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Standard Practices for Cycle Counting in Fatigue Analysis[1]

This standard is issued under the fixed designation E1049; 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 These practices are a compilation of acceptable procedures for cycle-counting methods employed in fatigue analysis. This standard does not intend to recommend a particular method.

1.2 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E912 Definitions of Terms Relating to Fatigue Loading; Replaced by E 1150 (Withdrawn 1988)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *constant amplitude loading—in fatigue loading*, a loading in which all of the peak loads are equal and all of the valley loads are equal.

3.1.2 *cycle—in fatigue loading*, under constant amplitude loading, the load variation from the minimum to the maximum and then to the minimum load.

NOTE 1—In spectrum loading, definition of cycle varies with the counting method used.

3.1.3 *mean crossings—in fatigue loading*, the number of times that the load-time history crosses the mean-load level with a positive slope (or a negative slope, or both, as specified) during a given length of the history (see Fig. 1).

3.1.3.1 *Discussion*—For purposes related to cycle counting, a mean crossing may be defined as a crossing of the reference load level.

3.1.4 *mean load, P_m—in fatigue loading*, the algebraic average of the maximum and minimum loads in constant amplitude loading, or of individual cycles in spectrum loading,

$$P_m = (P_{max} + P_{min})/2 \quad (1)$$

or the integral average of the instantaneous load values or the algebraic average of the peak and valley loads of a spectrum loading history.

3.1.5 *peak—in fatigue loading*, the point at which the first derivative of the load-time history changes from a positive to a negative sign; the point of maximum load in constant amplitude loading (see Fig. 1).

3.1.6 *range—in fatigue loading*, the algebraic difference between successive valley and peak loads (positive range or increasing load range), or between successive peak and valley loads (negative range or decreasing load range); see Fig. 1.

NOTE 2—In spectrum loading, range may have a different definition, depending on the counting method used; for example, "overall range" is defined by the algebraic difference between the largest peak and the smallest valley of a given load-time history.

3.1.6.1 *Discussion*—In cycle counting by various methods, it is common to employ ranges between valley and peak loads, or between peak and valley loads, which are not necessarily successive events. In these practices, the definition of the word "range" is broadened so that events of this type are also included.

3.1.7 *reversal—in fatigue loading*, the point at which the first derivative of the load-time history changes sign (see Fig. 1).

NOTE 3—In constant amplitude loading, a cycle is equal to two reversals.

3.1.8 *spectrum loading—in fatigue loading*, a loading in which all of the peak loads are not equal or all of the valley loads are not equal, or both. (Also known as variable amplitude loading or irregular loading.)

[1] These practices are under the jurisdiction of ASTM Committee E08 on Fatigue and Fracture and are the direct responsibility of Subcommittee E08.04 on Structural Applications.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

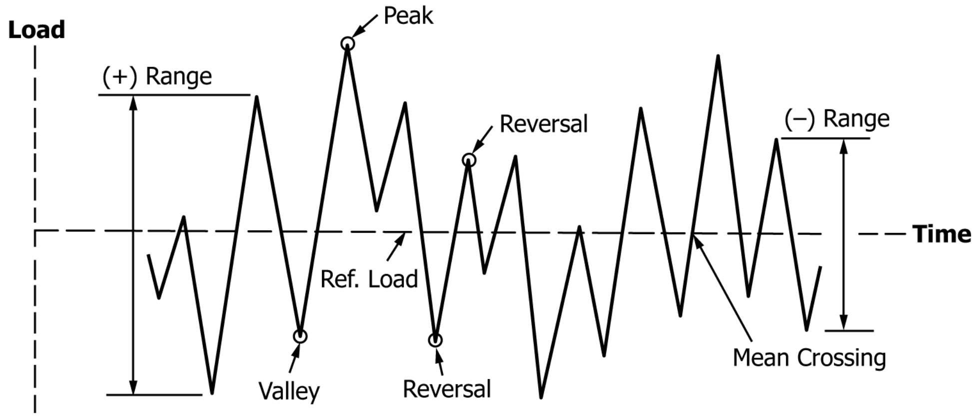

FIG. 1 Basic Fatigue Loading Parameters

3.1.9 *valley—in fatigue loading*, the point at which the first derivative of the load-time history changes from a negative to a positive sign (also known as trough); the point of minimum load in constant amplitude loading (see Fig. 1).

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *load*—used in these practices to denote force, stress, strain, torque, acceleration, deflection, or other parameters of interest.

3.2.2 *reference load—for spectrum loading*, used in these practices to denote the loading level that represents a steady-state condition upon which load variations are superimposed. The reference load may be identical to the mean load of the history, but this is not required.

3.3 For other definitions of terms used in these practices refer to Definitions E912.

4. Significance and Use

4.1 Cycle counting is used to summarize (often lengthy) irregular load-versus-time histories by providing the number of times cycles of various sizes occur. The definition of a cycle varies with the method of cycle counting. These practices cover the procedures used to obtain cycle counts by various methods, including level-crossing counting, peak counting, simple-range counting, range-pair counting, and rainflow counting. Cycle counts can be made for time histories of force, stress, strain, torque, acceleration, deflection, or other loading parameters of interest.

5. Procedures for Cycle Counting

5.1 *Level-Crossing Counting:*

5.1.1 Results of a level-crossing count are shown in Fig. 2(*a*). One count is recorded each time the positive sloped portion of the load exceeds a preset level above the reference load, and each time the negative sloped portion of the load exceeds a preset level below the reference load. Reference load crossings are counted on the positive sloped portion of the loading history. It makes no difference whether positive or negative slope crossings are counted. The distinction is made only to reduce the total number of events by a factor of two.

5.1.2 In practice, restrictions on the level-crossing counts are often specified to eliminate small amplitude variations which can give rise to a large number of counts. This may be accomplished by filtering small load excursions prior to cycle counting. A second method is to make no counts at the reference load and to specify that only one count be made between successive crossings of a secondary lower level associated with each level above the reference load, or a secondary higher level associated with each level below the reference load. Fig. 2(*b*) illustrates this second method. A variation of the second method is to use the same secondary level for all counting levels above the reference load, and another for all levels below the reference load. In this case the levels are generally not evenly spaced.

5.1.3 The most damaging cycle count for fatigue analysis is derived from the level-crossing count by first constructing the largest possible cycle, followed by the second largest, etc., until all level crossings are used. Reversal points are assumed to occur halfway between levels. This process is illustrated by Fig. 2(*c*). Note that once this most damaging cycle count is obtained, the cycles could be applied in any desired order, and this order could have a secondary effect on the amount of damage. Other methods of deriving a cycle count from the level-crossings count could be used.

5.2 *Peak Counting:*

5.2.1 Peak counting identifies the occurrence of a relative maximum or minimum load value. Peaks above the reference load level are counted, and valleys below the reference load level are counted, as shown in Fig. 3(*a*). Results for peaks and valleys are usually reported separately. A variation of this method is to count all peaks and valleys without regard to the reference load.

5.2.2 To eliminate small amplitude loadings, mean-crossing peak counting is often used. Instead of counting all peaks and valleys, only the largest peak or valley between two successive mean crossings is counted as shown in Fig. 3(*b*).

5.2.3 The most damaging cycle count for fatigue analysis is derived from the peak count by first constructing the largest possible cycle, using the highest peak and lowest valley, followed by the second largest cycle, etc., until all peak counts