SUCCESSFUL BRAZING

with

FLAGG FF® FLOW

threadless bronze fittings

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SECTION 1

WHERE AND WHY SILVER-BRAZED FITTINGS ARE USED

Cast bronze fittings fill a number of important needs in marine piping. When they are silver-brazed to pipe and tubes of copper, brass, copper-nickel or steel, they become parts of one-piece, solid metal assemblies. Such piping assemblies are vital links in the complex systems we find aboard modern ships today.

Salt water pipe lines, for fire, flushing, cooling, ballast and damage control are usually made of copper, brass or copper-nickel. They employ brazed construction with bronze fittings, flanges, valves, etc., for corrosion resistance and safety. Fresh water lines of the same corrosion-resisting materials are also highly desirable in shipboard work.

Oil—for fuel or lubrication—is handled in copper or brass systems with brazed fittings to avoid contamination, to eliminate the hazard of leaks and to gain compact piping designs.

Refrigeration systems, too, must be kept free from leakage or contamination. They employ copper, copper-nickel or steel tubing, depending on the type of refrigerant. Brazed fittings have been found most satisfactory for this service.

Vacuum lines present an ideal application for brazed fittings with copper or other types of tubing. Brazing produces a joint that is as tight as the pipe or fitting itself—an important operating and maintenance advantage where air leaks must be prevented.

Chemicals have to be handled in systems that will not be attacked or pitted by corrosive action on metal surfaces. Where the application is such that the basic metals stand up, brazing is a good joining method because a silver-brazed joint is generally as corrosion resistant as the parts themselves.

Air lines of all pressures are put together with brazed fittings and flanges. Special high-pressure fittings are made for pipe in 3000 psi service.

For low-pressure steam (200 psi at 425° F) or for boiler feedwater (400 psi at 150° F) standard brazed fittings and piping perform reliably.

The threadless silver-brazing fittings that we discuss in this book are covered by Military Specification MIL-F-1183.

Advantages of brazing

Brazed joints are stronger than threaded joints because the pipe or tube is not notched or mutilated. In a brazed system, the joints are just as strong as the piping or fittings themselves.

Vibration does not loosen brazed joints. If damaged in such a way as to bend the pipes out of shape, a brazed system stands a better chance than a threaded system to remain sound and on the job until repairs can be made.

Brazed joints don't leak. A well-made and carefully tested brazed assembly will stay pressure or vacuum tight throughout its service life.

Corrosion resistance is one of the main requirements of the kinds of piping and fittings commonly assembled by brazing. When copper, brass or copper-nickel alloy is used to combat rust and deterioration, the joining material must logically resist corrosion too. The silver brazing alloy employed with them is generally as resistant to attack as are these metals themselves.

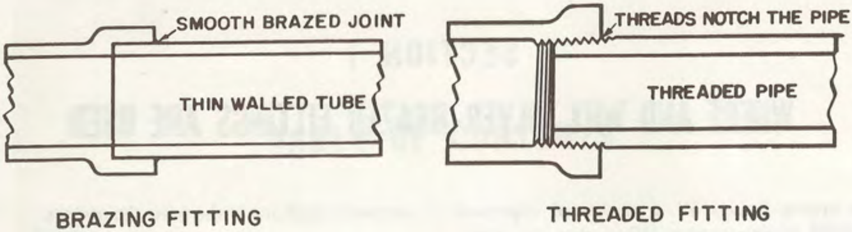


Figure 1-1 Brazed joints use all the strength of the pipe because they have no notches to cause weak spots.

Streamline design, which brazing makes possible, means less pressure drop, reduction of dead weight, less clogging, and reduced tendency to pit or erode piping near the fittings.

Accurate assemblies can be made by brazing. This is a very real advantage to the man responsible for putting the pieces together and making them fit. Pipe or tubes can be cut to exact dimensions; no guesswork allowance for threading is necessary. The angle of a fitting on a pipe can be pre-set. There is never a need for overtightening or slacking off to line parts up.

Temporary or emergency piping can be assembled rapidly by brazing.

Brazed piping can be taken apart, and all the pieces can be re-used.

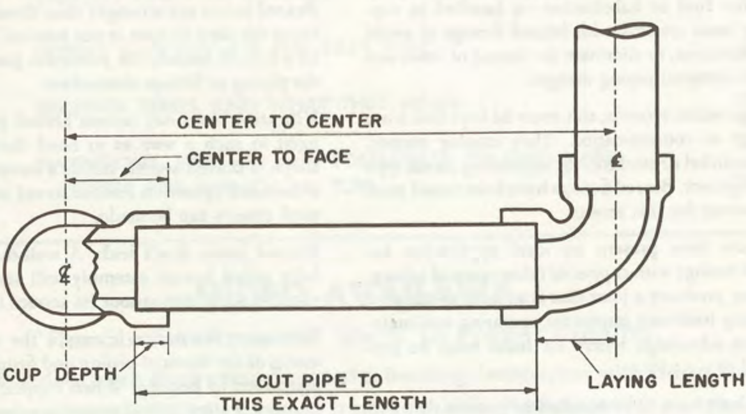


Figure 1-2 You can work to accurate measurements by brazing because the cut ends of every piece of pipe are seated against precision-machined shoulders in the fitting.

SECTION 2

WHAT HAPPENS WHEN YOU MAKE A SOUND BRAZED JOINT

Brazing joins piping and fittings into one continuous piece of metal. A brazed joint is far more than an adhesive seal or a friction-tight assembly.

The way molten brazing alloy works is to merge or dissolve into clean metal surfaces of the pipe and the fitting.

When it cools and solidifies, the alloy is part of both pieces. Only the composition and melting point of the material at the joint are different. In soundness of metal structure, the assembly is the same clear through.

How the brazing alloy gets into the clearance space

It helps to know something about the science behind brazing. The main reason for this is that you cannot really see everything that happens when you make a joint. The only way to see the brazing alloy that has filled the clearance space between a pipe and fitting bore is to cut through it and mutilate the work.

In making a joint with an interior that can't be seen, we depend on a coating of flux to help in a number of ways. Most important, the flux keeps the metal surfaces of the joint clean. Hot metal tends to form a scale of oxide. By protecting the pipe and fitting surfaces from oxygen in the air and by soaking up the few oxides that do form, flux keeps the clean, solid metal ready for a sound joint.

Molten brazing alloy can "wet" solid metal. We use the word "wet" because the alloy and the other metal tend to dissolve into each other. This action is far different from a mere sticking of molten brazing alloy to oxides of a metal or the partial bond that can be made on a dirty surface. For good brazing, all the metal surfaces must be clean to start with. (See Section 4.) Then, an effective flux must be used properly to keep them clean.

Wetting action during brazing is necessary for two reasons. First, it is required if we hope to get a one-piece finished job. Second, we use this soaking or blotter effect to guide the brazing alloy where we want it to go.

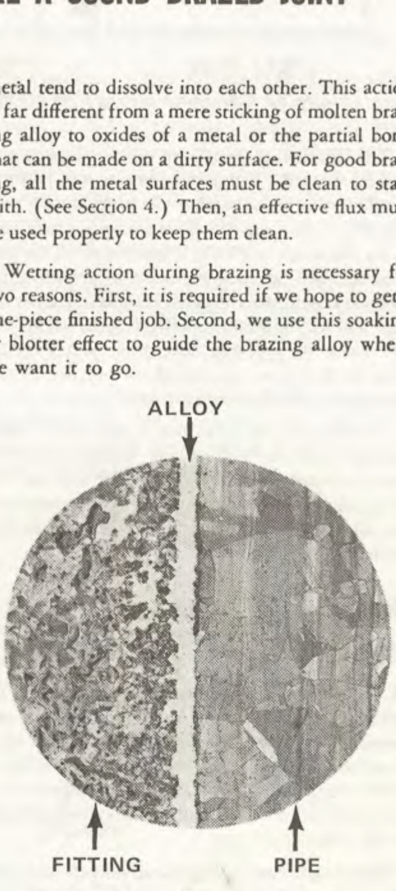


Figure 2-1 Magnification 100 diameters.

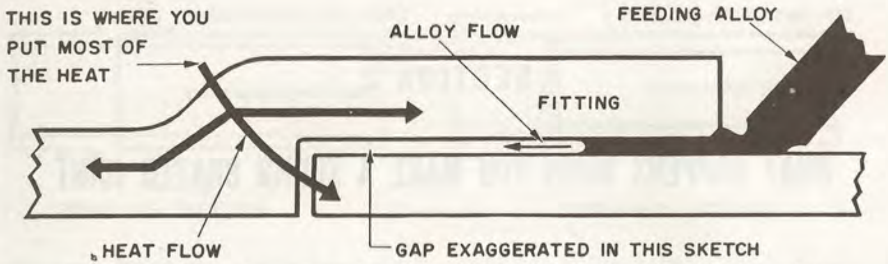


Figure 2-2 Heat sucks brazing alloy into the gap when the molten alloy wets both metal surfaces.

The clearance gap between the outside of a pipe and the bore of a fitting to be brazed will be small —only several thousandths of an inch. Molten brazing alloy in this gap, if it wets both parts, will tend to act like water in a wick. It soaks in to fill the gap. This is called capillary action. In places where the metal is hotter, the alloy will become a thinner liquid—and will flow more readily. It seeks out the hottest spots. By applying heat where you want the alloy to flow, you can control its direction of motion until it fills the clearance gap.

A well-prepared joint has a gap that is small enough—and the pull of the wetted surfaces is strong enough—so that molten alloy will not flow back out again once it is in place. As the parts cool, the alloy solidifies with an intimate bond to both of them.

How the size of the gap affects the strength of the joint

If the clearance between fitting and pipe is too great—in other words, if they don't fit well—the brazing alloy won't flow in readily. For pipe up to 2 inches, the maximum practical gap is 0.003 to 0.004 inch. Larger pipes, which are difficult to fit precisely, are sometimes brazed with alloys designed to fill a more open gap.

Tests show that, in addition to the practical problem of flowing alloy in between the parts, there are good reasons for close clearances from a strength standpoint. The chart here illustrates how the breaking strength goes up as the gap is made smaller. These tests were made with stainless steel, having a tensile strength of 160,000 pounds per square inch, to be sure that the break would come in the joint. The brazing alloy failed at loads that were far higher than its tensile strength of 42,000 pounds per square inch would promise. This bonus in strength that thin joints afford is one reason why a good fit contributes so much to good brazing.

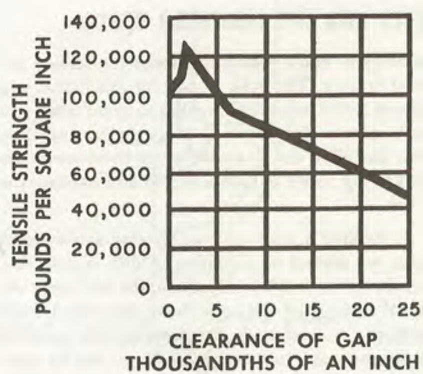


Figure 2-3 Tensile tests, with brazing alloy having a strength of 42,000 pounds per square inch, show that a small clearance gap makes a joint with as much as three times the strength of the alloy itself.

SECTION 3

THE RIGHT TOOLS AND MATERIALS ARE VERY IMPORTANT

It is far easier to do any job when you have the right equipment. Brazing is no exception. There is no reason for suffering the needless trouble of trying to make sound joints without the right tools if you are working in an established shop, yard or base where such things can be provided.

However, there may be times, aboard smaller ships at sea or at isolated bases, when you will need to use what you have. We shall try to show here what each tool does and why. If you must improvise, this will help you take the extra precautions that may be required for doing a satisfactory job under special conditions.

Tools for cutting pipe

The end of a pipe or tube to be brazed should be square and free from burrs. The outer surface, within an inch of the end, should be round and within a thousandth or two of a specified diameter.

Use a hack saw with a straight-edge ring jig or a square-end sawing vise to cut ends off. A band saw equipped for making perfectly square cuts will also do a good job. A pipe cutter can be used for trimming pipe to size, but it makes a reaming job necessary. Also a pipe cutter may reduce the outside diameter. If a pipe is sawed without a jig or vise, it should be filed square on the end.

Removing burrs can be performed with a file. Use an abrasive like sandpaper or emery cloth to take scale and dirt off. A plug sizing tool can be made to expand undersize tube ends.

In the absence of gauges or micrometers, you can judge whether the pipe diameter has the right relationship to the bore of the fitting. It should be a tight slip fit—without wobble.

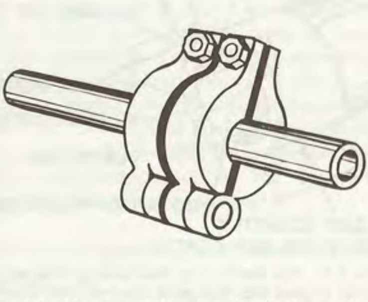


Figure 3-1 Use a straight-edge ring jig for sawing off pipe with a square end.

Figure 3-2 A square-end sawing vise holds the pipe and guides your hack saw for a square cut.

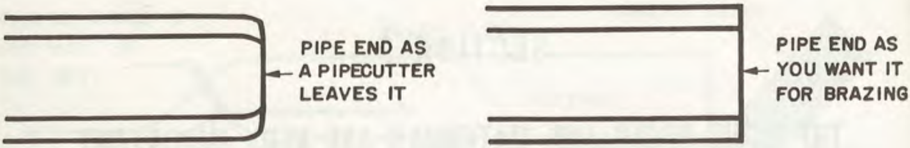


Figure 3-3 The sketch at the left shows, with some exaggeration, why using a pipe cutter makes extra work in preparing ends for brazing.

Cleaning gear

For most silver-brazing work, abrasive paper or emery cloth will be the only cleaning agent needed to take care of pipe and fittings.

Another way to get clean surfaces is to use an acid dip. Dilute muriatic or nitric acid is satisfactory. The tube end or fitting must be inserted in water immediately after the dip to prevent further attack and pitting. Acid cleaning is dangerous and should be practiced with care.

After the surface has been cleaned, remove any loose abrasive particles. Don't touch the clean metal with your fingers. Use a clean brush or an air hose.

Figure 3-5 Use abrasives to get scale and dirt off the end of the pipe.

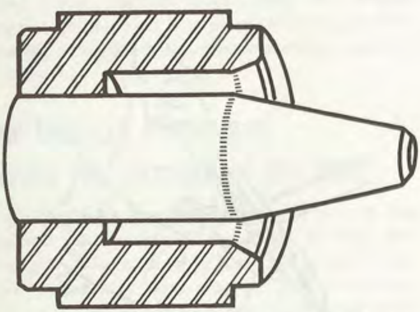


Figure 3-4 For tubing that is made to close tolerances on wall thickness—such as copper Type B tubing—a plug-type tool will be very effective in getting the outside diameter to size, true and round.

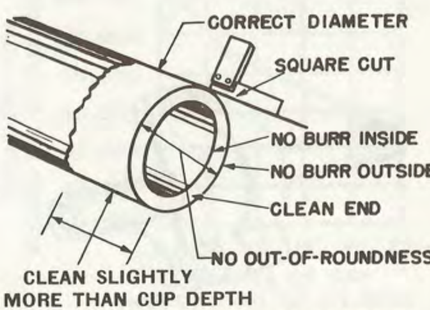


Figure 3-6 This sketch is a check-list on the requirements of a pipe that has been cleaned and sized for brazing.

Flux—and what it does

Flux is a chemical preparation that is applied to both sides of a joint before brazing. It is a paste, which can be thinned with water.

The kind of flux suitable for brazing pipe and bronze fittings is covered by federal specification O-F-499. A commercial designation is "Handy Flux."

The importance of using the right flux becomes clear when we consider all the things flux is called upon to do. It has to stay on the tube without blowing or washing away while being heated. The flux prevents oxidation from spoiling the clean metal surfaces when they are heated for brazing. As the brazing alloy flows in, the flux has to flow out of the joint without leaving impurities or inclusions. Finally, it should be possible to clean all flux off the parts easily after the joint has been made. Recommended types can be washed off with water.

Entirely apart from the protection job it performs on the joint, flux acts as a temperature indicator. Were it not for this feature, the problem of heating —without overheating—parts to be brazed would be extremely difficult.

When fluxed parts are warmed up, the water in the paste boils off at 212° F. Further heating to about 600° F makes the flux begin to "work" or bubble. At 800° F it quiets down, then begins to look clear and transparent. At 1100° F, in the range of brazing temperatures, the flux is a water-like fluid, and a bright metal surface can be seen underneath it. If the parts are progressively heated beyond this temperature, the flux remains active and protective up to about 1600° F.

Be sure to provide yourself with a clean brush for applying flux.

A caution may be in order here. Flux is a protective agent, not a cleaner.

Figure 3-7 Here is how flux behaves as a temperature indicator.

Jigs or temporary supports —prefabricated piping

Whether you are doing a job in a well-equipped shop or making repairs under miserable conditions, you will need some arrangement to keep your work lined up. The piping and fittings have to be held in the right positions without strain while you make the joint.

Vee blocks may be used on a bench for small assemblies. Temporary hangers can be made with wooden boards and strap iron. Rope and wire lashing will find usefulness in temporary setups.

For prefabricated piping, especially when a number of assemblies of the same design are needed, it pays to arrange more permanent jigs. Either with template wire or from piping plans, locations of the end connections can be established by jigs set up on a target floor. Intermediate hangers or supports should be provided as necessary. The heavier the piping, of course, the more hangers will be needed. Large fittings and valves require firm support to keep them properly lined up during brazing.

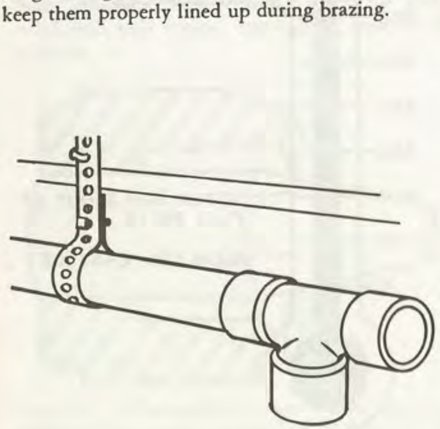


Figure 3-8 Make temporary supports out of strap steel, wire, or any similar material that will do the job.

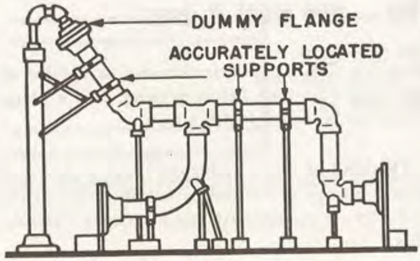


Figure 3-9 A target floor setup with the ends of pipe runs located and with supporting hangers for intermediate pieces.

Torches—tips and flexible extension

An oxyacetylene torch does such a satisfactory job in pipe brazing that other heating methods are seldom used. Experience has brought out several requirements that may well be considered absolute musts.

First, the tip should be drilled for a soft, spreading flame. This enables you to heat several square inches of area evenly. It is unsatisfactory to attempt brazing with a tip designed for welding or other purposes because its pointed flame makes a small hot spot instead of soaking the heat around the pipe. Tips with multiple holes are especially good for silver brazing.

Second, to do the normal type of pipe installation work in crowded conditions aboard ship, you will need a flexible extension for the tip at least 10 inches long. This is merely a length of soft copper tube that enables you to get the tip where you want it. To work on the back side of a joint near a bulkhead, for example, the extension can be bent into a hook shape to direct the flame toward you.

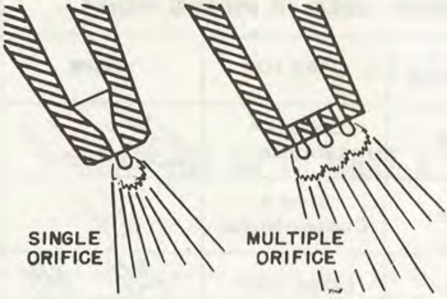


Figure 3-10 Brazing tips for acetylene torches have special drilling to give a spreading, wrapping flame that will heat a fairly large area.

Select a light, easily handled torch. Silver brazing takes relatively little heat compared to welding or high-temperature brazing. However, it requires a great deal of manipulation and shifting of the flame. This can mean unnecessary fatigue in a day's work if you use a heavy, unwieldy torch.

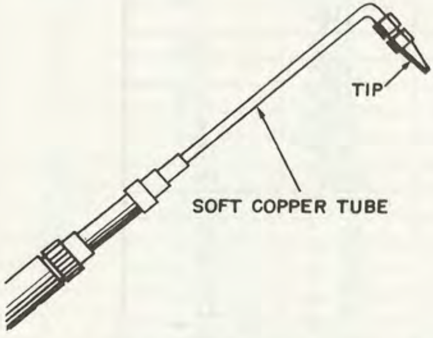


Figure 3-11 You can bend a flexible tip extension to direct the heat wherever you need it while working in crowded places.

Brazing alloys

The metal used to join bronze fittings with various types of pipes and tubes in marine work is a silver alloy. Its composition is designed to make it melt and flow readily at a temperature several hundred degrees cooler than the point where the pipe or fitting would be damaged. The alloy makes a strong, metallic, corrosion-resistant bond with both pipe and fitting.

Federal specification QQ-B-654A covers approved brazing alloys. They are furnished in a number of grades which suit different materials and different classes of work.

The alloy may come in rods or wire for feeding plain fittings. Some fittings come with preinserted rings of brazing alloy in them. The bore of such a fitting has a groove or reservoir in it filled with enough alloy to make a joint.

The most commonly used silver-brazing alloys are Grades 3, 4 and 5 or BCuP5, BAg1a and BAg3 to use the A.W.S. designation.

Grade 3 is used with copper and brass tubing joined by bronze fittings. This alloy has a melting point of 1185° F and a free-flowing temperature of 1300° F. It usually comes in 1/8 or 3/16-inch square rods 36 inches long, or in 0.050 by 1/8-inch strip 20 inches long. The shape helps identify the grade.

Grade 4 is absolutely required for brazing steel—for example, bulkhead and deck sleeves—to copper or brass pipe. It is also used on very light brass or copper connections. Copper-nickel pipe and tubing sometimes call for Grade 4 alloy because of its lower flow temperature. This alloy melts at 1160° F and flows freely at 1175° F. It is supplied in the form of coiled wire from 1/32 to 3/32 inch in diameter.

Grade 5 is recommended for lap seams in large sizes of copper pipe formed from sheet metal. It is able to fill a wider gap than the other alloys. Grade 5 melts at 1195° F and flows freely at 1270° F. It can be distinguished by its shape—usually hexagonal or octagonal in 36-inch rods.

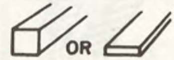
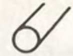
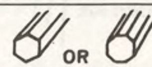
THE SILVER-BRAZING ALLOYS MOST USED IN PIPING WORK				
NAVY GRADE	FED. SPEC. QQ-B-654A	AWS DESIGNATION	USED FOR	SHAPE
III	BCuP-5	BCuP-5	Copper & Bronze	
IV	IV	BAg-1a	Steel & Copper-Nickel	
V	V	BAg-3	Large Gaps	

Figure 3-12

APPROXIMATE CONSUMPTION OF BRAZING ALLOY IN LINEAR INCHES

Pipe Size Inches	3/64″ Wire	1/16″ Wire	3/32″ Wire	.050″ x 1/8″ Strip
1/4	1 1/2	3/4	—	—
3/8	2	1	—	—
1/2	4	2	1	1 1/4
3/4	6	3	1 1/2	2
1	—	4	2	3 1/2
1 1/4	—	5	2 1/2	4
1 1/2	—	—	3 1/4	4 1/2
2	—	—	6 1/2	8
2 1/2	—	—	9 1/2	12
3	—	—	14 1/2	16
3 1/2	—	—	17	20
4	—	—	20	24
5	—	—	25	35
6	—	—	36	45
8	—	—	46	57
10	—	—	—	72
12	—	—	—	90

Figure 3-13

SECTION 4

WHAT YOU DO TO MAKE A TYPICAL BRAZED PIPE JOINT

In this section, we shall describe the things you do in making up an ordinary joint. Different kinds of work require special treatment. For example, some factors that you would consider in the way you handle a job are: the position of the joint, the type of fitting, the kind of pipe material, and the working pressure for which the system is designed.

To keep things simple, these variations are discussed separately in following sections. The material here applies to all pipe and tube brazing work.

Select torch tip

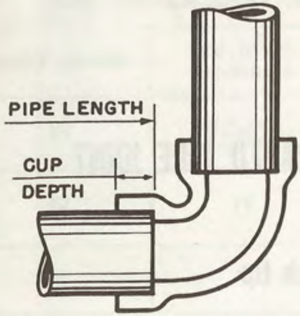
What size of tip to use depends on the size of piping to be brazed. The table below lists recommended tip size for ordinary I.P.S. size pipe and fittings. When brazing nominal or O.D. sizes of tubing, pick an I.P.S. size of about the same dimension and use the corresponding tip. If you are working on heavy tubing, for service at 800 psi or more, pick a tip one size larger than the one in the table.

RECOMMENDED TIP SIZES

Pipe Size (Inches)	Tip Size No.	Torch Tip Drill Size No.	Acetylene Consump. C.F.H.	Oxygen Pressure PSI—Approx.	Acetylene Pressure PSI—Approx.
1/4	4	54	15.9	4	4
3/8	4	54	15.9	4	4
1/2	5	51	24.8	5	5
3/4	5	51	24.8	5	5
1	6	48	31.6	6	6
1 1/4	6	48	31.6	6	6
1 1/2	7	44	38.7	7	7
2	8	40	60.0	7	7
2 1/2	8	40	60.0	7	7
3	9	35	70.0	7 1/2	7 1/2
3 1/2	9	35	70.0	7 1/2	7 1/2
4	10	30	88.5	9	9
5	10	30	88.5	9	9
6	10	30	88.5	9	9

These figures are based on Airco tip sizes.
Calculate oxygen consumption as 1.1 times acetylene consumption.
Increase gas pressures for hose lengths over 25 feet.

Figure 4-1



PIPE SIZE	CUP DEPTH (INCHES)
1/4	17/64
3/8	5/16
1/2	3/8
3/4	13/32
1	7/16
1 1/4	1/2
1 1/2	5/8
2	21/32

PIPE SIZE	CUP DEPTH (INCHES)
2 1/2	25/32
3	53/64
3 1/2	7/8
4	29/32
5	1
6	1 7/64
7	1 7/32
8	1 5/16

Figure 4-2 Use these standard cup-depth dimensions in determining exactly how long to cut each length of pipe.

RECOMMENDED PIPE AND FITTING DIAMETERS FOR PROPER GAP CLEARANCE				
PIPE SIZE	OUTSIDE DIAMETER OF PIPE		DIAMETER OF CUP IN FITTING	
	Minimum	Maximum	Minimum	Maximum
1/4	.538	.540	.540	.543
3/8	.673	.675	.675	.678
1/2	.838	.840	.840	.843
3/4	1.047	1.050	1.050	1.053
1	1.312	1.315	1.315	1.318
1 1/4	1.656	1.660	1.660	1.663
1 1/2	1.896	1.900	1.900	1.905
2	2.371	2.375	2.375	2.380
2 1/2	2.871	2.875	2.875	2.882
3	3.496	3.500	3.500	3.507
3 1/2	3.996	4.000	4.000	4.007
4	4.496	4.500	4.500	4.507
5	5.559	5.563	5.563	5.570
6	6.621	6.625	6.625	6.632
7	7.619	7.625	7.625	7.632
8	8.619	8.625	8.625	8.632

Figure 4-3

Prepare the end of the pipe

Make your layouts and measurements, then cut off the ends of pipe sections to exact lengths. With brazed fittings, instead of leaving a guesswork allowance for threading, you work to the shoulder in the bottom of the cup.

Cut the end of the pipe or tube off square. Use a hack saw or a band saw in preference to a pipe cutter, which tends to deform the pipe. Guide the saw for a square cut with a straight-edge ring jig or a square-end vise.

Clean off the burrs, both at the inside and outside edges of the cut.

Check the diameter of the end of the pipe, using a gauge, the fitting or a micrometer. Ideally, the clearance between the pipe and the bore of the fitting should be 0.0015 inch all around. This means that the pipe should be 0.003 inch smaller in diameter than the bore—and perfectly round.

Use the table on the opposite page for practical limits on fits and gap clearance. If the pipe is undersize, expand it with a plug or pin. Very large, thin pipe may need to be peened to increase its diameter at the end.

Figure 4-4 Use abrasives to get scale and dirt off the end of the pipe.

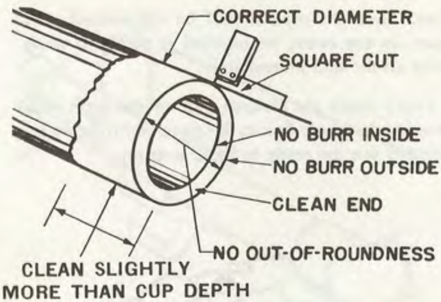


Figure 4-5 A well-prepared pipe end.

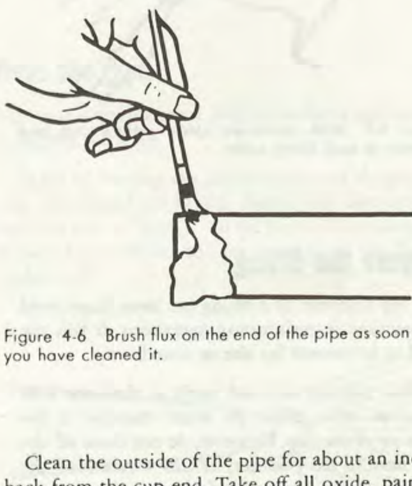


Figure 4-6 Brush flux on the end of the pipe as soon as you have cleaned it.

Clean the outside of the pipe for about an inch back from the cup end. Take off all oxide, paint, dirt, etc., with emery cloth or sandpaper. Don't try to polish the metal. This operation is only for cleanliness.

Another way to get a clean end on the pipe is to use an acid dip. If facilities are set up to dip parts in dilute acid, this method may be employed to save time. Then the pipe should be neutralized, and must, in any event, be inserted in water to wash away all the acid immediately.

Don't touch the cleaned part of the pipe with your hands. Apply flux to the clean end right away, whether you are ready to braze it or not.

Figure 4-7 With abrasives, clean out the cup and chamfer of each fitting outlet.

Prepare the fitting

The cup diameter of a fitting has been determined by precision manufacturing operations. It will not need to be reamed for size or roundness.

Clean out any dirt and oxide in the bore with abrasives. Also, clean the small chamfer at the entrance of the cup. However, do not clean off the face next to the chamfer, as this would lead the brazing alloy out and away from the joint.

Fittings with brazing alloy inserts should be cleaned more carefully than the plain ones designed for face feeding. If the cup is oxidized heavily, the ring of alloy is probably quite dirty too. Use abrasives or acid to clean the cup out thoroughly. A badly oxidized ring must be removed for cleaning. This will also allow you to clean out and flux the groove before you replace the ring.

Flux the bore and shoulder of the cup and also the chamfer at the entrance to the cup. This should be done right away with either type of fitting, even though the parts are not to be brazed immediately. The flux prevents oxidation, which would gradually affect clean metal surfaces even at ordinary room temperatures.

Figure 4-8 Flux all the cups on a fitting as soon as they are clean and assemble.

Figure 4-9 Add water as necessary to keep flux at the right consistency. Don't let the brush get dirty.

If fluxed surfaces dry out, add some fresh flux when you are ready to braze.

Use flux in the consistency of mucilage or honey. Add water if it gets stiff. A great deal of brazing trouble can be prevented by keeping the flux just right—not too thick and not too watery. Never use a dirty brush for applying flux.

Fit up and support the assembly

With fresh flux on both parts, slip the pipe into the cup of the fitting. Support the two parts so that they are lined up true and square. Be sure the pipe end is firmly against the shoulder of the fitting. Brush on some more flux at the joint around the chamfer of the fitting.

Use vee blocks, clamps, wire, wooden braces or pipe hangers to hold the work in place. The idea here is to take all strain off the cup of the fitting while it is being heated. Locate supports where they won't get in your way. Also, avoid massive metal supports or clamps with large areas in contact near the joint, as they will tend to absorb heat from the pipe and the fitting.

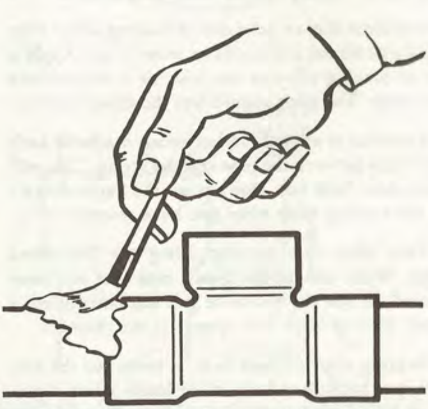


Figure 4-10 Brush more flux around the joint after you have fitted the two parts together.

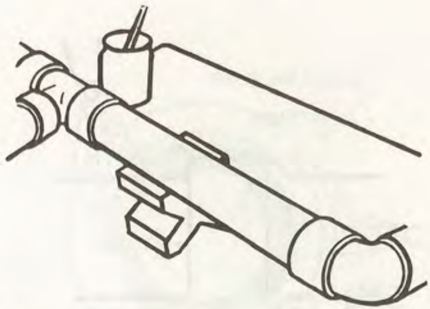


Figure 4-11 Support the pipe so that there will be no strain on the fitting, but don't put heavy supports too close to the joint.

Heat the pipe

Light the acetylene torch. Adjust the flame so that it is slightly reducing.

Begin by heating the circumference of the pipe near the face of the fitting. Don't hold the torch so close that it "blows" on the pipe as this causes localized overheating and may also cause the flux to flake off.

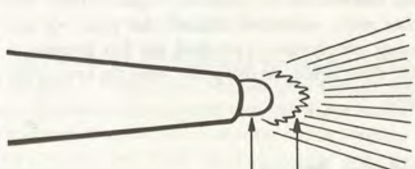


Figure 4-12 Add enough acetylene to the mixture to produce a slight green "feather" on the blue cone. This is a reducing flame.

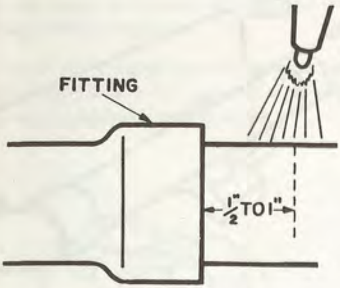


Figure 4-13 Heat the pipe, near the fitting, all around its circumference.

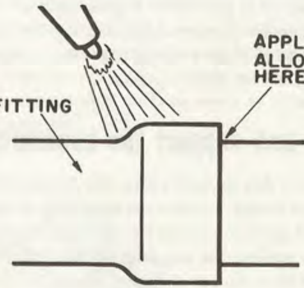


Figure 4-14 After the pipe is warmed up, shift the heat to the fitting. Keep the flame pointed toward the pipe.

Heating the pipe first makes it expand. This causes the pipe to press against the cup, and some heat gets carried through to warm up the fitting.

As you continue heating, water boils off and the flux turns into a white powder. Then it fumes and bubbles slightly. At this point, begin to concentrate on the sector that you are going to braze. On ½ inch pipe, continue to heat all around. For the ¾ and 1 inch sizes, work on one side first. On larger pipe, concentrate the heat on a space about two inches wide, measured around the pipe. As the brazing temperature is reached, the flux becomes a quiet, clear liquid. At this point, shift the heat to the fitting.

Heat the fitting

Now, working in the same areas as where the pipe was heated, direct the flame to the outside of the fitting cup. Point the flame toward the pipe, so that it will still get some heat. Watch the flux as it boils out of the joint. When the flux has gone through all its stages and appears clear and quiet, you are ready to braze.

Fill with alloy until fillet appears

Brush some flux on your rod of brazing alloy. Play the flame on the rod briefly to warm it up. Apply a bit of brazing alloy to the joint as a temperature indicator. The alloy should wet the fluxed surface.

Continue to apply heat, but sweep the flame back and forth between the pipe and the fitting. This will keep them both hot. Don't point the flame directly at the brazing alloy after you have warmed it up.

Feed alloy into the cup along the chamfered edge. Work around the 2-inch area that you have heated. When the clearance gap has been filled, a small fillet of alloy will appear at the chamfer.

Brazing alloy follows heat. It seeks out the hottest spot because it flows more freely when it gets more heat. Use this effect to guide the flow of alloy where you want it.

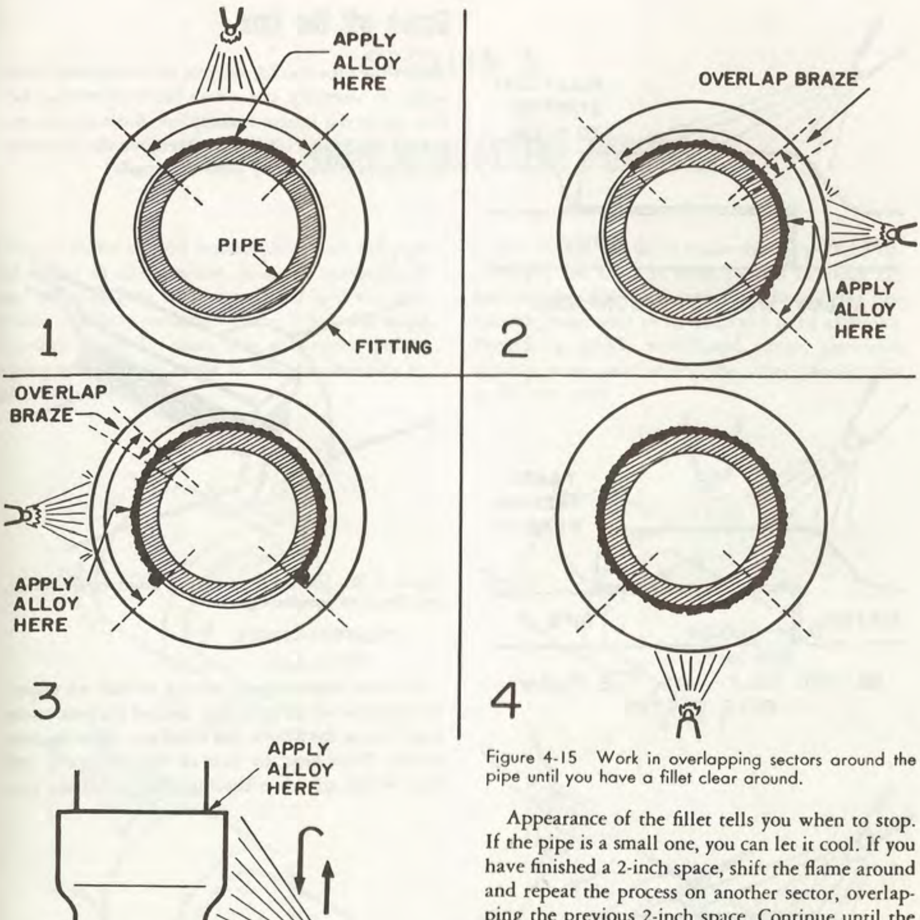


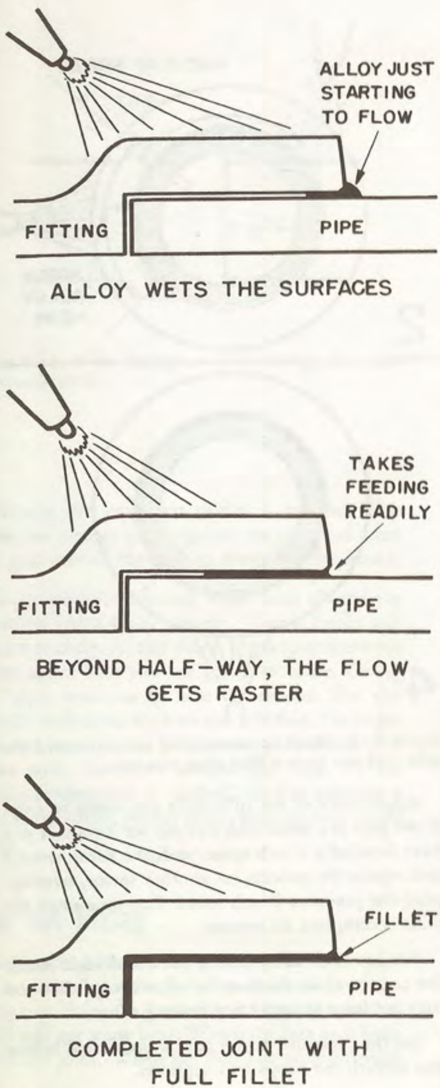
Figure 4-15 Work in overlapping sectors around the pipe until you have a fillet clear around.

Figure 4-16 Pull the alloy in with a brushing motion of the torch. Concentrate a good deal of the heat on the base of the cup.

Appearance of the fillet tells you when to stop. If the pipe is a small one, you can let it cool. If you have finished a 2-inch space, shift the flame around and repeat the process on another sector, overlapping the previous 2-inch space. Continue until the joint is complete all around.

Fittings with alloy inserts are handled in much the same way as the face-fed type except that you may not have to apply any brazing alloy.

Let the pipe and fitting cool a good deal before you disturb the props and supports.



Scrub off the flux

Before the pipe is cold, swab or brush the joint with water. If necessary, use a wire brush to remove the flux. After the system is complete, flush out the inside of the pipe with water to remove the flux that went inward when the joint was made.

Figure 4-18 Use water and a stiff brush to remove excess flux after completing a joint.

If visual inspection or testing reveals an imperfect joint, brush on more flux around the leak or the place where the fillet is not filled out. Heat the area evenly. Then heat the base of the fitting cup and flow in enough silver-brazing alloy to fill the gap.

Figure 4-17 Left, when a fillet of silver-brazing alloy has formed in the chamfer of the fitting and requires no more feeding, you know that the alloy has filled the gap.

SECTION 5

HOW TO WORK IN DIFFERENT POSITIONS

You can make a good brazed joint with the pipe and fitting in any position. It is not necessary to pour silver-brazing alloy downward into the gap, because capillary attraction draws it into the small clearance space. By using this attraction, molten brazing alloy can be made to flow horizontally or uphill into the joint.

The things you do to make the alloy travel upward are the same as what you do to make any brazed joint. However, some of the regular precautions may need to be observed more carefully. Provide a small, well-fluxed, clean gap with *slightly more heat where the alloy should flow* to fill the space.

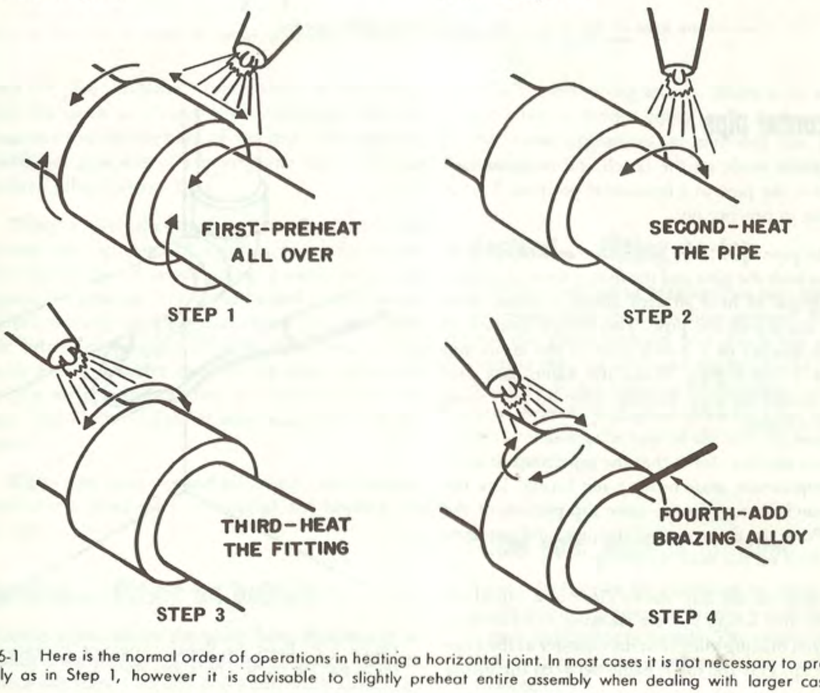


Figure 5-1 Here is the normal order of operations in heating a horizontal joint. In most cases it is not necessary to preheat assembly as in Step 1, however it is advisable to slightly preheat entire assembly when dealing with larger castings.

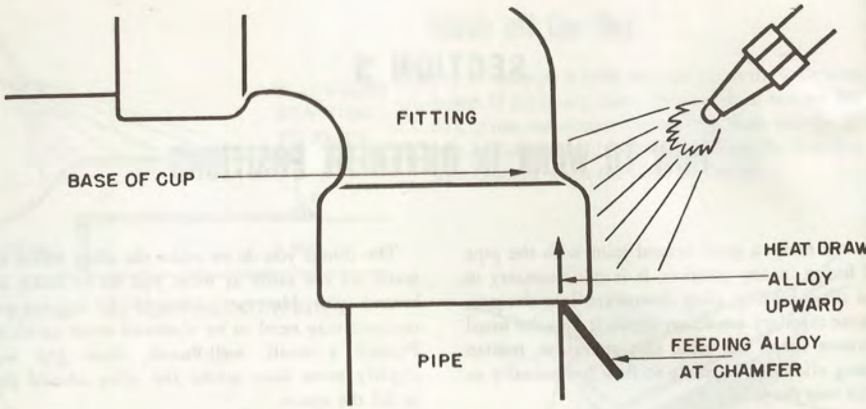


Figure 5-2 Concentrate heat at the base of the cup to draw alloy upward.

Horizontal pipe

Most joints made on the bench and many aboard ship have the pipe in a horizontal position. This is the joint to practice on.

If the pipe is of fairly large size, use the torch to preheat both the pipe and the fitting somewhat first. Then begin to heat an area about 2 inches wide across the top of the pipe. This would amount to the top quarter of a 2-inch pipe or the entire top half of a 1-inch pipe. Work the flame back and forth around the pipe, staying about an inch away from the fitting.

When the flux shows that the pipe is up to brazing temperature, start heating the fitting. Use the same torch motion on the same top portion of the joint. Point the flame toward the pipe, and put most of the heat on the base of the cup.

As soon as the flux shows clear and liquid all over the area where you are working, start feeding the fluxed brazing alloy into the chamfer at the edge of the cup. Play the torch flame between the fitting

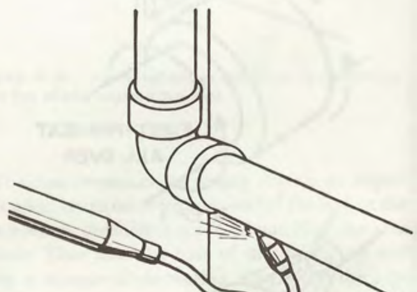


Figure 5-3 Bend the flexible extension on your torch tip to put the flame where you want it.

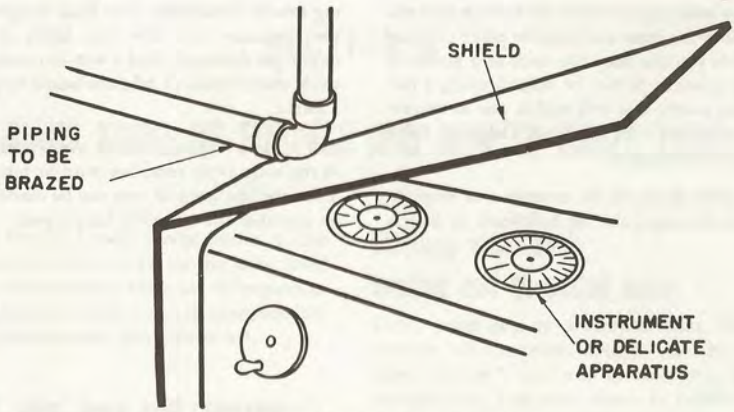


Figure 5-4 Fix a shield of metal, asbestos or wood to protect nearby apparatus.

and the pipe. However, concentrate on the fitting. Use the torch as a paint brush, stroking from the chamfer toward the base of the cup. This painting technique is a way of applying the basic rule that molten alloy follows heat.

When a fillet of alloy appears at the chamfer all across the top portion, shift to one side, to the bottom, or to an overlapping 2-inch space, and repeat the process. Allow the brazed portion to set before heating the next part. Heat the pipe, then the fitting, then apply alloy. Use the heat of the parts at the chamfer to melt the alloy. This will keep it melting only as fast as it can flow into the gap. Don't let an excess of alloy accumulate on the joint.

When you have worked all around the chamfer and have a good fillet all around, the brazing job is done.

Vertical—fitting on bottom

Making joints where the alloy flows downward is, perhaps, the easiest way to work. It doesn't matter where you start. Pick any place and work around in 2-inch, overlapping sectors. There is no need to let the alloy set before going to the next portion. Use the same operations as outlined for the other positions.

Vertical—fitting on top

The basic method of brazing does not change when you must make the alloy flow upward. If you find that the alloy tends to flow down the pipe, it is because the pipe is heated too much and the fitting too little. If this happens, let the alloy cool and set. Now, heat the fitting and draw the alloy up into the cup by making the base of the cup the hottest place in the joint.

When your work is crowded

Brazed joints can be made up in close quarters where screwed piping or flanges would be difficult or even impossible to handle. The extension tube on your torch tip is your prize tool when conditions are crowded.

Bend the extension to direct the flame where you want it. Find the most comfortable place to stand or sit where you can keep the torch in a generally horizontal position. It may be helpful to rig a polished metal mirror that will enable you to observe the flux on the far side of a pipe. The torch flame will supply illumination.

Use a hook shape on the extension to keep the flame from burning paint off bulkheads or scorching nearby equipment. Use your judgment, and if the apparatus near the joint looks as though it might get damaged, find a way to protect it. A wet swab, sheet metal, or asbestos board may be used as a shield.

It may be helpful to do as much work as you can in the shop from template wire or piping layouts. Then the last joint or two can be made in place to be sure that the assembly fits properly.

A number of copyrighted figures have been reproduced in this manual with the permission of Handy and Harman, New York, N.Y. This acknowledgment applies to Figures 2-3, 3-2, 3-5, 3-8, 3-11, 3-13, 4-4. 4-6, 4-7, 4-8, 4-10, 4-11, 4-12, 4-13, 4-14, 4-15, 4-16 and 10-2.

SECTION 6

VARIOUS KINDS OF FITTINGS AND HOW TO BRAZE THEM

Any type of fitting or valve can be brazed in the same way as any other, as far as the joint itself is concerned. Nevertheless, there are differences in the way you handle certain joints to accommodate features of the particular fitting involved.

Couplings, ells, tees and crosses

Clean all the cups on a fitting before making up the first joint. Keep them all fluxed while you are working in order to prevent oxides from forming. If the location is dirty or dusty, wrap paper around the open ends when you leave the job for any length of time.

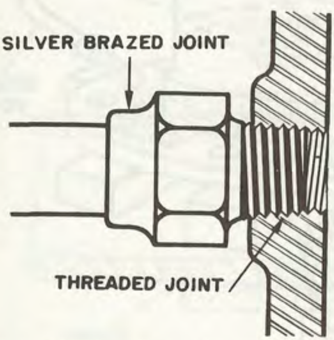


Figure 6-1 Always make up the silver-brazed joint first, as heat will damage pipe-thread compound. See that necessary unions are provided for disassembly and servicing.

Fittings with both brazed and threaded ends

Don't braze next to a screwed joint. Heat will damage the compound used to seal the threads. Make up the brazed end or ends first, then the threaded end. This point should be noted in laying out piping designs. A system will need a union to be practical if it requires a brazed fitting that screws into a tapped hole on stationary equipment.

Unions

Protect the ground sealing surfaces of unions with a generous coating of flux. This will keep them from tarnishing when heat is applied to make the joints. In any case, do not play the torch flame directly on the ground surfaces.

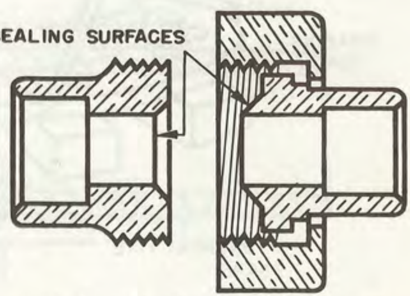


Figure 6-2 Flux the sealing surfaces of a union to prevent their tarnishing from the heat required during brazing.

As with threaded piping, be sure to slip the nut on the female half before both ends of the pipe have fittings attached. If the union is assembled during brazing, run the nut up only by hand. Temperature stresses will damage the union if it is heated while set up too tight.

Flanges

The mating, seating surface of a flange can be warped if heat is applied improperly. This will make it leak. In an extreme case, a flange can be cracked by careless heating.

The thing to remember is to keep heat away from the flat mating surface. Direct the torch flame against the hub where it will heat the cup. After heating the pipe, use a back-and-forth motion around the hub to heat the flange. Then, wipe the torch flame from the pipe across the hub and back again to keep both parts hot during the rest of the brazing operation.

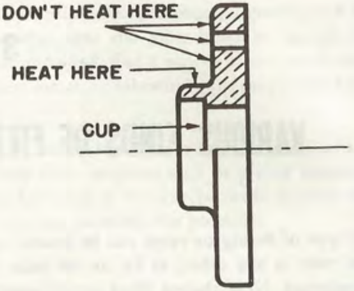


Figure 6-3 When brazing a flange, heat the base of the cup—not the outer part of the fitting.

Figure 6-4 This is the kind of setup you need for silver brazing large flanges.

Large flanges—over twelve inches—need another source of heat to warm them up all over during brazing. Using an oil, gas or charcoal fire, set the pipe and flange up over the flame as shown in the sketch on the opposite page. Leave spaces between the brick supports for the flame and heat. Level the bricks carefully.

With a slow, even fire, bring the joint up to brazing temperature as indicated by the flux. Now, lower the fire and begin to braze. Use the torch in the usual way, working on a 2-inch or 3-inch space at a time.

It helps to use a second torch on large flanges. This torch is not used for brazing, but just to warm up the joint about 90° ahead of the brazing area.

When brazing has been completed, cool the entire assembly slowly. Reduce the preheat fire gradually and leave the setup in place.

After the joint has set and cooled somewhat, scrub off the flux with warm water. This will allow you to inspect the joint carefully to see that the fillet has been perfectly formed all around.

Bulkhead and deck sleeves

The sleeves used for a welded seal, where piping goes through steel decks or bulkheads, are made of steel. For this reason, they should always be brazed with Grade 4 alloy.

Locate the place where the sleeve should go on the pipe from plans or measurements. Clean the pipe all over, to an inch beyond either end of the area which will be covered by the sleeve. Clean out the inside of the sleeve and its ends where the fillet will form. Flux the ends of the sleeve and the inside for about a half inch inward from each end. Flux the pipe to match the two bands of flux inside the sleeve.

Slip the sleeve on the pipe, locate it properly, and make a brazed joint on one end. The procedure is the same as for other typical joints. Let the first joint cool and set. Now, make a brazed joint at the other end. As you work on the last section of the second joint, you may see a bubbling action at the edge of the sleeve or at the vent hole. This is escaping gas. Impurities such as grease, dirt, etc. trapped

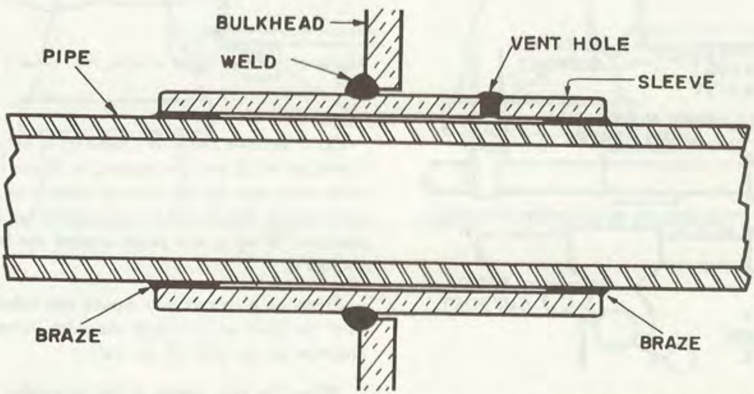


Figure 6-5 A steel sleeve, silver-brazed to the pipe at both ends, provides a sealing member that can be welded where the pipe passes through a bulkhead or deck.

between the two brazed joints will form a vapor and try to escape. Before finishing the last joint, heat the middle of the sleeve all over in order to drive these vapors out. Then finish the brazing.

If the sleeve has a vent hole in it, this hole should be closed with welded metal.

Return bends

When you are making up coils or heat-transfer systems with a number of return bends, remember to allow for expansion. The pipe is slightly longer while you are brazing one end than it will be after it cools.

If you keep both pipes of a U-shaped assembly locked up tight while working, the result will be a warped job. Always leave one end free to come and go. This can be accomplished if you assemble the entire coil by working from one end. If you like, you may put together a number of U-shaped sections, then join them with the return bends at the opposite end. Whatever your method, remember that the pipe you are brazing must be allowed to expand and contract.

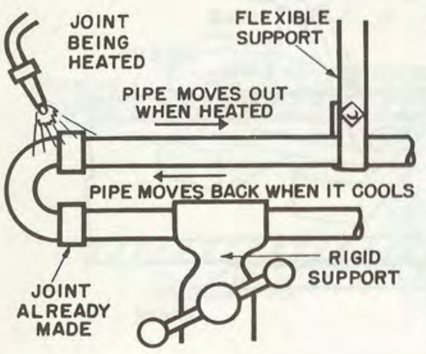


Figure 6-6 Leave one end free to come and go when you apply heat to a piping setup.

Valves

Should it be necessary to make up the joints on valves that have brazing ends, use the same tip size and the same general procedure as for other types of fittings.

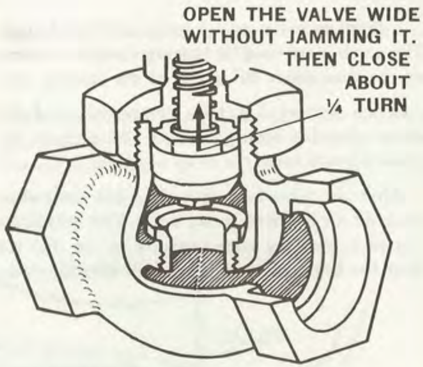


Figure 6-7 Open a valve wide, then close it part of a turn.

Don't remove the valve bonnet; it helps stiffen the valve while you are brazing it. Open the valve wide, then turn the handwheel slightly in a closing direction so that it will not be jammed in the open position. Wrap a wet swab around the bonnet to protect it.

Clean each cup as you would any other fitting. Flux the bore and the back shoulder. Also flux the chamfer at the end of the valve.

When the time comes to heat the valve, be especially careful about how you handle the torch. Keep the flame pointed toward the pipe. Don't direct the flame at the middle of the valve, but always near the end. You will want most of the heat at the base of the cup.

Scrub off the remaining flux after the parts have cooled.

Large sizes

We have described the use of a preheating fire for flanges larger than 12 inches. It is also true that any fitting over the 4-inch size can be brazed more easily if you have a second source of heat. Use another torch, if available, heating the general area on the far side of the joint from the place where you are brazing.

Fittings with preinserted rings

Fittings in this category are identical to the face fed fittings of the same pressure rating except that one and sometimes two grooves are cut in the cup of the fittings and the silver brazing alloy is preplaced in these grooves. Naturally one should know the type of piping material with which the fittings will be used so that the correct inserts may be specified. Federal specification QQ-B-654A lists the intended use of the various alloys and also covers the ring marking and identification. It is advisable for the mechanic to check the marking to ascertain that the fitting has the correct alloy for the job on which it will be used.

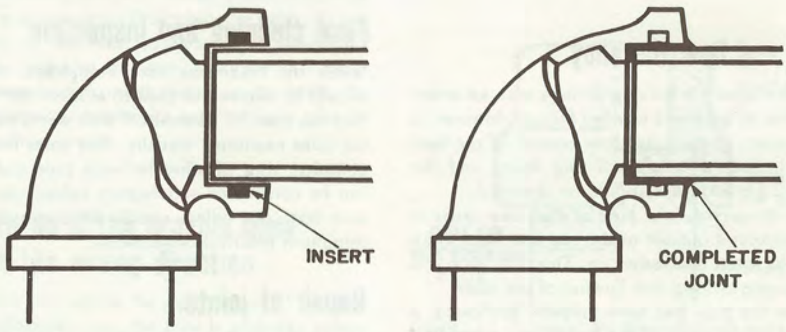


Figure 6-8 Preinserted silver-brazing alloy in a groove flows both ways through the cup to make a joint.

Cleaning

Fittings with inserts require more careful cleaning than face fed fittings because of the groove. If the cup is heavily oxidized, the insert should be removed and cleaned as well as the cup and groove. When replacing the insert be certain that it snaps back in place, otherwise it may project in the cup and prevent the tube from being inserted the full depth of the cup. It is advisable to scribe a line on the pipe at a distance of the cup depth of the fitting plus 1″. This scribed line can then be used to check whether or not the pipe has been inserted the full depth. (See Fig. 6-10.)

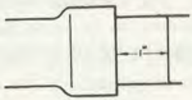


Figure 6-10

Heat and flow the alloy

The procedure for brazing fittings with an insert is similar to brazing a face fed fitting. However, it is necessary to exercise close control of the heat when brazing a preinserted ring fitting and the following precautions should be observed:

Do not overheat the pipe as this may cause it to overexpand outside of the cup and bend away from the insert inside the cup. This condition will impede the melting and flowing of the insert.

After the pipe has been properly preheated, a section of the band of the fitting (not exceeding 3″) should be heated. The torch flame should be applied to this area with a wiping motion from the back of the cup to the face of the fitting. When the insert begins to flow, the flame should be removed from the fitting. The heated segment will then contract and force the alloy through the joint area.

Overheating of the fitting will result in the loss of this squeezing action and make it more difficult to distribute the alloy throughout the joint.

If it appears that an area is being overheated it is advisable to move on to another segment and let the area in question cool down and rework it after other areas have been completed.

At times it may be necessary to use supplementary face feeding to prime a joint and start the alloy flowing or possibly to fill an area that the insert did not seal. Unfortunately, supplementary feeding of preinserted ring fittings has been abused and in extreme cases joints have resulted in which the insert was not melted and the joint was only sealed with a fillet. However, this is a quality control problem and it is our belief that supplementary feeding, used intelligently where required, will result in a higher percentage of sound, leak-tight joints.

Final cleaning and inspection

When the braze has been completed, the joint should be allowed to cool to at least 200° F. The flux can then be washed off with warm water and the joint examined visually. Any joint that has a complete ring of alloy between pipe and fitting can be considered satisfactory subject to a pressure test. Any fillets should be concave and of minimum practical dimensions.

Repair of joints

Unsatisfactory joints should be recleaned, fluxed and reworked. If there is just a small flaw in the braze then it may be feasible to rework just that portion of the joint. Should there be a large flaw or several small ones then it is usually advisable to rebraze the entire joint.

SECTION 7

SOME HELPS IN DOING A GOOD JOB THE EASY WAY

There is no need for making a hard job out of silver brazing. Furthermore, there is no need for turning out a high percentage of leaking joints that have to be made over.

The operation does have to be done right. A man should not be expected to go out on a job and do good work until he has learned, under supervision, what is expected of him. After he has demonstrated that he can do consistent work in the shop, and when he has an understanding of what is involved, then he is qualified to proceed on his own.

The following review of common difficulties may be of help in correcting faulty brazing habits. It is a repetition of the most important precautions to observe in order to stay out of trouble. All these points have been covered earlier in the book. As most experienced mechanics will testify, it pays to say some things twice.

What to do if the brazing alloy goes in the wrong direction

If the alloy runs down the pipe instead of flowing into the clearance gap, the pipe is probably hotter than the fitting. Also, the joint itself may not be clean and sufficiently well fluxed to draw the alloy into the gap.

Brazing alloy follows heat, and it will flow toward the hottest spot. However, this works only when the silver-brazing alloy actually wets the hot metal. If the metal is oxidized, alloy will ball up and be uncontrollable.

Another situation that may cause trouble is trying to fill too wide a gap. Grade 4 alloy does not have the bridging ability to flow well in a gap wider than 4 or 5 thousandths of an inch. If you have a joint with a sloppy fit and want to do a brazing job without expanding the tube, use Grade 5 alloy or Grade 3 if pipe is of nonferrous material.

The things to do when you fail to make the alloy flow the way you want it are these. First, let the joint cool. If you suspect a bad fit, oxide or dirty surfaces, heat the fitting again and disassemble the parts.

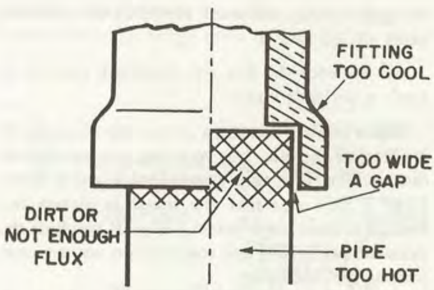


Figure 7-1 Some of the things that will make silver-brazing alloy flow the wrong way.

Fit them, clean them and flux them again. Brush flux around the joint after the parts are assembled. Now heat the pipe until the flux is clear and watery. Heat the fitting until the flux shows that it, too, is up to temperature. Now, feed alloy into the gap. Continue to heat the fitting, mostly near the base of the cup, to be sure that the silver-brazing alloy will travel to the end of the gap as you feed it in.

How to make the flux work right

Don't expect flux to clean a dirty metal surface. You have to take the hard scale off with abrasive paper, emery cloth or an acid dip. Oil and grease may be removed with a solvent if necessary. Then you have a clean metal surface. It is the job of the flux to protect it after that.

Oxidation, which corresponds to rusting of iron or steel, is like burning. Oxides are the ashes. Flux prevents this process during the heating of metal by keeping the air away. It also soaks up, like a blotter, the few oxides that may form.

When you think of flux as a blotter, it is easy to see why you need more of it on high-pressure joints that take longer to braze. Also, metals like copper-nickel and steel, which have a greater tendency to oxidize, take a thicker "blotting" coat of flux.

The way to use more flux is to keep the mixture thicker. To use a thin coat of flux, as on small sizes of copper tubing, add water to make a thin, flowing paste.

Always keep the flux and the brush you use to apply it perfectly clean.

While you are heating a joint, keep your eye on the state of the flux. It is your best temperature indicator. The clear, still, watery look it gets at about 1100° F tells you that the metal is almost hot enough to melt silver-brazing alloy. If you heat the parts too far beyond this temperature, you are only making the job harder.

Be sure to remove flux after you have finished brazing. Scrub it off with water around accessible joints. Flush out the insides of piping systems with water to take away the flux you cannot reach.

Timing: when to flux, when to heat, when to braze and when to clean

Brazing is a speedy operation. In fact, one of the worst things you can do is to make too long a job of it. It is a good idea to know what comes next at each step. Then you can pace your work to eliminate lost motion and to make each operation part of a routine.

The time to put on flux is right after a surface has been cleaned. When you have the metal surface in good shape, use flux to keep it that way. If the pipe or fitting was put aside and the flux has dried out by the time you are ready to heat it, put on more moist flux.

When you have the joint mated up, properly seated, completely fluxed and well supported, you are ready to start heating it with the torch. It is more important to know when to stop to avoid overheating.

As soon as the flux shows clear and quiet, you know that the metal underneath it is nearly hot enough to braze. Don't heat it beyond brazing temperature. Shift the torch flame from the pipe to the fitting and apply just enough heat to keep the alloy flowing.

Silver-brazing alloy will flow soon after the flux shows that the metal is hot enough. Start feeding

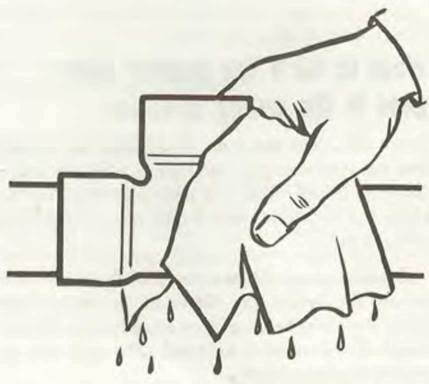


Figure 7-2 Get all the flux off after you finish a brazed joint.

alloy in right away, for there is nothing to be gained by keeping the joint hot and waiting. Work as rapidly as the alloy can be flowed in.

Take the torch flame away as soon as a fillet has been formed clear around the joint. Again, there is nothing to be gained by more heating.

Allow the joint to set. While the parts are still fairly hot is a good time to clean the flux off with a wet swab or with water and a stiff brush. If you wish, you may wait and scrub the flux off later, after the parts have cooled. The insides can be flushed later when the system is tested under water pressure.

In all this timing of your work, two points are most important. Apply flux immediately after cleaning, and don't heat any longer than necessary.

Setups for dimensional accuracy

Brazing is an assembly method that lets you work very accurately. When you cut off lengths of pipe or tubing, make them exactly the length you want—shoulder to shoulder—between fittings.

When we say "allow for expansion" because of the heat of brazing, we do not mean that the finished job will be different from the cut lengths. The pipe gets longer while you are heating it, but it shrinks down to size again when it cools to room temperature.

If you have a lot of assemblies to make to the same layout, set up dummy connections in the shop on the target floor. If the job is to be done aboard ship, locate all the fittings, equipment flanges, bulkhead sleeves, etc., that figure in lining up the assembly you have to make.

Bend the pipe or tubing in the usual way. Either template wire from the actual setup or measurements and piping plans can be used as a guide.

Figure out the order in which you want to make the joints. Most mechanics prefer to work from one end. The last joint to be made up will then be at—or near—the other end of the assembly. It may be helpful to cut the last piece of pipe after the rest of the assembly has been brazed. If you do this, put spacers between flange faces to take up the space

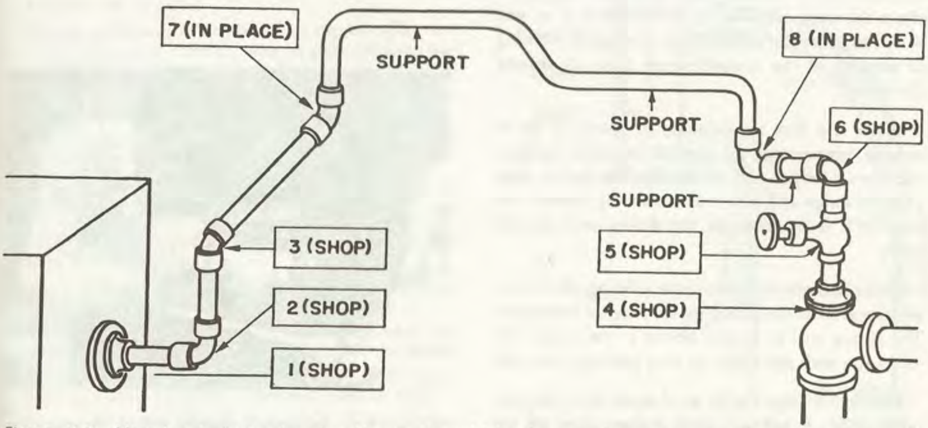


Figure 7-3 Here is a typical order of making up brazed joints for part of a piping system. You may work toward one end or toward an accessible fitting in the middle. It is often easier to make up small assemblies first at the bench.

that will be occupied by the gaskets while you are taking measurements. You will want to braze the second flange of each pair while they are temporarily bolted together in order to line up the holes.

Don't try to do any lineup work or accurate measuring while the pipe or fittings are hot. Let them cool to room-temperature length.

Keep a piping assembly well supported so that there are no strains on it while you work. See that permanent hangers are installed where they are needed after you finish.

How to take brazed piping apart

First, brush flux around the area of the fillet at the edge of the cup. Take any special precautions you would in brazing the particular kind of fitting you have—such as opening a valve, taking gaskets out, etc.

Put the pipe in a vise or find a way to hold it firmly. Heat the fitting as you would to braze it. Use the same size torch tip as you would for making the joint. Also, remember that you must allow just about the same amount of time to heat it as you would to make the brazed joint. Instead of working on sections of the circumference, heat all around the fitting.

When the flux shows that the metal is up to brazing temperature all around, continue to heat, and have a helper pull the fitting. Use hooks, bent wires or tongs and pull with a shaking motion. As soon as it is hot enough, the fitting will slip off easily.

Don't hammer or try to drive a fitting off. Silver-brazing alloy is too strong for that sort of treatment. The fitting will be ruined before it comes off. But when you melt the alloy, an easy pull does the job.

Pipe and fittings can be used again after they are taken apart. It helps to wipe molten alloy off the pipe and out of the cup before it sets. Then, wnen the parts are cool, start from the beginning and treat used pipe and fittings like entirely new material.

Testing brazed joints

For a quick test, apply air pressure to the line. Swab liquid soap around all the joints and look for bubbles. This will let you see any bad joints or—as may happen—any joints that have been fitted but not yet brazed.

A water-pressure test gives a more thorough indication. It helps get the flux out of the inside of the system. Also, if flux has sealed any pinhole leaks, water will dissolve it and find a way through. This may require from several hours to a day under test pressure.

After water testing, be sure to drain the line thoroughly before any electric welding is done on bulkhead and deck sleeves.

If you find a leak, drain the line before brazing. Flux the area around the leak. Heat the joint and flow in more alloy to seal the defective spot.

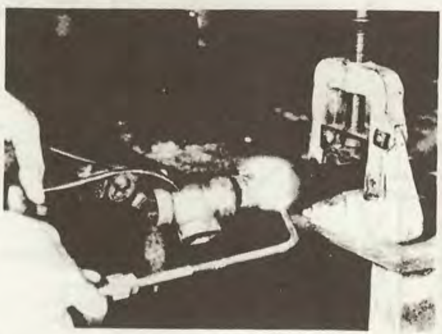


Figure 7-4 Shake and pull the fitting off when you have all the alloy up to flowing temperature.

SECTION 8

BRAZING TERMS AND WHAT THEY MEAN

Alloy: See "silver-brazing alloy."

Base of the cup: The deep end of the cup—near the shoulder. This part of a fitting is heated by directing a torch flame at the outside around the same general region as the interior shoulder of the cup.

Bore: The inside diameter of the cup on a fitting.

Brazing alloy: See "silver-brazing alloy."

Capillary action: Flow of a liquid when it is drawn into a small space between wet surfaces. In brazing, the liquid is molten silver-brazing alloy.

Cup: The accurately machined bore in a brazing fitting into which the pipe fits.

Face-fed: Describes the type of fitting which has no built-in supply of silver-brazing alloy. The necessary alloy is fed in from a strip or rod during the brazing operation.

Feed-in: See "face-fed."

Flexible extension: A length of soft copper tubing with fittings that adapt it for use with an acetylene torch tip—employed to position the tip as desired in close quarters.

Fillet: The small bead of alloy in the chamfer at the edge of the cup when a brazed joint is complete.

Flux: The preparation applied to metal surfaces for keeping them free of oxides during heating and brazing.

Gap: The space between the outside of the pipe and the inside of the cup. (If both are perfectly round, the gap will be one half the difference in diameters.) For lap seams and other types of joints, the gap is the clearance space to be filled with alloy.

Insert: A ring of silver-brazing alloy set into a machined groove in the cup of a fitting.

Oxide: The scale that forms on metal surfaces when they are exposed to air and, especially, when they are heated.

Oxidize: Of a metal—to combine chemically with oxygen, forming another composition which is called an oxide.

Pipe: Used in this book to mean I.P.S. pipe of various metals and also to include the thinner walled tubing used in silver-brazed piping systems.

Preinserted-ring type: Describes the kind of fittings that have inserts to supply silver-brazing alloy to their joints.

Reducing flame: An acetylene flame that has some extra gas in the mixture (contrasted with an oxidizing flame, which has extra oxygen in the mixture).

Shoulder: The machined ridge at the bottom or inner end of the cup, where the end of the pipe seats.

Silver-brazing alloy: Metal that contains silver in its composition, and which is designed especially for relatively low-temperature joining of metal parts such as pipe, tubing and fittings.

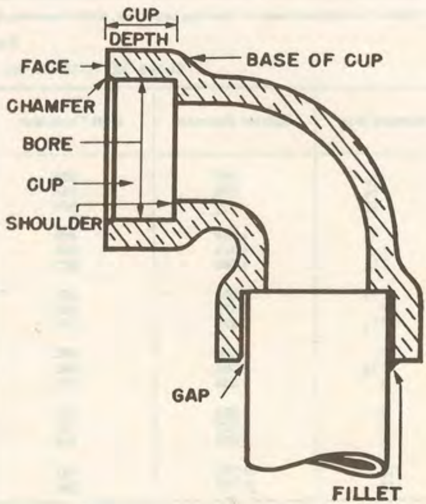


Figure 8-1

SECTION 9

TABLE I†
DIMENSIONS AND WEIGHTS, AND TOLERANCES IN DIAMETER AND WALL THICKNESS FOR COPPER THREADLESS PIPE (TP) SIZES

Standard Pipe Size, in.	Nominal Dimensions, in.			Cross-Sectional Area of Bore, sq. in.	Nominal Weight, lb. per ft.	Tolerances, in.	
	Outside Diameter	Inside Diameter	Wall Thickness			Average Outside Diameter,* all minus	Wall Thickness, plus and minus
¼	0.540	0.410	0.065	0.182	0.376	0.004	0.0035
⅜	0.675	0.545	0.065	0.333	0.483	0.004	0.004
½	0.840	0.710	0.065	0.396	0.613	0.005	0.004
¾	1.050	0.920	0.065	0.665	0.780	0.005	0.004
1	1.315	1.185	0.065	1.10	0.989	0.005	0.004
1 ¼	1.600	1.530	0.065	1.84	1.26	0.006	0.004
1 ½	1.900	1.770	0.065	2.46	1.45	0.006	0.004
2	2.375	2.245	0.065	3.96	1.83	0.007	0.006
2 ½	2.875	2.745	0.065	5.92	2.22	0.007	0.005
3	3.500	3.334	0.083	8.73	3.45	0.008	0.007
3 ½	4.000	3.810	0.095	11.4	4.52	0.008	0.007
4	4.500	4.286	0.107	14.4	5.72	0.010	0.009
5	5.562	5.298	0.132	22.0	8.73	0.012	0.010
6	6.625	6.309	0.158	31.3	12.4	0.014	0.010
8	8.625	8.215	0.205	53.0	21.0	0.018	0.014
10	10.750	10.238	0.256	32.2	32.7	0.018	0.016
12	12.750	12.124	0.313	115	47.4	0.018	0.020

* The average outside diameter of a tube is the average of the maximum and minimum outside diameters, as determined at any one cross-section of the tube.

† "Table I, 'Standard Specification for Threadless Copper Pipe', ASTM Designation: B 302 " reprinted with permission of the American Society for Testing and Materials.

TABLE II
CLASS 200 70-30 CU. NI. TUBE MIL-T-16420 (SHIPS)

Nominal Size	Outside Diameter	Wall Thickness	Weight per Foot Calculated	Weight per Foot (Max.)*	Outside Diameter Tolerance all Minus
¼	.540	.065	.376	.414	.005
⅜	.675	.065	.483	.531	.005
½	.840	.065	.613	.674	.006
¾	1.050	.065	.779	.857	.006
1	1.315	.065	.989	1.09	.008
1 ¼	1.660	.072	1.39	1.53	.008
1 ½	1.900	.072	1.60	1.76	.008
2	2.375	.083	2.32	2.55	.010
2 ½	2.875	.083	2.82	3.10	.010
3	3.500	.095	3.94	4.33	.012
3 ½	4.000	.095	4.51	4.96	.012
4	4.500	.109	5.83	6.41	.015
5	5.563	.125	8.28	9.11	.017
6	6.625	.134	16.60	11.70	.020
8	8.625	.148	15.30	16.80	.026
10	10.750	.187	24.00	26.90	.030
12	12.750	.250	38.00	41.80	.035

* Includes 10% overweight allowance per foot of individual tube.

Note: Copper and brass pipe must be of the proper O.D. for silver braze fittings.