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

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TITLE:

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

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SOLDERLESS CONNECTIONS

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

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FOREWORD

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284 IEC 60352-9 has been prepared by subcommittee SC 48B: Electrical connectors, of IEC
285 technical committee 48: Electrical connectors and mechanical structures for electrical and
286 electronical equipment. It is an International Standard.

287 The text of this an International Standard is based on the following documents:

Draft	Report on voting
XX/XX/FDIS	XX/XX/RVD

288

289 Full information on the voting for its approval can be found in the report on voting indicated in
290 the above table.

291 The language used for the development of this International Standard is English.

292 This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in
293 accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available

294 at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are
295 described in greater detail at www.iec.ch/standardsdev/publications.

296 The committee has decided that the contents of this document will remain unchanged until the
297 stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to
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- 299 • reconfirmed,
- 300 • withdrawn,
- 301 • replaced by a revised edition, or
- 302 • amended.

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304

INTRODUCTION

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

309 The process of ultrasonic welding relies on high frequency ultrasound waves being used to
310 create frictional heat at the connection point. High temperature is not required for this special
311 method of welding, making it one of the most cost-effective ways to join two materials together.
312 It also requires fewer steps than traditional methods, meaning it can be completed quickly and
313 with minimal resources.

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

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

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

333 IEC Guideline 109 advocates the need to minimize the environmental impact of a product during
334 its life cycle phases. It is anticipated that some of the materials, manufacturing and assembly
335 processes approved under this standard may have adverse effects on the environment. In this
336 case, these materials, manufacturing, and assembly processes should be avoided. If further
337 technological developments lead to acceptable alternatives for these materials, they shall be
338 tested according to test program C.

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SOLDERLESS CONNECTIONS

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

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1 Scope

347 IEC 60352-9 that provides guidelines for welding and testing of ultrasonically welded
348 connections.

349 This document covers the requirements for ultrasonically welded connections with wires made
350 of copper or a copper alloy, as well as aluminium or aluminium alloy. These welded metal to
351 metal connections should have a stranded wire cross-sectional area of 0,08 mm² to 160 mm²
352 and not exceed a total cross-sectional area of 200 mm². For aluminium or aluminium alloys, the
353 minimum required cross-sectional area is 2,5 mm². Additionally, information on materials, data
354 from industrial experience and test procedures are included to ensure electrically stable
355 connections under prescribed environmental conditions. Lastly, this document aims to achieve
356 comparable results when using ultrasonic welding equipment with similar performance and
357 specifications as the termination manufacturers.

358 NOTE – Figures in this document demonstrate possible solutions of ultrasonic connections (for example of
359 rectangular shape), but not restricted to the solution displayed.

2 Normative references

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

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

367 IEC 60050(841), *International Electrotechnical Vocabulary (IEV) – Part 841 – Industrial*
368 *electroheat*

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

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

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

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

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

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

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

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

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

- 388 IEC 60512-5-2, *Connectors for electronic equipment - Tests and measurements - Part 5-2:*
389 *Current-carrying capacity tests - Test 5b: Current-temperature derating*
- 390 IEC 60512-6-4, *Connectors for electronic equipment - Tests and measurements - Part 6-4:*
391 *Dynamic stress tests - Test 6d: Vibration (sinusoidal)*
- 392 IEC 60512-11-1, *Connectors for electrical and electronic equipment - Tests and measurements*
393 *- Part 11-1: Climatic tests - Test 11a - Climatic sequence*
- 394 IEC 60512-11-4, *Connectors for electronic equipment - Tests and measurements - Part 11-4:*
395 *Climatic tests - Test 11d: Rapid change of temperature*
- 396 IEC 60512-11-7, *Connectors for electronic equipment - Tests and measurements - Part 11-7:*
397 *Climatic tests - Test 11g: Flowing mixed gas corrosion test*
- 398 IEC 60512-11-9, *Connectors for electronic equipment - Tests and measurements - Part 11-9:*
399 *Climatic tests - Test 11i: Dry heat*
- 400 IEC 60512-11-10, *Connectors for electronic equipment - Tests and measurements - Part 11-*
401 *10: Climatic tests - Test 11j: Cold*
- 402 IEC 60512-11-12, *Connectors for electronic equipment - Tests and measurements - Part 11-*
403 *12: Climatic tests - Test 11m: Damp heat, cyclic*
- 404 IEC 60512-16-4, *Connectors for electronic equipment - Tests and measurements - Part 16-4:*
405 *Mechanical tests on contacts and terminations - Test 16d: Tensile strength (crimped*
406 *connections)*
- 407 IEC 60512-16-7, *Connectors for electronic equipment - Tests and measurements - Part 16-7:*
408 *Mechanical tests on contacts and terminations - Test 16g: Measurement of contact deformation*
409 *after crimping*
- 410 IEC 60721-3-1, *Classification of environmental conditions - Part 3-1: Classification of groups of*
411 *environmental parameters and their severities – Storage – 2023*
- 412 IEC 60947-1:2020, *Low-voltage switchgear and controlgear - Part 1: General rules*
- 413 IEC 60999-1, *Connecting devices - Electrical copper conductors - Safety requirements for*
414 *screw-type and screwless-type clamping units - Part 1: General requirements and particular*
415 *requirements for clamping units for conductors from 0,2 mm² up to 35 mm² (included)*
- 416 ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers*
- 417 ISO 6892-1, *Metallic materials - Tensile testing - Part 1: Method of test at room temperature*
- 418 ISO 10447, *Resistance welding - Testing of welds - Peel and chisel testing of resistance spot*
419 *and projection welds*

420

421 **3 Terms and definitions**

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

424 ISO and IEC maintain terminological databases for use in standardization at the following
425 addresses:

- 426 • IEC Electropedia: available at <http://www.electropedia.org/>
- 427 • ISO Online browsing platform: available at <http://www.iso.org/obp>

428 **3.1**

429 **ultrasonic welding**

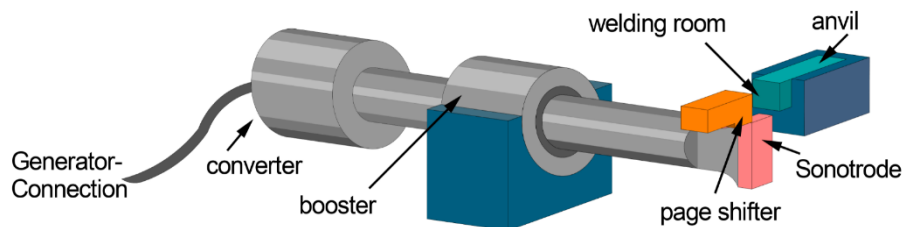
430 process, in which the mechanical oscillations of a small amplitude and frequency of ultrasonic
431 range, together with static pressure, enable the junction of materials at a much lower
432 temperature than the melting point.

433 [SOURCE: IEC 841-33-03]

434 3.2

435 ultrasonic welding machine - ultrasonic welding system

436 system for ultrasonic welding consists of an ultrasonic generator, an ultrasonic converter, a
 437 sonotrode and the necessary electrical and mechanical accessories to operate it.
 438 Note1 to entry – Figure 1 shows the construction of an ultrasonic welding system specifically designed for splicing
 439 wire. An ultrasonic welding machine is a device designed with specialized technology that can join together at least
 440 two wires. The process of joining the wires together is known as "splicing", and this machine makes the process
 441 much easier and more efficient than any manual method.



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

444 3.3

445 ultrasonic generator

446 source that generates high frequency electrical energy to the ultrasonic transducers

447 3.4

448 ultrasonic converter

449 a ultrasonic converter is a device that takes electrical energy at an ultrasonic frequency and
 450 converts it into mechanical oscillations or vibrations.

451 3.5

452 sonotrode

453 the component that transmits ultrasonic vibrations directly to the parts to be welded.

454 3.6

455 vibration booster

456 intermediate member between the converter and the sonotrode, amplifying the ultrasonic
 457 oscillations.

458 3.7

459 surface or anvil plate

460 only Splice welding machines are equipped with a passive wall located below or to the side of
 461 the anvil and separated from the sonotrode by a defined gap to prevent contact and any possible
 462 damage to tools.

463 3.8

464 ultrasonic side slider

465 the ultrasonic side slider is a device used to adjust the welding width.

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

468 3.9

469 anvil

470 the anvil is a component of the ultrasonic welding machine, located on the opposite side of the
 471 horn and forming one wall of the welding room.

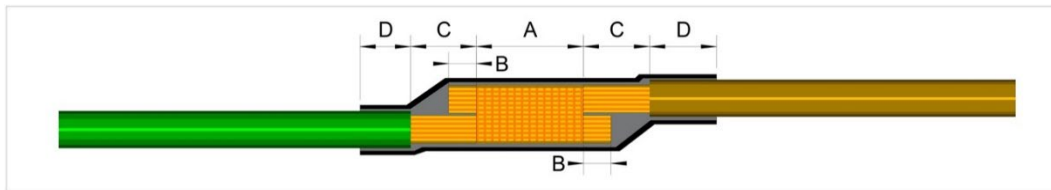
472 3.10

473 ultrasonic welding room

474 the ultrasonic welding room is an application specific area designed for inserting the materials
 475 and components that need to be welded together.

476 **3.11**
477 **ultrasonically welded splice length**

478 system-specific area of the sonotrode, which define the length of the weld package.



479

480

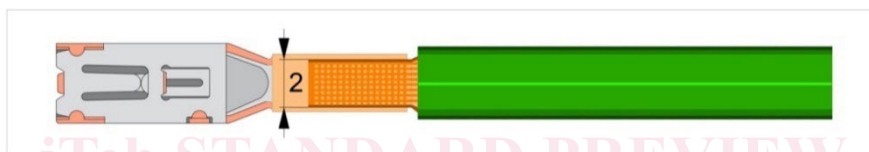
Figure 2 – Ultrasonically welded splice of two wires protected by a shrink tube

481 Note 1 to entry: Figure 2 provides a visual for an ultrasonically welded splice of two wires protected by a shrinking
482 tube. Caption A reveals the splice's length, with Caption B indicating wire overhang at the end of the splice.
483 Caption C highlights the distance between insulation and splice, while Caption D shows the overlapping length of
484 the shrinking tube and wire insulation.

485 **3.12**

486 **ultrasonic weld width**

487 the welding width is defined by the passive tools of the welding machine that form the welding
488 room.



489

490

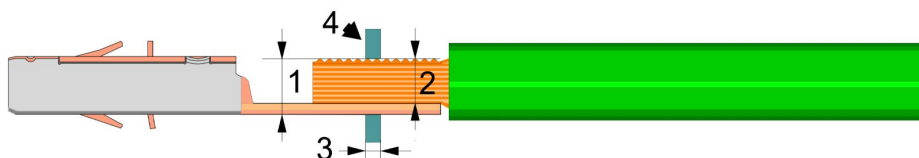
Figure 3 – Wire ultrasonically welded on a terminal

491 Note 1 to entry: Caption 2 in Figure 3 shows the weld width.

492 **3.13**

493 **ultrasonic weld height**

494 the height of the weld, in this document only the welded material (i.e., strands) is meant. Many
495 application specifications will specify the welding height, along with the sheet thickness of the
496 contact. This is because it's simpler to measure the welding height accurately by using either a
497 calliper gauge or an outside micrometre. In order for both instruments to be up to the task, their
498 discs should be larger than the distance between hills in order for accurate measurements to
499 be taken.



500

501

502

Figure 4 – Wire ultrasonically welded on a terminal

503 Note 1 to entry: Captions in Figure 4 shows (1) height including welding pad, (2) welding height, (3) measuring tool
504 width, (4) measuring tool.

505 **3.14**

506 **ultrasonically welded end compaction**

507 a wire whose strands are welded together at one non-insulated end.