UNIT-1WELDING IN AIRCARFT STRUCTURAL COMPONENTS

Types of Welding

Gas Welding

Electric Arc Welding

Shielded Metal Arc Welding (SMAW)

Gas Metal Arc Welding (GMAW)

Gas Tungsten Arc Welding (GTAW)

Electric Resistance Welding

Spot Welding

Plasma Arc Welding (PAW)

Nearly all gas welding in aircraft fabrication is performed with oxy-acetylene welding equipment consisting of:

• Two cylinders, acetylene and oxygen.

• Acetylene and oxygen pressure regulators and cylinder pressure gauges.

• Two lengths of colored hose (red for acetylene and green for oxygen) with adapter connections for the regulators and torch.

• A welding torch with an internal mixing head, various size tips, and hose connections.

• Welding goggles fitted with appropriate colored lenses.

• A flint or spark lighter.

• Special wrench for acetylene tank valve if needed.

• An appropriately-rated fire extinguisher

Before starting to weld, the following typical list of items should be checked:

• Is the proper personal safety equipment being used, including a welding helmet, welding gloves, protective clothing, and footwear; if not, in an adequately ventilated area, appropriate breathing equipment?

• Has the ground connection been properly made to the work piece and is it making a good connection?

• Has the proper type and size electrode been selected for the job?

• Is the electrode properly secured in the holder?

• Does the polarity of the machine coincide with that of the electrode?

• Is the machine in good working order and is it adjusted to provide the necessary current for the job?

Characteristics of a Good Weld

A completed weld should have the following characteristics:

1. The seam should be smooth, the bead ripples evenly spaced, and of a uniform thickness.

2. The weld should be built up, slightly convex, thus providing extra thickness at the joint.

3. The weld should taper off smoothly into the base metal.

4. No oxide should be formed on the base metal close to the weld.

5. The weld should show no signs of blowholes, porosity, or projecting globules.

6. The base metal should show no signs of burns, pits, cracks, or distortion.:

7. Little or no splatter on the surface of the plate.

8. An arc crater in the bead of approximately 1⁄16-inch when the arc has been broken.

9. The bead should be built up slightly, without metal overlap at the top surface.

10. The bead should have a good penetration of approximately 1⁄16-inch into the base metal.

Maintenance of Equipment

All equipment used in manual electric arc welding operations, including power supply system, welding equipment, ventilation system, the associated safety devices, and personal protective equipment, should be regularly checked for performance and maintained in good working condition. The proprietor should assign competent persons with appropriate training and experience to undertake the checking and maintenance work. Performance check includes general examination of the equipment as well as pre-use equipment check.

All defective or damaged equipment should be taken out of service immediately and replaced by suitable ones, and should be repaired or disposed of as appropriate. Equipment or system under maintenance/ repair or found defective should be properly labeled, marked or otherwise highlighted to warn workers not to use it. Equipment or system which has been repaired or maintained should be checked to ensure proper performance before it is used.

The examinations should be carried out by competent persons having the appropriate training and experience to undertake the checking and maintenance of electric arc welding equipment and the associated engineering control measures for the welding operation.

All equipment involved in manual electric arc welding operation should be regularly examined according to manufacturer's recommendations for defects and malfunctions and with records kept for the purpose of providing information to facilitate maintenance work. The frequency of examination depends on the frequency of use and the conditions in which it is used, such as the aggressive nature of the working environment.

The ventilation system of the workplace should be regularly checked to ensure its proper performance, such as the rate of air change in the workplace and quality of air supply.

Regular examination of the welding equipment includes the inspection for the following defects: (a) physical damage to electrode holder, welding cables, cable terminations and connections, welding transformer, primary power supply cables and the power supply system; (b) improper connection of welding equipment including the welding cables, the primary supply cables and all earthling connections; and (c) faulty or defective equipment of the power supply system, switch, circuit breaker, fuse unit, power socket, RCD, etc

After the welding operation, the worker should:

(a) Properly shut down the power supply to the welding equipment; (b) disassemble all welding equipment connections;

(c) Check that the welding equipment including the welding cables are in good conditions and ready for future use;

(d) Return all welding equipment and personal protective equipment to the store;

(e) Report to the supervisor or storekeeper should there be defects found in the welding equipment, protective equipment and the personal protective equipment; and

(f) Ensure that the work piece is cooled down and no hot slag, globules of molten metal or other similar hot residues remain before leaving the welding workplace.

Brazing and Soldering

Brazing

Brazing is a joining process wherein metals are bonded together using a filler metal with a melting (liquid us) temperature greater than 450 °C (840 °F), but lower than the melting temperature of the base metal. Filler metals are generally alloys of silver (Ag), aluminum (Al), gold (Au), copper (Cu),cobalt (Co) or nickel (Ni).

How is soldering different from brazing?
Soldering is a joining process wherein metals are bonded together using a non-ferrous filler metal with a melting (liquidus) temperature lower than 450 °C (840 °F). Whenever the filler metal liquidus is greater than 450 °C (840 °F), the joining process is considered to be a brazing process rather than a soldering process.

How is brazing different from welding?
Welding is a joining process wherein metallic components are joined through fusion (melting) or crystallization of the base metal by applying heat, pressure or both. This process differs from brazing, where only the filler metal melts during processing.

Braze metal considerations
Strength
Coefficient of expansion
Potential metallurgical
Reactions
Melting point
Service conditions

Torch Brazing of Steel The definition of joining two pieces of metal by brazing typically meant using brass or bronze as the filler metal. However, that definition has been expanded to include any metal joining process in which the bonding material is a nonferrous metal or alloy with a melting point higher than 800 °F, but lower than that of the metals being joined.

Induction brazing
Electric coils, which are designed for specific joint geometries, are used to heat the part and the brazing filler metal until the liquid metal flows via capillary attraction into the joint. This process is primarily used for brazing with copper and silver alloys. A typical application is a tube to tube assembly.

Brazing requires less heat than welding and can be used to join metals that may be damaged by high heat. However, because the strength of a brazed joint is not as great as that of a welded joint, brazing is not used for critical structural repairs on aircraft. Also, any metal part that is subjected to a sustained high temperature should not be brazed.

Brazing is applicable for joining a variety of metals, including brass, copper, bronze and nickel alloys, cast iron, malleable iron, wrought iron, galvanized iron and steel, carbon steel, and alloy steels. Brazing can also be used to join dissimilar metals, such as copper to steel or steel to cast iron. When metals are joined by brazing, the base metal parts are not melted. The brazing metal adheres to the base metal by molecular attraction and intergranular penetration; it does not fuse and amalgamate with them.

In brazing, the edges of the pieces to be joined are usually beveled as in welding steel. The surrounding surfaces must be cleaned of dirt and rust. Parts to be brazed must be securely fastened together to prevent any relative movement. The strongest brazed joint is one in which the molten filler metal is drawn in by capillary action, requiring a close fit.

A brazing flux is necessary to obtain a good union between the base metal and the filler metal. It destroys the oxides and floats them to the surface, leaving a clean metal surface free from oxidation. A brazing rod can be purchased with a flux coating already applied, or any one of the numerous fluxes available on the market for specific application may be used. Most fluxes contain a mixture of borax and boric acid.

Braze Filler Metals

Braze filler metal alloying elements
Various elements are added to braze filler metals. The purpose and behavior of these alloying elements are listed below.

Nickel (Ni) Provides desirable high temperature chemical and physical properties. Very compatible with other alloying elements.

Cobalt (Co) Has physical behavior that is very similar tonic eland can be freely substituted for a major portion of the nickel in any specific formulation. When added to nickel, it provides increased solubility, higher service temperature and increased matrix strength.

Manganese (Mn) Functions as a melting temperature suppressant.
Boron (B) Acts as a temperature suppressant aids wetting through self-fluxing of oxides and contributes to high temperature strength and oxidation resistance. As an effective de oxidizer, boron provides additional joint strength and corrosion resistance. Can be readily diffused from the braze deposit.

Silicon (Si) Behaves in much the same manner as boron. Primary duty is as a self-fluxing temperature suppressant. Secondary role is as a grain refiner affording strength, oxidation resistance and corrosion resistance to the joint at elevated temperatures. Cannot be readily diffused.

Iron (Fe) Appears to promote flow of the molten alloy and tends to make a sounder, tougher joint. Acts as a barrier to the migration of base metal elements into the braze joint. Chromium (Cr) Enhances both joint strength and high temperature oxidation resistance.

Tungsten (W) Improves matrix strength and corrosion résistance. Through matrix solid solutioning, it aids in resisting deformation under high temperature stressing.

Aluminum (Al) Is both a grain refiner and oxidation resistant additive.

Copper (Cu) Improves wetting and molten metal flow characteristics, benefiting corrosion resistance.

Available forms of braze filler metals
Braze products can be purchased in a variety of forms. Where available, customers can choose the form that is most convenient and efficient for their particular production needs

Braze powder is produced by a process that generates clean, dense, spherical and dry particles. Each particle contains precise amounts of all the elements of a particular alloy and the powders are uniform and homogeneous.

Braze paste is composed of one or more braze alloy powders and a neutral, flux-free binder. The binder content ranges between10 and 14 percent by weight, which results in a consistent, easily extruded braze paste. Binders may be water or organic based, producing pastes that are slow drying or fast
are available.

Braze tape is manufactured by casting uniform layer of braze alloy and a binder wound in rolls for ease of handling. The tapes are made to order with a specified thickness and width suitable for the component to be brazed. Adhesive can be applied to one or both sides of the tape.

Braze preforms are custom shapes cut from braze tape that are easy to apply for brazing. The adhesive backing will hold the reforms in place during assembly and brazing of component parts.

Braze foil is a flexible material that contains no binders or fluxes and can be as thick as0.06 mm (0.0025 in.). Foil can be cut into shapes and resistance tacked (spot welded)into place prior to assembly or brazing of components. Several sheets of foil can be used for added thickness.

Braze rod and wire are binder free and are commonly used in torch or induction brazing applications. Rod and wire materials are typically available in diameters from 0.8 to9.5 mm (0.3125 to 0.375 in.). Cored forms of these products may also contain flux materials.

Joint properties

Shear strength The ability to resist the angular deformation, calculated as the sideways displacement of two adjacent planes divided by the distance between them.

Butt tensile strength The ability to resist a force applied perpendicular to a given plane without rupturing.

Stress rupture A fracture caused as a result of repeated physical strain.

Hardness The ability of a material to resist scratching, abrasion, indentation or machining, as measured by a specifically chosen method or standard.

Corrosion resistance The ability of a material to resist attack resulting from environmental, chemical or galvanic action.

Oxidation resistance The ability of a material, particularly a metal, to resist reaction with oxygen, which can cause a loss of structural integrity resulting from the formation of undesirable oxide compounds.

Microstructure The composition and microscopic structure of a material, as studied using metallographic Methods.

Joint configuration The design and shape of the joint chosen to join members that will meet or exceed

structural requirements in service. Types of joint configurations include lap, butt, tee, tubing, tube thru plate and scarf (see section on Joint configuration

Soldering

Intoduction

Soldering is the process of joining two or more metals together at a temperature lower than the melting points of the metals. In its molten state, solder chemically dissolves part of the metal surfaces to be joined. However, most metals exposed to the atmosphere acquire a thin film of tarnish or oxide; the longer the exposure the thicker the film will become. This film is present even though it is not visible, and solder alone cannot dissolve it.

1. Soldered connections are used in aircraft electrical wiring to form a continuous and permanent metallic connection having a constant electrical value The importance of establishing and maintaining a high standard of workmanship for soldering operations cannot be overemphasized.

2. This section describes the materials and equipment used in soldering aircraft interconnecting wiring. It also describes and illustrates preparation and care of equipment, procedures to be followed, and the soldering techniques necessary to make a good soldered joint.

Soft solder is chiefly used to join copper and brass where a leak proof joint is desired, and sometimes for fitting joints to promote rigidity and prevent corrosion. Soft soldering is generally performed only in minor repair jobs. Soft solder is also used to join electrical connections. It forms a strong union with low electrical resistance.

Reference specifications and standards

The following specifications and standards are applicable to soldering:
ANSI/J-STD-004 Requirements for Soldering Fluxes
ANSI/J-STD-006 Requirements for Electronic Grade Solder Alloys
MIL-HDBK-454 General Guidelines for Electronic Equipment
0-F-499 Flux, Brazing, Silver Alloy, Low Melting Point
QQ-B-654 Brazing Alloy, SilverTT-I-735 Isopropyl Alcohol

Soft soldering does not require the heat of an oxy-fuel gas torch and can be performed using a small propane or MAPP® torch, an electrical soldering iron, or in some cases, a soldering copper, that is heated by an outside source, such as an oven or torch. The soft solders are chiefly alloys of tin and lead. The percentages of tin and lead vary considerably in the various solders with a corresponding change in their melting points ranging from 293 °F to 592 °F. Half-and-half (50/50) is the most common general-purpose solder. It contains equal portions of tin and lead and melts at approximately 360 °F. To get the best results for heat transfer when using an electrical soldering iron or a soldering copper, the tip must be clean and have a layer of solder on it. This is usually referred to as being tinned.

The hot iron or copper should be fluxed and the solder wiped across the tip to form a bright, thin layer of solder. Flux is used with soft solder for the same reasons as with brazing. It cleans the surface area to be joined and promotes the flow by capillary action into the joint. Most fluxes should be cleaned away after the job is completed because they cause corrosion. Electrical connections should be soldered only with soft solder containing rosin. Rosin does not corrode the electrical connection.

Aluminum Soldering

The soldering of aluminum is much like the soldering of other metals. The use of special aluminum solders is required, along with the necessary flux. Aluminum soldering occurs at temperatures below 875 °F. Soldering can be accomplished using the oxy-acetylene, oxy-hydrogen, or even an air propane torch setup. A neutral flame is used in the case of either oxy-acetylene or oxy-hydrogen. Depending on the solder and flux type, most common aluminum alloys can be soldered. Being of lower melting temperature, a tip one or two size smaller than required for welding is used, along with a soft flame setting.

Silver Soldering

The principle use of silver solder in aircraft work is in the fabrication of high-pressure oxygen lines and other parts that must withstand vibration and high temperatures. Silver solder is used extensively to join copper and its alloys, nickel and silver, as well as various combinations of these metals and thin steel parts.

Silver soldering produces joints of higher strength than those produced by other brazing processes. Flux must be used in all silver soldering operations to ensure the base metal is chemically clean. The flux re

Resistance Soldering
Resistance soldering is frequently used in large volume production where the operation is standardised.In this method, a low voltage transformer is used and the metal to be soldered is heated by the resistance to a flow of electric current. The work is gripped between two electrodes, completing the circuit and heating the metal for soldering. In another application, a carbon pencil is used as one electrode and the metal to be soldered forms the other electrode. When contact is established through the carbon pencil, intense heat is generated at the point of contact. Resistance soldering is well adapted to the soldering of small parts or for congested assemblies where it is desired to restrict heat to a small part of the assembly.

Torch Soldering
Torch soldering is used where a high heat is required - as in silver soldering. This process is also suitable for soft-soldering large work which is not part of an assembly or when the part to be soldered can be removed for soldering. For example, wires may be torch soldered to large contacts that have been removed from MS connectors. Torch soldering is not suitable for soldering small parts.

Dip Soldering
Dip soldering is the process of immersing connections in molten solder; one or more connections can be made in a single operation. This process is used on printed circuits, where the conductor pattern is on one side of the board and the components on the opposite side. Joints are mechanically secured, dipped first into liquid flux, then into molten solder. moves the film of oxide from the base metal and allows the silver solder to adhere to it.

Typical Soldering Operations

Following are examples of typical soft-soldering operations used in aircraft electrical wiring:
a. Tinning - wires or cables preparatory to joint soldering and to fuse ends; contact pins and inside surfaces of solder cups; shielded wire braid, after twisting, to fuse, terminate, and connect.
b. Soldering - wires and cables, previously tinned, inserted into solder cups of terminals, or mechanically wrapped on shaped lugs and post or hooked terminals; twisted connections, or broken wire for emergency repair; printed circuit
conductor pattern defects, or component leads and lugs to conductor pattern terminal areas.
. De-soldering - soldered joints prior to re-making; printed circuit component connections to remove component for replacement.
Soldering Iron Maintenance
19. Prior to use, remove the tip from the iron and clean out the black scale from the inside of the iron and from the tip with fine steel wool. When the iron or tip is new, coat the inside of the shank with dry flake graphite or anti-seize material to prevent freezing, and to ensure maximum heat transfer. When replacing the tip, make sure it is inserted to the full depth of the casing and seated firmly against the heating element.

During use and just before each application, pass the soldering iron tip (with a rotary motion) through the folds of a damp cleaning sponge or wipe on a wiping pad. This will remove the surface dross and excess solder from the working surface.

Preparation and maintenance of the soldering iron

General

For successful, effective soldering, the soldering iron tip must be tinned to provide a completely metallic
surface through which the heat may flow readily from the iron to the metal being soldered. If no tinning is present,
the iron will oxidize and the heat cannot flow through.
Copper has a very high rate of heat conductivity, but
copper tips oxidize quickly and must be frequently
cleaned and re-tinned. If a tip has become badly burned
and pitted as a result of overheating, replace it.

Preparing the Soldering Iron

Before using the soldering iron prepare it as follows:
With the iron shut off, file each working surface of the soldering iron tip with a double-cut mill file until it is smooth and a bright copper colour. Remove copper fuzz from dressed edges with a file card.
Plug in the iron and apply cored solder just as the bright dressed copper colour is turning to a pigeon-blue, bronze, oxide colour. This will allow the flux to “wet” and clean the working area when the solder melts to form an even, bright silver coating on the tip. **c.** Wipe off excess solder with a damp sponge or cloth.
Some copper soldering iron tips used in production soldering are coated with pure iron to help prevent oxidation. Follow manufacturer’s instructions for cleaning such irons. A clean damp cloth may be used to wipe the iron.

edges with a file card.

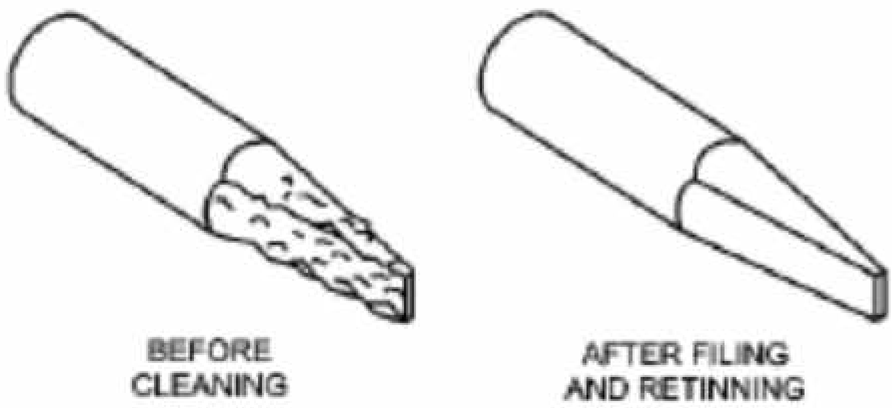

Figure 7–1 Soldering Iron Tip Before and After Cleaning

Figure 7–2 Tinning Soldering Iron Tip

Inspecting a finished solder joint

Acceptable Solder Joint

38. A good soldered joint will have a bright silvery appearance, with smooth fillets and feathered non sharp, edges. The entire joint will be covered with a smooth even coat of solder, and the contour of the joint will be visible.

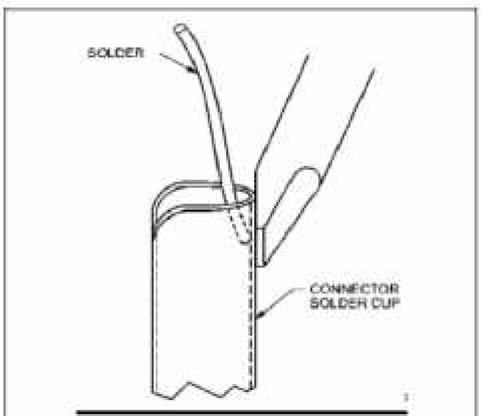

Figure 7–4 Correct Solder Application

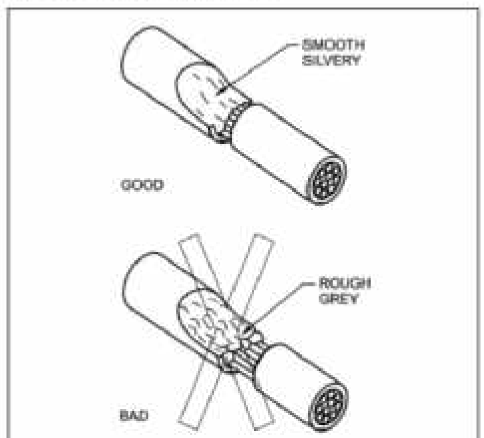

Figure 7–5 Good and Bad Soldered Connections

Unacceptable Solder Joint

39. Any of the following indicate a poor solder joint and are cause for rejection:

a. Dull grey, chalky, or granular appearance -evidence of a cold joint.

b. Hair cracks or irregular surface - evidence of a disturbed joint.

c. Grayish, wrinkled appearance - evidence of excessive heat.

d. Partially exposed joint - evidence of insufficient solder.

e. Scorched wire insulation or burned connector inserts.

f. Globules, drips, or tails of solder.