AIR FORCE
QUALIFICATION TRAINING PACKAGE (AFQTP)

FOR

HEATING, VENTILATION, AIR CONDITIONING/REFRIGERATION (HVAC/R) (3E1X1)

MODULE 12

PIPING/TUBING

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MODULE 12

PIPING/TUBING

Career Field Education and Training Plan (CFETP) references from 1 July 2002 version.

OPR: HQ AFCESA/CEOF
(SMSgt Dan Sacks)
Supersedes AFQTP 3E1X1-12, 30 Jun 00

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Pages: 28/Distribution F

AIR FORCE QUALIFICATION TRAINING PACKAGES
FOR
HEATING, VENTILATION, AIR CONDITIONING/REFRIGERATION (HVAC/R)
(3E1X1)

INTRODUCTION

Before starting this AFQTP, refer to and read the **"**AFQTP TRAINER/TRAINEE GUIDE**."**

AFQTPs are mandatory and must be completed to fulfill task knowledge requirements on core and diamond tasks for upgrade training. ***It is important for the trainer and trainee to understand*** that an AFQTP ***does not*** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks*.*

MANDATORY minimum upgrade requirements:

Core task:
AFQTP completion
Hands-on certification

Diamond task:
AFQTP completion
CerTest completion (80% minimum to pass)

Note: *Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location*.

Put this package to use. Subject matter experts, under the direction and guidance of HQ AFCESA/CEOF, revised this AFQTP. If you have any recommendations for improving this document, please contact the HVAC/R Career Field Manager at the address below.

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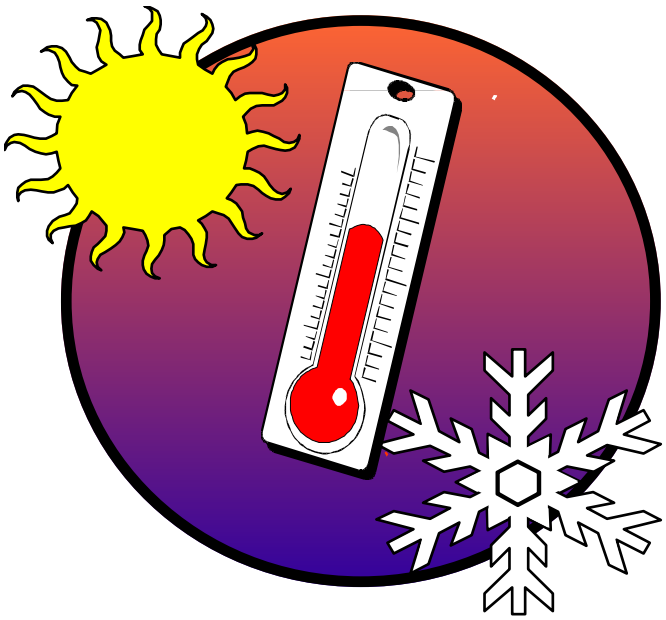
Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.



PIPING SYSTEMS FABRICATION

MODULE 12 AFQTP UNIT 4

FABRICATE PIPING AND TUBING SYSTEMS (12.4.1.)

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

FABRICATE PIPING AND TUBING SYSTEMS

Task Training Guide

STS Reference Number/Title:	12.4.1. - Fabricate Piping and Tubing System.
Training References:	1. Technical Order (TO) 34W4-1-5, *Operator's Manual, Welding Theory and Application.* 2. TO 34W4-1-8, *Use of Welding, Brazing, and Silver Soldering Electrodes, Rods, and Wire.* 3. CerTest Video # 802830, *Pipe and Pipe Fitting*. 4. Career Development Course (CDC) HVAC/R Journeyman 3E151D, Volume 2, Unit 2, Sections 2-1, *Steel Piping Applications* and 2-2, *Copper Tubing Applications*.
Prerequisites:	1. **Possess as a minimum a 3E131 AFSC** 2. **Review the following references:** 2.1. TOs 34W4-1-5 & -8. 2.2. CerTest Video # 802830. 2.3. CDC HVAC/R Journeyman 3E151D, Volume 2, Unit 2, Sections 2-1 and 2-2. 3. **Complete AFQTP Module 3E1X1-13, 13 Dec 02*: Welding & Cutting.***
Equipment/Tools Required:	1. Gloves. 2. One table vise. 3. Tape measure. 4. Pencil. 5. Two Acid Brushes. 6. Two 10" pipe wrenches. 7. Fine tooth hacksaw, or pipe cutter. 8. Pipe threader. 9. Rags. 10. Steel brush. 11. Metal file. 12. Pipe compound. 13. Oxyacetylene rig. 14. ½" Mechanical Tubing Bender. 15. Tubing Cutter. 16. Two Adjustable Wrenches. 17. Fine Sand Paper or Emory Cloth. 18. Piping System Material (Table 4-1). 19. Tubing System Material (Table 4-2).
Learning Objective:	Safely fabricate piping and tubing systems.
Samples of Behavior:	Trainee will safely fabricate a watertight piping and tubing system to within ½" of specification.
Notes:	
1. To successfully complete this portion of the element follow the steps outlined. 2. Trainer must insure that trainee has read all the material, that trainee followed all outlined procedures, and that trainee's system is water tight and within ½" of specification listed. 3. Any safety violation is an automatic failure.	

FABRICATE PIPING AND TUBING SYSTEMS

1. Background. Throughout your career as an HVAC/R mechanic you will be tasked with installing different types of piping systems. Different types of pipes, tubing, and their associated fittings are used in the installation of an HVAC/R system. Each type of pipe, tubing or fitting is used for a specific purpose depending on the installation and its requirements. Some pipes, tubing, or fittings are made in different weights and strengths for use in gravity or pressure systems. Many materials are available for use in installing permanent HVAC/R systems. Among those commonly used are iron, steel, PVC (Polyvinyl Chloride), and copper.

2. Fabricate Piping System.

2.1. Types of Pipe.

2.1.1. Black iron pipe is most commonly used in the HVAC/R field. It is used for compressed gasses (air, gaseous fuels), steam, condensate returns, and oil. It is not recommended for sewer lines due to rust and stoppage.

2.1.2. A second type of pipe is galvanized or coated pipe. Galvanized pipe is black iron that has been dipped in a zinc bath solution. It is used for hot or cold water lines. It is not normally used for natural gas lines due to flaking action of the zinc coating.

2.1.3. A third type of pipe is PVC pipe. This type of pipe is used for chilled water, wastewater, low-temp hot water, and many other low pressure, low temp applications.

2.2. Sizes of Pipe. HVAC/R systems use pipe ranging from $^{1}/_{8}$" up to 12" (diameter). The most common sizes are: $^{3}/_{8}$" to 2". The average length of each piece of pipe furnished to the Air Force is 21 feet. Pipe size is usually determined by the inside diameter (ID) of the pipe.

2.3. Classes of Pipe. There are three classes of pipe used in HVAC/R systems. They are:

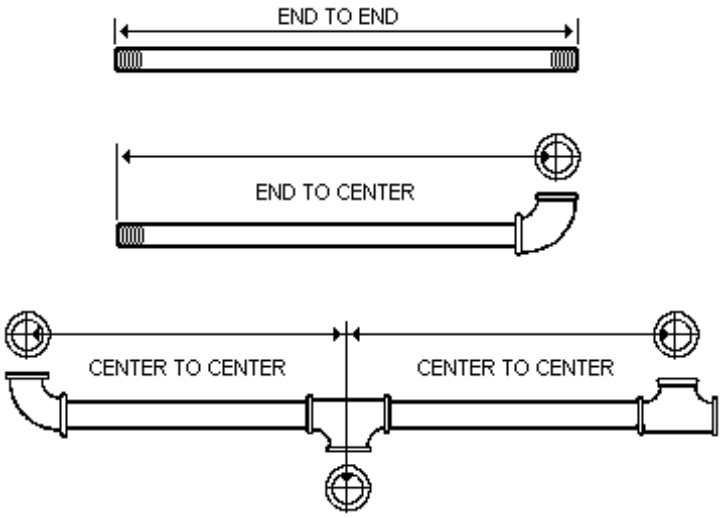
2.3.1. Standard weight. (125 psi)

2.3.2. Extra strength. (250 psi)

2.3.3. Double extra strength. (600 psi)

2.4. Measuring Piping and Tubing. There are several different methods of measuring steel piping and tubing. Among these are end-to-end measurements, center-to-center measurements, and end-to-center measurements, as indicated in Figure 4-1.

Figure 4-1. Measuring Steel Piping and Tubing.



2.4.1. End-to-End. End-to-end measurement is measuring from one end of pipe to the other end including the threads.

2.4.2. End-to-Center. End-to-center measurements are used when a pipe has a fitting screwed on one end only.

2.4.3. Center-to-Center. Center-to-center measurement is from the center of the outlet on one end along the pipe, to the center of the outlet on the other end. You must always remember, the length of the thread on the pipe and the center measurement of the fittings to be used must be considered when determining the length to cut a pipe.

2.5. Teflon. When wrapping Teflon take the pipe threads away from you in your left hand. With your right hand, take the Teflon roll and feed a little off. Set the Teflon on the pipe leaving one to two threads clear and run the roll around the pipe. If you hold the roll so that the tape is coming off the bottom of the roll, the tape will stay tight as you wrap.

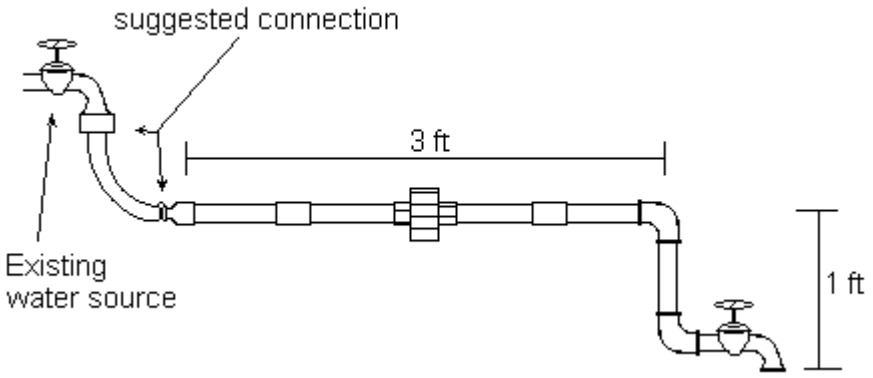
NOTE TO TRAINER/CERTIFIER:

If a piping project is not available, the minimum requirement for task certification is the following: the trainee is required to fabricate the pipe system shown in Figure 4-2 in a suitable amount of time dictated by the trainer. The trainee will use the materials listed in Table 4-1 and the diagram provided to construct his/her system. The size of pipe may be changed to meet local limitations in materials, but the number or type of pipefitting used may not be changed. The hose and hose fittings may be of any length or type necessary to attach to an existing water source for the purpose of testing the integrity of the connections. Teflon tape may also be substituted for pipe dope. It is incumbent on the trainee to acquire the necessary materials to complete the task, and upon the trainer/certifier to insure they are available.

Table 4-1. Material List.

QUANTITY	NOMENCLATURE
1 ea	4’ section of 1” Pipe (black iron or galvanized)
1 ea	1” Union (must match pipe)
2 ea	90^0 1” Elbows (must match pipe)
2 ea	1” Coupling (must match pipe)
1 ea	1” Gate Valve
Suggested Method to Pressure Check System	
1 ea	1’ to ½” Bell Reducer
1 ea	¾” Hose Clamp
1 ea	2’ section of ¾” Hose with female hose end

Figure 4-2. Piping System Diagram.



2.6. Piping System Procedures. Follow these steps to fabricate a piping system:

Step 1: Measure and cut the pipe.

Step 2: Then inspect the threads to determine that they are clean and properly cut.

Step 3: Thread the cut ends.

Step 4: Clean the excess oil and burrs from the threads.

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

Step 5: Coat the male threads of the pipe evenly with pipe-joint compound or, if this is not available, anti seize (Teflon) tape may be used.

Step 6: Be sure to leave the first two threads clean.

Step 7: Start the fitting on the male thread of the pipe by hand, exercising care not to cross the threads.

Step 8: Apply a pipe wrench to the fitting and adjust for a snug fit. The pipe wrench should be placed on the shoulder of the fitting that is on the end of the fitting being connected. If the wrench is applied to any other part of the fitting, distortion of the fitting may be caused and result in a leaking joint.

Step 9: Attach the elbows to the system as they appear in the Figure 4-2.

Step 10: Attach valve and tighten.

Step 11: Attach hose to system and water.

Step 12: Turn on water.

Step 13: Mark any leaks.

Step 14: Repair leaks.

Step 15: Retest and repair as needed.

Step 16: Clean work area.

2.7. Leak Testing Piping System. Once the piping system is assembled, it should be checked for leaks.

2.7.1. Piping systems, for the purpose of conveying water or oil, can be leak checked simply by putting water or oil pressure in the system and observing the connections for leakage.

2.7.2. Piping for the conveyance of natural or LP gas should be leak checked by the application of a soap solution on the connections. A leak will then be detected by the appearance of soap bubbles at the site of the leak.

3. Fabricate Tubing System.

3.1. Measure Tubing. Copper tubing is measured in length the same as steel or black iron pipe: end-to-end when no fittings are used; end-to-center when one fitting is used; and center-to-center when a fitting is used on both ends. Unlike steel or black iron pipe, the diameter is usually measured by outside diameter (OD). What makes a connection a perfectly airtight and watertight joint? One prime step is the correct preparation of the tubing.

3.2. Bend Tubing. Soft drawn copper tubing can be formed into desired bends where necessary to change direction of the tubing. If care is taken, copper tubing may be bent by hand, but the slightest excess pressure at one particular point will result in a flattened or kinked tube, rendering it useless.

3.2.1. Hard tubing requires annealing (softening) the portions to be bent. Annealing is accomplished by heating that portion of the tubing, with a torch, until it turns red. Applying cold water soaked rags to the heated portion helps the annealing and cools the tubing quickly.

3.2.2. Some of the methods used to bend tubing are a bending block (Figure 4-3) and filling the tube with sand (never use the sand method on Refrigeration tubing), bending the sand filled tube by hand (Figure 4-4). The two most common methods are the spring bender and the mechanical tube bender.

Figure 4-3. Bending Block.

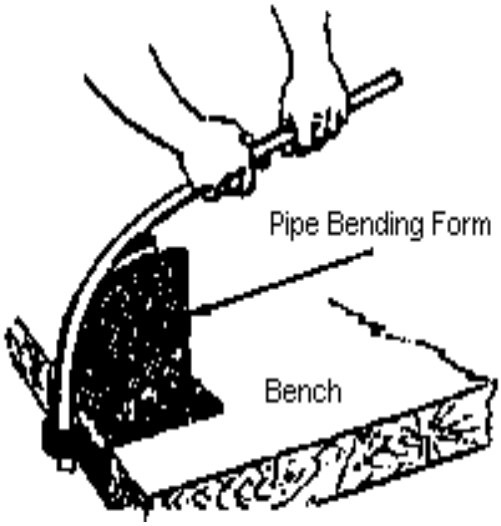
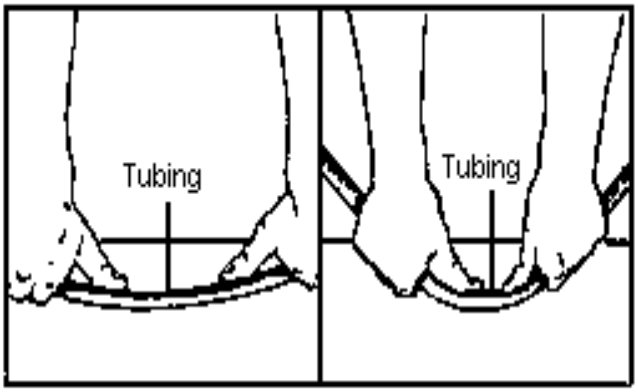


Figure 4-4. Sand Filled Tubing.



3.2.3. Spring Bender. Place the correct size flexible bending spring over the tubing and gradually form it with the thumbs at the same time pressing the tubing against a table or flat surface (Figure 4-5).

Figure 4-5. Spring Bender.

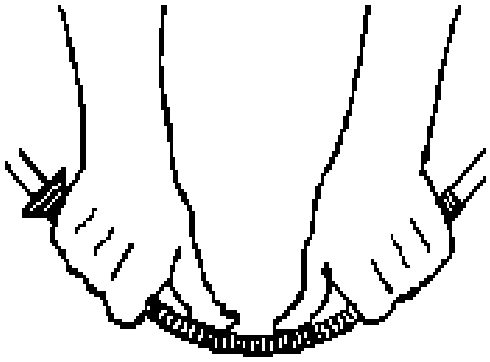
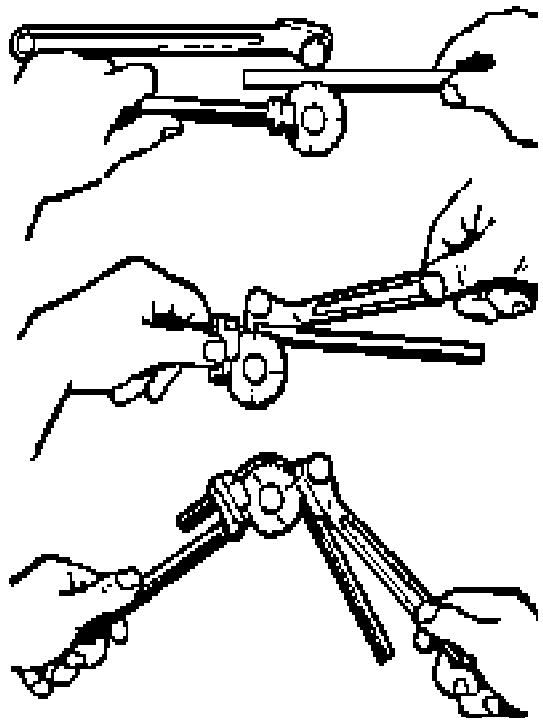


Figure 4-6. Mechanical Bender.

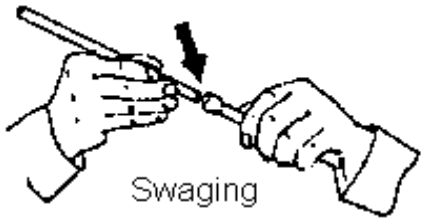


3.2.4. Mechanical Tube Bender. Mechanical tube benders are considered the most practical way to bend copper tubing. They are made in many sizes and designs. Figure 4-6 illustrates a tube bender and the steps used in bending tubing. When placing the tubing in the bender, raise the right handle of the bender as far as it will go so that it rests in a horizontal position. Raise the clip and drop the tubing in the space between the handle slide block and the bending form. (Drop clip over the tube and turn handle slide bar around the pin and press to the right.) Note that the ZERO mark on bending form will line up with the mark on the slide bar. Proceed to bend to the desired angle.

3.3. Connect Tubing. They are four ways of connecting tubing: swaging, flaring, ferrule, and soft soldering.

3.3.1. Swaging. Swaging is the process by which the end of the one piece of tubing is stretched or expanded so that the end of another piece of tubing of the same size will fit into it (Figure 4-7). The joint will then be sealed by soldering or brazing. The swag eliminates the need for a coupling. Swaging can be used in close places where there is not room for fittings. A good swage connection will reduce the possibilities of leaks.

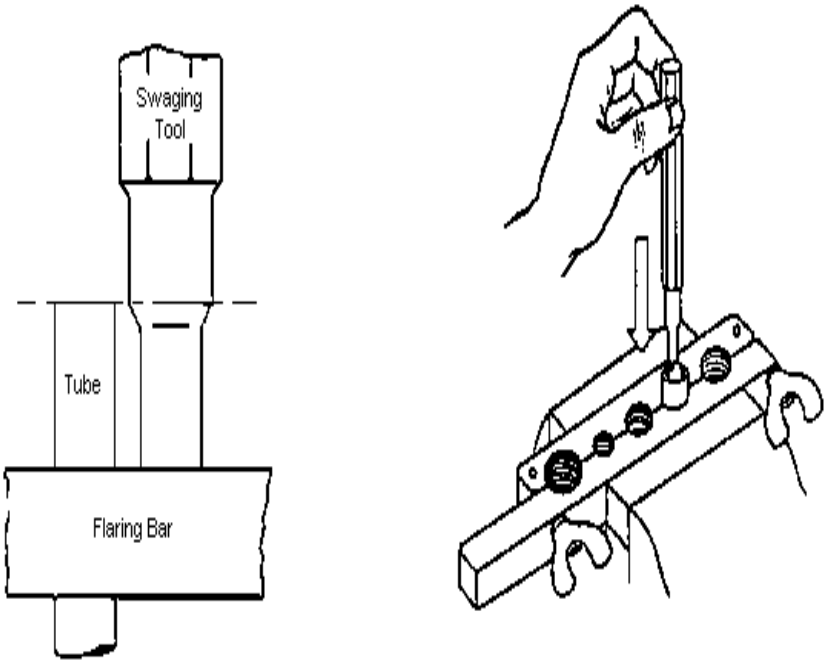
Figure 4-7. Swaging.



3.3.1.1. Two types of swaging kits are the standard and the universal swaging kits.

3.3.1.1.1. Standard Kit. The standard swaging kit consists of a swaging punch and a swaging block, as illustrated in Figure 4-8. The swaging punch has a small portion (called a pilot) which fits easily into the inside of the tubing, and a tapered lead which connects this pilot with an enlarged portion which is slightly larger than the outside diameter of the tube.

Figure 4-8. Standard Kit.



3.3.1.1.2. Universal Kit. The universal swaging kit consists of a conventional flaring block, swaging spreader and yoke (Figure 4-9). Swaging with the universal kit should be accomplished as follows:

3.3.1.1.2.1. Place tubing in a conventional flaring block and extend above the face of the flaring block approximately $^{1}/_{8}$" more than the diameter of the tube you are swaging. (Example: $^{3}/_{8}$" tubing + $^{1}/_{8}$" = $^{4}/_{8}$" or $^{1}/_{2}$").

3.3.1.1.2.2. Tighten the flaring block down to prevent tubing from slipping. (Slippage will cause damage to tubing and swaging spreader.)

3.3.1.1.2.3. Select the proper sized swaging spreader and screw into the yoke screw. (Example: $^{3}/_{8}$" swaging spreader for $^{3}/_{8}$" tubing.)

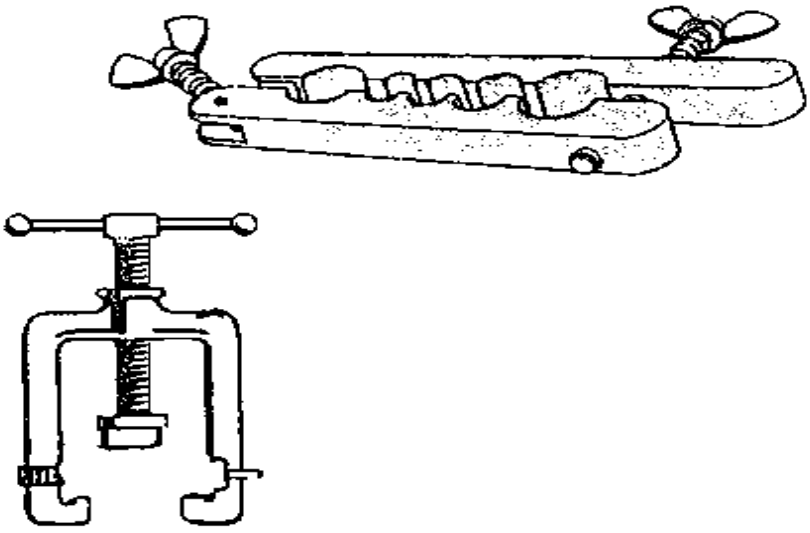
HINT:

The small spreader takes care of three sizes, $^{3}/_{16}$", $^{1}/_{4}$", and $^{3}/_{8}$" O.D. tubing. There is a separate spreader for every other size. Slip yoke over the bar and turn in a clockwise direction so that it hooks the bar.

3.3.1.1.2.4. Screw the spreader into the tubing (making sure to center it) until it gets to the point where the top of the upper shoulder on the spreader is bearing on the tube.

3.3.1.1.2.5. Hold the yoke so it will not twist off the bar as you unscrew the spreader from the tube.

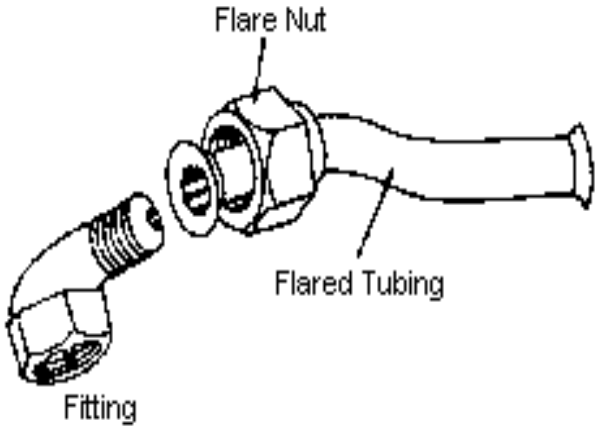
Figure 4-9. Universal Kit.



3.3.2. Flaring. An easy and satisfactory method of joining copper tubing is done by flaring the ends of the tubing and pressing the flared end against the tapered surface in the fittings and then screwing the flare nut tight over the end of the fitting (Figure 4-10).

3.3.2.1. An advantage of this type of fitting is that it is easily disassembled. This means, by using the correct size wrench, you simply unscrew the flare nut that makes up the flare-type connection, a simplified operation when it is necessary to make repairs.

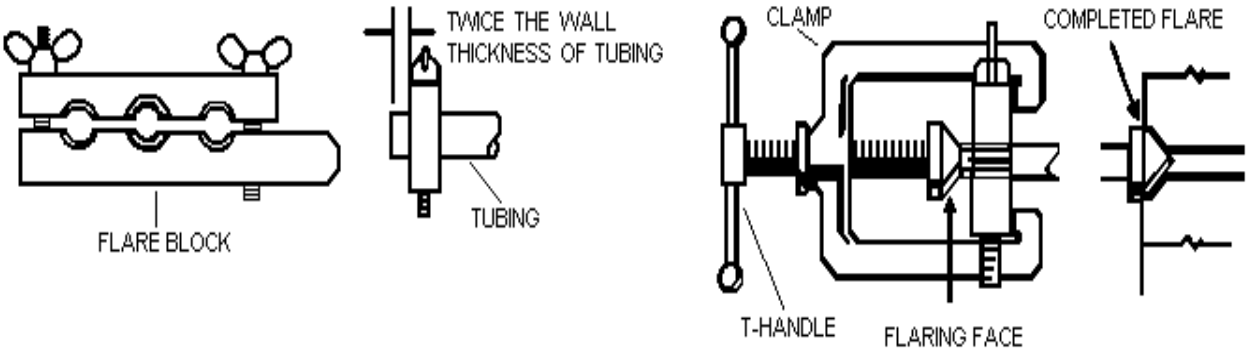
Figure 4-10. Flaring.



3.3.2.2. To prepare the flare (Figure 4-11), insert the end of the tubing into the correct size hole in the flaring block and extend the end of the tubing above the face of the block double the wall thickness of the tubing. This allows enough tubing to spread over the surface of the taper on the fitting. The clamp is then attached to the flaring block and the cone is centered over the end of the tubing. The cone is then screwed into the center of the tubing by rotating the handle on the clamp clockwise. The tubing is then expanded just enough to fit into the flare nut and over the end of the fitting.

HINT:
Remember to install the flare nut before flaring the tubing.

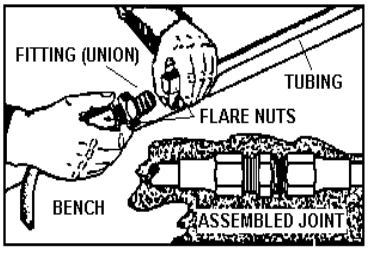
Figure 4-11. Flare Type Connections.



3.3.2.3. After flared the tubing, putting the joint together is very simple. Slip the flare nut up against the flare and then screw the nut into the flare fitting, as shown in Figure 4-12. Use two wrenches to tighten or loosen the joint. Make sure that your wrenches fit snugly to avoid damaging the fittings. Do not use tools that will mar or scar the fittings. It is not necessary to exert excessive pressure when tightening the fittings because copper and brass are soft and contain a certain amount of lubricant that helps to seal them when a minimum amount of pressure is applied. A properly flared copper connection will withstand up to 3000 psi. A cross section view of a flared fitting is shown in Figure 4-13.

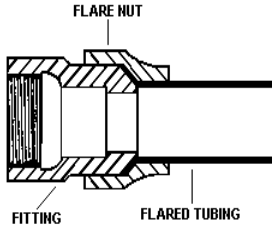
3.3.2.4. When installing a piping system using copper tube, there are many different types of flare fittings to choose from. Select any combination that fits the job. Figure 4-13 shows a typical copper fitting that is available to use.

Figure 4-12. Parts and Assembled Joint.



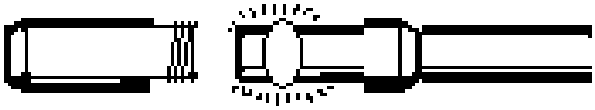
PARTS AND ASSEMBLED JOINT

Figure 4-13. Copper Fitting.



3.3.3. Ferrule (Compression). Compression connections have three parts: The fitting, the nut, and the brass ferrule sleeve (Figure 4-14). To make this type of connection, cut the copper tubing to the correct length. Next, ream the inside of the tubing to remove the burr. Slip the nut on the tubing first, then the ferrule. Next, slide the end of the tubing into the fitting, and slide the ferrule up against the fitting. Screw the nut onto the fitting. Use a wrench to finish tightening the nut on the fitting. Tightening the nut squeezes the ferrule into the tubing and against the fitting. This makes a watertight and airtight seal. As with flared connections, use two wrenches when assembling ferruled connections to protect the tubing from damage and prevent leaks.

Figure 4-14. Ferruled Connections.



3.3.4. Soft Solder. The previous methods of copper connection are known as mechanical joints. The last method we will look at is soldering (sweat) connection. Soldering of copper connections is done by a process commonly refer to as soft soldering which requires a temperature of around $350^0 – 550^0$ F. Soft soldering joins two metals together by allowing the molten solder to run between the copper and fitting. The law of capillary attraction governs the force responsible for the bonding in solder joints. Joint preparation and the soldering process is covered in Module 3E1X1-13, 13 Dec 03, *Braze and Solder*.

NOTE TO TRAINER/CERTIFIER:

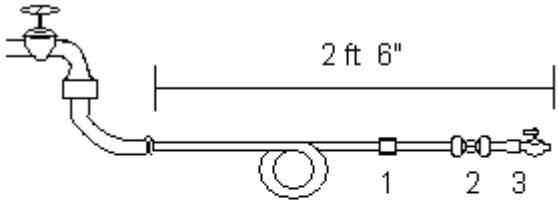
If a tubing project is not available, the minimum requirement for task certification is the following: the trainee is required to fabricate the tubing system shown in Figure 4-15 in a suitable amount of time dictated by the trainer. The trainee will use the materials listed in Table 4-2 and the diagram provided to construct his/her system. The size of tubing may be changed to meet local limitations in materials, but the number or type of fittings used may not be changed. The hose and hose fittings may be of any length or type necessary to attach to an existing water source for the purpose of testing the integrity of the connections. It is incumbent on the trainee to acquire the necessary materials to complete the task, and upon the trainer/certifier to insure they are available.

Table 4-2. Material List.

QUANTITY	NOMENCLATURE
1 jar	Silver Soldier Flux
1 roll	Silver Solder
3 ft	½" Flexible Copper Tubing
1 ea	½" Compression Coupling
1 ea	Flaring/Swaging Kit
1 ea	Flare Union
2 ea	Female Flare Fittings
1 ea	½" ¼ Turn Stop Valve Sweat Type
Suggested Method to Pressure Check System	
1 ea	1' Section of ¾" tubing
1 ea	¾" Hose Clamp
1 ea	¾" to ½" Reducer
2 ft	Section of ¾" hose with female hose end.

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

Figure 4-15. Tubing System Diagram:



1 Compression coupling

2 Flare coupling

3 Swage fit 1/4 turn valve

3.4. Tubing System Procedures. Follow these steps to fabricate a tubing system:

Step 1: Cut tubing to required length:

1.1. One 6”.

1.2. One 9”.

1.3. One the trainee measures to fit.

Step 2: Ream cut to clean burs and return copper to true round.

Step 3: Use Emory cloth to properly clean ends.

NOTE:
Remember to allow $^{1}/_{8}$” to $^{1}/_{4}$" extra on any piece that will be flared.

Step 4: Flare one end of the 6” and 9” pieces.

Step 5: On the long end mark the center and use mechanical bender to put the loop there.

Step 6: Slide compression cap on one end of long piece.

Step 7: Slide ferrule on same piece attach to compression union.

Step 8: On 9” piece slide compression cap then ferrule.

Step 9: Attach 9” piece to compression coupling and tighten.

Step 10: Slide flare cap down 6” piece and attach to flare union.

Step 11: Swag the other end of the 6” piece.

Step 12: Disassemble valve.

Step 13: Flux end of the valve.

Step 14: Insert end of valve into swage.

Step 15: Insert whole system into table vise.

Step 16: Don appropriate safety gear.

Step 17: Set pressures on oxy-acetylene rig.

Step 18: Wrap the valve and the flare with damp rags.

Step 19: Light the torches.

Step 20: Solder the joint.

Step 21: Properly shut down the torch.

Step 22: Clean the joint.

Step 23: Rebuild the valve and tighten.

Step 24: Attach end of hose without the female spigot attachment to the copper tubing with the pipe clamp.

Step 25: Attach female spigot end to the spigot.

Step 26: Turn on water spigot.

Step 27: Make note of any leaks in system (if any).

Step 28: Disconnect from spigot and drain.

Step 29: Make any repairs as needed.

Step 30: Repeat as needed until system pressurizes without leaking.

Step 31: Clean the work area.

REVIEW QUESTIONS
FOR
FABRICATE PIPING AND TUBING SYSTEMS

QUESTION	ANSWER
1. What are the three classes of pipe used in HVAC/R systems?	a. Standard weight (125 psi), Extra strength (250 psi), Double extra strength (600 psi). b. Standard weight (225 psi), Extra strength (350 psi), Double extra strength (800 psi). c. Standard weight (25 psi), Extra strength (125 psi), Double extra strength (400 psi).
2. How is pipe measured?	a. End to End. b. End to Center. c. All of the above. d. None of the above.
3. To flare the tubing how much is extended past the flaring block?	a. ¼". b. A nickels width. c. Wall thickness. d. Two times wall thickness.
4. What is swaging?	a. Tubing type. b. Stretching tubing. c. An educated guess. d. A method for creating tubing.

FEEDBACK: Trainer/Certifier should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer/certifier.

FABRICATE PIPING AND TUBING SYSTEMS

PERFORMANCE CHECKLIST

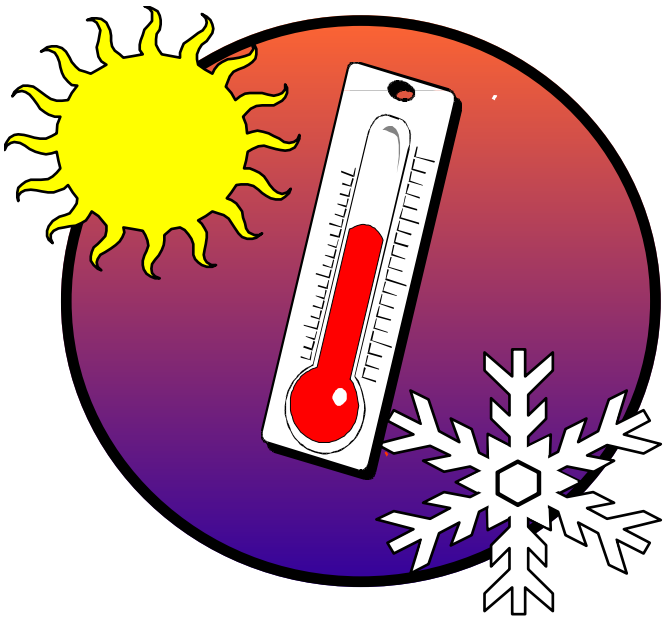
INSTRUCTIONS:

The trainee must satisfactorily perform all parts of the task without assistance. Evaluate the trainee's performance using this checklist.

DID THE TRAINEE…	YES	NO
Fabricate Piping System		
1. cut pipe to required length?		
2. thread pipe correctly?		
3. clean excess oil from threads?		
4. use brush to remove metal filings?		
5. correctly applied pipe dope or Teflon tape?		
6. use backup wrench to tighten fitting?		
7. remove excess pipe dope with rag (if used)?		
8. piping system measure length wise 2' 11 ½" to 3' ½ " from end to mid first elbow?		
9. piping system measure height wise 11 ½" to 1' ½" from bottom of valve opening to mid elbow?		
10. valve run straight up and down/ handle parallel to ground?		
11. vertical leg run 90° to ground and horizontal?		
12. on FIRST attempt make water tight connections?		
13. meet time requirement?		
14. require ANY assistance from trainer/certifier?		
15. clean up work area?		
16. finish product have a professional appearance?		
17. comply with all safety requirements?		
Fabricate Tubing System		
1. cut tubing to required length?		
2. use reamer on cutter to clean burs and return copper to true round?		
3. use Emory cloth to properly clean ends?		
4. flare seated properly in flare nut?		
5. use back up wrench to properly secure joint?		
6. insure the swage was not warped, too deep, too shallow?		
7. set correct welding pressures on ox-acetylene rig?		
8. correctly fluxed valve?		
9. disassemble valve prior to soldering?		
10. use wet rags to heat sink valve?		
11. warp valve seat?		
12. clean excess solder from fitting?		
13. use mechanical bender correctly?		
14. create a nice continuous loop?		
15. insure tubing was straight with neither valve nor loop askew?		

FABRICATE PIPING AND TUBING SYSTEMS (CONTINUED)

DID THE TRAINEE…	YES	NO
16. on FIRST attempt make water tight connections?		
17. meet time requirement?		
18. require ANY assistance from trainer/certifier?		
19. clean up work area?		
20. finish product have a professional appearance		
21. comply with all safety requirements?		



PIPING SYSTEMS FABRICATION

MODULE 12 AFQTP UNIT 4

INSTALL PIPING AND TUBING SYSTEMS (12.4.2.)

INSTALL PIPING AND TUBING SYSTEMS

Task Training Guide

STS Reference Number/Title:	12.4.2., Install Piping and Tubing Systems
Training References:	1. Technical Order (TO) 34W4-1-5, *Operator's Manual, Welding Theory and Application.* 2. TO 34W4-1-8, *Use of Welding, Brazing, and Silver Soldering Electrodes, Rods, and Wire.* 3. Career Development Course (CDC) HVAC/R Journeyman 3E151D, Volume 2, Unit 1, Section 1-2; *Protection of Potable Water Supplies*.
Prerequisites:	1. **Possess a minimum of a 3E1X1 AFSC.** 2. **Review the following references:** 2.1. TOs 34W4-1-5 & -8. 2.2. CDC HVAC/R Journeyman 3E151D, Volume 2, Unit 1, Section 1-2. 3. **Successful completion of AFQTP Module 3E1X1-12, Unit 2; *Fabricate Piping and Tubing Systems*.**
Equipment/Tools Required:	1. Oxyacetylene Rig. 2. One Roll Silver Solder. 3. One Acid Brush. 4. One jar silver soldier flux. 5. 3' of ½" flexible copper tubing. 6. Two ½" compression to thread union. 7. One flaring/swaging kit. 8. One flare union. 9. Two flare caps. 10. Fine sand paper or Emory cloth. 11. One tubing cutter. 12. Wet rags. 13. One 3' x 1' Piece of ¾" plywood. 14. Two metal angles 4" x 4". 15. Wood screws. 16. Drill. 17. Two adjustable wrenches. 18. Gloves.
Learning Objective:	The trainee will know the steps required to safely install piping and tubing systems.
Samples of Behavior:	Trainee will safely install tubing system.
Notes:	
1. To successfully complete this element follow the steps outlined in the applicable technical manual, manufactures manual or local procedures. 2. Trainer must develop a training scenario based on local applications of piping and tubing systems to validate ability of trainee to meet the learning objective and samples of behavior. 3. Any safety violation is an automatic failure.	

INSTALL PIPING AND TUBING SYSTEMS

1. Background. Now that you've had the opportunity to be a little creative you should be feeling pretty good. The question though is not one of "can you create" but rather can you create to fit, function, last, and look professional? In this section we'll test your ability to do just that. Anyone can take something and "make it work" for the short term, but few can produce a truly professional product, our goal here.

2. Fit. Your tubing system should fit, without excessive twists and turns, into the space designated for it. It should not be 3" too long with a bow in it to make it work. Neither should it have extra pieces scabbed onto it to "make up" the difference. All soldered joints should be clean and neat, without a lot of solder pooled up on one edged or running down the tubing. Pipe joints should be tight and clean without an excess of pipe dope oozing out of the joint. The tubing should be the same size throughout the installation with only those joints necessary to fill the function of the instillation.

3. Function. The tubing or piping system should perform the job it was intended for, THE FIRST TIME. Vertical runs should be properly supported and insulated.

3.1. Modifications. Mixing metals is never a good idea, but in those instances where the technician has no choice the technician must insure that some form of galvanic protection is afforded the system. This eliminates the extremely corrosive effects of mixing metals. Without this union the more ferrous metal would rust away to nothing in a very short time. The same problem exists when adding new pipe to an existing older installation. Even though the pipe is the same type, the newer pipe has different electrical properties than the old pipe, causing it to act as an anode in a cathodic system. The new pipe would give up its electrons to the older pipe and rust away to nothing in a very short time. Anytime a vertical leg is lifted from a buried pipe a dielectric union must be used. This isolates the leg feeding the building or system from the ground circuit and keeps the galvanic protection on the ground circuit from discharging to the building electrical system and corroding the ground pipe.

3.2. Support. On new installations mixed metals is not a problem. But support can be. These installations require the technician to take the time to properly plan the job. Vertical runs must be properly supported. Vertical runs of pipe without support place extreme weight on the horizontal legs causing them to slowly warp and break. With tubing supporting vertical legs is critical. The tubing, a much weaker metal, can work harden and break as it becomes more and more brittle. Table 4-3 (derived from table 3-2 of the 2000 Uniform Plumbing Code) provides data for generic support. For new installations check with your engineering section for the correct spacing for your application and the correct hanger for the supporting material and the application. To prevent work hardening or holes from rubbing, the pipe or tubing must be tight in the support with rubber or some other cushioning material between the support and the pipe.

Table 4-3. Pipe Support Spacing

Materials	Type of Joints	Horizontal	Vertical
Copper Tube and Pipe	Soldered, Brazed or Welded	1 ½ " and smaller, 6 feet 2" an larger, 10 feet	Each floor not to exceed 10 ft
Steel and Brass Pipe for Water or DWV*	Threaded or Welded	¾" and smaller, 10 feet 1" and larger, 12 feet	Every other floor, not to exceed 25 ft.

* DWV= Drain, Waste, Vent

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

3.3. Insulation. All runs of pipe or tubing where heat transfer could occur should be insulated. This insulation can very from the preformed slide over type to the pipe wrap, or to fiber insulation under a metal strap down cover. Anytime insulation is used, the technician should plan to leave enough room between the wall, or any other adjacent structure and the insulated pipe. The important thing to remember is just to insulate!

3.4. Appearance. The finished product should look like a professional was just there. Vertical runs of pipe or tubing will be straight, and perpendicular to the ground. Horizontal legs will be just that, horizontal to the ground. Runs should not be angled or cantered one way or the other. Use a water level and plan your installation cuts and joints to fit properly. This will insure that the work you do, is the best that can be done.

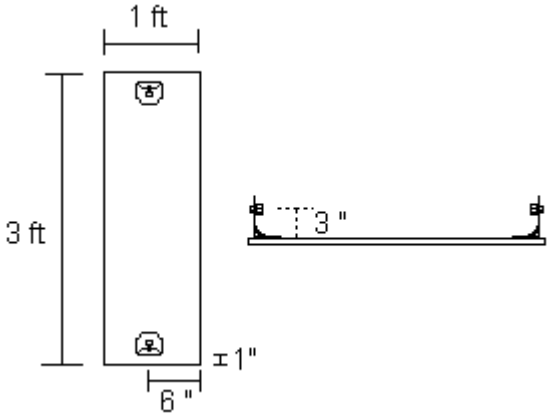
NOTE TO TRAINER:

If a install pipe/tubing project is not available, the minimum requirement for task certification is to have the trainee to construct the items in Figure 4-16 and 4-17 using the steps below.

4. Procedures. Follow these steps to install a tubing systems:

4.1. Prepare Material.

Figure 4-16. Backboard for Installation Exercise.



Step 1: Take a 3 foot x 1 foot section of ¾" plywood.

Step 2: Attach two metal right angles as shown in Figure 4-16.

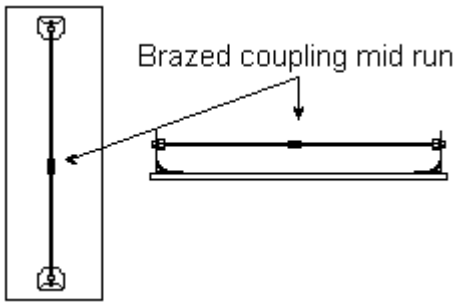
Step 3: To the right angles centered and 3 inches from the plywood screw in one brass thread to compression fitting. The compression side of the fittings should now be facing each other in a straight-line centerboard and 3 inches from the plywood.

Step 4: Mount completed backboard vertically.

Step 5: Organize the remainder of the materials for the exercise.

4.2. Install Tubing System.

Figure 4-17. Completed Project.



Step 1: Referring to Figure 4-17, measure the distance between the two fittings allowing for that part of the tubing that will fit inside the fittings.

Step 2: Cut the tubing to the desired length, then cut it in half.

Step 3: Ream the tubing to return the tubing to round.

Step 4: Place compression cap over one end of each of the two pieces of tubing.

Step 5: Next slide a ferrule down the same ends.

Step 6: Take one of the ferrule ends and insert into top compression fitting and tighten.

Step 7: Flux the bottom of the tubing and slide the coupling up onto the tubing.

Step 8: Flux the other piece of tubing and insert the compression end into the bottom fitting and the top end into the coupling.

Step 9: Apply heat sinks where necessary.

Step 10: Solder the coupling.

Step 11: Clean work area.

REVIEW QUESTIONS
FOR
INSTALL PIPING AND TUBING SYSTEMS

QUESTION	ANSWER
1. Anytime a vertical leg is raised from an in-ground pipe what must be installed between the horizontal and vertical legs?	a. Bi-electric union. b. Di-electric union. c. Galvanizer. d. Vibration eliminator.
2. ½" vertical steel pipe must be supported not more than every _____.	a. 25 ft. b. 20 ft. c. 15 ft. d. 10 ft.
3. When attaching new steel pipe to an old black iron system, which will corrode first?	a. The new steel. b. The Old black Iron. c. Both will corrode simultaneously. d. Neither will, the system will stabilize.
4. 1" horizontal copper tubing must be supported every ____.	a. 6 ft. b. 10 ft. c. 12 ft. d. 25 ft.

INSTALL PIPING AND TUBING SYSTEMS

PERFORMANCE CHECKLIST

INSTRUCTIONS:

The trainee must satisfactorily perform all parts of the task without assistance. Evaluate the trainee's performance using this checklist.

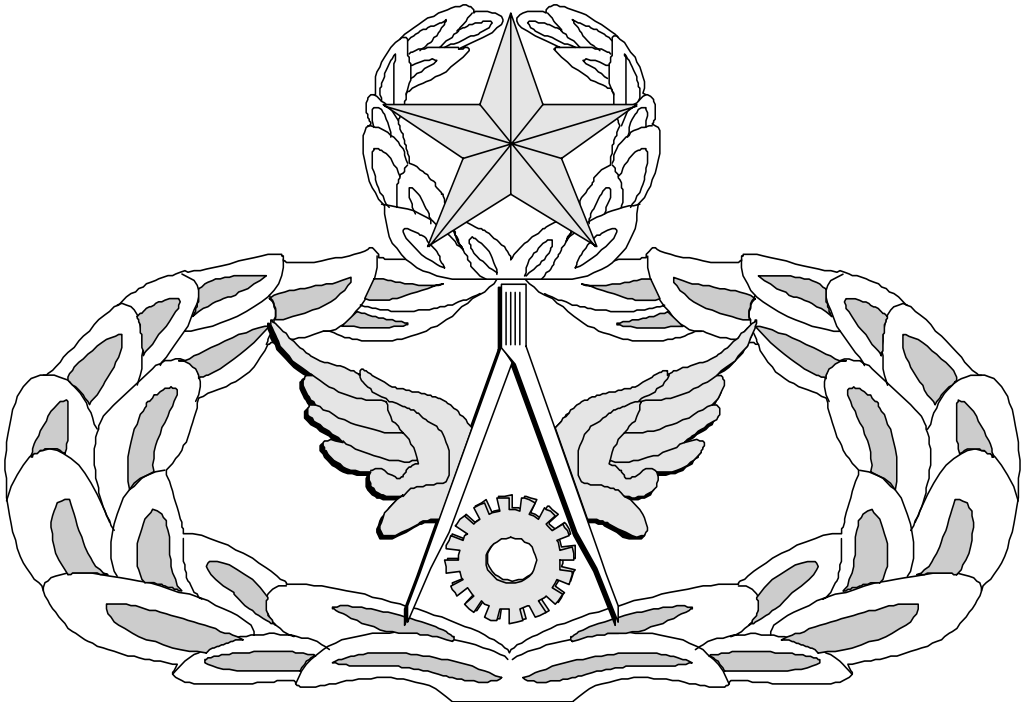
DID THE TRAINEE…	YES	NO
1. arrive at the job site with all necessary tools and equipment?		
2. properly attach the compression fittings?		
3. solder the coupling correctly?		
4. leaving a clean professional joint?		
5. burn or scorch the wood?		
6. clean the tubing?		
7. insure the tubing was straight without bends and bows?		
8. produce a professionally looking installation?		
9. clean work area?		
10. comply with all safety requirements?		

FEEDBACK: Trainer/Certifier should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer/certifier.

Air Force Civil Engineer

QUALIFICATION TRAINING PACKAGE (QTP)

REVIEW ANSWER KEY



FOR

HEATING, VENTILATION, AIR CONDITIONING/REFRIGERATION (HVAC/R) (3E1X1)

MODULE 12

PIPING/TUBING

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

FABRICATE PIPING AND TUBING SYSTEMS
(3E1X1-12.4.1.)

QUESTION	ANSWER
1. What are the three classes of pipe used in HVAC/R systems?	a. Standard weight (125 psi), Extra strength (250 psi), Double extra strength (600 psi).
2. How is pipe measured?	c. All of the above.
3. To flare the tubing how much is extended past the flaring block?	d. Two times wall thickness.
4. What is swaging?	b. Stretching tubing.

INSTALL PIPING AND TUBING SYSTEMS
(3E1X1-12.4.2.)

QUESTION	ANSWER
1. Anytime a vertical leg is raised from an in-ground pipe what must be installed between the horizontal and vertical legs?	b. Di-electric union.
2. ½" vertical Steel pipe must be supported not more than every _____.	a. 25 ft.
3. When attaching new steel pipe to an old black iron system, which will corrode first?	a. The new steel.
4. 1" horizontal copper tubing must be supported every ____.	a. 6 ft.

MEMORANDUM FOR HQ AFCESA/CEOF
139 Barnes Drive Suite 1
Tyndall AFB, FL 32403-5319

FROM:

SUBJECT: Air Force Qualification Training Package Improvement

1. Identify module.

   Module # and title_____

2. Identify improvement/correction section(s)

   _____ STS Task Reference
   _____ Training Reference
   _____ Evaluation Instructions
   _____ Performance Resources
   _____ Steps in Task Performance
   _____ Performance Checklist
   _____ Feedback
   _____ Format
   _____ Other

3. Recommended changes--use a continuation sheet if necessary.

   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

4. You may choose to call in your recommendations to DSN 523-6445 or FAX DSN/Commercial 523-6488 or (850) 283-6488 or email ceof.helpdesk@tyndall.af.mil.

5. Thank you for your time and interest.

YOUR NAME, RANK, USAF
Title/Position