zero by more than ±0.5 g-m, reclean the rollers in accordance with 13.1 or recalibrate in accordance with Section 11.

12.2.1 The dry reading on a properly calibrated instrument is directly related to the condition of the top (measuring) roller; therefore, large deviations from zero are suspect. Usual causes are inadequate cleaning, residual sample or wash-up solvent, or mechanical damage. *Do not turn the ZERO button, as doing so will shift the scale. Do not attempt to compensate by subtracting the dry reading from the test reading. Always reclean or recalibrate.* Should large deviations from zero persist, contact the manufacturer about the possibility of serious mechanical damage.

12.3 Turn the instrument off, disengage the rollers, and fill the pipet as in 9.2. Transfer its contents to the vibrator in a series of thin ribbons around the middle 5 in. (125 mm) of the roller. Wipe any specimen remaining in the pipet onto a clean place on the same roller. Reengage the rollers.

12.4 Distribute the specimen on the rollers and start the run as follows:

12.4.1 *Mechanical Models with Electronic Transmission*:

12.4.1.1 Manually turn the motor coupling about ten revolutions, or until the specimen appears evenly distributed among the three rollers.

12.4.1.2 Set the gears at 400 r/min, start the motor and the stopwatch simultaneously, and let the ink distribute for 15 s. Stop the motor but not the stopwatch.

12.4.1.3 Quickly switch the gears to the test speed (specified in 10.3.2) and immediately restart the motor, noting the time on the stopwatch.

12.4.2 *Mechanical Model MBC*:

12.4.2.1 Place the fingertips against the sides of the brass roller and manually turn about ten revolutions, or until the specimen appears evenly distributed among the three rollers. Do not touch the surface of the rollers.

12.4.2.2 Place the speed control switch at the 150 r/min position. Simultaneously depress the power switch and start the stopwatch. Let the ink distribute for 15 s.

12.4.2.3 Quickly reposition the speed control switch to the test speed, noting the time on the stopwatch.

12.4.3 *Electronic Models*:

12.4.3.1 Place the fingertips against the sides of the brass roller and manually turn about ten revolutions, or until the specimen appears evenly distributed among the three rollers. Do not touch the surface of the rollers.

12.4.3.2 Depress the DRIVE button and simultaneously activate the stopwatch. Let the ink distribute for 15 s at the automatic LOW speed of 150 r/min.

12.4.3.3 Quickly switch to the test speed (preset in 12.1) by depressing the HIGH/LOW button again, noting the time on the stopwatch.

12.5 After 60 s of running at the test speed, record the apparent tack of the test specimen from the balance beam (see A1.4); direct-reading attachment, or the recorder of a mechanical model or the digital readout, recorder, or printer of an electronic model.

12.6 *Optional*—Rather than restrict the test to a single apparent tack determination, valuable information may, in some cases, be gained by continuing the run, taking readings at uniform time intervals (facilitated by the use of a recorder) until the apparent tack begins to decrease. Alternatively, the tackmeter speed may be varied stepwise and a tack reading taken after a specified time at each speed.

12.7 After the run, stop the instrument and clean up, as directed in Section 13.

12.8 Make a replicate test with another specimen of the same sample by repeating 12.2-12.6. The two tests should

TABLE 1 Standard Deviation and Precision of Apparent Tack Readings

Samples	Tackmeter Type	Speed of Rollers, r/min	Standard Deviation				Repeatability		Reproducibility	
			Within-laboratory		Between-laboratory		1 min	5 min	1 min	5 min
			1 min	5 min	1 min	5 min				
Ink	mechanical	800	0.49	0.47	0.52	0.97	2.0	1.8	2.0	3.8
	electronic	800	0.31	0.46	0.67	1.26	1.2	1.8	2.6	5.0
Vehicles	electronic	400	0.38	0.37	1.30	1.60	1.1	1.0	3.8	4.7
	electronic	800	0.26	...	1.20	...	0.7	...	3.4	...

agree within the repeatability given in Table 1.

13. Wash-up Procedure

13.1 With the tackmeter running at the lowest speed, apply a small amount of wash-up solvent to the rollers. Remove most of the specimen from the system by placing pads of the clean, soft, absorbent lint-free rags or wipers firmly against the bottom of the brass roller. Repeat this procedure with additional solvent and pads until the rollers are free from ink or vehicle. If any material remains on the edges of the composition rollers, remove very gently with a solvent-moistened rag. (**Warning—**Remove material directly from the measuring or vibrator rollers with extreme care. Undue pressure will cause uneven wear of the rollers and may place significant strain on the torsion bar of the electronic model. Use extreme care to ensure that the cleaning pad does not go through the roller nip; otherwise, serious mechanical problems may result and recalibration will be essential.)

13.2 Dry the rollers thoroughly by running them in contact at high speed for a minimum of 5 min or until all of the solvent has evaporated.

13.3 Check the zero reading as in 12.2. Continue cleaning and drying until the dry reading reaches 0 ±0.5 g-m.

13.4 When the rollers are satisfactorily clean, stop the Inkometer and disengage the measuring and vibrator rollers.

13.5 Clean the pipet, the ink knife, and the glass plate with a solvent-wet rag.

14. Report

14.1 Report the following information:

14.1.1 Complete identification of the sample,

14.1.2 Tackmeter model used,

14.1.3 Test speed,

14.1.4 Ambient temperature,

14.1.5 Any modifications to this test method,

14.1.6 Whether significant flying or misting was observed,

14.1.7 Whether squeal was noted during the test,

14.1.8 Average apparent tack reading of two determinations, and

14.1.9 Any additional apparent tack readings determined at constant speed-constant time intervals or varying speeds-constant time intervals.

15. Precision and Bias

15.1 *Precision*:

15.1.1 In an interlaboratory study[2] of this test method six inks with a broad range in tack were measured for apparent tack ten times at 1 min and 5 min on mechanical in six laboratories and on electronic tackmeters in eight laboratories.

15.1.2 In a separate interlaboratory study[3] of this test method, four quick-set vehicles and four heat-set vehicles with a broad range in tack were measured in duplicate on two different days at 1 min and 5 min at 400 r/min on electronic Inkometers in six laboratories. The four quick-set vehicles were also measured at 1 min at 800 r/min.

15.1.3 The within-laboratory and between-laboratory standard deviations are shown in Table 1. Based on these standard deviations the following criteria should be used for judging the acceptability of results at the 95 % confidence level:

15.1.3.1 *Repeatability*—Two individual results obtained by the same operator should be considered suspect if they differ by more than the values given in Table 1.

15.1.3.2 *Reproducibility*—Two results, each the mean of two readings, obtained by operators in different laboratories should be considered suspect if they differ by more than the values given in Table 1.

15.2 *Bias*—Bias cannot be determined as there are no known methods for measuring actual splitting forces. There are indications that apparent tack measurements from three-roller tackmeters correlate best with transfer performance when a series of test samples is based on the same vehicle chemistry.

16. Keywords

16.1 apparent tack; printing inks; splitting forces; tack; tackmeters; three-roller tackmeters; vehicles

[2] Supporting data are available from ASTM International Headquarters. Request RR:D01-1039.

[3] Supporting data are available from ASTM International Headquarters. Request RR:D01-1062.

ANNEX

(Mandatory Information)

A1. INFORMATION CONCERNING THREE-ROLLER TACKMETERS

A1.1 Routine Maintenance of the Tackmeter

A1.1.1 Routine maintenance is extremely important to the mechanical integrity of the instrument; see the manufacturer's current instruction manual for the specific model.

A1.1.2 The measuring and vibrator rollers may acquire a glazed or shiny appearance with use, depending on the test system and the wash-up solvent. This glaze may result in a significant change in the apparent tack reading of an ink or vehicle. The glaze may be removed by extra cleaning with a strong solvent such as acetone. If not, the composition rollers should be replaced.

A1.2 Breaking-in the Tackmeter Rollers

A1.2.1 New tackmeter measuring and vibrator rollers may selectively absorb certain components of some test systems, up to a saturation point, at which point they may be said to be broken in. Until this selective absorption is complete, tack determinations made with these rollers may not be repeatable. Break in new rollers using the following procedure:

A1.2.1.1 Place the rollers on the instrument. Choose as break-in samples those representative of the system that will be evaluated on the rollers. Run approximately 1.0 to 1.5 mL of the break-in sample for extended periods of time, wash-up with the solvent to be used, reapply the sample, run, wash-up, etc.

NOTE A1.1—The wash-up is a significant part of the break-in process.

A1.2.1.2 Break-in time may vary from several hours to several days. Reproducible apparent tack readings on standard samples (see A1.5.1), over a period of several days, indicate that the rolls are broken in; they may then be put into routine use.

A1.2.2 A major change in ink systems may adversely affect the rollers. When a set of rollers has been used for one system, and it is to be used for another, use this same break-in procedure. The rollers may then no longer be suitable for the original system.

A1.3 Temperature Control of the Tackmeter Water Bath

A1.3.1 Extremely precise temperature control of the water bath is essential for repeatable apparent tack readings.

A1.3.2 The thermometer furnished with mechanical models, and the temperature gage of electronic models are accurate to ±0.5°F (±0.3°C).

A1.3.2.1 It may be advantageous to use a Bomb Calorimeter Thermometer ASTM 56F, 66.0 to 95.00°F, with divisions of 0.05°F, or ASTM 56C, 19.00 to 35.00°C, with divisions of 0.02°C, in the water bath. Position the thermometer in such a manner that the bottom of the mercury bulb is in line with the return inlet from the brass roller.

A1.3.3 The temperature-control system of the instrument is capable of controlling the temperature inside the brass roller within ±0.5°F (±0.3°C).

A1.3.3.1 It may be advantageous, particularly, if high-tack samples are run for extended periods of time, or if the instrument is in constant use, to augment the temperature control system with a cold-water cooling coil. A coiled length of ¼-in. (6.3-mm) outside-diameter copper tubing may be placed in the water-bath reservoir, in the flow area away from the thermometer. The coil is connected to a cold-water tap with a pressure regulator and emptied into a sink or drain.

A1.4 Reading the Balance-Beam of Mechanical Tackmeters

A1.4.1 In order to take a reading from the balance beam of a mechanical model, disengage the beam and move the sliding weight until the beam is continuously in balance. Read the scale at the left of the sliding weight, using the scale alignment cutout to facilitate reading.

A1.4.2 Minimization of parallax is necessary for repeatable apparent tack readings. It may be useful to mount a small reflective surface on the beam stop behind the zero indicator and the balance beam. The zero indicator and the zero line on the balance beam are aligned in the reflective surface when an apparent tack reading is being taken.

A1.4.3 Reengage the balance beam immediately after taking the reading.

A1.5 Standard Test Samples

A1.5.1 It may be useful to designate one or more inks or vehicles as standards. Samples that are stable and have a good shelf life without a change in apparent tack reading (for example, tack rated or tack graded) are appropriate. Daily apparent tack readings on these samples ensures that the instrument is in calibration and serves as a check on repeatability.