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Industrial Plastic Working Equipment & Precision Instruments

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Ultrasonic Staking and Spot Welding of Thermoplastic Assemblies

See Insertion on page 5

The basic principle of ultrasonic assembly involves conversion of high-frequency electrical energy to high-frequency mechanical energy in the form of reciprocating longitudinal motion which, when applied to a thermoplastic, generates frictional heat at the plastic/plastic or plastic/metal interface creating a localized melt.

In ultrasonic staking, also referred to as ultrasonic "heading" or "riveting," the controlled flow of the molten plastic is used to capture or retain another component, usually of a different material, in place.

Ultrasonic staking provides an alternative to welding when the two parts consist either of dissimilar materials which cannot be welded, or when simple mechanical retention of one part relative to another is adequate (i.e. as distinct from molecular bonding).

The most common application involves the attachment of metal to plastic. A hole in the metal part receives a pre-molded plastic boss. The horn tip, vibrating at high frequency contacts the boss, and through friction, creates localized heat. As the boss melts due to frictional heat, the light pressure from the horn forms a head to a shape determined by the horn tip configuration. When the vibrations stop, the plastic material solidifies, and the dissimilar materials are fastened together.

Unlike ultrasonic plastics welding, staking requires that out-of-phase vibrations be generated between the horn and the plastic surfaces. Light initial contact pressure is therefore a requirement for out-of-phase vibratory activity within the limited contact area. It is the progressive melting of the plastic boss under continuous, but light pressure, that forms the head. When staking, low pressure rather than high pressure is usually recommended.

With staking, tight assemblies are possible because mating parts are clamped under the pressure of the horn until the rivet head solidifies. There is no elastic recovery as is the case with heat staking or cold forming.

Ultrasonic staking should be considered when the parts to be assembled are still in the design stage. Several configurations for boss/cavity design are available, each with specific features and advantages. Their selection is determined by such factors as type of plastic, part geometry, assembly requirements, machining and molding capabilities, and cosmetic appearance. The principle of staking is the same for each: the area of initial contact between the horn and the boss is kept to a minimum, in order to concentrate the energy and produce a rapid melt.

The integrity of an ultrasonically staked assembly depends greatly upon the geometric relationship between the boss and the horn cavity. Proper design will produce optimum strength with minimum flash.

Whenever possible, the bosses should be designed with an undercut radius at the base to prevent fracturing or melting and should be tapered from the base to the top. Holes in the mating parts should be radiused or at least deburred. Long bosses should be avoided.

The boss should be properly located and rigidly supported from below to ensure that the energy will be dissipated at the horn/boss interface rather than exciting the entire plastic assembly and fixture.

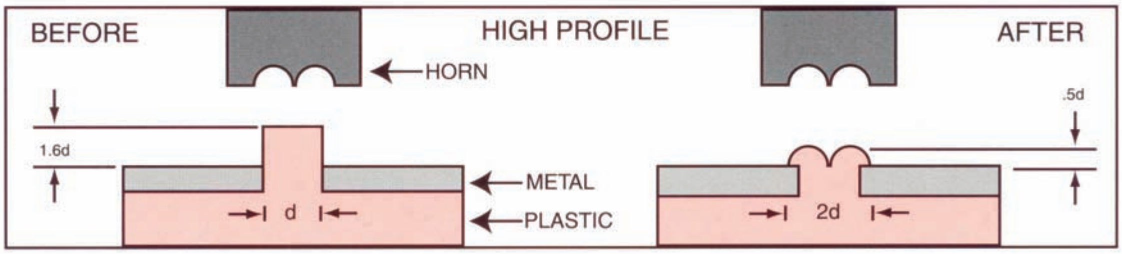
Best staking results are obtained when the ultrasonic vibrations are started before the horn contacts the boss. This prevents "cold forming" and allows for the gradual reforming of the boss. The pretriggering of the ultrasonic vibrations is normally accomplished using a pretrigger switch.

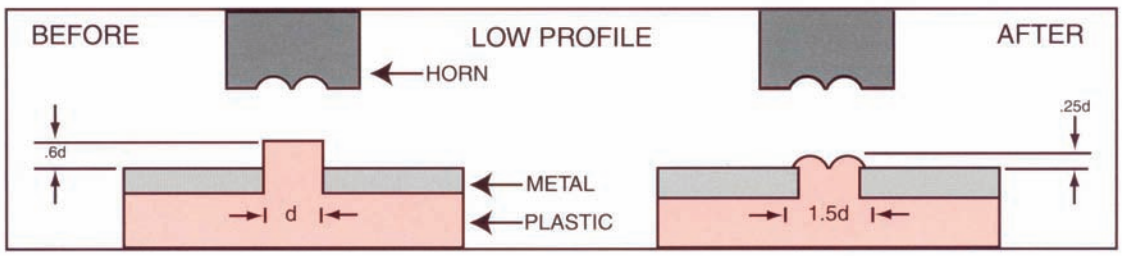
To obtain repeatable results when staking, the distance that the horn travels should be consistent and limited by the positive stop adjustment.

Staking

STANDARD FLARED STAKE

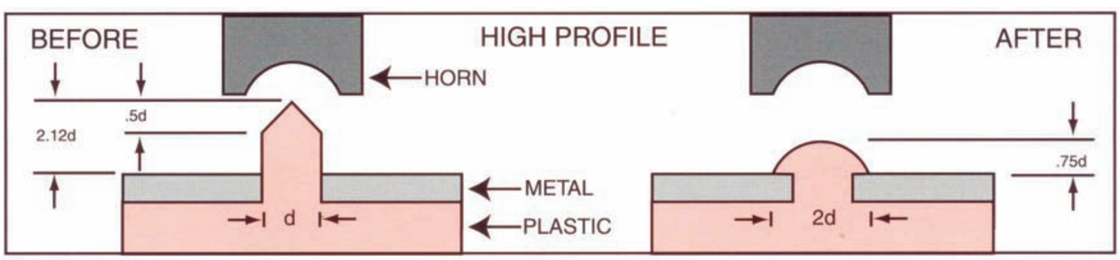
The standard flared stake satisfies the requirements of most applications. This stake is recommended for bosses with an O.D. of 1/16 inch (1.6 mm) or larger, and is ideally suited for low density, nonabrasive amorphous plastics.

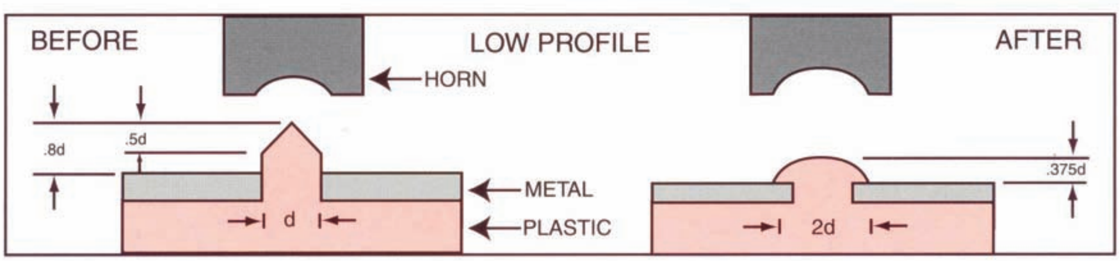




SPHERICAL STAKE

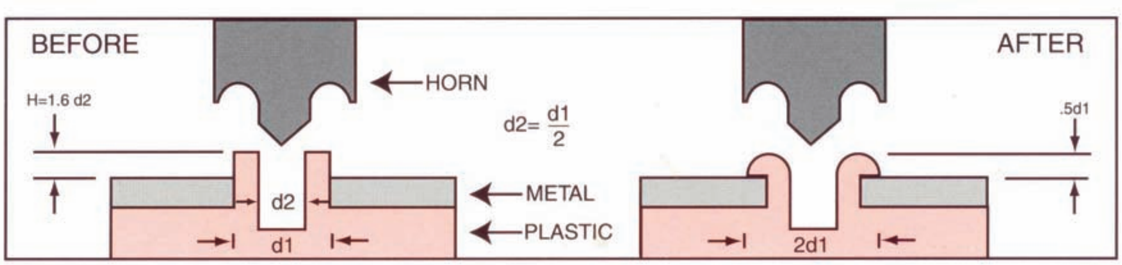
The spherical stake is preferred for bosses with an O.D. less than 1/16 inch (1.6 mm) and is recommended for rigid crystalline plastics with sharp highly defined melting temperatures, for plastics with abrasive fillers, and for materials that degrade easily.





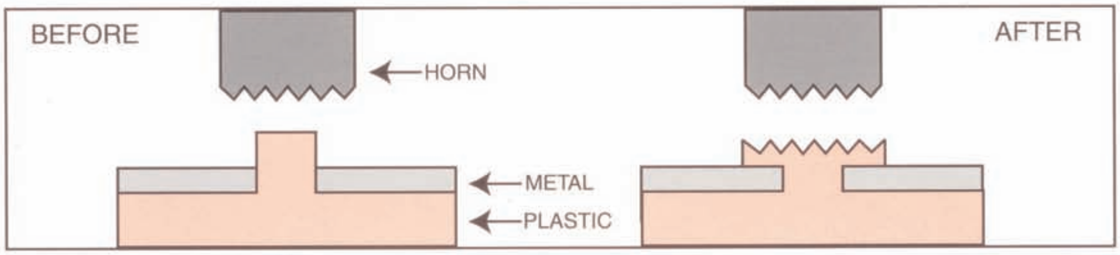
HOLLOW STAKE

Bosses with an O.D. in excess of 5/32 inch (4 mm) should be made hollow. Staking a hollow boss produces a large, strong head without having to melt a large amount of material. Also, the hollow stake avoids sink mark on the opposite side of the component, and enables the parts to be reassembled with self-tapping screws should repair and disassembly be necessary.



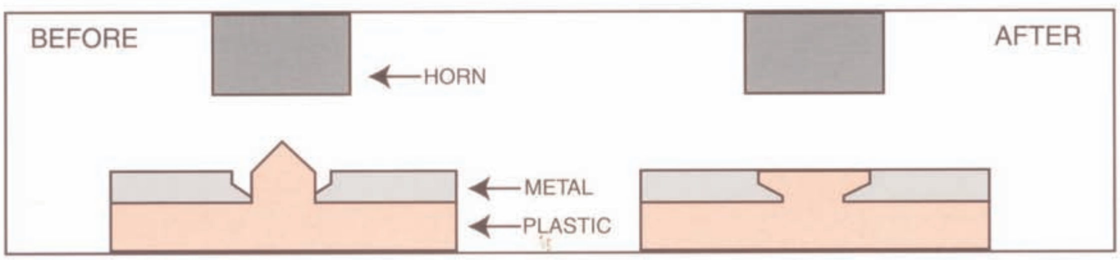
KNURLED STAKE

The knurled stake is used in applications where appearance and strength are not critical. Since alignment is not an important consideration, the knurled stake is ideally suited for high volume production, and is often recommended for use with a hand held ultrasonic spot welder. Knurled tips are available in a variety of fine, medium and coarse configurations.



FLUSH STAKE

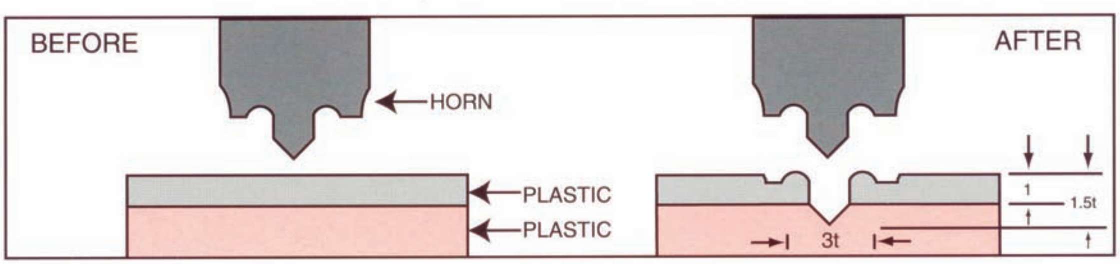
The flush stake is used for applications requiring a flush surface. The flush stake requires that the retained piece has sufficient thickness for a chamfer or counterbore.



Spot Welding

Using an ultrasonic spot welder and standard replaceable tips, large thermoplastic parts, and those with hard-to-reach joining surfaces can easily be welded together.

Vibrating ultrasonically, the pilot of the tip penetrates the top sheet and enters the bottom sheet to a depth of one-half the top sheet thickness. The displaced molten plastic is shaped by a radial cavity in the tip to form an annular formation around the weld. Simultaneously, the molten plastic displaced from the second sheet flows into the preheated area and forms a permanent molecular bond.



Staking/Welding Tips

Standard threaded tips available for staking and spot welding are listed on the back cover. Special carbide faced wear resistant tips are available for standard horns. Horns which cannot accept replaceable tips can readily be carbide coated. Most frequently bosses are ultrasonically staked one at a time using a standard horn and replaceable tip. It is possible, however, to stake several bosses simultaneously using a larger horn with multiple tips. Multi-element horns can be designed to satisfy applications where component geometry precludes the use of standard horns. Horns with up to six tips have been used successfully in multiple staking applications.

Staking

Plastic Boss Diameter		TIP CODE LETTER								HORN REQUIRED	
		Solid Boss Flare Head				Conical Boss Spherical Head		Hollow Boss	Horn Diameter	Horn Series "E"	
inches	mm	High Profile		Low Profile		High Profile	Low Profile			Thread Size	Part No.
		Tip Size	Stud Height*	Tip Size	Stud Height*						
1/32	0.793	A	.050	G	.019	AA	GG	-	1/2" or 5/8"		
1/16	1.587	B	.100	H	.0375	BB	HH	-		1/4-28	050000
3/32	2.381	C	.150	I	.056	CC	II	-			
1/8	3.175	D	.200	J	.075	DD	JJ	R		1/4-28	062000
5/32	3.969	E	.250	K	.094	EE	KK	S			
3/16	4.762	F	.300	L	.112	FF	LL	T			
7/32	5.556	M	.350	O	.1312	MM	OO	U			
1/4	6.350	N	.400	P	.150	NN	PP	V	5/8"	5/16-24	062000

NOTE:
Flat tips are available with all of the above horns. Non-standard size tips are available upon request.
All material is titanium.
*Stud height above part to be staked.

Spot Welding

Material Thickness (t)		TIP CODE LETTER	HORN REQUIRED		
			Horn Diameter	Horn Series "E"	
inches	mm			Thread Size	Part No.
1/32	0.793	SA	1/2"	1/4-28	050000
3/64	1.190	SB	or		
1/16	1.587	SC	5/8"	1/4-28	062000
5/64	1.984	SD			
3/32	2.381	SE			
7/64	2.778	SF			
1/8	3.175	SG			
5/32	3.969	SH			
3/16	4.762	SI	3/4"	3/8-24	075000
7/32	5.556	SJ			
1/4	6.350	SK			
9/32	7.143	SL	1"	1/2-20	100000

Ordering Information

HORN
Specify horn required using code letter.

Example: Series "E" 050000, 1/4-28 indicates a 1/2" diameter tapped horn with 1/4-28 threads.

TIPS
Specify tip required using code letter.

Example: Staking Tip "A" indicates a tip used for staking a 1/32" solid boss with a high profile flared head. Spot Welding Tip "SA" indicates a tip used for spot welding 1/32" thick material.

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Ultrasonic Installation of Inserts in Thermoplastic Components

The basic principle of ultrasonic assembly involves conversion of high-frequency electrical energy to high-frequency mechanical energy in the form of reciprocating longitudinal motion which, when applied to a thermoplastic, generates frictional heat at the plastic/plastic or plastic/metal interface.

In ultrasonic insertion, a metal insert is placed in a cored or drilled hole which is slightly smaller than the insert. This hole provides a certain degree of interference and also serves to guide the insert into place. The vibrating ultrasonic horn contacts the insert and the ultrasonic vibrations travel through the insert to the interface of the metal and plastic. Heat, generated by the insert vibrating against the plastic, causes the plastic to melt, and as the horn advances, the insert is imbedded into the component. The molten plastic flows into the serrations, flutes, or undercuts of the insert and, when the vibrations terminate, the plastic resolidifies and the insert is securely encapsulated in place. In ultrasonic insertion, a slow horn approach, allowing the horn to develop a homogeneous melt phase, is preferable to "pressing" the insert.

Ultrasonic insertion provides the high performance strength values of a molded-in insert while retaining all of the advantages of post-molded installation. Inserts can be ultrasonically installed in most thermoplastics. Some of the advantages of ultrasonic inserting over other methods include rapid installation, minimal residual stresses in the component following insertion, elimination of potential mold damage, reduced mold fabrication costs and increased productivity as a result of reduced mold cycle times.

In some applications, multiple inserts can be imbedded simultaneously with special horns, increasing productivity and further reducing assembly and manufacturing costs.

Ultrasonic insertion is not restricted to standard-type threaded inserts. Inserts that can be installed ultrasonically include a variety of bushings, terminals, ferrules, hubs, pivots, retainers, feed-through fittings, fasteners, hinge plates, binding posts, handle-locating pins and decorative attachments.

Typically, the plastic component is fixtured and the insert is driven in place by the horn (Figure 1). However, in some cases, the part configuration might prohibit insert contact by the horn, and the horn is made to contact the plastic component instead of the insert (Figure 2). The functional characteristics or requirements of an application actually determine the insert and hole configuration. In all cases, a sufficient volume of plastic must be displaced to fill the under cuts, flutes, knurls, threads and/or contoured areas of the insert. Care should be exercised in selecting the proper inserts. Inserts are designed for maxi-

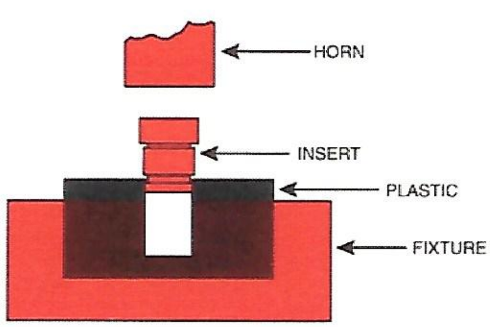


FIGURE 1

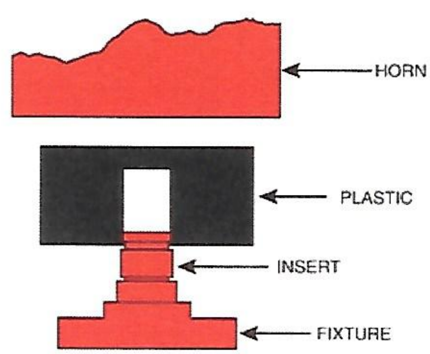


FIGURE 2

mum pull-out strengths, torque retention or some combination of both. Inserts with horizontal protrusions, grooves, or indents are usually recommended for high pull-out strength requirements. Inserts with vertical grooves, or knurls, are usually recommended for high torque retention. In regard to the hole configuration or insert selection, the recommendations provided by the insert manufacturer should always be observed.

Because the horn contacts the metallic insert, it is subjected to some wear. As a result, horns used for insertion are usually made of hardened steel or titanium. Carbide coating of titanium horns is also available.

for low volume applications, titanium horns with replaceable tips can be utilized.

Ideally, the diameter of the horn should be twice the diameter of the insert.

To prevent a "jack-out" condition, the top of the seated insert should be flush or slightly above the surface of the part.

Rigid fixturing should be placed directly under the insert.

In most instances, it is necessary to initiate ultrasonic vibrations prior to horn contact with the insert.

To maintain an accurate depth of insertion, the total distance the horn travels should be limited either mechanically by a positive stop, or electrically by a lower-limit linear encoder, or both.

CAUTION: When inserting, do not use weld time in excess of 1-1/2 seconds.

Ultrasonic Insertion Troubleshooting Guide

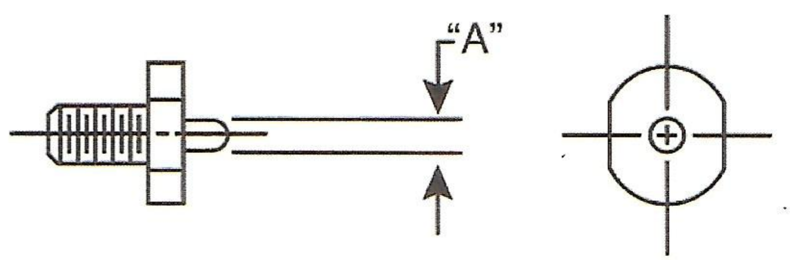
PROBLEM	SOLUTION
Insufficient pull-out or torque strength	Decrease pressure. Increase weld time. Increase amplitude (change booster). Decrease down speed. Increase insert interference Insert is too small or hole is too large. Increase hole depth. Decrease screw length.
Damage to insert	Decrease weld time or energy. Decrease amplitude (change booster). Increase pressure. Increase down speed.
Plastic cracks	Confirm that ultrasonics is on. Decrease pressure. Walls surrounding hole are too thin. Increase weld time or energy. Decrease amplitude (change booster). Decrease down speed. Enlarge hole diameter.
Partial insertion	Increase pressure. Decrease down speed. Decrease amplitude (change booster). Increase weld time or energy. Increase hole depth. Adjust positive stop. Check fixturing. Horn is at the end of its stroke.

Ultrasonic Insertion Troubleshooting Guide (Continued)

PROBLEM	SOLUTION
Inserting time is excessive	Decrease weld ti me or energy. Decrease hold time. Decrease amplitude (change booster). Increase pressure. Increase down speed. Insert is too large or hole is too small. Improper fixturing. Power required exceeds capability of power supply.
System overloads	Decrease pressure. Decrease down speed. Decrease amplitude (change booster). Tune power supply. Check for loose studs. Check coupling between horn and booster. Power required exceeds capability of power supply.
Insert does not remain inserted	Increase hold time.
Plastic fills the threaded bore of the insert	Increase hole depth. Insert is too large or hole is too small. Insert is too long.
Horn wears prematurely	Use hardened steel or carbide faced horn. Decrease amplitude (change booster). Insert is too large or hole is too small. Plastic is too abrasive.
Application is noisy	Start the ultrasonics just prior to the horn contacting the insert. Decrease amplitude (change booster). Increase pressure. Increase down speed. If possible contact plastic rather than insert. Use sound enclosure or hearing protectors.
Plastic flows over the top of the insert	Adjust positive stop to limit depth of insertion. Decrease weld time or energy. Insert is too large or hole is too small.
Horn heats up	Decrease amplitude (change booster). Air cool the horn. If possible contact plastic rather than insert. Check coupling between horn, booster and converter.

Inserting Tips

Insert Size	Inside Diameter Of Insert	Pilot Diameter Of Tip (Dim. A-inches)
SAE		
4-40	0.088	0.078
6-32	0.106	0.096
8-32	0.133	0.123
10-24	0.147	0.137
10-32	0.160	0.150
1/4-20	0.200	0.190
1/4-28	0.211	0.201
5/16-18	0.262	0.252
METRIC		
2.5 x 0.45	0.079	0.069
3 x 0.5	0.097	0.087
3.5 x 0.6	0.114	0.104
4 x 0.7	0.129	0.119
5 x 0.8	0.165	0.155
6 x 1	0.195	0.185
8 x 1.25	0.265	0.255



NOTE: Specify insert size (SAE or Metric) when ordering inserting tip.

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