# IEC 60352-9

Edition 1.0 2024-02

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

colour inside

## Solderless connections – Part 9: Ultrasonically welded connections – General requirements, test methods and practical guidance

## Connexions sans soudure – Partie 9: Connexions soudées par ultrasons – Exigences générales, méthodes d'essai et guide pratique



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# SOLDERLESS CONNECTIONS –

# Part 9: Ultrasonically welded connections – General requirements, test methods and practical guidance

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| Draft | Report on voting |
|---|---|
| 48B/3080/FDIS | 48B/3084/RVD |

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# INTRODUCTION

This part of IEC 60352 covers ultrasonically welded connections and includes requirements, tests and practical guidance information.

Ultrasonic welding is a form of cold friction welding that is becoming increasingly popular in many industries. This type of welding uses ultrasonic vibration to join materials together, creating a bond that is both strong and reliable. Ultrasonic welding has been identified as a process in ISO 4063-41 by the International Organization for Standardization (ISO).

The process of ultrasonic welding relies on high frequency ultrasound waves being used to create frictional heat at the connection point. High temperature is not required for this special method of welding, making it one of the most cost-effective ways to join two materials together.

It also requires fewer steps than traditional methods, meaning it can be completed quickly and with minimal resources.

Ultrasonic welding has been around for decades but only recently has become more widely utilized due to advances in technology and its availability at lower cost. It can be used on many different materials including plastics, rubbers, metals, textiles, and composites. Due to its precision and strong bonds it creates, it has become extremely popular in manufacturing processes such as automotive industry, electronics industry, furniture production and even medical device production.

This document outlines a system of product classification according to the intended use of the end-product. Three general end-product levels, known as class A, B, and C products, are identified. Class A products are for general use and include consumer products, computers, and computer peripherals for applications where the major requirement is function of the assembly. Class B products are dedicated service electronic items providing high performance and extended life. Finally, Class C products are for high performance with zero tolerance for equipment downtime; this includes life support systems and other critical systems. The developer or user of ultrasonically welded connections should determine the class to which their end-product belongs.

This document outlines the test requirements for ultrasonically welded connections deemed to be used in class A, B and C products. Test groups P0-P11 are specified, with additional optional test groups P9 and P12 available if required by the manufacturer and user.

Three test schedules – A (basic), B (intermediate) and C (full) - are provided, based on a specific selection of test groups, each representing the minimum requirements for each correspondingly identified end-product class.

# SOLDERLESS CONNECTIONS –

# Part 9: Ultrasonically welded connections – General requirements, test methods and practical guidance

## 1 Scope

This part of IEC 60352 covers ultrasonically welded connections and includes requirements, tests and practical guidance information.

This document covers ultrasonically welded connections made with stranded or flexible wires (class 2, 5 or 6 per IEC 60228) of copper or copper alloy, as well as of aluminium or aluminium alloy.

These welded metal-to-metal connections shall employ wires with cross-sectional area of 0,08 $mm^2$ to 160 $mm^2$ and shall not exceed a total cross-sectional area, in case of wire bundle, of 200 $mm^2$.

For aluminium or aluminium alloy wires, the minimum required cross-sectional area is 2,5 $mm^2$.

Additionally, information on materials, data from industrial experience and test procedures are included to ensure electrically stable connections under prescribed environmental conditions.

Lastly, this document aims to achieve comparable results when using ultrasonic welding equipment with similar performance and specifications as specified by the termination manufacturer.

NOTE Figures in this document show examples of possible solutions of ultrasonically welded connections of rectangular shape, but solutions are not restricted to the shape displayed.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-581, *International Electrotechnical Vocabulary (IEV) – Part 581 – Electromechanical components for electronic equipment*

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-60, *Environmental testing – Part 2-60: Tests – Test Ke: Flowing mixed gas corrosion test*

IEC 60228, *Conductors of insulated cables*

IEC 60512-1, *Connectors for electrical and electronic equipment – Tests and measurements – Part 1: Generic specification*

IEC 60512-1-1, *Connectors for electronic equipment – Tests and measurements – Part 1-1: General examination – Test 1a: Visual examination*

IEC 60512-1-2, *Connectors for electronic equipment – Tests and measurements – Part 1-2: General examination – Test 1b: Examination of dimension and mass*

IEC 60512-2-1, *Connectors for electronic equipment – Tests and measurements – Part 2-1: Electrical continuity and contact resistance tests – Test 2a: Contact resistance – Millivolt level method*

IEC 60512-2-2, *Connectors for electronic equipment – Tests and measurements – Part 2-2: Electrical continuity and contact resistance tests – Test 2b: Contact resistance – Specified test current method*

IEC 60512-2-5, *Connectors for electronic equipment – Tests and measurements – Part 2-5: Electrical continuity and contact resistance tests – Test 2e: Contact disturbance*

IEC 60512-3-1, *Connectors for electronic equipment – Tests and measurements – Part 3-1: Insulation tests – Test 3a: Insulation resistance*

IEC 60512-4-1, *Connectors for electronic equipment – Tests and measurements – Part 4-1: Voltage stress tests – Test 4a: Voltage proof*

IEC 60512-5-2, *Connectors for electronic equipment – Tests and measurements – Part 5-2: Current-carrying capacity tests – Test 5b: Current-temperature derating*

IEC 60512-6-4, *Connectors for electronic equipment – Tests and measurements – Part 6-4: Dynamic stress tests – Test 6d: Vibration (sinusoidal)*

IEC 60512-11-1, *Connectors for electrical and electronic equipment – Tests and measurements – Part 11-1: Climatic tests – Test 11a – Climatic sequence*

IEC 60512-11-4, *Connectors for electronic equipment – Tests and measurements – Part 11-4: Climatic tests – Test 11d: Rapid change of temperature*

IEC 60512-11-7, *Connectors for electronic equipment – Tests and measurements – Part 11-7: Climatic tests – Test 11g: Flowing mixed gas corrosion test*

IEC 60512-11-9, *Connectors for electronic equipment – Tests and measurements – Part 11-9: Climatic tests – Test 11i: Dry heat*

IEC 60512-11-10, *Connectors for electronic equipment – Tests and measurements – Part 11-10: Climatic tests – Test 11j: Cold*

IEC 60512-11-12, *Connectors for electronic equipment – Tests and measurements – Part 11-12: Climatic tests – Test 11m: Damp heat, cyclic*

IEC 60512-16-4, *Connectors for electronic equipment – Tests and measurements – Part 16-4: Mechanical tests on contacts and terminations – Test 16d: Tensile strength (crimped connections)*

IEC 60512-16-7, *Connectors for electronic equipment – Tests and measurements – Part 16-7: Mechanical tests on contacts and terminations – Test 16g: Measurement of contact deformation after crimping*

IEC 60947-1:2020, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60999-1, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm$^2$ up to 35 mm$^2$ (included)*

IEC 61191-1:2018, *Printed board assemblies – Part 1: Generic specification – Requirements for soldered electrical and electronic assemblies using surface mount and related assembly technologies*

ISO 1463:2021, *Metallic and oxide coatings – Measurement of coating thickness –*

*Microscopical method*

ISO 6722-1, *Road vehicles – 60 V and 600 V single-core cables – Part 1: Dimensions, test methods and requirements for copper conductor cables*

ISO 6722-2, *Road vehicles – 60 V and 600 V single-core cables – Part 2: Dimensions, test methods and requirements for aluminium conductor cables*

ISO 10447, *Resistance welding – Testing of welds – Peel and chisel testing of resistance spot and projection welds*

ISO 21747:2006, *Statistical methods – Process performance and capability statistics for measured quality characteristics*

## 3 Terms and definitions

For the purpose of this document, the terms and definitions of IEC 60050-581, IEC 60512-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
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**3.1**
**ultrasonic welding**
welding with pressure in which mechanical vibrations of high frequencies and of low amplitude, superimposed on a static force, make a weld between the two workpieces to be joined at a temperature well below the melting point of the material

[SOURCE: ISO /TR 25901-3:2016, 2.2.1.6.1]

**3.2**
**ultrasonic welding machine – ultrasonic welding system**
system for ultrasonic welding consisting of an ultrasonic generator, an ultrasonic converter, a sonotrode and the necessary electrical and mechanical accessories to operate it

Note 1 to entry: Figure 1 shows the construction of an ultrasonic welding system specifically designed for splicing wire.

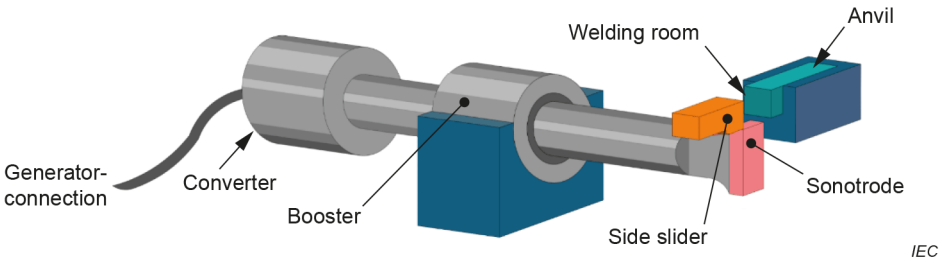



**Figure 1 – Ultrasonic welding machine designed to make splices between at least two wires**

**3.3**
**ultrasonic generator**
source that generates high frequency electrical energy to the ultrasonic transducers

**3.4**
**ultrasonic converter**
device that takes electrical energy at an ultrasonic frequency and converts it into mechanical oscillations

**3.5**
**sonotrode**
component that transmits ultrasonic vibrations directly to the parts to be welded

**3.6**
**vibration booster**
intermediate member between the converter and the sonotrode, amplifying the ultrasonic oscillations

**3.7**
**surface plate**
**anvil plate**
a passive wall located below or to the side of the anvil and separated from the sonotrode by a defined gap to prevent contact and any possible damage to tools

Note 1 to entry: A surface or anvil plate is foreseen only in a splice welding machine, which is a subset of ultrasonic welding machine.

**3.8**
**ultrasonic side slider**
device used to adjust the welding width

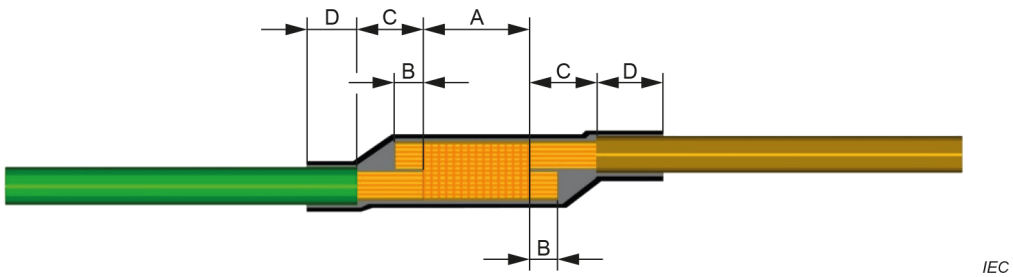
Note 1 to entry: The ultrasonic side slider is a device used to control the width of welding and can be positioned either over the sonotrode or above the anvil depending on the type of ultrasonic welding machine.

**3.9**
**anvil**
a component of the ultrasonic welding machine, located on the opposite side of the horn and forming one wall of the welding room

**3.10**
**ultrasonic welding room**
application specific area designed for inserting the materials and components that need to be welded together

**3.11**
**ultrasonically welded splice length**
system-specific area of the sonotrode, which defines the length of the weld package

Note 1 to entry: See Figure 2.




**Key**

A splice's length

B wire overhang at the end of the splice

C distance between insulation and splice

D overlapping length of the shrinking tube and wire insulation

**Figure 2 – Ultrasonically welded splice of two wires protected by a shrinking tube**

**3.12**
**ultrasonic weld width**
is defined by the passive tools of the welding machine that form the welding room

Note 1 to entry: See Figure 3.

Dimensions in millimetres



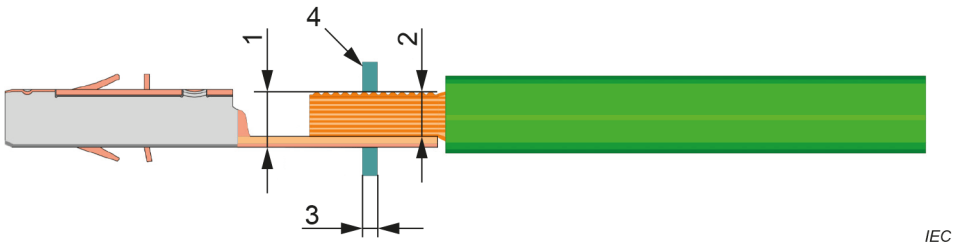

**Key**

2 weld width

**Figure 3 – Top view of an ultrasonically welded wire on a terminal**

**3.13**
**ultrasonic weld height**
height of the weld material (i.e., strands)

Note 1 to entry: See Figure 4.




**Key**

1 height including welding pad

2 welding height

3 measuring tool width

4 measuring tool

**Figure 4 – Side view of an ultrasonically welded wire on a terminal**

**3.14**
**ultrasonically welded end compaction**
wire whose strands are welded together at one non-insulated end

Note 1 to entry: See Figure 5.

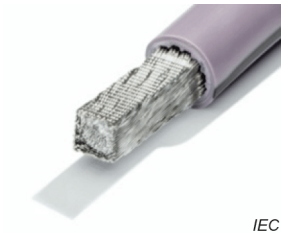



**Figure 5 – Ultrasonically welded end compaction**

**3.15**
**ultrasonic compaction ratio**
ratio of the cross-sectional area of the welded wires to the cross-sectional area of the sum of all strands to be welded

**3.16**
**ultrasonic weld package**
welded connection of strands with each other or in connection with components, in relation to package length and package width

**3.17**
**ultrasonically welded splice connection**
**inline splice**
package that has two or more wires welded together in the axial direction

**3.18**
**ultrasonically welded end splice**
way to securely connect two or more wires together in one direction

Note 1 to entry: See Figure 6.