



Standard Practice for Tire Testing Operations—Basic Concepts and Terminology for Reference Tire Use¹

This standard is issued under the fixed designation F 1806; 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 presents some basic concepts for tire testing and a standard set of terms relating to the use of reference tires frequently used for comprehensive tire testing programs. The tests may be conducted in a laboratory on various dynamometer wheels or other apparatus as well as at outdoor proving ground facilities. The overall objective of this practice is to develop some elementary principles for such testing and standardize the terms used in these operations. This will improve communication among those conducting these tests as well as those using the results of such testing.

1.2 In addition to the basic concepts and terminology, a statistical model for tire testing operations is also presented in Annex A1. This serves as a mathematical and conceptual foundation for the terms and other testing concepts; it will improve understanding. The annex can also serve for future consultation as this practice is expanded to address additional aspects of the testing process.

1.3 This overall topic requires a comprehensive treatment with a sequential or hierarchical development of terms with substantial background discussion. This cannot be accommodated in Terminology F 38.

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. Referenced Documents

2.1 ASTM Standards:

- E 1136 Specification for a Radial Standard Reference Test Tire²
- F 538 Terminology Relating to the Characteristics and Performance of Tires³
- F 1082 Practice for Tires—Determining Precision for Test Method Standards³
- F 1650 Practice for Evaluating Tire Traction Performance Data Under Varying Test Conditions³

3. Significance and Use

3.1 Tire testing operations usually consist of a sequence of tests that involve special “reference” tires in addition to the candidate tires being evaluated for their performance characteristics. Reference tires serve as an “internal benchmark” which may be used to adjust for variation in test results to give improved comparisons among the candidate tires. Numerous approaches have been adopted using different terminology for such testing. This causes confusion and the purpose of this practice is to standardize some of the elementary concepts and terminology on this topic.

4. Summary of the Practice

4.1 Elementary testing concepts, terms, and definitions are developed in hierarchical or sequential order beginning with basic testing operations. Each definition may be accompanied by a specific discussion or expanded text section appropriate to general definitions. Many of the terms could be defined as adjectives; however, as recommended by ASTM policy, the word “tire” is included in each definition avoiding the complication of defining adjectives. The definitions apply equally to items or objects other than tires.

5. Basic Testing Concepts and Terms

5.1 Background on Testing:

5.1.1 Despite the adoption of standardized testing procedures, test result variation influences data generated in any type of testing. As outlined in Annex A1, there are two main categories: [1] variation inherent in the production process for a group of nominally identical objects or tires and [2] variation due to the measurement operation. Each of these two sources may be further divided into two types of variation; [1] systematic or bias variation (the variation causing one laboratory to be consistently different from another laboratory) and [2] random error variation. Both types can exist simultaneously for either of the main categories.

5.1.2 Random variation can be reduced to a low level by appropriate replication and sampling procedures, but bias variation cannot be so reduced. Bias variation can be reduced or eliminated by the appropriate use of reference objects or tires. This is the major rationale for their use in testing operations (see Annex A1).

5.1.3 Bias variation can also be reduced or eliminated by comprehensive programs to sort out causes of such perturbations and eliminate these causes.

¹ This practice is under the jurisdiction of Committee F-19 on Tires and is the direct responsibility of Subcommittee F09.94 on Terminology.

Current edition approved May 10, 1997. Published April 1998.

² Annual Book of ASTM Standards, Vol 04.03.

³ Annual Book of ASTM Standards, Vol 09.02.

5.2 Elementary Testing Terms:

5.2.1 *test (or testing), n*—a procedure performed on an object (or set of nominally identical objects) using specified equipment that produces data unique to the object (or set).

5.2.1.1 *Discussion*—Test data are used to evaluate or model selected properties or characteristics of the object (or set of objects). The scope of testing depends on the decisions to be made for any program, and sampling and replication plans (see definitions below) need to be specified for a complete program description.

5.2.2 *test tire, n*—a tire used in a test.

5.2.3 *test program, n*—an ordered series of tests grouped together using a predefined plan.

5.2.3.1 *Discussion*—A test program may include multiple test repetitions over an extended time period.

5.2.4 *test tire set, n*—one or more test tires as required by the test equipment or procedure, to perform a test, thereby producing a single test result.

5.2.4.1 *Discussion*—The four nominally identical tires required for vehicle stopping distance testing constitute a test tire set. In the discussion below where the test tire is mentioned, it is assumed that test tire set may be substituted for test tire, if a test tire set is required for the testing.

5.2.5 *candidate tire, n*—a test tire that is part of a test program.

5.2.5.1 *Discussion*—The term “candidate object” may be used in the same sense as *candidate tire*.

5.2.6 *candidate tire set*—a set of candidate tires.

5.3 Tire testing may be divided into two major categories:

5.3.1 *local testing, n*—testing conducted at one laboratory or test site for the purpose of comparing a number of candidate tires for selected characteristic properties.

5.3.1.1 *Discussion*—A tire manufacturer’s internal development programs and proving ground testing conducted by a contract testing organization to compare commercial market tires are two examples of local testing.

5.3.2 *global testing, n*—testing conducted at two or more laboratories or test sites for the purpose of comparing candidate tire performance at each location for selected characteristic properties.

5.3.2.1 *Discussion*—Producer-user testing or interlaboratory comparisons for such properties as rolling resistance, endurance, or high speed dynamometer wheel performance are examples of global testing.

5.4 *sample, n*—a selected number of n test objects that accurately represent the lot or population of interest.

5.4.1 *Discussion*—A lot is a finite number of objects such as a limited period of tire production at a given facility or a selected number of tires of a particular commercial market type. A population is the collection (or potential collection) of all objects produced by a given process or operation.

5.5 *sampling, v*—the act of selecting samples.

5.5.1 *Discussion*—The primary purpose of sampling is the reduction of random production process variation. See Annex A1 for details.

5.6 *replicate, n*—either (1) an individual test object from a sample of n objects or (2) one of m individual test values for a test object.

5.6.1 *Discussion*—Each test object of a set of replicates is nominally identical to all other objects from that particular source. Nominally identical implies that in long run testing all objects would give essentially identical average test values.

5.7 *replication, v*—the act of selecting and testing a number of replicates.

5.7.1 *Discussion*—The primary purpose of replication is the reduction of random measurement variation. See Annex A1 (A1.3.6) for additional discussion on types of replication.

6. Reference Tire Concepts and Terms

6.1 In this section a basic term, reference tire, is defined. A number of terms, each describing a special type of reference tire, are derived from the basic term. Reference tires usually have special characteristics unique to a particular test program. However, for some testing programs the same reference tire may be used for more than one purpose.

6.1.1 *reference tire, n*—a special tire included in a test program; the test results for this tire have significance as a base value or internal benchmark.

6.1.2 There are two types of reference tires or objects that may be used in any test program.

6.1.2.1 *Type 1 (reference tire), n*—tires subject to production, composition, and often, performance specifications; they are designed to have minimal variation and to be stable in their characteristic properties for an extended period of time.

6.1.2.2 *Type 2 (reference tire), n*—tires appropriately selected from a lot by a process that ensures minimal variation characteristic properties for the duration of any test program.

6.1.2.3 *Discussion*—Type 2 reference tires may be selected on an ad hoc basis and when the test program is complete they are no longer considered as reference objects.

6.1.3 *control tire, n*—a reference tire of used in a specified manner throughout a test program.

6.1.3.1 *Discussion*—A control tire may be of either type and typical tire use is the reference (control) tire in Practice F 1650 that provides algorithms for correcting (adjusting) test data for bias trend variations (See Practice F 1650 and Annex 1).

6.1.4 *surface monitoring tire, n*—a reference tire used to evaluate changes in a test surface over a selected time period.

6.1.5 *standard reference test tire (SRTT), n*—a tire that meets the requirements of Specification E 1136, commonly used as control tire or a surface monitoring tire.

6.1.5.1 *Discussion*—This is a Type 1 reference tire.

6.1.6 *witness tire, n*—a reference tire with an extended period of stability for specified characteristic properties.

6.1.6.1 *Discussion*—A Type 1 reference tire is typical for this application.

6.1.7 *master set, n*—a selected group of witness tires, each different test response characteristics to provide a range of values for the measured property or properties.

6.1.7.1 *Discussion*—A master set is frequently tested to determine if a test device is functioning in a normal or intended manner. If certain known or expected relationships are not found among the witness tires constituting the set, remedial action is required for the testing equipment. Master sets are frequently used for global testing.

6.1.8 *test matrix, n*—a group of candidate tires usually

specified reference tires; all tests are normally conducted in one test program.

6.1.8.1 *Discussion*—A test matrix may be used in either a local or global test program. See also *candidate tire set*.

6.1.9 *calibration tire, n*—a witness tire designed to provide a fixed or known test value for selected properties.

6.1.9.1 *Discussion*—Calibration tire test results can be used as standard values to determine acceptability of laboratory or test site performance. If a specified performance level is not found, certain instrument adjustments may be made to compensate for unavoidable biases in interlaboratory or between-site programs.

7. Evaluating Testing Precision

7.1 As indicated in Annex A1 there are two categories of variation: production process and measurement. Each of these may in turn have two subclassifications: basis deviations and random deviations. The potential effect of all these sources can exert a profound influence on the variability of test data. The presence of these sources is the rationale for using reference tires and for designing comprehensive testing programs with appropriate replication to reduce the effect of such variations.

7.2 *Evaluating Precision*—Special programs to evaluate the magnitude of variability for any routine or special test operations are part of the effort to reduce variability and improve test precision. Precision is defined in Practice F 1082 as “a measurement (testing) concept that expresses the ability to generate test results that agree with each other in absolute magnitude.” The parenthetical word “testing” is added to this definition for this purposes of this practice to indicate that is is the overall testing process, which includes sampling and replication, that should be considered when discussing precision.

7.2.1 For local testing, this action usually consists of appropriate sampling and replication plans and the evaluation of “test-to-test” variation for candidate tires. With a “test-to-test” standard deviation (or variance) obtained under the appropriate conditions, decisions on statistical (and technical) differences between candidate tires can be made for a program at any specific location. For global testing, programs can be organized to evaluate another “test-to-test” standard deviation, where this now applies to between-lab as well as to between-test comparisons.

7.3 *Repeatability and Reproducibility:*

7.3.1 The terms repeatability and reproducibility are frequently used when discussing testing and the results of testing programs. Some interpretations of these terms are different than the standard definitions given in Practice F 1082.

7.3.1.1 *repeatability, n*—an established value, below which the absolute difference between two “within-laboratory” or

“within test site” test results may be expected to lie, with a specified probability (Practice F 1082).

7.3.1.2 *Discussion*—The two test results are obtained with the same method on nominally identical test materials under the same conditions (same operator, apparatus, laboratory, location, and specified time period), and in the absence of other indications, the specified probability is 0.95 (that is, 95 %). The established value also may be called a “critical difference.”

7.3.1.3 *reproducibility, n*—an established value, below which the absolute difference between two “between-laboratory” or “between test site” test results may be expected to lie, with a specified probability (Practice F 1082).

7.3.1.4 *Discussion*—The two test results are obtained with the same method on nominally identical test materials under different conditions (different laboratories, locations, operators, apparatus, and in a specified time period), and in the absence of other indications, the specified probability is 0.95 (that is, 95 %). The essential characteristic of reproducibility is the variability of test results among typical laboratories or test sites.

7.3.2 Both repeatability and reproducibility are to some degree generic in their definition. Additional information must be supplied before the terms can be used without ambiguity. The most important issue is the between-test result time period or frequency; it must be specified. What constitutes a test result must be defined. Both of these are addressed in Practice F 1082. Other details on testing are also needed. It is important to emphasize tow details about repeatability and reproducibility; (1) both are statistical parameters; defined as $2.83 \times S$, where S is the standard deviation for either parameter measured in a specified way as outlined in Practice F 1082 and (2) both parameters indicate precision in an inverse manner; high precision equals small values for either parameter.

NOTE 1—One source of confusion is the use of the words repeatability and reproducibility alone to indicate a desired or high level of precision. “A test has repeatability” is an inappropriate use of the word repeatability if consistency with Practice F 1082 is desired. “A test has good (or low) repeatability” is appropriate usage.

7.4 *Process and Measurement Variation:*

7.4.1 Annex A1 contains a brief section (A1.4) on evaluating process and test measurement variance. This can be done rather easily for a non destructive test such as tire wet traction testing or rolling resistance testing. A more detailed analysis on this topic is beyond the scope of this practice in its present format.

8. Keywords

8.1 control tire; monitoring tire; reference tire; reproducibility; repeatability; test matrix; witness tire