# Amplitude Reference Guide

An ultrasonic weld is governed by the following formula: $E = P \times T$, where $E$ = energy, $P$ = power, and $T$ = time. Power is a function of force times velocity: $P \approx F \times V$. Force is derived from pressure and down speed, and velocity is derived from frequency and amplitude. (See Figure 1.)
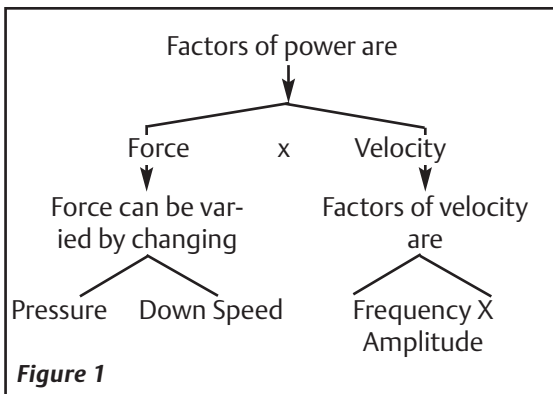


Factors of power are

Force x Velocity

Force can be varied by changing

Factors of velocity are

Pressure   Down Speed

Frequency X Amplitude

*Figure 1*

Amplitude is defined as the peak-to-peak longitudinal displacement at the face of the horn. (See Figure 2.) It has the most impact on the ultrasonic process, in that the heat generated at the joint interface is based on the *square* of the amplitude. Therefore, small increases or decreases in amplitude have a greater affect than changes to other parameters, because the results are magnified by the square rather than incrementally.
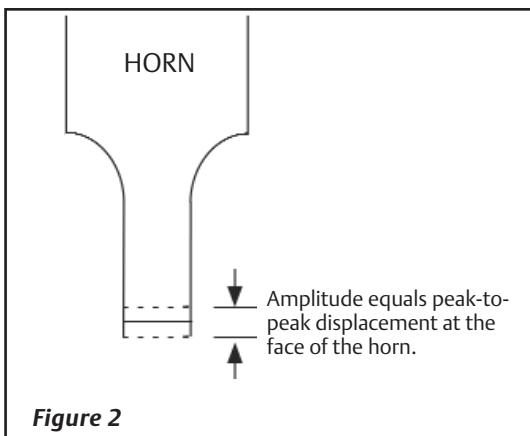


HORN

Amplitude equals peak-to-peak displacement at the face of the horn.

*Figure 2*

One can calculate amplitude by using static gain factors of the components that make up an acoustic stack: the converter, booster, and horn. (Gain is the ratio of output amplitude to input amplitude of a horn or booster.) To arrive at approximate stack amplitude, multiply the amplitude of the converter by the gain factors of the booster and horn. (See Figure 3.) For example:

$$\text{Amplitude}_{output} = \text{Amplitude}_{converter} \times \text{Gain}_{booster} \times \text{Gain}_{horn}$$



| Converter 20 Microns | X | Black Booster 1 : 2.5 | X | Horn 2 = 100 Microns |

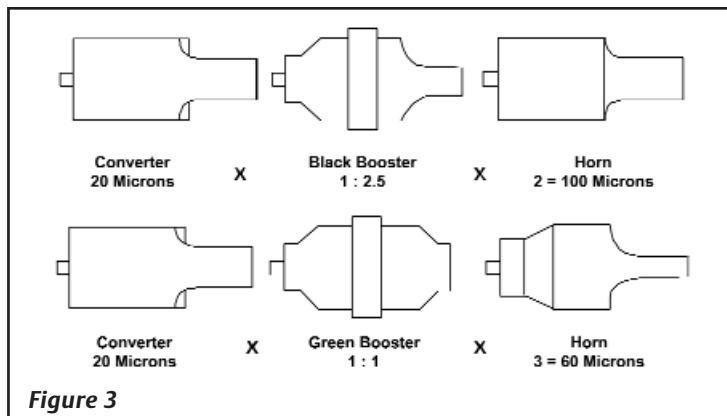| Converter 20 Microns | X | Green Booster 1 : 1 | X | Horn 3 = 60 Microns |

*Figure 3*

Depending on the material and ultrasonic process utilized, different amplitudes will be necessary. Amplitude can be measured in either thousandths of an inch or microns (0.001″ = 25 microns).

Amplitude guidelines based on material and process have been arrived at through research and practical experience. The matrix on the reverse side of this page should be used as a ***guideline*** to determine amplitude for the setup of your particular application, based on the frequency of the equipment.

**EMERSON**
Industrial Automation

# AMPLITUDE REFERENCE GUIDE for ULTRASONIC WELDING (in Microns (μm))

| Resin | Frequency | | | |
|---|---|---|---|---|
| **Amorphous** | **15 kHz** | **20 kHz** | **30 kHz** | **40 kHz** |
| Acrylonitrile Butadiene Styrene (ABS) | 36-84 | 30-70 | 24-56 | 18-42 |
| Acrylonitrile Styrene Acrylate (ASA) | 36-84 | 30-70 | 24-56 | 18-42 |
| Polycarbonate (PC) | 72-120 | 60-100 | 48-80 | 36-60 |
| PC/ABS | 72-120 | 60-100 | 48-80 | 36-60 |
| Polycarbonate/Polyester | 60-120 | 50-100 | 40-80 | 30-60 |
| Polyetherimide (PEI) | 84-120 | 70-100 | 56-80 | 42-60 |
| Polyethersulfone (PES) | 84-120 | 70-100 | 56-80 | 42-60 |
| Polymethyl Methacrylate (Acrylic, PMMA) | 48-84 | 40-70 | 32-56 | 24-42 |
| Polyphenylene Oxide (PPO) | 60-108 | 50-90 | 40-72 | 30-54 |
| Polystyrene (PS) | 36-84 | 30-70 | 24-56 | 18-42 |
| Polysulfone (PSU) | 84-120 | 70-100 | 56-80 | 42-60 |
| Polyvinyl Chloride (rigid PVC) | 48-96 | 40-80 | 32-64 | 24-48 |
| Styrene-Acrylonitrile (SAN) | 36-84 | 30-70 | 24-56 | 18-42 |
| **Semi-Crystalline** | | | | |
| Cellulosics (CA, CAB, CAP) | 72-120 | 60-100 | 48-80 | 36-60 |
| Liquid Crystal Polymer (LCP) | 84-144 | 70-120 | 56-96 | 42-72 |
| Polyoxymethylene, Polyacetal (POM) | 84-144 | 70-120 | 56-96 | 42-72 |
| Polyamid (Nylon, PA) | 84-144 | 70-120 | 56-96 | 42-72 |
| Polybutylene Terephthalate (Polyester, PBT) | 84-144 | 70-120 | 56-96 | 42-72 |
| Polyethylene Terephthalate (Polyester, PET) | 96-144 | 80-120 | 64-96 | 48-72 |
| Polyetheretherketone (PEEK) | 84-144 | 70-120 | 56-96 | 42-72 |
| Polyethylene (PE) | 108-144 | 90-120 | 72-96 | 54-72 |
| Polyphenylene Sulfide (PPS) | 96-144 | 80-120 | 64-96 | 48-72 |
| Polypropylene (PP) | 108-144 | 90-120 | 72-96 | 54-72 |

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