AWS C3.15M/C3.15:2026
An American National Standard

Standard Methods for Evaluating the Strength of Soldered Joints

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Standard Methods for Evaluating the Strength of Soldered Joints

First Edition

Prepared by the
American Welding Society (AWS) C3 Committee on Brazing and Soldering

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This standard describes the test methods used to obtain the strength of soldered joints. Monotonic (unidirectional) and cyclic (fatigue) testing are considered in this standard. Sample geometries are described that allow for the application of stresses in tension, shear, bending moment, and peel configurations. Details are provided, which describe specimen preparation methods, soldering procedures, testing parameters, and methods for data analysis.

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Foreword

This foreword is not part this standard but is included for informational purposes only.

The American Welding Society (AWS) C3 Committee on Brazing and Soldering developed and maintains the specification on the mechanical testing of braze joints entitled: "AWS C3.2M/C3.2, *Standard Method for Evaluating the Strength of Brazed Joints*." This document provides guidance towards the standardization of test specimens and methods to allow for an accurate comparison of data obtained at different test facilities.

The requirement for a separate specification that addresses soldered joints arises from the latter having several properties that distinguish them from brazed joints. First, with very few exceptions, soldering filler metals have lower bulk strengths than the base materials used in typical soldered joints. Deformation and fracture take place almost exclusively within the joint clearance. Therefore, soldered joint strength is sensitive to its dimensions—joint clearance and footprint (area). Secondly, tin (Sn)- and indium (In)-based soldering filler metals are strain rate sensitive. As a result, the soldered joint strength is prone to be sensitive to test speed. Third, interface reaction layers, which are typically intermetallic compounds (IMCs), provide the bond between the soldering filler metal and the base material so that, together with the soldering filler metal and base material, determine the soldered joint mechanical strength. Fourth, soldering filler metals are used at relatively high homologous temperatures.[1] Their microstructures and thus, their mechanical properties, can evolve over time even when held at only room temperature.

Traditionally, the mechanical testing of soldered joints has been performed with a particular engineering application in mind. The base materials, filler metal, and in particular, the soldered joint geometry are developed to replicate that application to assure relevance of the data to the intended service. The drawback of this methodology is that soldered joint strengths are obtained from a wide range of test configurations and equipment parameters. Therefore, test data cannot be readily compared between different soldering filler metals, base materials, and joint clearances, to either optimize soldered joint design or provide consistent validation data for computational models.

The purpose of this specification is to provide the needed standardization of soldered joint testing. Monotonic (unidirectional) and cyclic (fatigue) testing are considered in this document. Sample geometries are described that allow for the application of stresses in tension, shear, bending moment, and peel configurations. Details are included in the text, which describe specimen preparation methods, soldering procedures, testing parameters, and methods for data analysis.

Comments and suggestions for the improvement of this standard are welcome and should be sent to the Secretary, AWS C3 Committee on Brazing and Soldering, American Welding Society, 8669 NW 36th Street, Suite #130, Miami, FL 33166.

[1] The homologous temperature, T_h, is defined as the ratio of the absolute temperature of the use condition over the absolute temperature of the solidus point. For example, 63Sn-37Pb soldering filler metal has a solidus temperature of 183 °C (456K). At 25 °C (298K), the T_h is 298K/456K, which equals 0.65. By comparison, a T_h of 0.65 would be equivalent to 814 °C for a nickel-based alloy having a solidus temperature of 1400 °C (1673K), hence, the analogy with the jet engine application.

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Standard Methods for Evaluating the Strength of Soldered Joints

1. General Requirements

1.1 Scope. The purpose of this document is to standardize the methods used to obtain reproducible strength data on soldered joints. Requirements are made with respect to base materials—metal alloy and ceramic; test specimen geometries; soldered joint clearance; test specimen fabrication processes; mechanical testing procedures; as well as data reporting and failure analysis. The standardization of these requirements will allow for the comparison of soldered joint strength data between different testing sources. The objective of this specification is to describe those standard requirements for design, process, reliability, and test engineers and operators.

The user will note that specific base material metal (alloy) and ceramic compositions are specified for the test specimens. This requirement was introduced, once again, with the objective of standardizing the mechanical test data. However, applications may arise whereby the user would deviate from these base material requirements in order to measure the effects on soldered joint mechanical strength caused by the combined effects of temperature cycling and dissimilar coefficients of thermal expansion (CTEs) between base materials or between the base materials and the soldering filler metal. Test documentation should reflect these deviations.

1.1.1 Printed Circuit Board Soldered Joints. This specification does not address the mechanical testing of soldered joints used on printed circuit boards (PCBs). The omission of this topic does not imply that the mechanical properties of PCB soldered interconnections are of lesser importance in soldering technology. Rather, addressing this specific category of soldered joints would require a separate set of requirements to address the sheer breadth of materials and design configurations that are used on PCBs. Such an effort was beyond the scope of this document. Nevertheless, the test procedures and analysis techniques, which are discussed in the following paragraphs, could be applied to the development of mechanical tests for PCB soldered joints.

1.1.2. Computational Modeling. Lastly, the level of rigor underlying the requirements in this specification will result in property data with sufficient fidelity to validate computational model predictions.

1.1.3. Control Documents. Control documents shall have the following order of authority from highest to lowest: instructions from the Organization Having Quality Responsibility (OHQR), assembly drawings, contract or purchase order contents, and this specification. The OHQR shall have the authority to make any modifications to the requirements in this document or other control document(s) and the responsibility to communicate those modifications to the relevant engineer(s), operator(s), or both. Any and all modifications to control documents shall be fully documented by the OHQR.

1.2 Units of Measurement. This standard makes use of both the International System of Units (SI) and U.S. Customary Units. The latter are shown within brackets ([ ]) or in appropriate columns in tables and figures. The measurements may not be exact equivalents; therefore, each system must be used independently.

1.3 Safety. Safety and health issues and concerns are beyond the scope of this standard; some safety and health information is provided, but such issues are not fully addressed herein.

Safety and Health information is available from the following sources: