

# Ultrasonic Welding Guide

Dedicated engineering reference guide for buyers, engineers, and sourcing teams

## Based on article:

<https://nylonplastic.com/ultrasonic-welding-plastics-guide/>

## Quick Overview

Ultrasonic welding joins thermoplastic parts in under a second by converting 20-40 kHz electrical energy into mechanical vibration. The vibration generates frictional heat at the joint interface, melting and fusing the plastic in a fraction of the time required by adhesives, solvent bonding, or hot-plate welding. It is the dominant assembly method for consumer electronics, medical devices, and automotive components — anywhere that speed, cleanliness, and repeatability matter.

But ultrasonic welding is unforgiving of poor joint design. The energy director geometry, material pair, and amplitude setting must align precisely, or welds come out weak, inconsistent, or visually marred. This guide covers the parameters that separate a reliable production weld from a costly rework loop.

A piezoelectric transducer converts electrical power (typically 500-4,000 W) into high-frequency mechanical vibration. A booster amplifies or reduces the amplitude, and a horn (sonotrode) delivers the vibration to the part surface. The energy travels through the upper part to a molded-in energy director at the joint interface — a triangular ridge, typically 0.3-0.8 mm tall with a 60-90° peak angle. Friction melts this ridge first, and the molten material flows across the joint under pressure, solidifying into a homogeneous bond within 0.5-2.0 seconds.

## Engineering Notes

### How Ultrasonic Welding Works

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### Frequency Selection and Amplitude by Material

Best ultrasonic material; forgiving parameter window Higher energy needed; prone to stress cracking if over-welded Must be dry (<0.2% moisture); requires higher amplitude Semi-crystalline needs high amplitude; near-field only Low friction coefficient requires aggressive energy director Similar to PC; brittle — avoid over-welding High melt temp (343°C); requires very high energy input

### Energy Director and Joint Design

The energy director is a triangular ridge molded into one part half that concentrates ultrasonic energy at a precise point. Standard design: 90° included angle, 0.3-0.8 mm height, continuous around the joint perimeter. Shear joint: Used for semi-crystalline plastics (PP, PA, POM) where energy directors struggle — one part wedges into the other with 0.2-0.4 mm interference, creating shear heating along the sidewall rather than at a single point. Near-field welding (horn distance < 6 mm from joint) Far-field welding (horn >6 mm from joint) requires stiffer, amorphous plastics that transmit vibration well — ABS and PC work; PP and PE lose too much energy over distance. For semi-crystalline plastics, always design for near-field horn placement.



## Design Rules for Ultrasonic Welding

Energy director height: 0.4-0.6 mm: For parts up to 50 mm joint length. Increase to 0.6-0.8 mm for joints over 100 mm. Shorter directors melt too fast and produce weak bonds; taller directors require excessive energy and flash. Joint alignment within 0.05 mm: Misalignment of 0.1 mm or more creates inconsistent energy transfer, localized overheating, and weak spots. Use alignment pins or tongue-and-groove features to guide the horn and part halves. Keep horn-to-joint distance within 6 mm: Energy drops roughly 50% per 6 mm of travel through plastic. For parts taller than 6 mm, use a near-field horn contact point close to the joint line. Avoid sharp internal corners at joint: Radius all internal corners at the weld joint to at least 0.5 mm. Sharp corners act as stress risers that amplify vibration and cause cracking during or after welding. Wall thickness at joint: 1.5-3.0 mm: Thinner walls melt through; thicker walls transmit insufficient energy. The sweet spot for most amorphous plastics is 2.0-2.5 mm. Add a support rib 2-3 mm behind the weld surface for thinner walls.

## Process Parameters by Application

Phone/laptop housings, charger cases 20 kHz, 1.0s weld, 0.5s hold Cosmetic surface, no flash IV connectors, filter housings, syringes 30 kHz, 0.5s weld, clean room Particulate-free, validated process Sensor housings, lamp assemblies, fluid reservoirs 20 kHz, 1.5s weld, high strength Temperature cycling resistance Blister packs, tube sealing, tamper-evident caps

## Cost Decision Framework

Equipment cost: Benchtop ultrasonic welder: \$8,000-25,000 (20 kHz, 1,500-3,000 W). Automated system with handling: \$40,000-120,000. Horn tooling: \$500-3,000 per design (aluminum for prototypes, titanium for production). Per-part economics: Ultrasonic welding costs \$0.002-0.01 per cycle in electricity, plus horn amortization (\$0.001-0.003 per part over 500,000 cycles). Compare to adhesive bonding at \$0.05-0.50 per part (adhesive + cure time + labor). The break-even on equipment against adhesives is typically 50,000-100,000 parts. Volume decision: Under 10,000 parts annually, adhesives or mechanical fasteners often win on upfront cost. Above 50,000 parts, ultrasonic welding dominates on speed, cleanliness, and per-part cost. Medical and electronics add an intangible: ultrasonic welds leave no chemical residue, simplifying regulatory compliance.

## Common Defects and Solutions

Parts separate with minimal force Insufficient amplitude; wet nylon; wrong energy director Increase amplitude 20%; dry nylon to <0.2% moisture; verify ED at 90° Molten plastic extruding from joint line Excessive energy; too-high pressure; no flash trap Reduce weld time 15%; add 0.5mm flash trap groove; reduce trigger pressure Horn contact area shows scuffing or dents Horn surface worn or misaligned; excessive amplitude Resurface horn; add PE film between horn and part; reduce amplitude 10% Inconsistent weld strength Bond varies ±30% part-to-part Fixture movement; part dimensional variation; moisture Lock fixture alignment; check molded part dimensions; control humidity

## RFQ Checklist

- Application environment: temperature, moisture, UV, chemicals, sterilization, or outdoor exposure.
- Mechanical requirements: load, stiffness, impact, wear, friction, creep, and fatigue life.
- Drawing requirements: tolerance class, critical dimensions, surface finish, threads, inserts, and inspection method.
- Production needs: prototype or production quantity, expected annual volume, target unit cost, and lead-time window.
- Material notes: preferred grade, color, reinforcement, flame rating, certification, and substitute-material flexibility.

### Need manufacturing support?

Share your drawing, target material, working environment, tolerance requirements, and quantity. Nylon Plastic can help evaluate manufacturability, material alternatives, and production quotation details.

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