Soldering

Weld Tech News

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WELD TECH NEWS is a newsletter for welders working primarily in maintenance and repair. Each issue contains useful information on materials (cast iron, steels, aluminum, copper alloys, etc.), welding products and welding techniques. By collecting each issue, the reader will soon have a handy reference manual covering all aspects of welding, brazing and soldering for maintenance and repair.

SOLDERING

What It Is — How It Works

Soldering is joining two pieces of metal, using another metal as a filler, generally at temperatures below 1000°F, and usually between 300° to 600°F.

In this joining process, a non-ferrous filler metal is heated to melting temperature (below 800°F and below that of the base metal) and distributed between 2 or more close-fitting parts by capillary attraction.

- the parts are joined without melting the base metal,
- the filler metal melts at a temperature below 840°F and,
- the filler metal wets the base metal surfaces and is drawn into, or held in, a close fitting joint by capillary attraction.

Brazing is similar to soldering, except that the filler metal melts at a temperature above 840°F.

Ordinary soft solder is a fusible alloy, consisting essentially of tin and lead, and used for the purpose of joining together two or more metals at temperatures below their melting points.

Soft solders secure attachment by virtue of a metal solvent or intermetallic solution action that takes place at relatively low temperatures. Soft solders, therefore, are not to be confused with "hard solders," or brazing alloys, whose action involves the formulation of a fusion alloy with the metal that is joined; nor should they be confused with welding alloys, whose action again involves actual fusion of the metals.

The solvent property of molten solder at low temperatures is then a fundamental property which differentiates the behavior of a "soft solder" from that of a brazing or welding alloy.

A soldered joint is chemical in character rather than purely physical because the attachment is formed in part by chemical action rather than by mere physical adhesion.

The Tin-Lead Fusion Diagram
The point at which there is an alloy of the lowest melting point of tin and lead consists of 63% tin and 37% lead, and has a sharp and distinct melting point of 361°F.

All other solders in the tin-lead series are mixtures which do not melt sharply at any one temperature. The melting point of solder, therefore, requires two figures: one is the temperature of original plasticity — the other is the temperature of complete liquefaction.

Between these two temperatures, solder is neither completely liquid nor completely solid. The difference between the temperatures is called the "plastic range of solder."

The overall quality of a solder is governed by several factors:

- speed of alloy formation
- flow and spread of solder
- chemical stability of the soldered connection
- soundness and porosity of the joint
- physical resistance to shock, strain and stress

The quality of a solder can be viewed at the level of tin usage. Alloys approaching equal proportions of tin and lead are the most effective and efficient solders.
However, the cost of tin can in some cases be prohibitive. The 40/60 solder (40% tin-60% lead) occupies a high degree of quality, is readily procurable and cheaper than higher tin alloys, and is one of the most widely used of all compositions in the tin-lead series.

The Soldering Flux

All common metals are covered with a non-metallic film known as an oxide, which forms an effective insulating barrier that prevents metals from touching each other.

As long as this non-metallic barrier is present on the surface of metals, the metals themselves cannot make actual metal-to-metal contact, and intermetallic solvent action (soldering) cannot take place.

It is the function of the SOLDERING FLUX to remove the non-metallic oxide film from the surface of metals and keep it removed during the soldering operation.

Soldering fluxes may be conveniently divided into three general groups or classifications:

1. The Chloride or "Acid" type
2. The Organic Type
3. The Rosin or Resin type flux

The Chloride type fluxes are the most active of the three types and are effective on all common metals except aluminum and magnesium. Along with high activity, these fluxes are also the most corrosive. In addition to this corrosive quality, there is a hygroscopic character of the flux residue. The fused residue gradually absorbs water from the air, which finally dissolves and dilutes it, and causes the residue to spread over a wide area of the soldered unit.

The Chloride fluxes are unsuited for soldering fine electrical assembly units, where corrosion and electrical conductance are factors of vital importance.

However, the outstanding characteristic of the Chloride type flux is that the residues of these fluxes will not burn, boil or carbonize, but will retain their activity under the most extreme conditions of time and temperature.

The Organic type fluxes are comprised largely of mild organic acids and bases and hydrohalides. Their period of activity is short because they are less stable and have a greater susceptibility to thermal decomposition.

This feature of decomposition of the Organic fluxes affords a means of limiting or controlling corrosion.

An organic flux is highly useful and efficient for fast soldering and extremely oxidized work applications where soldering must be very effective and where minimal amounts of corrosion may be tolerated. These fluxes are less well adapted to applications requiring high stability under sustained or prolonged heat.
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The Rosin or Resin type flux enjoys a unique position in the field of solder fluxes because of its unequalled character of the flux residue;

- Rosin does corrode the metal, while it is in the hot liquid state, but on cooling to the solid state, it reverts to a completely inert and inactive form.
- Rosin molecules are locked together.
- In this inert form the Rosin molecules are impervious to the entrance of external agents, and are isolated from external influence.

However, when heated or otherwise suitably treated, the anhydride structure is broken and the latent activity of the confined molecules is released for fluxing action, which continues as long as heat is applied.

Since Rosin must be in solid form in order to be non-corrosive and non-conductive, it is obvious that all liquid external Rosin fluxes are corrosive and conductive substances. This chemical activity is imparted by virtue of the solvent.

In addition to being non-corrosive, Rosin is electrically non-conductive.

An Activated Rosin might be defined as a physically and chemically homogeneous resinous substance made by incorporating a second substance into a pure Rosin, which imparts to the Rosin at the temperature of soldering, an order of activity greater than that of the pure Rosin alone.

There has never been an authentic case of corrosion from the use of an Activated Rosin Core Solder. There is also a group of Resins that might be classed as "pseudo-activated." Also, there are resinous substances which, although they are perfectly homogeneous, do not exhibit a flux action any different from that of pure Rosin for ordinary production-line soldering. These Resins are more properly termed "Stabilized Rosins" instead of "Activated Rosins."

Solder As a Superior Method

Exactly how is solder superior as a means of metal attachment, and what are the fundamental reasons for using it?

1. Soldering provides the fastest and easiest method known for joining (alloying) together two or more metals.
2. The completely metallic soldered connection insures a permanent and constant electrically conductive medium.
3. A soldered connection remains secure and sound when subjected to physical stress, such as torsional strain, vibration, expansion and contraction due to changes in temperature, general atmospheric corrosion, and the many stresses normal in industrial usage.
4. Soldering is the most inexpensive method of joining metals; it does not require expensive tools, elaborate equipment, or skilled labor.
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The Welding Shop

SOLDER - TECHNIQUES AND MATERIALS

The low application temperatures and flow qualities achieved by solders are used in many maintenance and repair welding situations. In some cases, it is the only technique that will work. Rockmount alloys have been developed specifically for soldering versatility, and they will allow the maintenance welder to achieve the best results.

Joint Design

The diagram below shows examples of good and poor joint designs. Joint clearances should range from 0.002" to 0.005".

The strength of the joint should not be dependent upon the solder strength, because the solder alloys are of low strength compared to the base metals that are soldered.

The clearance between the parts to be joined must be as small as possible. However, there must be enough clearance to allow capillary action to draw the solder into the joint. In the same vein, the clearance must not be so great that the molten solder cannot fill the space.
In order to apply the solder, it may be necessary to clamp or jig an assembly together prior to heating. Flamehold is a Rockmount heat resistant compound with a clay like consistency. Many welders use it to hold odd-shaped or small parts in position for the solder application.

Joint Preparation

The surfaces to be joined must be cleaned to allow the solder to flow and join properly. This is especially important because the low heat used for soldering will not help in removing contaminants. Any foreign materials, such as paint, grease, oil or rust must be removed. Mechanical cleaning methods may be required, although sanding or steel wool often is sufficient. Particles of sand could be embedded in the surface, so sandblasting should be avoided.

Cleaning should also go beyond the actual joint area. Solvents can be used for degreasing. It is important to remember that any residue from the cleaning solution must be removed.

Heating

Most repair and maintenance solder repair are accomplished using either a gas flame, soldering iron, or furnace. Rockmount solders are engineered to accomplish solder joints with any of these methods. For most applications when heating with a flame, apply the heat indirectly. Let the base metal conduct the heat to the joint and feed the solder as the temperature melts the alloy.

The most common problem in soldering repairs is overheating the joint area. If, when applied, the solder boils or balls-up and does not flow, then the base metal is too hot. Flux should be applied before heating.

Since solder alloys do not require as much heat as other types of welding alloys, many different means can be used to apply the necessary heat to create solder joints. Production solder applications include such means as infrared heating and ultrasonic soldering.

The Problem of Solderability

One outstanding requisite to successful soldering is the preliminary provision for solderability on the part of the metal to be soldered. This provision may take the form of:

1) Selection of a type of metal in which there is a chemical affinity or metal solubility with solder.

2) Pre-plating treatment with a solder-soluble metal.

Solder will not form a joint with a metal in which it is insoluble or incapable of metallurgical action.
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Soldering Aluminum

Soldering Methods — Except for the fluxes and solders used, soldering aluminum is much like soldering any other metal. Joint designs are the same as those used with steel and copper alloys. Lap, tee, strap, and crimp joints are designed to fill with solder and allow an exit for the flux. Dissimilar metals can be soldered to aluminum without particular difficulty. Copper, nickel, silver, zinc, lead, tin, and tin-plated surfaces are not likely to cause problems. Galvanized steel can be soldered to aluminum by the use of a zinc-based solder. Surfaces that are difficult to solder can be rendered easier by electroplating them with an easily soldered metal; unfortunately, difficult-to-solder materials are often also difficult to plate.

Solder Alloys

Rockmount engineers have developed a selection of soldering alloys which gives the maintenance welder great versatility in being able to perform solder applications. Many of the following filler alloys can be used in a wide range of applications on many metal types. The proper selection should take into consideration such factors as service, temperature, strength, base metal, and service environment.

The final choice of filler metals discussed below, would depend on that best suited for the particular job situation. Rockmount solder fluxes are listed and then solder filler metals in order of their melting temperatures.

**Gemini Solder Flux** is an inorganic type acid flux in a convenient liquid form. Its active cleaning action makes it suitable for most applications, except electrical. To avoid possible continued corrosion by the flux residue, it can be washed by warm water.

**Gemini Neutral Solder Flux** is a liquid, mildly active, rosin type flux, most suitable for electrical applications. It has good fluxing action without being corrosive.

**Neptune Solder Flux** is a special flux for use with Neptune-SS solders on aluminum solder jobs and soldering aluminum to other metals. Overheating should be avoided, and the flux residue removed with warm water.

**Neptune-SS** is a very low temperature solder alloy that melts at 320°F, (160°C). It will join aluminum and solder aluminum to other metals. It is also ideal for white metals and zinc die castings. It may be preplaced and has a tensile strength of 7500 psi with good flowing qualities.

**Gemini-SCA** is solder in a paste form with an acid flux for conventional soldering applications. It is ideal for tinning joints, and has a melting temperature of 370°F (188°C) with a tensile strength of 8000 p.s.i. It can be painted on the surface and then heated slowly. Excess flux should be removed with warm water. **Gemini-SCA** can be used on all metals except white metals.

**Gemini-S** is a high-silver content solder, that has a great versatility in soldering applications. Its low melting temperature, 420°F (215°C), makes it ideal for many metal repairs and it works well on virtually
any metal except white metals. It contains no health hazardous metals, such as lead, cadmium, zinc, or antimony. Its silver content gives it excellent flow qualities and good corrosion resistance with very high strength (16,000 p.s.i.). On stainless it gives good color match and stays bright. It can be used either with Gemini Solder Flux or Gemini Neutral Solder Flux.

**Gemini-SA** is the same as the Gemini-S, but this version is in a convenient acid flux core form. The core of the wire contains Gemini Solder Flux, providing flux to the joint as it is heated. Like Gemini-S, Gemini-SA is packaged in spools, but the 1/16" size is also available in handy pocket size tubes containing nine feet of coiled solder.

**Gemini-SR** is the rosin flux core version of Gemini-S, containing Gemini Neutral Solder Flux. Gemini-SR is also available in tubes in 1/16" size and is ideal for electrical repairs.

**Gemini-SSP** is a silver solder powder that is premixed into an acid flux paste. It has high strength, 16,000 p.s.i., low melting temperature, 420°F (215°C), and excellent flow qualities that can be used to join all metals including dissimilar - not including white metals. The paste form is ideal for preplacing in joints of intricate assemblies, which can then be heated indirectly allowing the base metal to conduct the heat to the joint.

**Neptune-S** is a self fluxing solder for aluminum. Its melting temperature of 670°F (354°C) is lower than that of aluminum, avoiding the problem of melting the base metal. When deposits do not require high strength, Neptune-S is ideal for sealing cracks, holes, or building up worn areas on aluminum.

All of these Rockmount solders can be used with gas, iron, or furnace as a heat source.

**Glossary of Soldering Terms**

**Brazing** — A joining process whereby a non-ferrous filler metal is heated to melting temperature (above 840°F) and distributed between two or more close-fitting parts by capillary attraction. At its liquidus temperature, the molten filler metal interacts with a thin layer of the base metal, cooling to form an exceptionally strong joint due to grain structure interaction.

**Capillary Attraction** — A natural force of adhesion governed by the relative attraction of liquid molecules for each other and for those of two adjoining solids. As applied to soldering or brazing, the process by which liquid flux and filler metal are transported along the length of a close-fitting joint.

**Filler Metal** — An alloy or pure metal which, when heated, liquefies to flow onto the space between two close-fitting parts, creating a brazed or soldered joint.

**Fillet** — A clearly-defined bead of solder or brazing alloy which forms on and around the completed joint.

**Plastic Range** — The temperature span between liquidus (flow point) and solidus (melting point). It can be a few degrees to several hundred degrees.
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**Tinning** — A pre-coating process that covers the base material with another metal or solder. The coating does not necessarily have to contain tin, and can be used on a wide variety of metals or solders. Tinning is most appropriate for coating surfaces that are difficult to solder.

**Wetting** — The formation of a continuous, permanent film on the base metal surface to enhance bonding of the solder to the base material.

**Safety Tips for Welders**

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