Designation: D 1828 – 96

# Standard Practice for Atmospheric Exposure of Adhesive-Bonded Joints and Structures[1]

This standard is issued under the fixed designation D 1828; 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 practice defines the procedure for the direct exposure of adhesive bonded joints and structures to natural atmospheric environments.

1.2 The procedure for sheltered atmospheric exposure, such as a Stevenson screen **(1)**,[2] of adhesive-bonded joints and specimens is the same except for the requirements of facing south and measurement of solar radiation.

1.3 This practice is limited to the procedure by which samples are exposed and does not cover the tests that may be used to evaluate the effects of atmospheric exposure on these adhesive-bonded joints and structures. These samples could be any one of several varieties.

1.3.1 A complete structure for test,

1.3.2 A section of a structure for test,

1.3.3 A complete structure or section with strength observations on specimens cut therefrom,

1.3.4 Test specimens themselves, or

1.3.5 Any of the above, mounted under stress.

1.4 Suitable test methods for evaluation of the effects of exposure include nondestructive qualitative or quantitative observations on the same sample at prescribed intervals, or destructive tests on separate sets of specimens in accordance with such tests as Test Method D 1002.

NOTE 1—See Test Methods D 896 and D 897.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *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 896 Test Method for Resistance of Adhesive Bonds to Chemical Reagents[3]

D 897 Test Method for Tensile Properties of Adhesive Bonds[3]

D 907 Terminology of Adhesives[3]

D 1002 Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-To-Metal)[3]

## 3. Terminology

3.1 *Definitions:*

3.1.1 Many terms used in this practice are defined in Terminology D 907.

## 4. Significance and Use

4.1 The atmospheric exposure tests described in this practice will evaluate the stability of the adhesive bond only in terms of a particular natural atmosphere. Since the atmospheric conditions vary greatly from year to year, these results will not be as reproducible as those derived from laboratory aging procedures. Considerable research has shown that laboratory artificial weathering tests will not give consistently good correlation with outdoor test exposures **(2, 3, 4)**.

## 5. Exposure Sites

5.1 The choice of exposure sites is dependent upon the objective of the particular test program.

5.2 In the cases of both metallic and nonmetallic adherends, choose exposure sites to include variations in average temperature (and temperature range), relative humidity, and precipitation.

## 6. Apparatus

6.1 *Racks*—Expose the sample on racks[4] which are so positioned that the exposed surfaces are at an angle of 45 ° to the horizontal and facing true south. Exceptions to the direction that the specimens face will be permitted in the case of beach exposures, where the specimens usually face parallel to the beach. Place racks on a supporting frame high enough and so constructed that there will be no background for a distance of

[1] This practice is under the jurisdiction of ASTM Committee D-14 on Adhesives and is the direct responsibility of Subcommittee D14.40 on Adhesives for Plastics.

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

[3] *Annual Book of ASTM Standards*, Vol 15.06.

[4] Blueprints of ASTM standard racks and pipe frames may be obtained from ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428. Request Adjunct No. ADJD1828.

at least 30 cm (11.8 in.) in any direction from the back of specimens mounted on them. When the frame is positioned on soil, ensure that the distance between the bottom edge of any specimen and the plane of the cleared area great enough to prevent any undesirable effects of grass or plant growth during the period of exposure. In case of roof exposure, ensure that surrounding walls do not shade the specimens or impede the air flow over them. Design the racks that samples or specimens will be affixed directly to the rack by means of a clamping device made of an inert, insulating material that will allow them to expand or contract with thermal and humidity changes.

6.2 *Climatological Instruments*—If detailed information is necessary, operate instruments suitable for determining average daily temperature, average daily relative humidity, and total daily rainfall at or near each of the exposure sites **(6, 7, 8)**. If such instruments are available at some already existing installation or U. S. Weather Bureau Station in the vicinity of any site, the records from these are to be considered satisfactory (Note 2). If complete characterization of climatological conditions is necessary (for transparent adherends, for instance), make a record of total daily solar radiation, reported $MJ/m^2$ (langleys) (Note 3).

NOTE 2—Weather may vary appreciably at two locations only a relatively short distance apart. It must be established to the satisfaction of the operator that no significant error will be introduced by using climatological data from a site other than the exposure site.

NOTE 3—A pyrheliometer in conjunction with a recording potentiometer has been found suitable for recording solar radiation **(9)**.

## 7. Test Specimens

7.1 In cases where quantitative evaluation is to be made on specimens cut or machined from the exposed sample, prepare the specimen in accordance with the specific test method. Recognize that this is not as severe a test as when the specimen edges have been exposed before evaluation. In cases where it is desired to know the effect of the exposure on exposed edges, expose test specimens rather than samples prior to testing. Where specimens are cut from an exposed sample, record the relative location of the specimens in the sample, as effects that depend on the distance of the specimen from the exposed edge of the sample have been noted.

7.2 Provide for the number of specimens required by each test method plus at least one additional specimen for each test method with the number of specimens cut from each sample. The additional specimens serve as spares in the event of an anomalous or faulty specimen.

NOTE 4—It is recommended that control specimens of a material of known behavior be included in each exposure test to serve as at least a qualitative measure of weather variability.

7.3 The number of samples is based on a statistical analysis of the test program consistent with the number of specimens in each sample. The number of specimens for each removal period is in accordance with the number required by each test method and includes specimens from at least two exposed samples.

7.4 Evaluation intervals for exposed specimens depend on the purpose and test duration. Generally, at least three withdrawal intervals are needed to give a reasonable indication of a material's weathering characteristics **(10)**.

## 8. Procedure

8.1 Prior to exposure, condition all samples at the standard conditions of 23.0 ± 1°C (73.4 ± 1.8°F) and 50 ± 2 % relative humidity for not less than 40 h. Then test a control of the number of specimens required by the test specifications and record the results. Store a second control at standard conditions of 23.0 ± 1°C (73.4 ± 1.8°F) and 50 ± 2 % relative humidity to be tested at the conclusion of the exposure period.

8.2 Inscribe the specimens to be exposed with an identifying number, letter, or symbol so that they are readily identified after exposure. Ensure that the identifier does not interfere with either the exposure or subsequent testing.

8.3 Measure the dimensions and note the appearance of the test specimens in accordance with the exposure test specifications and record these values.

NOTE 5—If appearance of the adhesive as observed through the adherend is one of the factors of the test program, a system of uniform observation based on intensity and discoloration on an area basis should be developed.

8.4 Affix the specimens to the exposure racks by means of inert insulating materials with the edge of the overlap on the exposed face parallel to the ground and facing downward.

8.5 Test for a minimum of one year, unless a shorter time is necessary because of the lack of durability of the adherends. Where tests of less than one year duration are to be used, start exposure in the spring and continue for the first few weeks of cool weather. In southern areas, such as Florida, where climatic conditions are more uniform throughout the year, the time of year when short-term exposure is carried out may be less critical. In all localities, the longer period of exposure produces more reliable results.

8.6 After exposure, again note and record the appearance of the specimens. When performing other than visual appearance tests, condition the specimens for not less than 40 h at 23.0 ± 1°C (73.4 ± 1.8°F) and 50 ± 2 % relative humidity. Measure the dimensions, including warpage if any, of the specimens after the conditioning period just prior to testing.

8.7 Measure the dimensions, including warpage if any, of the stored control specimens, and test these specimens at the conclusion of the exposure period along with the exposed specimens.

## 9. Report

9.1 Report the following:

9.1.1 Duration of exposure of each specimen at each site.

9.1.2 Original general appearance and original dimensions of the control and exposed specimens, and properties of the original control specimens.

9.1.3 General appearance, dimensions (including warpage), and properties of the specimens after the exposure and control storage periods; and average properties and dimensional change for each set of specimens. When changes of less than 5 % in any critical dimension of the specimen are observed, base the computation of properties on the post-exposure dimensions. When changes of 5 % or more in any critical dimension have taken place, base the computation of properties upon both the original and post-exposure dimensions, and two sets of values of the properties shall be reported.

9.1.4 Climatological information accumulated during exposure. This includes average monthly relative humidity, average monthly temperature, and total monthly rainfall at each site for each month of exposure. When available, report the average daily solar radiation for each month at each site and the total solar radiation received by each set of test specimens. Give any reliable air-pollution data that are available.

9.1.5 The location of the exposure sites used including a general description of the terrain, the manner in which the specimens were exposed, a description and the location of the instruments used to obtain climatological data, and an adequate description of the method by which the tests were performed.

## 10. Precision and Bias

10.1 Precision and bias does not exist for this practice because resources necessary for round-robin testing have not been forthcoming.

## 11. Keywords

11.1 adhesive bonded joints; adhesive bonded structures; adhesives; atmospheric exposure; weathering

## REFERENCES


(**1**) Middleton, W. E. K., "Meteorological Instruments," Second Ed., University of Toronto Press (also Oxford University Press), 1943, p. 57.

(**2**) Reinhart, F. W., "Degradation of Plastics," *SPE News* (now *SPE Journal*), Soc. Plastics, Vol 4, Sept., 1948, p. 3.

(**3**) Reinhart, F. W., "Conditioning and Weathering of Adhesives and Plastics," *Symposium on Plastics Testing—Present and Future*, *ASTM STP 123*, ASTM, 1952, pp. 61–70; and *Symposium on Conditioning and Weathering*, *ASTM STP 133*, ASTM, 1952, pp. 42–51.

(**4**) Reinhart, F. W., "Relation Between Actual and Artificial Weathering of Organic Materials," *Symposium on Some Approaches to Durability in Structures*, *ASTM STP 236*, ASTM, 1958, pp. 57–66.

(**5**) Discussion of ASTM test sites, *Proceedings*, ASTM, Vol 58, 1958, p. 232.

(**6**) "Instructions for Climatological Observers," *Circular B*, Tenth Ed., U. S. Government Printing Office, Washington, DC, Nov., 1952.

(**7**) Shelter, Instrument, Medium Standard Cotton Region Type, U. S. Weather Bureau Specification 450 0615, Revised July 1, 1953.

(**8**) Drawing 450.03061a, U. S. Weather Bureau, Washington 25, DC, June, 1951.

(**9**) Hand, I. F., "Pyrheliometers and Pyrheliometric Measurements" U. S. Weather Bureau, Washington, DC 20025 (Nov., 1946).

(**10**) Davis, A. and Sims, D. *Weathering of Polymers*, Elsevier Applied Science Publishers, 1983, p. 51.