



Standard Practice for Contact Performance Classification of Electrical Connection Systems¹

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1. Scope

1.1 This practice provides a uniform method of specifying performance requirements for (or reporting test results of) electrical contact and connection systems. Both conductor and connector system performance may be specified by this practice, separately or in combination.

1.2 This practice may be used for separable or permanent contacts employing metallic conductors and contacts.

1.3 This practice provides methods for both signal and power applications.

1.4 This practice does not specify the sample preparation or test sequences required for determining contact performance. It is the responsibility of the user of this practice to determine the applied test sequence(s) appropriate for the application.

1.5 *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:

B 539 Test Methods for Measuring Contact Resistance of Electrical Connections (Static Contacts)²

B 542 Terminology Relating to Electrical Contacts and Their Use²

B 812 Test Method for Resistance to Environmental Degradation of Electrical Pressure Connections Involving Aluminum and Intended for Residential Applications²

2.2 UL Standard:

UL 486B Wire Connectors for Use with Aluminum Conductors, Third Edition, 1991³

2.3 EEI-NEMA Standard:

EEI-NEMA Standard TDJ-162 (ANSI C119.4), "Connectors for Use Between Aluminum-to-Aluminum or

Aluminum-to-Copper Bare Overhead Conductors"⁴

3. Terminology

3.1 Terms used in this practice are defined in Terminology B 542 except as noted in 3.2.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *conductor, n*—electrically conductive member carrying current to a contact interface. Examples are wire and cable, busbar, and conductive paths on an etched printed circuit board.

3.2.2 *contact performance, n*—contact interface behavior as indicated by initial electrical resistance and resistance change under the applied test conditions.

4. Summary of Practices

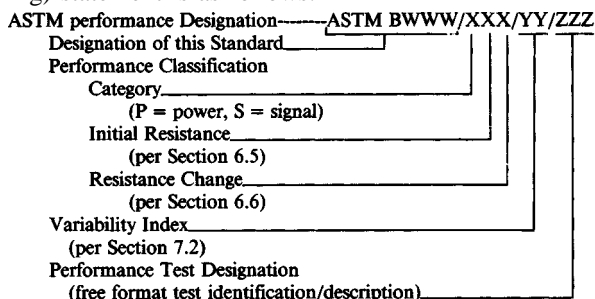
4.1 The prescribed performance specification (or reporting) statement consists of three sections, as follows:

4.1.1 *Performance Classification*, in accordance with this practice (Section 6).

4.1.2 *Variability Index*, determined by sample size and distribution of resistance values measured at end of test, in accordance with this practice (Section 7).

4.1.3 Statement of test method employed to determine performance classification.

4.2 The format for the performance specification (or reporting) statement is as follows:



5. Significance and Use

5.1 This practice is based on the use of electrical resistance as an indicator of contact performance.

5.2 Existing standards, such as those referenced in Section 2 as representative examples, provide the basis for applied test

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² *Annual Book of ASTM Standards*, Vol 03.04.

³ Available from Underwriters Laboratory, 333 Pfingsten Rd., Northbrook, IL 60062.

⁴ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

conditions. Modifications in procedure or sample size, or both, of existing standards may have to be made to provide for resistance measurement and to meet variability index requirements that a user may specify.

5.3 This practice accommodates the use of multiple test methods, as may be required to assure satisfactory performance in a given application.

6. Performance Classification

6.1 The performance classification statement consists of three letters in sequence indicating, respectively, category of contact (signal or power), average initial contact resistance, and change of average contact resistance as a consequence of the applied test conditions.

6.2 For this standard classification method, the performance of a connection system for power applications is expressed as the ratio of the contact resistance to the equivalent resistance of the attached conductor. The equivalent resistance of the conductor is the resistance of a length of solid circular conductor exactly one diameter in length. The conductor size used for the evaluation shall be that which is normally specified or utilized with the particular connection system being evaluated.

6.2.1 For connection systems involving solid circular conductors, the equivalent resistance R_d is calculated according to the formula:

$$R_d = R \times D \quad (1)$$

where:

R_d = equivalent resistance,

R = resistance per unit length, Ω , and

D = diameter of conductor (in same length unit).

6.2.1.1 Appendix X1 provides representative nominal data for some common sizes of copper and aluminum conductors of circular cross section for the purpose of establishing instrumentation requirements.

6.2.2 For conductors with other than solid circular cross section, equivalent diameter based on actual conductive cross-section area shall be used. For example: a conductor of rectangular cross section 0.5 by 6 mm has a cross-section area equal to that of a solid circular conductor 1.95 mm in diameter, and therefore D in the equation in 6.2.1 is 1.95 mm.

6.2.3 For contacts incorporating or connecting conductors of different materials or cross section, or both, the R_d value used for contact performance determination shall be based on the conductor of minimum resistance per unit length.

6.2.4 For contacts involving a connector, the conductor material and cross section used for determination of the R_d value to be used shall be the wire, busbar, circuit board conductive strip, or other, as appropriate for the rating or representative application of the connector. The conductor size may be determined according to the connector manufacturer's specification, current rating, or conventional application practice.

6.2.5 Conductor resistance per unit length is preferably determined by measurements incorporating the same instrumentation used for contact resistance measurements, at the same ambient temperature and current as for the contact performance test being applied.

6.2.6 When conductor resistance is determined at the same

time as contact performance in accordance with 6.2.5, and the conductor is solid with circular cross section, potential drop measurements may be used without conversion for the purpose of determining contact performance. (See example, Appendix X2.)

6.3 Contact resistance shall be measured in accordance with Test Methods B 539.

6.3.1 For power connections, resolution of resistance determination shall be $0.1 R_d$ or better. For most applications, this requires potential drop resolution of $10 \mu\text{V}$ at a measurement current density approximately equal to conductor ratings. (See Appendix X1.) Use Test Method B of Test Methods B 539 adjusting the current to meet the stated current requirements.

6.3.2 For signal connections, resolution of resistance determination shall be at 10 % of the average initial contact resistance or better, using Test Method C of Test Methods B 539.

6.3.3 For contact configurations in which bulk conductor or connector resistance is included in the measured contact resistance, a single value of measured bulk resistance (see Test Methods B 539) shall be subtracted from the measured contact resistance values. Resolution of the bulk resistance measurement shall be $0.1 R_d$ or finer, and the bulk resistance measurement error tolerance shall be no greater than $\pm 0.2 R_d$.

6.4 The first letter of the performance classification, indicating contact category, shall be "P" for power contacts and connections and "S" for signal contacts and connections. The letter is assigned according to the intended application for each of the applied test conditions.

6.4.1 A given connector type may be intended for multiple applications, both signal and power (example: circuit board connector). The category used for performance classification for each test sequence applied shall be that for which the test sequence is intended.

6.5 The letter indicating performance with respect to average (arithmetic mean) initial resistance of all samples tested shall be in accordance with Table 1.

6.6 The letter indicating performance with respect to resistance change of the worst-case sample tested shall be in accordance with Table 2.

7. Variability Index

7.1 *Variability Index for Power Category (P):*

7.1.1 The variability index V for power category connections is calculated from the resistance values determined at the end of the test sequence, expressed to two significant figures or to a resolution of $0.1 R_d$.

TABLE 1 Initial Resistance Indicator

Initial Resistance Indicator	Average Initial Resistance	
	Power Category (P)	Signal Category (S)
A	$R_c < 1.1 R_d$	$R_c < 5 \text{ m}\Omega$
B	$< 2 R_d$	$< 10 \text{ m}\Omega$
C	$< 5 R_d$	$< 20 \text{ m}\Omega$
D	$< 10 R_d$	$< 50 \text{ m}\Omega$
E	$< 100 R_d$	$< 100 \text{ m}\Omega$
F	$< 1000 R_d$	$< 200 \text{ m}\Omega$
G	$\geq 1000 R_d$	$\geq 200 \text{ m}\Omega$

TABLE 2 Resistance Change Indicator

Change Indicator	Power Category (P)	Signal Category (S)
	Ratio: Final/Initial Resistance of Worst-Case Sample	Resistance Change of Worst-Case Sample (Initial to Final R_c), mΩ
A	<1.1	<0.5
B	<2	<1.0
C	<5	<2.0
D	<10	<5.0
E	<100	<10
F	<1000	<20
G	≥1000	≥20

7.1.2 For power category connections, the variability index is calculated by the following formula (see Note 1):

$$V = \sqrt{\frac{\sum_{i=1}^n (R_f/R_d - \bar{R}_f/R_d)^2}{n-1}}$$

where:

R_f = final resistance for each connection tested, and

\bar{R}_f = arithmetic mean final resistance for the total set of n connections tested.

NOTE 1—While the variability index is numerically the same as the statistical sample standard deviation, it should not be used for statistical predictions of contact performance.

7.2 Variability Index for Signal Category (S):

7.2.1 The variability index V for signal category connections is calculated from the resistance change from beginning to end of the test sequence, expressed to two significant figures or to a resolution of 0.1 mΩ.

7.2.2 For signal category connections, the variability index is calculated by the following formula (see Note 1):

$$V = \sqrt{\frac{\sum_{i=1}^n (R_c - \bar{R}_c)^2}{n-1}} \quad (2)$$

where:

R_c = resistance change for each connection tested, mΩ, and

\bar{R}_c = arithmetic mean resistance change for the total set of n connections tested, mΩ.

8. Format

8.1 A format for specifying connection or contact performance is: “Connections shall meet or exceed ASTM BWW Class XXX with YY variability index when tested according to the applied conditions of ZZZ”, where “XXX” is the performance classification (Section 6), “YY” is the variability index (Section 7.1.1), and “ZZZ” is the specified test method. A condensed form is: “Connections shall meet or exceed ASTM BWW Class XXX/YY/ZZZ.”

8.2 A format for reporting contact performance test results is: “Performance is ASTM BWW Class XXX with YY variability index when tested according to the applied conditions of ZZZ.” A condensed form of the statement is: “Tested contact performance is ASTM BWW Class XXX/YY/ZZZ.”

8.3 Parentheses may be used to indicate specific applied conditions, sample size, conductors used, duration of test, portion of procedure applicable, or other necessary information.

8.4 When a connections system is rated for application to multiple types or combinations of conductors, but is specified by a single classification, the worst-case performance classification shall be used. Multiple classifications may be utilized, provided that the conductor combinations for which the classifications apply are adequately described. (Examples are provided in Appendix X2.)

8.5 The value of R_d used shall be reported for other than solid circular conductors.

8.6 According to the requirements of the application, more than one test procedure can be specified.

8.7 Example of use, including multiple test procedures and additional parenthetical information is: “Connections shall meet or exceed ASTM BWW Class PAB/1.0/ASTMB812 – 90 (20 weeks, with any number of conductors, conductor material combinations, conductor size combinations for which the connector is rated to be used); ASTM BWW Class PAB/0.4/UL486B (Section 6.11 of UL486B, with any number of conductors, conductor material combinations, or conductor size combinations for which the connector is rated to be used).”

8.8 A detailed test record, including description of applied conditions, test data, and the calculations for equivalent diameter, if other than solid circular conductor and R_d , shall be available.

8.9 Examples of application of the performance classification method to several connection systems are provided in Appendix X2. (Note: the examples provided in Appendix X2 to illustrate application of the classification method are not to be interpreted as specifications of test requirements.)

9. Precision and Bias

9.1 Precision and bias are those of the test method(s) applied.

10. Keywords

10.1 classification; conductor; connector; contact; electrical contact; electrical connection systems; metallic; resistance