# Technical Brief: Joining Solid Zinc Strip

## Soldering

Solid zinc strip alloys can be successfully soldered. The surface should be solvent cleaned and flux sparingly applied, not poured on the surface. A short time should be allowed for the metal flux reaction to take place. A solution of zinc chloride can be used as a flux, which can also be mixed with ammonium chloride. Some proprietary non-acid fluxes are also available.

The melting point of a good flux should be below that of the solder, so that melting and flow will be produced from the heat of the soldering iron. A 60/40 or 50/50 tin/lead solder should be used. Antimony-bearing solder is not satisfactory because it produces brittle joints. Strong, neat joints are not so easily made with solders containing less than 45%tin.

Heat and solder may be applied with a large soldering iron, so that the joint faying surface may be abraded slightly to begin fusing action. Neither preheating nor pretinning are needed in normal practice. Flame heating is not recommended. It is important that the soldering iron moves slowly in one direction only so that the solder following the iron flows into the seam. The iron must not be heated to redness nor allowed to dwell in one spot because of the risk of melting the base metal.

A back and forth movement of the soldering iron may cause zinc to dissolve in the solder. This makes the solder gritty, sluggish and brittle. If a non-corrosive flux is desired, as in electronic assemblies, faying surfaces must be precoated with solder.

The soldering iron should be cleaned with ammonium chloride solution from time to time. When completed, the soldered joint should be washed with water or wiped with a wet rag to remove excess acid and flux.

Best results are achieved with a solder stick 0.0625 X 0.1875 inch (1.6x 4.8 mm) cross section. The narrow edge permits the bar to touch the surfaces close to their intersection. The wide edge is better for finished fillets.

Solder joints should be formed with a lap at least 0.0625 inches (1.6mm) wide. Butt joints are much weaker and should be avoided when there is the possibility of the joint being stressed during use. When soldering a joint more than 0.625 inches (15 mm) long, the joint should be tacked with solder at intervals which will prevent movement.



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## Welding

Welding of solid zinc strip is best done under controlled shop conditions; for joining during erection of structures, soldering is much preferred. Sheets less than 0.040 inches (1 mm) thick are flanged or lapped and welded together without use of filler metal. The joint may be tacked at intervals to prevent joint movement during welding. In all cases, it is advisable to minimize heat input to the joint because of the possibility of recrystallization of adjacent areas, which will weaken the joint.

Resistance welding can provide sound welds with the least heat input compared to gas or arc welding. Sheets less than 0.125 inches (3.2 mm) thick should be welded using a square butt joint, with a gap equal to the metal thickness. Zinc sheets thicker than this should be beveled to form a $70^{o}$ to $90^{o}$ included angle with little or no land. Lap joints may also be used, with a fillet weld generally being made on both sides of the sheets. Resistance welding, using either spot welds or seam welding, is always done on lap or flanged joints. The thickness of the sheet dictates the minimum overlap of the joint, and is given in the schedule shown in Table 1.

## Surface Preparation

Joint areas must be thoroughly cleaned and abraded. Cleaning methods include grinding, machining, buffing, and abrading with an emery board or sandpaper. All have given good results and should be followed by degreasing if necessary. As with most metals the area to be fused into the weld should be clean and free of any foreign material.

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# Welding Processes

## Arc Welding

Although gas welding processes are used more often, arc welding, specifically the gas tungsten arc process, will produce uniform penetration and satisfactory welds in rolled zinc alloys. It is possible to limit heat input to the base metal more easily with arc welding, because a very short arc length can be used. Argon shielding gas allows for use of the longer arc lengths together with lower voltages minimizing heat input. Pulsing of high frequency current over a base 60 cycle alternating current power supply is necessary to overcome interference with arc stability caused by the presence of titanium, aluminum, and zinc oxides.

Manual arc welding requires considerable skill, especially in field erection. Automatic welding, usually performed under controlled shop conditions, produces best results, because the arc length and travel speed can be accurately controlled. Inert gas backing on the backside of the joint root is recommended to overcome the tendency of lack of fusion at the butting edges of the joint root, a condition caused by the formation of oxides when plain refractory or copper backup materials are used.

Gas tungsten arc welding of zinc-copper-titanium alloys requires use of filler metal that will produce grain refinement in the deposit, without appreciably reducing the ductility by precipitation hardening reaction during cooling. Titanium content in the filler metal produces grain refinement of the cast structure, but it may also cause a precipitation reaction, decreasing the ductility of the weld deposit. Titanium contents of the deposit should be no greater than 0.08 to 0.12% to be effective. Filler metal should contain at least 0.10% titanium and have the same copper content as the base metal. This composition will produce the soundest and most ductile weld deposit.

Tests for bending transverse to the weld axis indicate that the welds that had been hot rolled for 15% reduction at 300°F (149°C), and annealed at 550oF (188oC) for one hour, produced successful 90° bends on a mandrel with a radius five times the thickness of the zinc.

In tensile testing, the highest ductility with moderate strengths was obtained after hot rolling and annealing. The tensile strength was 19,000 psi (131 MPa) with an elongation of 5% across the weld deposit. The joint strength was approximately 90% of base metal strength.

Arc welding schedules for zinc-copper-titanium alloy are given in Table 2.

Gas metal arc welding is not used on zinc based alloys, due to excessive spatter and erratic transfer associated with this process.

## Gas Welding

A small welding torch tip should be used to minimize heat input into the base metal. For example, a tip suitable for welding 0.031 inch (0.8mm) steel is suitable for welding 0.125 inch (3mm) zinc. To minimize surface oxide, the flame should be neutral or slightly reducing.

The filler metals may be either zinc or the same composition as the base metal. Filler rod diameter should be approximately two-thirds the thickness of the metal being welded, to a maximum of0.16 inch (4mm). The tendency for overheating the base metal may be minimized by using larger diameter rods, or directing the flame of the torch onto the filler rod.

Since holes may be formed if the torch is held vertically, the flame should be maintained at an angle of 15 to 45° to the work depending upon the sheet thickness. The thinner the material, the smaller the angle. In groove welding the flame is directed towards the rod, which is raised out of the flame after each drop is deposited. The torch should be oscillated to prevent burning through the sheet. Backhand or forehand welding technique is satisfactory. The joint must have adequate support to prevent excessive drop through. Back up materials may be graphite, fire clay or plaster of paris.

To improve strength and ductility, the weld joint may be peened. This operation, however, must be done between 200-300oF (93-149°C). Peening at room temperature or above 300oF (149°C) may crack the weld.



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## Resistance Welding

Solid zinc strip alloys may be resistance, spot or seam welded with relatively high welding currents and low electrode forces. Compared to steel, zinc alloys have approximately twice the electrical conductivity, much lower melting ranges, approximately the same specific heats, and higher thermal conductivities. Because of the softness and generally greater thicknesses of zinc alloy work-pieces, a low-inertia follow- up for welding electrode control is needed. A 150 KVA single phase alternating current spot welding machine is suitable. If zinc areas are reasonably clean, only degreasing is necessary. Otherwise, mechanical cleaning is required.

Internal defects (cavities) are common in zinc alloy spot weld nuggets. These can be minimized by using a welding schedule employing a forging force. The forging force has little effect on spot weld strength. Direct tension-tensile shear ratios of spot weld strengths are approximately 0.35 for 0.075 inch (1.9 mm) thick zinc-copper-titanium alloy. This ratio is a measure of spot weld ductility and should be at least 0.5 for the weld to be considered ductile.

# Joining of Solid Zinc Strip

Table 1 -- Spot welding schedules for wrought zinc-copper-titanium alloy

| Thickness in. | Electrode Diameter, in. | Electrode Force, lbs. | Weld Time, cycles | Approximate Weld Current, amps | Minimum Overlap, in. | Minimum Weld Spacing, in. | Weld Diameter, in. | Average Weld Strength, lbs. |
|---|---|---|---|---|---|---|---|---|
| 0.010 | 1/2 | 100 | 1 | 7000 | 3/8 | 1/4 | 0.075 | 60 |
| 0.020 | 1/2 | 180 | 3 | 9500 | 3/8 | 5/16 | 0.120 | 200 |
| 0.030 | 1/2 | 260 | 5 | 12000 | 7/16 | 3/8 | 0.160 | 330 |
| 0.040 | 5/16 | 350 | 6 | 17000 | 1/2 | 1/2 | 0.195 | 460 |
| 0.050 | 5/8 | 420 | 8 | 18000 | 9/16 | 9/16 | 0.220 | 600 |
| 0.060 | 5/8 | 500 | 9 | 19000 | 5/8 | 3/4 | 0.250 | 740 |
| 0.070 | 3/4 | 580 | 11 | 20500 | 11/16 | 7/8 | 0.270 | 880 |
| 0.080 | 3/4 | 660 | 13 | 21500 | 3/4 | 1 | 0.290 | 1000 |
| 0.090 | 3/4 | 740 | 14 | 23000 | 3/4 | 1 1/8 | 0.300 | 1150 |
| 0.100 | 7/8 | 820 | 16 | 24500 | 7/8 | 1 1/4 | 0.315 | 1280 |
| 0.110 | 7/8 | 900 | 17 | 26000 | 7/8 | 1 3/8 | 0.330 | 1420 |
| 0.120 | 7/8 | 980 | 18 | 27000 | 1 | 1 1/2 | 0.340 | 1550 |
| 0.130 | 7/8 | 1050 | 19 | 28000 | 1 | 1 5/8 | 0.360 | 1680 |



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Table 2 – Gas tungsten-arc welding schedules for zinc-copper-titanium wrought zinc alloys

| Thickness in. | A-C Current, amps | Arc Voltage | Arc Length, in. | Tungsten Electrode | | Argon Flow, efh | Travel Speed, imp | Filler Metal |
|---|---|---|---|---|---|---|---|---|
| | | | | Diameter in. | Stick-out, in. | | | |
| Automatic Welding -- Butt Joint | | | | | | | | |
| 0.024 | 54 | 10.5 | 0.062 | 0.040 | 3/16 | 8 | 48 | None |
| 0.062 | 98 | 17-18 | 0.075 | 0.062 | 5/16 | 25 | 52 | |
| 0.075 | 125-130 | 11.5 | 0.093 | 0.062 | 5/16 | 18 | 30 | Base Metal |
| 0.125 | 172-180 | 13-15 | 0.125 | 0.125 | 3/8 | 25 | 20 | Pure Zinc |
| Automatic Welding -- Fillet Overlap | | | | | | | | |
| 0.062 | 94 | 17-18 | 0.093 | 0.062 | 5/16 | 25 | 52 | None |
| 0.075 | 105 | 20 | 0.093 | 0.062 | 5/16 | 18 | 30 | None |
| 0.125 | 140 | 17-18 | 0.156 | 0.062 | 5/16 | 25 | 19 | None |
| Manual Welding -- Butt Joint | | | | | | | | |
| 0.040 | 30 | | 0.062 | 0.062 | 5/16 | 25 | 6 | Base Metal |
| 0.075 | 150 | | 0.125 | 0.062 | 5/16 | 25 | 18 | Base Metal |



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