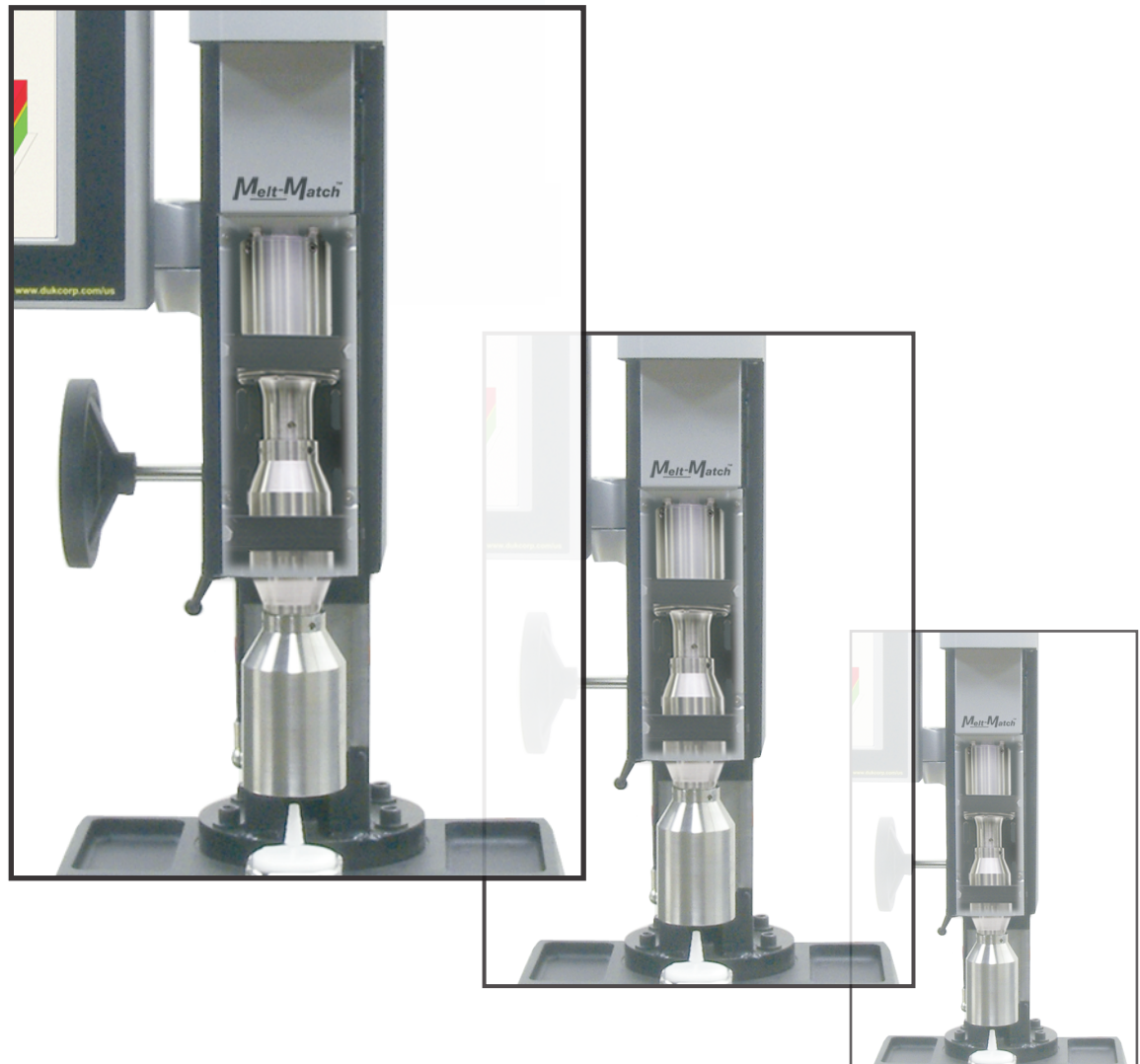


Ultrasonic Probes/Stacks

Understanding and Caring for the Heart of Your Ultrasonic System



Dukane White Paper No. 11667-C-09

Dukane Intelligent Assembly Solutions • 2900 Dukane Drive St. • Charles, Illinois 60174 USA • TEL (630) 797-4900 • FAX (630) 797-4949



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This ultrasonic equipment is manufactured under one or more of the following U.S. Patents:

3,780,926 3,825,481 4,131,505 4,277,710 5,798,599 5,880,580 6,984,921, 7,225,965, and 7,475,801

Revision History

Revision Number	Revision Summary	Date
- 08	Update publication.	03/21/2008
- 09	Add Troubleshooting section. Add Air Quality requirements.	12/05/2009

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SECTION 1

Theory of Operation

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Ultrasonic Probe

Plastic welding is the most common application of ultrasonic assembly. To perform ultrasonic plastic welding, a vibrating tip is brought into contact with one of the work pieces as shown in Figure 1–1. Pressure is applied and ultrasonic energy travels through the material, increasing the kinetic energy (or heat) at the contact point of the two parts. The heat melts a molded ridge of plastic on one of the pieces and the molten material flows between the two surfaces. When the vibration stops, the material solidifies forming a permanent bond.

Probe Configuration

A basic ultrasonic probe consists of :

1. A housing which contains the transducer which converts electrical energy into mechanical vibrations.
2. A horn to transfer the mechanical vibrations from the transducer to the parts to be welded. A basic ultrasonic probe is shown in Figure 1–2. As indicated, the horn is secured to the transducer with a threaded stud. The transducer housing also has a connector for attaching the high voltage coaxial cable which delivers the high–frequency electrical signal for exciting the transducer. This signal is supplied by a separate ultrasonic generator.

Transducer

The transducer supplies the ultrasonic vibrations by means of piezoelectric converters which transform electrical energy into mechanical movement. Power applied to the transducer at 20kHz can range from less than 50 Watts up to 3000 Watts.

The transducer is made from a number of polycrystalline ceramic elements separated by thin metal plates, clamped together under high pressure.

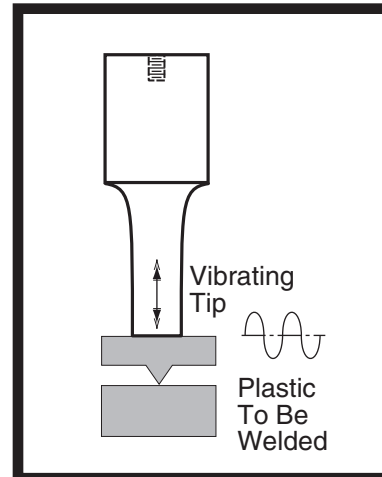


Figure 1–1 Vibrating Tip Welding Plastic Parts

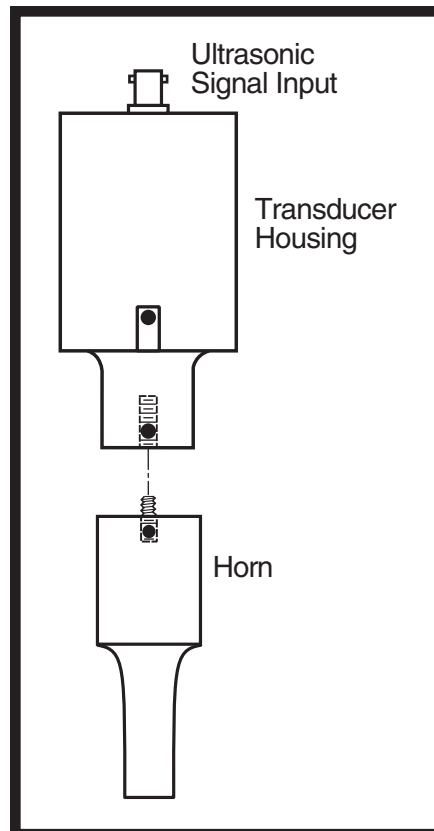


Figure 1–2 Ultrasonic Probe with Transducer and Horn

When an alternating voltage (dV/dt) is applied to the converters (or ceramics), a corresponding electric field (dE/dt) is produced which results in a variation in thickness (dL/dt) of the ceramic elements. This variation in thickness induces a pressure wave (dP/dt). Because the molecules or atoms of a solid are elastically bound to one another, the pressure wave results in a wave propagating through the material which is reflected by the ends the metal mass of the converter.

See Figure 1–8 for a graphical representation of this. When the length of the assembly is tuned to its frequency of excitation, it resonates and becomes a source of standing waves. A typical transducer without its housing is shown in Figure 1–3. The output amplitude from a 20kHz transducer is only about 20 microns (0.0008 inches), so this amplitude needs to be amplified by the horn (and possibly a booster) to do useful work.

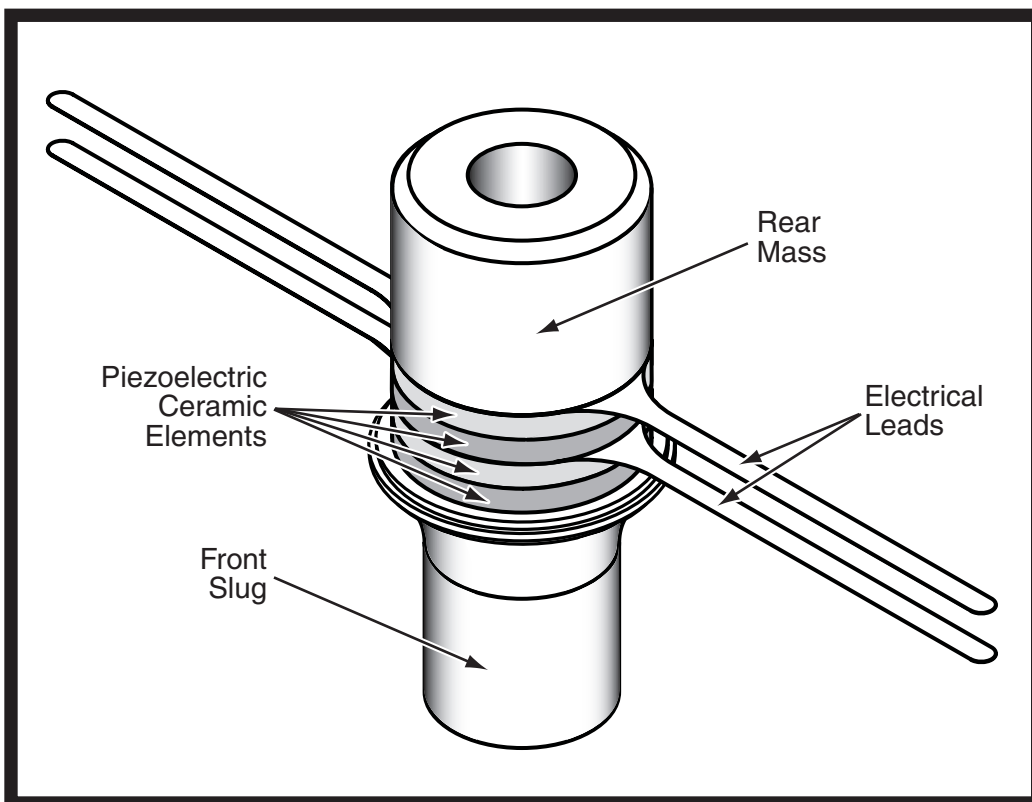


Figure 1–3 Components of an Ultrasonic Transducer

Horn

The horn acts as an acoustic waveguide or transformer to amplify and focus the ultrasonic vibrations to the work piece. The horn has three primary functions:

1. It transfers the ultrasonic mechanical vibrational energy (originating at the transducer) to the plastic parts through direct physical contact, and localizes the energy in the area where the melt is to occur.
2. It amplifies the vibrational amplitude to provide the desired tip amplitude for the thermoplastic and weld process requirements
3. It applies the pressure necessary to form the weld once the joint surfaces are melted.

The horn is precision machined and designed to vibrate at either 15kHz, 20kHz, 30kHz, 40kHz,



Figure 1-4 Five Horns Ranging from 15kHz to 50kHz

50kHz or 70kHz. Figure 1–4 shows five aluminum alloy horns ranging from 15kHz to 50kHz. The higher the frequency, the shorter the acoustic wavelength, and consequently the smaller the horn. Notice that the 30Khz horn is only half the length of the 15kHz horn. The tuning of a horn is accomplished using electronic frequency measurement. Inherent variations in material composition prevent tuning by dimensional machining alone. Horns are usually manufactured from high–strength aluminum alloys or titanium. Both metals have excellent acoustical properties to transmit the ultrasonic energy with very little attenuation.

There are many different horn shapes and styles depending upon the process requirements. Factors which influence the horn design are the materials to be welded and the method of assembly. The gain of the horn is determined by its profile. Figure 1–5 shows four different gain profiles. The input vibration amplitude to a horn from a 20kHz transducer is only about 20 microns. This is not enough to generate enough friction achieve a melt temperature for most thermoplastics. Therefore the horn must amplify the mechanical vibration so that the amplitude is sufficient to melt the thermoplastic. The amplitude at the tip of the horn typically ranges from 30 to 125 microns (1.2 to 5.0 thousandths of an inch) at 20kHz.

An optional threaded tip can also be used when the application calls for staking, a swagging profile or a pointed spot weld. In Figure 1–1, one of the plastic parts had a small ridge used to initiate the melt process. Here in Figure 1–6, the tip provides the energy director since there is only one piece to be melted in a staking operation. Replaceable tips are not commonly used in high–volume production environments. For long–term or high–wear production, a horn with a custom machined tip coated with chrome, carbide or titanium nitride will provide excellent wear resistance.

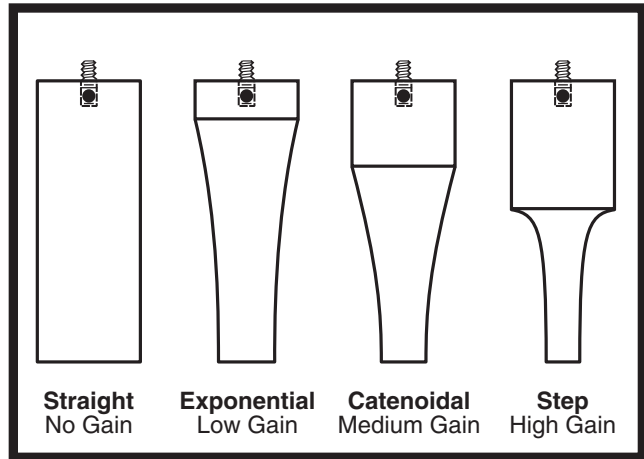


Figure 1–5 Different Horn Gain Profiles

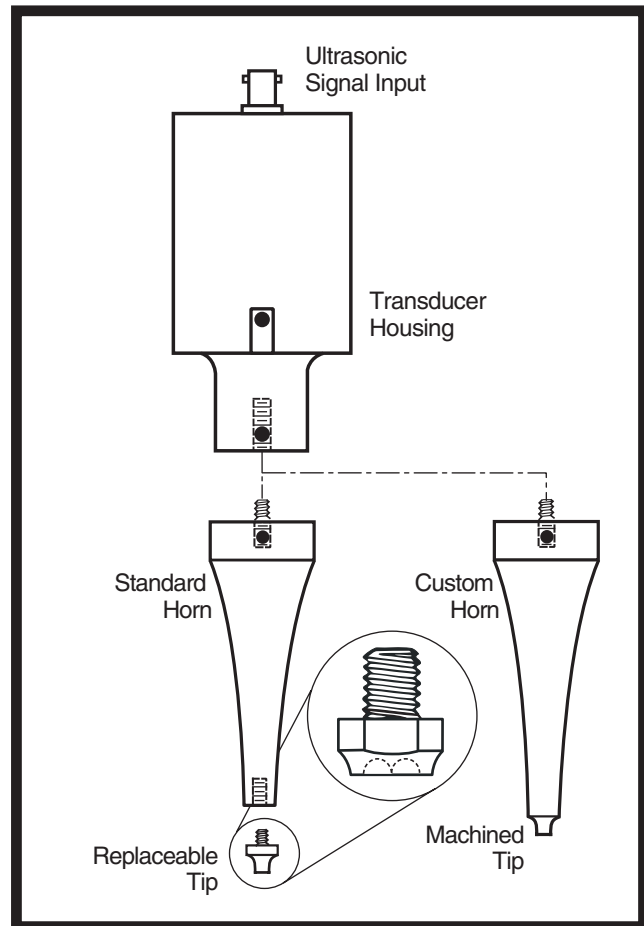


Figure 1–6 Ultrasonic Probe with Transducer, Horn and Tip

As the frequency increases, vibration amplitude typically decreases. Higher frequencies are used for seaming of thin materials and delicate parts that do not require a lot of amplitude. Since the horns become smaller at higher frequencies, closer spacing can also be achieved. Some factors to consider for high-frequency (e.g. 40kHz) ultrasonic welding versus lower-frequency (e.g. 20kHz) ultrasonic welding are listed here.

1. For a given amplitude, stress in the horn increases at higher frequencies.
2. Wear on the horn is greater at high frequencies.
3. Clean and flat mating surfaces between the horn, booster and transducer are more critical as the frequency increases. At 40kHz, surface flatness specifications are between 0.0005” and 0.001” (13 to 25 microns).

Booster

The primary function of a booster is to alter the gain (i.e. output amplitude) of the probe. A booster is amplifying if its gain is greater than one and reducing if its gain is less than one. Gains at 20kHz typically range from less than one-half to about three. A booster designed to be mounted in a fixture between the transducer and horn is shown in Figure 1–7. This is commonly referred to as a probe stack. Since the horn cannot be clamped, only the transducer and booster can be secured. Therefore a secondary function (and sometimes sole purpose) of a booster is to provide an additional mounting location without altering the gain when the probe stack is secured in a press. The neutral (1:1) or coupling booster is added between the transducer and horn and mounted in the press by its mounting ring which is placed at the nodal point (where the standing wave has minimal amplitude). See Figure 1–8 for a graphical representation. Note that the maximum stress occurs at the nodal points.

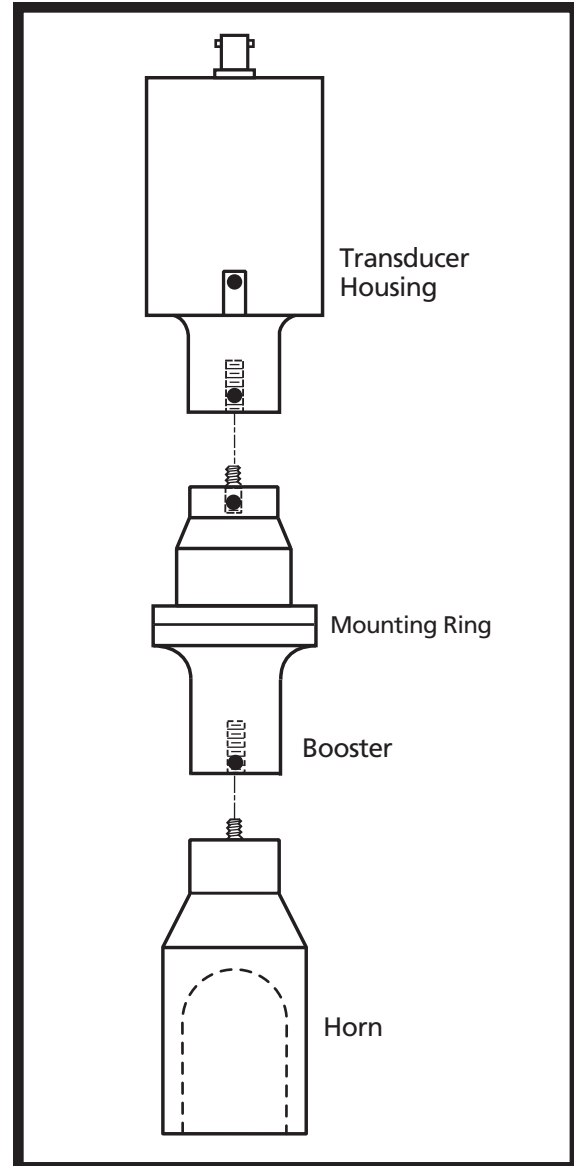


Figure 1–7 Probe Stack - Transducer, Booster and Horn

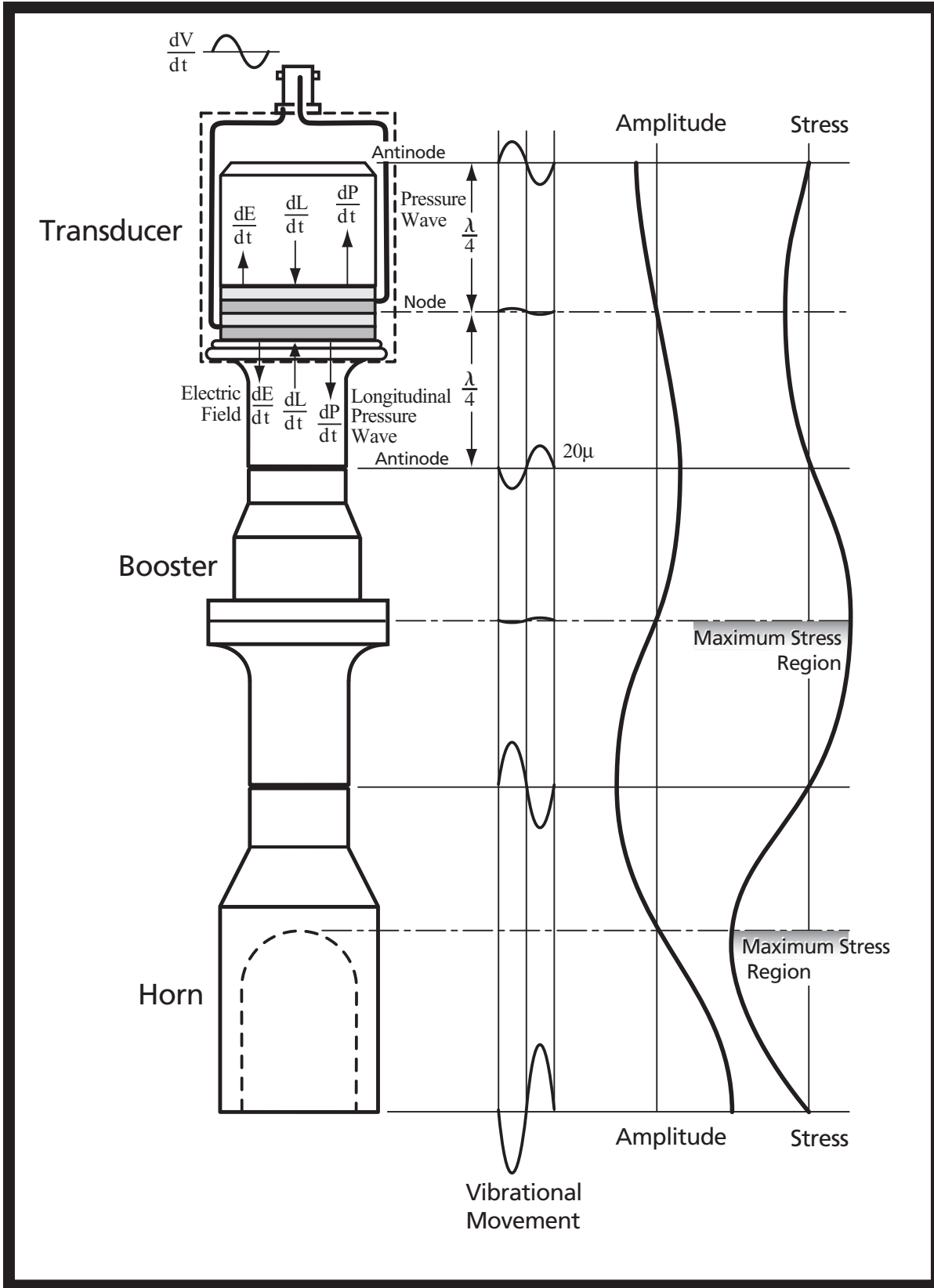


Figure 1-8 Graph of Vibrational Movement, Amplitude and Stress

SECTION 2

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Stack Assembly

Attaching a Replaceable Tip to a Horn


1. Inspect all horn and tip surfaces for stress cracks, chips, or gouges. Any of these irregularities will affect operation and could lead to further equipment damage. Contact the Dukane Ultrasonics Tooling Department concerning damaged horn components.
2. Apply an extremely thin layer of a high temperature, high pressure silicon grease to the back surface that mates with the horn. The grease will allow both surfaces to intimately mate and become acoustically transparent which improves the energy transfer. Do not apply any grease to the threads. We recommend Dow–Corning #4 (or #111 as an alternate). A small packet of Dow–Corning #4 is supplied with the system. If you cannot use a silicon–based grease in your facility, a petroleum–based grease may be used. However, it is likely to leave carbonaceous deposits on the surface, and require more frequent joint maintenance. Failure to follow these instructions, may result in the mating surfaces bonding and difficulty removing the tip from the horn.
3. Thread the tip into the horn and tighten to the torque specifications below using an open end wrench of the correct size to fit the wrench flats of the tip. This is illustrated in Figure 2-1. If necessary, use a spanner wrench (on horns with spanner wrench holes) or an open end wrench (on horns with wrench flats) to keep the horn from turning in your hand. A canvas strap wrench is permissible if it does not gouge or scratch the horn.

Replaceable Tips to Horn

inch-lb	ft-lb	N-m	Size
360	30	40.7	1/2" x 20 tpi tip threads
336	28	38	3/8" x 24 tpi tip threads
300	25	33.9	5/16" x 24 tpi tip threads
240	20	27.1	1/4" x 28 tpi tip threads

Table 2-1 Tip Torque Unit Conversions

NOTE
Do not apply any grease to the threads of the replaceable tip. This may cause the tip to loosen from the horn resulting in inconsistent operation.

CAUTION
 NEVER clamp the horn in a vise. The resulting scratches or gouges in the surface are stress risers which may result in cracks.

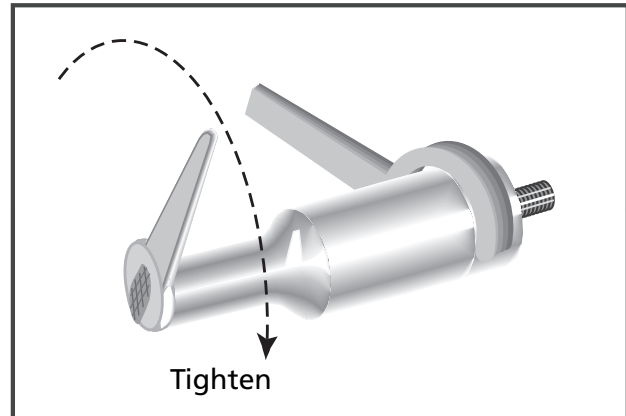


Figure 2-1 Replaceable Tip Installation

NOTE
Dukane Part No. for the 20kHz spanner wrenches is 721-68.

Dukane Part No. for the 40kHz spanner wrenches is 721-44.

Attaching the Mounting Stud to a Horn or a Booster

1. Inspect the stud for cracks or damaged threads. Replace the stud if it is cracked or otherwise damaged.
2. Remove any foreign matter from the threaded stud and the mating hole.
3. Thread the mounting stud into the input* end of the horn or the input* end of the booster and tighten to the following torque specifications using an Allen wrench in the socket head of the mounting stud. Table 2-II lists the torque specifications in units for both English and Metric systems of measurements.

DO NOT hold the booster by the mounting rings when tightening stud. The mounting rings have a shear pin which could snap under excessive torque. Use a spanner wrench (on horns with spanner wrench holes) or an open end wrench (on horns with wrench flats) to keep the horn or booster from turning in your hand.

in-lb	ft-Lb	N-m	Size
12-18	1 - 1.5	1.4 - 2	1/2" x 20 tpi studs
12-18	1 - 1.5	1.4 - 2	3/8" X 20 tpi studs
12-18	1 - 1.5	1.4 - 2	8 mm studs

Table 2-II Stud Torque Unit Conversions

* Always assemble the mounting studs that mate boosters, transducers and horns to the input end of the horn or the input end of the booster first. This is shown in Figure 2-5.

NEVER thread a stud into the transducer or the output end of the booster first. See *Booster Notes* in this section for correctly identifying the output end of a booster.

NOTE

Do not apply any grease to the stud threads or the tapped hole. This may cause the stud to loosen. If the stud wanders within the joint, it can vibrate, resulting in excessive heat. In some cases, this can melt the tooling material.

NOTE

To convert inch-lbs to ft-lbs, divide by 12.
 To convert inch-lbs to Nm, divide by 8.852.
 To convert ft-lbs to Nm, multiply by 1.356.
 To convert Nm to ft-lbs, multiply by 0.7376.

Torque specifications have a tolerance of about $\pm 10\%$.

Attaching the Horn to a Booster/Transducer or Booster to a Transducer

1. Inspect all surfaces to be joined for stress cracks, chips, or gouges. Any of these irregularities will affect operation and could lead to further equipment damage. Contact the Dukane Ultrasonic Tooling Department concerning a damaged booster.
2. Ensure that the mating surfaces of the two components are clean and smooth. These surfaces must make intimate contact for the mechanical energy to pass from one component to the next. Pitting or a buildup of old grease and dirt on a mating surface will interfere with the energy transfer and reduce the power delivered.
3. Make sure that the stud in the horn or booster is tight. See the preceding mounting stud assembly instructions for torque specifications.
4. Remove any foreign matter from the threaded stud and mating hole.
5. Apply an extremely thin layer of a high temperature, high pressure silicon grease to the surface that mates with the horn. The grease will allow both surfaces to intimately mate and become acoustically transparent which improves the energy transfer. We recommend Dow–Corning #4 (or #111 as an alternate). A small packet of Dow–Corning #4 is supplied with the system. If you cannot use a silicon–based grease in your facility, a petroleum–based grease may be used. However, it is likely to leave carbonaceous deposits on the surface, and require more frequent joint maintenance. Grease may be omitted if mylar washers are preferred on systems that require frequent changes. Because Mylar is plastic and will creep under compression, establish a system maintenance plan that includes washer inspection and replacement. Mylar is not recommended for systems that are not changed frequently.

Failure to follow these instructions, may result in the mating surfaces bonding and difficulty removing the horn from the booster or the booster from the probe.

NOTE

Always remove a probe stack from the machine in which it is mounted before attaching or removing a horn.

CAUTION



Never leave a horn or booster assembly hand tight. Torque it to the proper specifications before proceeding. If the assembly is installed without being properly torqued down, the assembly may vibrate severely, damaging the mating surfaces and causing the generator to overload.

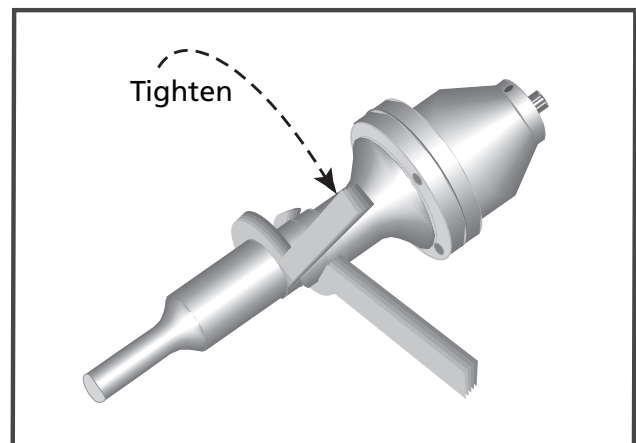


Figure 2-2 Stack Assembly Procedure

6. Thread the components together and tighten to the following torque specifications using only the correct size wrenches. Use spanner wrenches on components with spanner wrench holes or an open end wrench on components with wrench flats. See Figure 2-2 for the correct procedure. Refer to Table 2-III for torque unit conversions. Be careful not to overtighten.

In-lb	Ft-lb	N-m	kHz
540	45	61	15 kHz stack
420	35	47.5	20 kHz stack
216	18	24.4	30 kHz stack
216	18	24.4	40 kHz stack

Table 2-III Horn/Booster Torque Unit Conversions

NOTE

Horn and booster torque specifications are higher than stud torque specs. Be sure to tighten the horn or booster joints to the higher torque limits. Do not tighten the studs to these higher ratings as it may induce unnecessary stress in the assembly.


Stack Disassembly

Stack disassembly is required when changing the booster or horn, or for a thorough inspection of all stack components. In mounted systems, always remove the stack from its mounting to disassemble the stack components.

To establish a maintenance schedule, inspect the mating surfaces after the first 200–400 hours of operation. If they require cleaning, halve the time between inspections. If the surfaces do not require reconditioning, then double the time between inspections. Each system is different due to the large number of operational parameters and stress factors.

The assembly and disassembly procedures for a hand probe are shown in Figure 2–3. It makes no difference whether the horn is attached to the booster first, or the booster is attached to the probe first.

CAUTION



Never hold a probe by the housing when tightening or loosening an adjoining component. The probe housing has anti-rotation devices to keep the transducer aligned. These could shear under excessive torque.

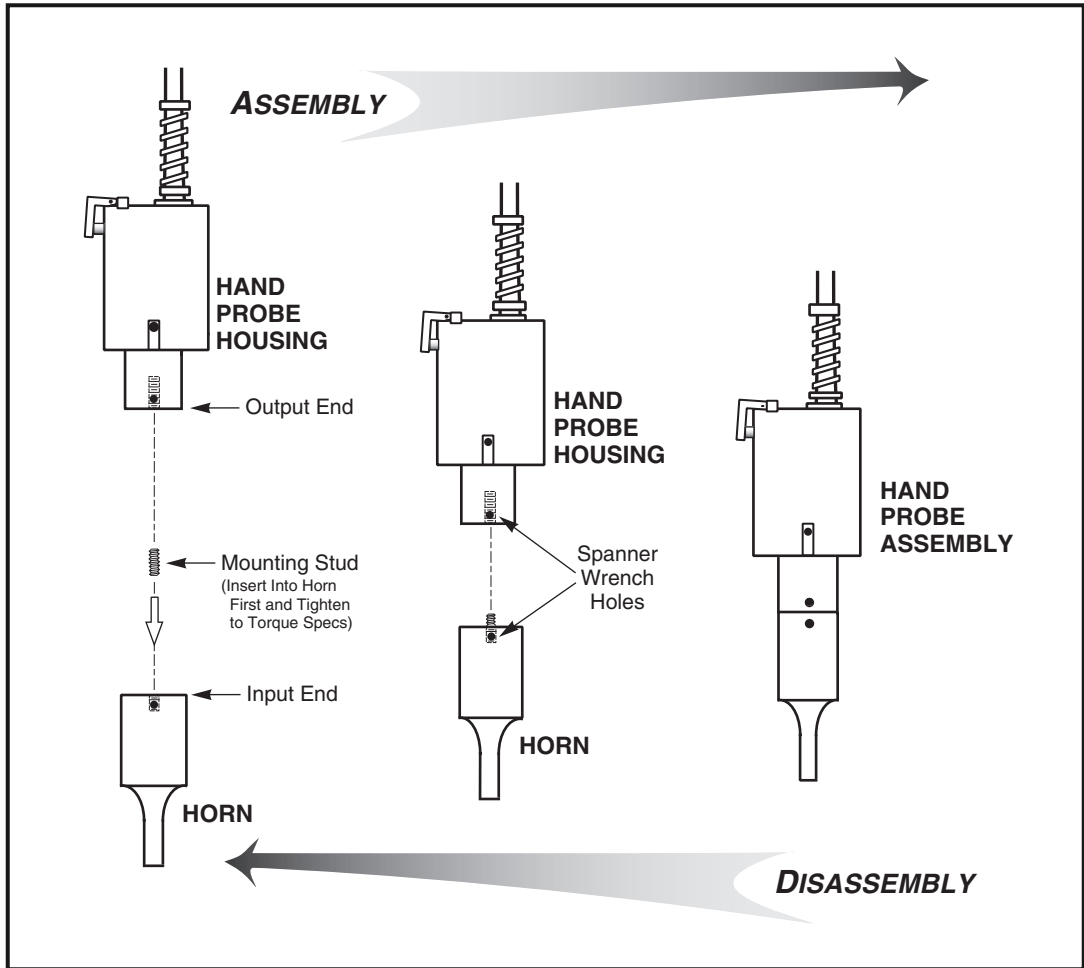


Figure 2–3 Hand Probe Assembly and Disassembly

The assembly and disassembly procedures for a hand probe are shown in Figure 2-3. The same procedure for a probe stack with booster is shown in Figure 2-4. It makes no difference whether the horn is attached to the booster first, or the booster is attached to the transducer first.

CAUTION

Never hold a transducer by the housing or a booster by the mounting rings when tightening or loosening an adjoining component. The transducer housing and booster rings have anti-rotation devices to keep the transducer and booster aligned and could shear under excessive torque.

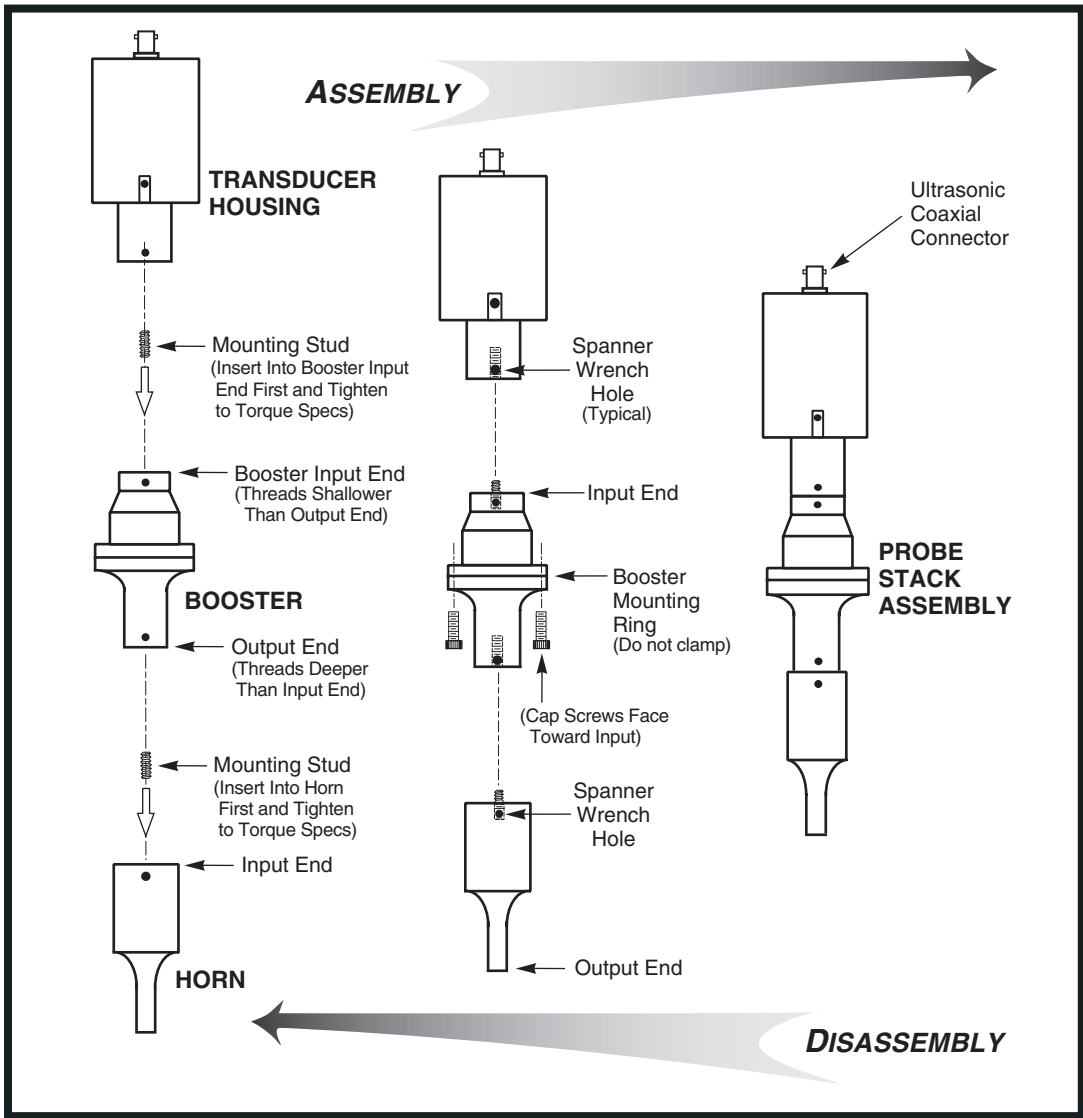


Figure 2-4 Assembly and Disassembly of Probe Stack with Booster

Separating the Horn from a Booster, Booster from a Probe or Horn from a Probe

On all transducers and horns with spanner wrench holes, use only the correct size spanner wrench that came with your system to provide sufficient torque to loosen a joint. See Figure 2–5.

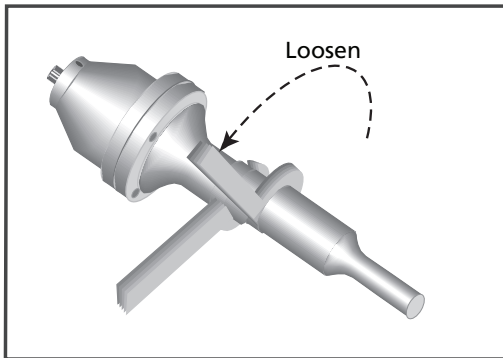


Figure 2–5 Separating the Horn from the Booster

On boosters and horns with wrench flats, use only the correct size wrench to provide sufficient torque to loosen a joint when necessary.

Removing the Mounting Stud from a Horn or Booster

Only use an Allen wrench of the correct size in the socket head's stud to remove the stud from the horn or booster.

Removing Replaceable Tips from a Horn

Use an open end wrench of the correct size to fit the wrench flats of the detachable tip. Use a spanner wrench (on horns with spanner wrench holes) or an open wrench (on horns with wrench flats) to provide an opposite force to keep the horn from turning in your hand. Refer to Figure 2–6 for the correct tip removal procedure.



CAUTION

Never clamp a horn or booster in a vise. The resulting scratches or gouges in the surface are stress risers that may result in cracks.

Dukane has a stainless steel tool vise (Part No. UFTV20.) for clamping 20kHz boosters and transducers to facilitate disassembly of stubborn components without damage. It accepts transducer and booster tooling diameters of 1.5 and 1.81 inches and has replaceable anitrotation pins.



NOTE

Do not hold a booster by the mounting rings when removing the stud from the booster. Use a spanner or open-end wrench to provide opposite force and keep the horn or booster from turning in your hand when loosening the stud. Use a spanner wrench on horns and boosters with spanner wrench holes. Use an open end wrench on horns and boosters with wrench flats.

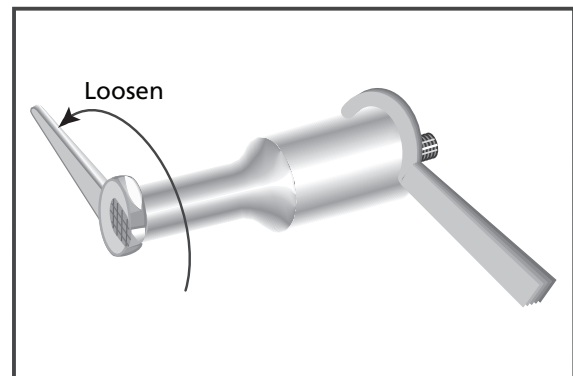


Figure 2–6 Removing a Replaceable Tip from the Horn

Grease or Washer?

Deciding What to Use on Stack Mating Surfaces

Deciding to use silicone grease on stack mating surfaces or to use Mylar washers between the parts of the stack depends on several considerations:

1. What is your application? Most applications can use either grease or the Mylar washers.
2. What are your preferences?

Either product is effective if properly applied.

In most cases, ultrasonic performance for silicone grease and the Mylar washer is equal.

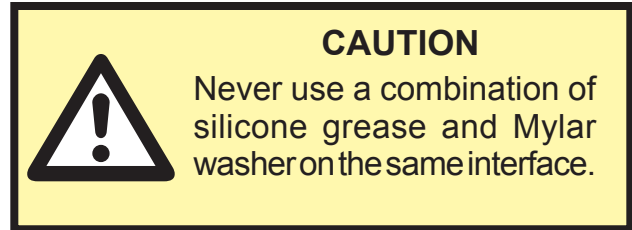
However, here are some things to consider:

Grease:

It is difficult to get consistency in the thickness of the grease layer applied to the mating surfaces. Also, if different people assemble stacks, that would most likely affect overall stack measurement.

Mylar Washer:

Stacks built using a washer between mating surfaces will have a consistent overall stack measurement. Using different people to assemble stacks with washers would not change that.



Mylar Washer Benefits

Overall, using Mylar washers (vs. silicone grease) results in lower stack maintenance. Here are some specific benefits of using the Mylar washers instead of silicone grease:

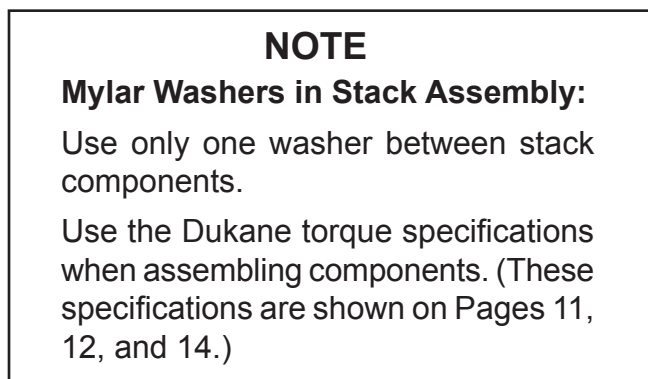
- In most cases the washer will last longer in production.
- Interface fretting (deterioration) is reduced.
- Stack assembly is more consistent.
- Stack disassembly will often require less torque and reduce the possibility of damaging components.

When to Use Mylar Washers

Performance characteristics of Mylar washers can be beneficial in applications requiring these techniques:

- Continuous welding, and
- Plunge welding

Stack gain, duty cycle, power draw and environmental conditions are all factors to think about in deciding whether to use Mylar washers.



Booster Notes

How to Tell the Booster Input End from the Output

1. The depth of the threaded hole on the output end is always deeper than the threaded hole on the input end.
2. On an amplifying booster (gain > 1.0), the larger diameter end is the input end. On a reducing booster (gain < 1.0) the larger diameter end is the output end. On a neutral acting booster the diameters are equal.
3. The cap screws on the booster mounting rings are always inserted from the output end toward the input end. See Figure 2-4.
4. Most Dukane boosters have this mark on their side:
HORN >
This is a reminder to orient the booster so the “arrow end” of the booster mates with the horn.

How to Tell if the Booster Is Amplifying or Reducing

Boosters have a die-stamped number on their surface that indicates their gain or reduction. If the number is greater than 1.0 (e.g. 1.5), it is an amplifying booster. If the number is less than 1.0 (e.g. 0.6), it is a reducing or reverse booster. A neutral booster has no gain and has 1.0 stamped on it. A neutral or coupling booster is used to provide another probe stack clamping location for added stability.

CAUTION



NEVER install a booster upside down to change an amplifying system to a reducing system. The boosters are dimensionally asymmetric. They are tuned from input to output to act like an acoustic lens. Reversing them will not give the expected results and may cause damage to the system.

Stack Mounting

A transducer-horn assembly or transducer-booster horn assembly (stack) can be mounted into a customer-provided machine to ensure stability and proper alignment during operation or for automated operation. A stack is secured in a machine by clamping the transducer (and booster, when present) at designated locations. Clamping at these designated locations provides stability to the stack and at the same time does not interfere with the transmission of ultrasonic vibrations of the stack components. The following rules apply when mounting a probe system stack.

1. A transducer may be clamped anywhere along its body (except the 41S30). If it has a side mounted BNC, then it may require a thin mounting ring if it is to be clamped near the top. It may also be clamped below the BNC connector.
2. Secure a transducer-horn stack by clamping the probe in two places.
3. Secure a transducer-booster-horn stack by clamping the transducer in one place and the booster in one place.

For mounting guidelines, including clamping specifications, see Application Note AN504 - "Ultrasonic Acoustic Stack Mounting Guidelines" - at:

http://www.dukane.com/us/DL_ApplData.asp

4. Never clamp the horn.

NOTE

Never hold a transducer by the housing or booster by the mounting rings when tightening or loosening from an adjoining component (see Figures 2-5 and 2-6 to identify these parts). Always use the proper spanner wrenches when tightening or loosening the horn or booster.

NOTE

Cooling - Use air only! No water!

Provide adequate cooling air for your application/process in accordance with these air quality standards (ISO 8573-1):

Class 3 (or higher)

Max. Particle Size (μ) ----- 5.0

Max. Concentration (mg/m^3) ----- 5.0

Class 4 (or higher)

Max. Pressure Dew Point ($^{\circ}\text{F}$) --- +37.4

Max. Oil Content (mg/m^3) ----- 5.0

SECTION 3

Stack Maintenance

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Stack Surfaces

It is essential that the mating surfaces of the acoustic stack components be flat and smooth. When the components are joined together and tightened, there must not be any air gap between the surfaces. If there is any air gap, there will be a loss in power and efficiency. Air has much higher transmission losses than the metal horn. Whenever the wavefront encounters an air gap, the propagation velocity is significantly reduced and attenuated. This results in considerable loss. In some cases, the union between the mating surfaces could be so poor as to prevent the probe stack from operating. This could result in excessive power drawn from the generator and may damage the mating surfaces. Figure 3–1 shows the mating surfaces on a typical transducer and booster assembly.

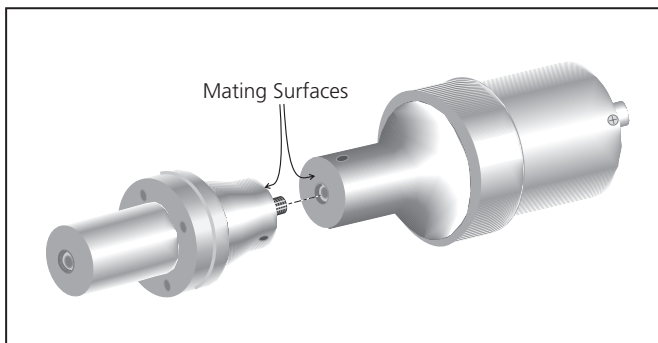


Figure 3–1 Location of Stack Mating Surfaces

Stack Inspection

Examine the mating surfaces of the horn and probe (and booster if applicable). Look for a shiny, burnished area. This indicates where the surfaces have been in contact. It will indicate whether the surfaces are flat and making good contact, or if they are uneven and making poor contact.

Inspection Schedule

To establish a maintenance schedule, inspect the mating surfaces after the first 200–400 hours of operation. If they require cleaning, halve the next inspection time. If the surfaces do not require reconditioning, then double the next inspection time.

Surfaces with Even Contact

A flat surface will make even contact and its surface will be evenly burnished across the entire contact area. Figure 3–2 shows a surface that has made even contact.

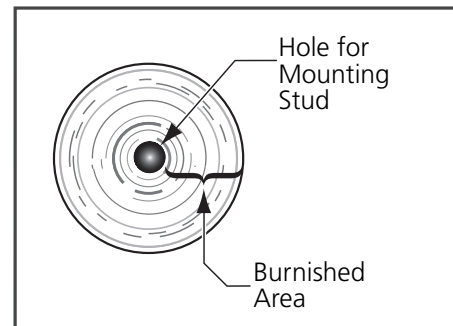


Figure 3–2 Flat Surface with Even Contact

Surfaces with Uneven Contact

A surface that is not completely flat will make uneven contact. Its surface will be burnished only in the area where it has made contact. Figure 3–3 shows what such a surface would look like. The inner and outer areas have no marks on it indicating there has been no contact in these areas.

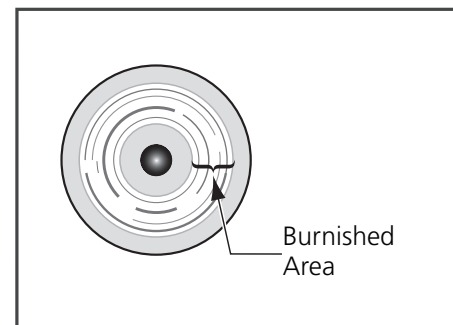


Figure 3–3 Flat Surface with Uneven Contact

Crowning

A surface which is burnished only in the inner ring area around the stud, indicates the surface is convex or crowned. An example of this is shown in Figure 3–4. To get an idea of the amount of deviation from a flat surface, place a straight edge along the stack element. Since its surface is higher at the center than at the edges, there will be a gap at the outer edge of the element.

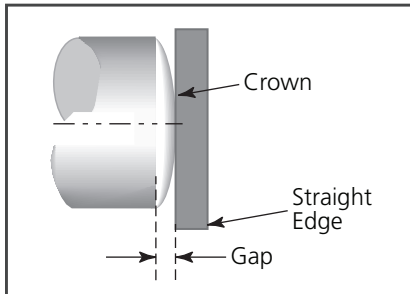


Figure 3–4 Crowned Surface

Center Depression

A surface which is burnished only in the outer ring area around the edge, indicates the surface is concave or depressed. An example of this is shown in Figure 3–5. To get an idea of amount of deviation from a flat surface, place a straight edge along the stack element. Since its surface is higher at the edge than at the center, there will be a visible gap near the center indicating the depth of the depression.

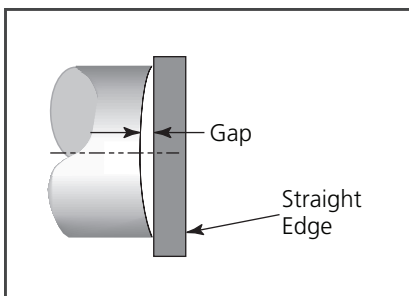


Figure 3–5 Center Depression

Corrosion

Corrosion is a factor to consider when determining the overall system performance. Over time, corrosion can build up on the acoustic stack mating surfaces. This buildup interferes with the efficient transfer of ultrasonic energy to the parts to be welded. It may contribute to a performance loss. Evidence of corrosion buildup includes mating surfaces discolored or encrusted with hard deposits. To extend equipment life and maintain performance levels, minimize the system’s exposure to corrosive sources.

Reconditioning Overview

Stack components need reconditioning when the mating surfaces become uneven or corroded. These conditions cause poor contact between the mating surfaces which wastes power. It also makes tuning the stack difficult, can cause heat damage to the transducer, and can contribute to a higher system noise level.

Machining the Mating Surfaces

Instructions on how to properly machine the stack components is beyond the scope of this white paper. Please call Dukane’s Tooling Support Team for machining information.

NOTE

Before reconditioning the mating surfaces yourself, consider calling Dukane’s Tooling Support team to discuss the situation. This is especially important if the mating surfaces are uneven, because machining of the component(s) may be required.

Removing more than a few thousandths of an inch from the mating surfaces will alter the running frequency of the system and may cause damage.

Factory personnel can offer their skills to help determine the best options for your needs.

Manual Resurfacing

To manually resurface the stack component mating surfaces, follow the steps given here.

1. Disassemble the acoustic stack and wipe all the mating surfaces clean. Use a clean cloth or a paper towel.
2. Examine all the surfaces. If any are corroded, discolored or coated with hard deposits, they should be reconditioned.
3. If the surfaces appear to be in good condition, proceed to Step 11.
4. Remove the mounting stud(s) if any are installed.
5. Tape a clean sheet of #400 grit (or finer) emery cloth grit side up to a clean, flat surface such as a piece of plate glass.
6. Hold the stack component with one hand near the bottom as shown in Figure 3–6. This view shows the thumb covering one of the three spanner wrench holes.

Without applying any downward pressure, carefully stroke the part **in one direction** across the emery cloth. The component's weight alone is enough pressure as the part is moved across the emery cloth. Complete a second stroke across the cloth just like the first.

7. Keep the element's surface flat against the emery cloth and turn it 120° (one-third of a complete rotation) so the thumb covers the next spanner wrench hole. Again move the part twice across the emery cloth as covered in the previous step.
8. Give the part a final one-third turn and repeat the two strokes described in Step 6.
9. Reexamine the mating surfaces. Repeat Steps 6 through 8 until the corrosion has been removed.
10. Clean any grit from the resurfaced element and the stud mounting threads using a clean cloth or paper towel.



CAUTION

An improperly altered horn can cause destructive stress to the transducer, booster, generator and horn. The horn should only be modified by Dukane's Horn Department.

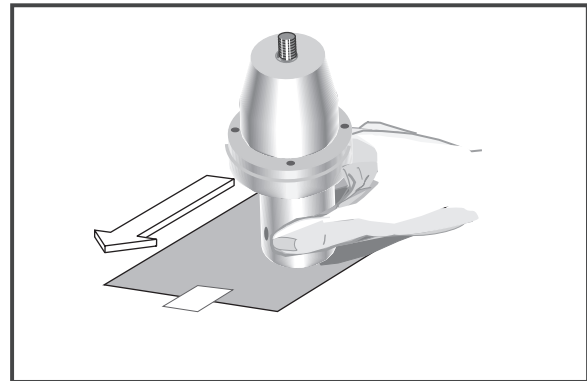


Figure 3–6 Manual Resurfacing



CAUTION

Use extreme care to keep the part level when moving it across the emery cloth. Be careful not to tilt the part. An uneven mating surface could leave the mating surface inoperative.

Surface flatness is more important than surface finish.

11. If you had to remove the mounting studs, they need to be reinserted. Before they are reinserted, it is necessary to ensure proper thread engagement.
 - a. Inspect and clean the stud.
 - b. Clean the threaded hole with a clean cloth.
 - c. Thread the stud into the hole. Tighten the stud to the torque specifications given in Table 2—II.
12. Reassemble the stack and install it using the procedure in Section 2 using Figures 2-3 and 2-4 as guides.
13. Perform an Operational Test.



CAUTION

It is important to perform only two strokes each time the component is rotated. Performing more than two strokes affects whether the surface remains flat. It is important for the mating surface to maintain its perpendicularity in relationship to the component's centering axis. If this relation between the surface and the axis is altered, the welding system may become inoperative.

NOTE

If the studs are overtightened, the threads may deform. Removing a stud that has been overtightened could damage the threads in the horn/booster. If this should happen, retap the horn/booster threads, and replace the stud with a new one.

SECTION 4

Troubleshooting

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Troubleshooting Tips

Problem - Excess noise or system overload.

1. Ensure proper cooling is in place.
2. Inspect entire acoustic stack for over temperature.
Components that have experienced excessive heat may be permanently damaged, consult factory before putting units back in production.
3. Remove acoustic stack from mount. Inspect for missing components; inspect for nicks, cracks, scrapes or evidence of metal to metal contact.
4. Inspect mount to ensure proper clamp torque and tolerances.
5. Disassemble and re-assemble acoustic stack following proper procedures. Application Note AN 504 may be of some help: *Ultrasonic Acoustic Stack Mounting Guidelines*, found at:
http://www.dukane.com/us/DL_ApplData.asp
6. If problem still exists, contact Dukane.

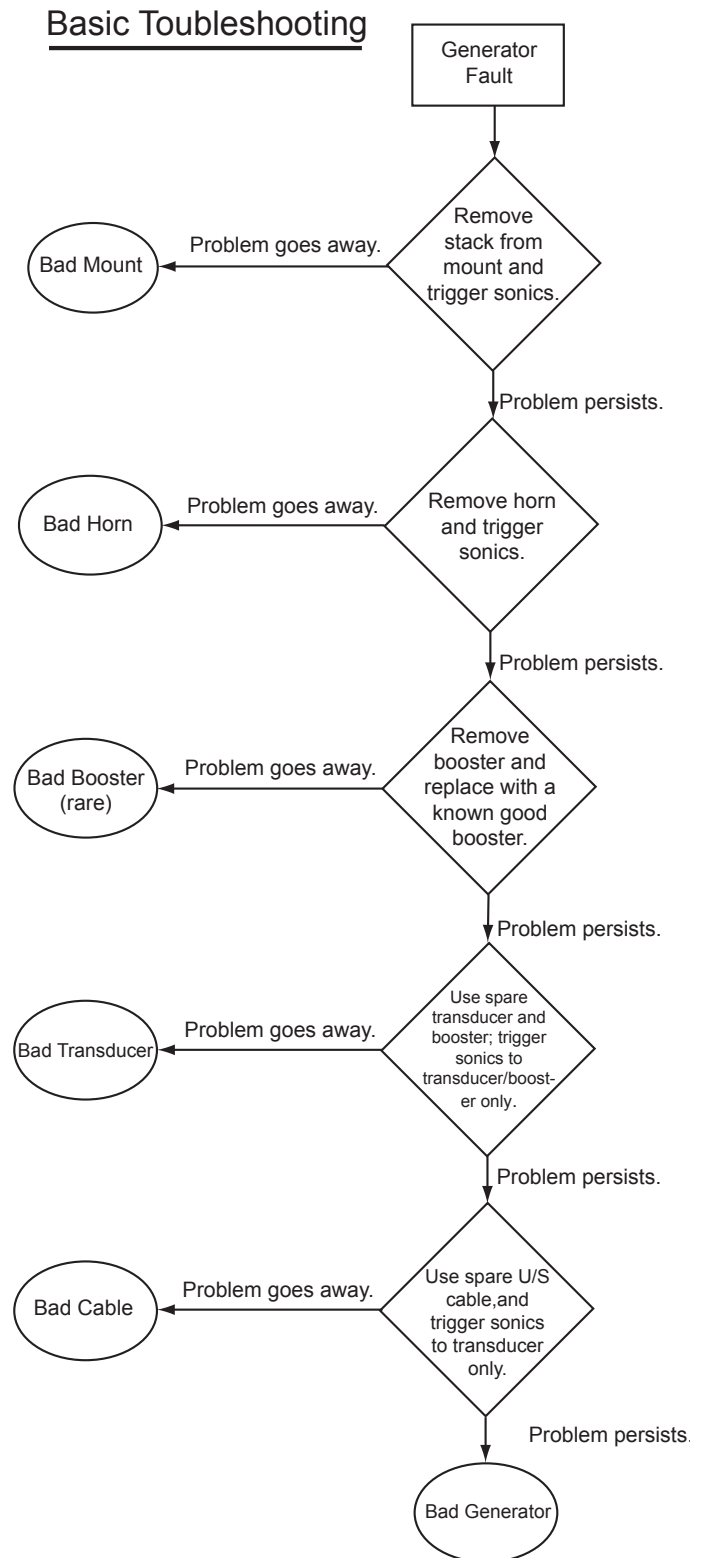


Figure 4-1 Basic Troubleshooting Chart

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SECTION 5

Contacting Dukane

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Contacting Dukane

Identify Equipment

When contacting Dukane about a service-related problem, be prepared to give the following information:

- Model number, line voltage and serial number
- Fault/error indicators from the LCD display
- Software version (Press **INFO**. With pointer at **System Information**, press **ENTER** to get this data.)
- Problem description and steps taken to resolve it

Many problems can be solved over the telephone, so it is best to call from a telephone located near the equipment.

Intelligent Assembly Solutions

Mailing Address:

Dukane Intelligent Assembly Solutions
2900 Dukane Drive
St. Charles, IL 60174 USA

Phone: (630) 797-4900

Fax:

Main (630) 797-4949

Service & Parts (630) 584-0796

Website

www.dukane.com

From the website's home page you can find information about our products, processes, solutions, and technical data. Downloads are available for many kinds of literature.

You can locate your local representative at:

www.dukane.com/us/sales/intsales.htm

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SECTION 6

Glossary

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Acoustic Impedance	The acoustic impedance of a material (Z) is defined as the product of its density (ρ) and acoustic velocity (v) of the material $Z = \rho v$. Acoustic impedance is important in the determination of transmission and reflection losses at the boundary of two materials having different acoustic impedances. For example at the boundary of titanium and 2024 T4 Aluminum, the transmission efficiency is 95.4% due to a 4.6% reflection loss.
Amorphous Plastic	A thermoplastic polymer which has a random molecular structure (e.g. ABS Polycarbonate, Polystyrene). At low temperatures, there is no molecular mobility and the material is rigid and glassy. As the Glass Transition Temperature (T_g) is reached, the material exhibits a sudden change and becomes rubbery. Amorphous polymers are generally transparent.
Amplitude	The peak-to-peak excursion of a horn or a booster at its workface. It is usually measured in tens of microns or thousandths of an inch.
Booster	A mechanical device used to increase or decrease the amplitude of the horn vibrations. Sometimes it has unity gain and provides an additional clamping surface to secure the stack.
Boss	The hollow stud into which an insert is driven.
Converter	See Transducer .
Dampen	To restrain or suppress the amplitude of the vibration. Both mechanical and electrical systems have natural frequencies of vibration which occur when the system is excited.
Degating	A process by which injection-molded plastic parts are removed from the runners and sprue at the gate.
Diaphragming	Part flexing that can cause stress, fracturing, or undesirable melting of thinsectioned flat parts. Diaphragming is also referred to as “oil-canning,” which describes the way the plastic part bends up and down when subjected to ultrasonic energy.
Digital Timer	A device used to accurately control the duration of a weld or a hold time by signaling the value to the acoustic stack assembly to extend and retract the horn and by activating the ultrasound for a predetermined time span.
Dual Pressure	A feature of Dukane ultrasonic assembly systems that allows the use of two different pressures during the assembly (welding, inserting, staking, etc.) process. Typically a weld is started at lower pressure and finished at a higher pressure.
Energy Director	A triangular-shaped ridge of plastic molded into a part and typically running around the entire perimeter of a joint. When ultrasonic energy passes through the ridge, it concentrates the energy at the director’s apex, resulting in rapid heat buildup, melting, and subsequent welding of the parts.

Far Field	Refers to the distance that ultrasonic energy is transmitted from the horn to the joint interface. When the joint is more than about 0.25 inch (6mm) from where the horn contacts the part, the weld is considered far field. Also see Near Field .
Filler	An inert substance that is added to a resin to modify its physical characteristics.
Fixture	A device used to align and support the parts to be assembled. It is sometimes referred to as a nest.
Flash	The overflow of plastic from a welded joint area.
Frequency	The number of cycles per second measured in hertz (Hz).
Gain	The ratio of output amplitude to input amplitude of a horn or a booster. When the gain is greater than one, the output amplitude is larger than the input amplitude.
Gate	The area through which molten plastic flows into the mold cavity. Also see Degating .
Generator	An electronic device that converts standard 120/240 volt, 50/60 Hz line voltage into high power (100 to 4000 Watts), high-frequency (15kHz to 70kHz) electrical energy for powering an ultrasonic probe or stack.
Hermetic Seal	An airtight and liquid-tight seal.
Hold Time	The length of time allotted for the melted plastic to solidify.
Horn	An acoustical tool designed to transfer mechanical vibrations from the transducer-booster assembly directly to the parts to be welded together. Horns are sometimes referred to as a <i>Sonotrodes</i> .
Hygroscopicity	The tendency of some thermoplastic materials to absorb moisture from the air. Nylon is very hygroscopic.
Hz or Hertz	Cycles per second. Ultrasonic waves are measured in kHz or thousands of cycles per second.
Insert	A metal fastener designed to be installed in a plastic part.
Insertion	An ultrasonic assembly technique that embeds a metal insert (usually threaded) into a plastic part.
Joint Design	Molding the shape of mating thermoplastic parts to achieve the intended assembly results. Proper joint designs provide a small initial contact area (energy director), a uniform welding area, and a means of aligning the mating halves that are to be welded together.

Load Cell	A device that changes its electrical properties in response to an applied force. The heart of a load cell is a strain gauge which is attached to the surface to be measured. As the surface becomes strained, the gauge stretches or compresses changing its resistance in exact proportion to the applied load thereby allowing precise measurements of applied force.
Marking	Cosmetically scuffing or marring of plastic parts by the horn or the fixture.
Mold Release	A substance added to plastics so that parts are easily removed from the mold.
Near Field	Refers to the distance that ultrasonic energy is transmitted from the horn to the joint interface. When the joint is about 0.25 inch (6mm) or less from where the horn contacts the part, the weld is considered near field. Also see Far Field .
Nodal Point	The point in a booster or horn where little or no linear motion or vibration (due to the ultrasonic wave) occurs. A booster has its mounting ring at the nodal point.
Piezoelectric Material	A permanently polarized material such as Quartz (SiO ₂) or Barium Titanate (BaTiO ₃) that produces an electric field when the material changes dimension as a result of an imposed mechanical force. Conversely, an applied electric field will cause a piezoelectric material to change dimensions. This phenomenon is known as electrostriction, or the reverse piezoelectric effect and is the key to the operation of a transducer.
Pneumatic	Powered, operated, or controlled by gas or compressed air, typically in a cylinder. A hydraulic cylinder transfers energy (since liquids are incompressible) while a pneumatic cylinder stores (compressed gas) and transfers energy.
Polymer	Long-chain molecules with linear, branched or cross-linked structures. Polymers are chains and each link of the chain is the ‘-mer’ or basic unit that is usually made of carbon, hydrogen, oxygen and/or silicon. To make the chain, many links or ‘-mers’ are hooked or polymerized together. Some polymers contain only carbon and hydrogen (e.g. polypropylene, polybutylene, polystyrene). Oxygen, chlorine, fluorine, nitrogen, silicon, phosphorous and sulfur are other elements that are found in the molecular makeup of polymers. Polyvinyl chloride (PVC) contains chlorine, nylon contains nitrogen, teflon contains fluorine while polyester and polycarbonate contain oxygen. Polymers are also referred to as resins.
Press	A pneumatically-operated device used to support and manipulate the acoustic stack assembly in the work area in a controlled and repeatable manner. It is essentially a thruster mounted on a column with a press support casting, and a base. Also see Thruster .

Probe	An assembly typically consisting of a transducer and the horn.
Probe Stack	See Stack .
Regrind	Plastic material that has been recycled or reprocessed and added to the original resin.
Replaceable Tip	A machined titanium tip threaded to attach to a horn. Tips are commonly used in staking, swagging and spot welding assembly.
Resin	Any of numerous physically similar polymerized synthetics or chemically modified natural resins including thermoplastic materials and thermosetting materials that are used with fillers, stabilizers, pigments, and other components to form plastics. Also see Polymer .
Resin Grade	Refers to the classification of the physical and chemical properties of a resin.
Semi-Crystalline Plastic	A thermoplastic which has an orderly and repeated molecular structure (e.g. Nylon, Polyethylene, Polypropylene). At low temperatures, there is no molecular mobility and the material is rigid and glassy. As the Glass Transition Temperature (T _g) is reached, the material exhibits a gradual change and becomes rubbery, but the crystals confer strength and stiffness. The result is a gradual softening until the crystalline melting temperature (T _m) is reached and the material becomes a viscous melt. The higher the degree of crystallinity, the less light can pass through the polymer. Therefore, the degree of translucence or opaqueness of the polymer is directly affected by its crystallinity.
Shear Joint	A joint design formed by the controlled, telescoping melt of two contacting surfaces. A certain amount of interference must be designed into one of the mating parts to accomplish the weld.
Sound	Mechanical, radiant energy (vibrations) that is transmitted by longitudinal waves in a material medium, such as air, water, or metal.
Spot Welding	An ultrasonic assembly method where two thermoplastic components are joined at localized points. The components joined by spot welding are typically cast or extruded.
Stack	An assembly typically consisting of three components: the transducer, a booster and the horn. A stack is normally mounted in a thruster.
Staking	An ultrasonic assembly technique by which a plastic stud is formed into a rivet head to capture another part, which may be of a dissimilar material.
Stud	The plastic protrusion that is shaped into a rivet head to attach two parts together during staking.

Swaging	An ultrasonic assembly technique by which a ring or a ridge of plastic is formed by the horn face to capture another part.
Thermoplastic	A synthetic or manufactured material which undergoes no permanent change when heated. It softens when heated and hardens when cooled. Once a thermoplastic polymer is formed it can be heated and reformed over and over again. This property allows for easy processing and facilitates recycling.
Thermoset	A synthetic or manufactured material which undergoes an irreversible change during processing and become permanently formed. Reheating will cause the material to degrade or scorch. Epoxy resins are thermoset.
Titanium	A high–strength metal with good acoustic properties used in the manufacture of horns and boosters. Titanium is half the weight of steel but possesses a mechanical quality factor (Qm) 20 times higher than steel. Moreover, titanium has a lower coefficient of thermal expansion than either steel or aluminum. The titanium used by Dukane for horns and boosters is an alloy with enhanced properties.
Thruster	A pneumatically-operated device serving the same function as a press. A thruster can be mounted in a smaller area or otherwise nonstandard position. Also see Press .
Transducer	A piezoelectric device that converts high-frequency electrical energy into corresponding high-frequency mechanical vibrations. Some manufacturers refer to the transducer as a Converter. Also see Piezoelectric Material .
Tuning	The process of matching the output frequency of the generator to the resonant frequency of the transducer-booster-horn assembly.
Ultrasonic Waves	Sound waves above the frequency normally detectable by the human ear (above 18kHz). Alternate compressions and rarefactions in the transmitting material exist along the wave propagation direction.
Ultrasound	Same as Ultrasonic Waves .
Weld Time	The length of time the parts to be assembled are exposed to the ultrasonic energy.
Welding	An ultrasonic assembly technique that uses frictional heat to permanently bond thermoplastic parts.

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SECTION 7

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Dukane ISO

ISO CERTIFICATION

Dukane chose to become ISO 9001:2000 certified in order to demonstrate to our customers our continuing commitment to being a quality vendor. By passing its audit, Dukane can assure you that we have in place a well-defined and systematic approach to quality design, manufacturing, delivery and service. This certificate reinforces Dukane's status as a quality vendor of technology and products.

To achieve ISO 9001:2000 certification, you must prove to one of the quality system registrar groups that you meet three requirements:

1. Leadership
2. Involvement
3. Quality in Line Organizations and Quality System Infrastructure.

The ISO 9001:2000 standard establishes a minimum requirement for these requirements and starts transitioning the company from a traditional inspection-oriented quality system to one based on partnership for continuous improvement. This concept is key in that Dukane no longer focuses on inspection, but on individual processes.

Dukane's quality management system is based on the following three objectives:

1. Customer oriented quality. The aim is to improve customer satisfaction.
2. Quality is determined by people. The aim is to improve the internal organization and cooperation between staff members.
3. Quality is a continuous improvement. The aim is to continuously improve the internal organization and the competitive position.



Please refer to our website at:
www.dukane.com/us/sales/intsales.htm
to locate your local representative.

Ultrasonic Probes/Stacks

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Dukane Intelligent Assembly Solutions • 2900 Dukane Drive St. • Charles, Illinois 60174 USA • TEL (630) 797-4900 • FAX (630) 797-4949