

# AIR FORCE QUALIFICATION TRAINING PACKAGE (AFQTP)



FOR  
UTILITIES SYSTEMS  
(3E4X1)

MODULE 14

UTILITIES FUNDAMENTALS

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| Career Field Education and Training Plan (CFETP) references from 1 Jul 02 version. |
|--|

OPR: HQ AFCESA/CEOF  
(SMSgt James B. Lucas)  
Supersedes AFQTP 3E4X1-11, 1 Oct 1999

Certified by: HQ AFCESA/CEOF  
(CMSgt Myrl F. Kibbe)  
Pages: 17/Distribution F

**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.

**AIR FORCE QUALIFICATION TRAINING PACKAGES  
FOR  
UTILITIES SYSTEMS  
(3E4X1)**

**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:**

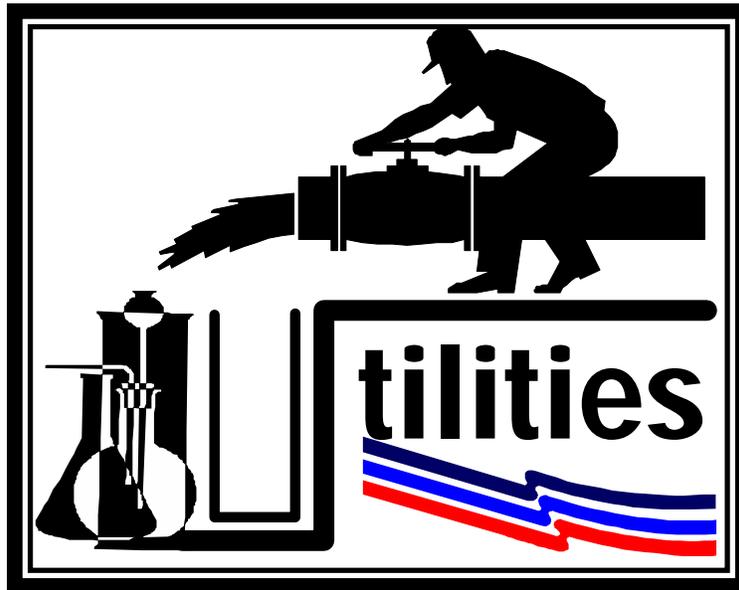
AFQTP completion  
CerTest completion (80% minimum to pass)

**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 Career Field Manager at the address below.

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## UTILITIES FUNDAMENTALS

### PIPING

MODULE 14

AFQTP UNIT 6

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MEASURE (14.6.1.)

CUT (14.6.2.)

REAM (14.6.3.)

THREAD (14.6.4.)

SWEAT (14.6.5.)

---

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## MEASURE, CUT, REAM, THREAD, AND SWEAT PIPING

### *Task Training Guide*

|   |   |
|---|---|
| <b>STS Reference Number/Title:</b>            | 14.6.1., 14.6.2., 14.6.3., 14.6.4., & 14.6.5., Measure, Cut, Ream, Thread, and Sweat Piping.  |
| <b>Training References:</b>                   | <ol style="list-style-type: none"> <li>1. CerTest Video # 830 <i>Pipe and Pipefitting</i>.</li> <li>2. Career Development Course (CDC) 3E451A Vol. 2, Trade Fundamentals.</li> <li>3. CD-ROM Air Force Qualification Training Package (AFQTP) 3E4X1 Utilities, Version 1.0, Feb 00: <i>The Repair of Water &amp; Wastewater Piping Systems</i>.</li> <li>4. Uniformed Plumbing Code.</li> </ol>   |
| <b>Prerequisites:</b>                         | <ol style="list-style-type: none"> <li>1. <b>Possess as a minimum a 3E431 AFSC.</b></li> <li>2. <b>Review the following references:</b> <ol style="list-style-type: none"> <li>2.1. Uniformed Plumbing Code.</li> <li>2.2. CDC 3E451A Vol. 2, Trade Fundamentals.</li> </ol> </li> <li>3. <b>Complete the following references:</b> <ol style="list-style-type: none"> <li>3.1. CerTest Video # 830 <i>Pipe and Pipefitting</i>.</li> <li>3.2. CD-ROM AFQTP 3E4X1 Utilities, Version 1.0, Feb 00: <i>The Repair of Water &amp; Wastewater Piping Systems</i></li> </ol> </li> </ol> |
| <b>Equipment/Tools Required:</b>              | <ol style="list-style-type: none"> <li>1. Computer to support AFQTP CD-ROM.</li> <li>2. Basic Plumbing Tool Kit.</li> <li>3. Tubing Cutter.</li> <li>4. Pipe Cutter.</li> <li>5. Torch Kit.</li> <li>6. Fitting Brush.</li> <li>7. Emery Cloth.</li> <li>8. Flux.</li> <li>9. Solder.</li> <li>10. Fire Extinguisher.</li> <li>11. Manual and Power Pipe Threader.</li> <li>12. Hand Reamer.</li> <li>13. Pieces of piping (steel, copper tubing, PVC).</li> </ol>  |
| <b>Learning Objective:</b>                    | The trainee will properly measure, cut, ream, thread, and sweat pipe.   |
| <b>Samples of Behavior:</b>                   | Trainee will understand the steps to measure, cut, ream, thread, and sweat pipe.  |
| <b>Notes:</b>                                 |   |
| Any safety violation is an automatic failure. |   |

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## MEASURE, CUT, REAM, THREAD, SWEAT

**1. Background:** Repairing broken pipes are tasks that utilities craftsmen face daily. Because of the wide variety of materials used in piping systems, care must be taken when attempting to repair or replace them. It is essential that you know the fundamentals of planning your work; measuring, cutting, reaming, threading, and sweating the different types of piping used in water and wastewater distribution systems.

**2. Complete the CerTest Video #830: Pipe and Pipefitting and the CD-ROM AFQTP 3E4X1 Utilities, Version 1.0, Feb 00: The Repair of Water & Wastewater Piping Systems. Upon completion of the above-mentioned video and CD-ROM properly measure, cut, ream, thread, and sweat pipes using the step-by-step procedures listed below.**

**3. Planning Your Work.** Your first task is to determine how the pipe is to be routed. Suppose you wished to install a water line from a hot water heater to a sink several feet away. Your first step is to properly survey and plan your jobsite. You will need to take a tablet, pencil, and tape measure with you.

**3.1. To perform the task, follow these steps for planning:**

### Step 1: Sketching your work.

- 1.1. Make a crude drawing of how you want the line to run (Figure 1).
- 1.2. The drawing has to mean something to you, but it need not be fancy. There is no need to show how to prepare mechanical drawing here.
- 1.3. Remember, you can make only 90- and 45-degree turns, and your measurements and drawing must reflect the types of turns you are going to use.

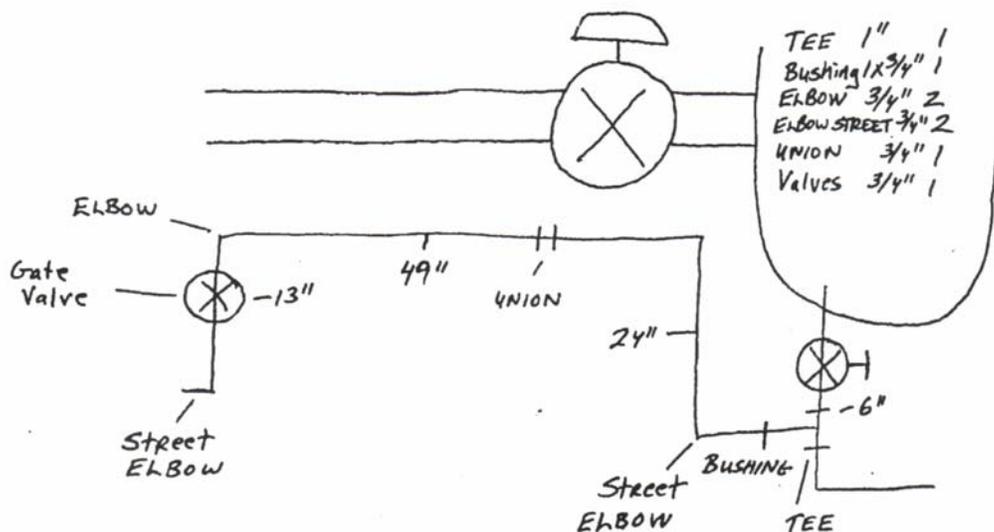


Figure 1. Sketch your work.

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**Step 2: Selecting your fittings.**

2.1. Now look at your drawing and determine what type of fittings you are going to need. A good thought to keep in mind here is that the fewer fittings needed, the fewer places exist where leaks can occur.

2.2. You also have to determine what size pipe you will use. Annotate the length of that pipe on your drawing.

2.3. Now, count everywhere you will need an elbow and write this number on your drawing.

**4. Threading Pipe.** There are different methods and equipment used to thread pipe. If you are on an isolated job site or working with smaller diameter pipe you may have to thread pipe manually using a manual pipe threader. In other cases where you are working on a large project or the pipe is larger in size you may have to use a power driven threader.

4.1. There are three major steps to threading pipe: cutting the pipe, reaming the pipe to restore the inside diameter, and threading the pipe.

4.2. *To perform this task, follow these steps for threading:*

**SAFETY:**

**BEFORE USING A POWER THREADER INSPECT THE EQUIPMENT AND POWER SOURCE TO ENSURE IT IS PROPERLY GROUNDED AND ALL PARTS ARE IN GOOD WORKING CONDITION. DO NOT WEAR JEWELRY, GLOVES, OR LOOSE CLOTHING. KEEP YOUR FINGERS AND LIMBS AWAY FROM MOVING PARTS. USE SAFETY GLASSES OR FACE SHIELDS TO PROTECT YOU FROM PIPE SHAVINGS.**

**Step 1: Measure pipe.**

1.1. Measure pipe to appropriate length to accomplish job using a standard tape measure.

**Step 2: Cut pipe.**

2.1. Cut the pipe with a pipe cutter, a power threader, or a hacksaw keeping the cut as straight and square as possible.

**Step 3: Ream pipe.**

3.1. Ream the pipe using a hand reamer, power threader, or a file. (Reaming the pipe restores the inside diameter of the pipe by removing any burrs, which are created during the cutting of the pipe.)

**Step 4: Inspecting equipment.**

4.1. Inspect the die segments to ensure that they are sharp and free from excessive wear.

**NOTE:**

If using a power threader, ensure that the cutting oil in the reservoir is at the proper level. Application of cutting oil will cool the dies and prevent damage to the pipe threads.

**Step 5: Threading pipe.**

5.1. When threading pipe, first insert pipe into the vice.

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- 5.2. Place the manual pipe threader on the pipe and applying force to get the dies started with the heel of your hand.
- 5.3. Make three or four short turns in a clockwise direction to start the dies.
- 5.4. Once you have started the dies apply cutting oil every two or three strokes of the handle.
- 5.5. Continue this until approximately two newly cut threads project beyond the die segments.

**NOTE:**

When using a power threader swing the die head into position, ensuring the dies are closed and are set to the proper size for the pipe you are threading. Next turn on the machine to ensure that the cutting oil is flowing. Use the handle on the moving carriage to push the dies onto the pipe with firm pressure; once the dies begin to thread release the carriage handle. Allow the threader to self-feed. Once two newly cut threads extend beyond the die segments, lift the die release lever and back off the carriage. On some newer dies there is an automatic release lever that kicks the die off the pipe once the appropriate amount of threads have been reached.

**Step 6: Clean the new threads.**

- 6.1. Use a wire brush.

**Step 7: Remove the pipe.**

**Step 8: Clean equipment.**

- 8.1. Clean the die segments using a wire brush to remove any shavings and wipe up any excess oil.

**NOTE:**

When using the power threader also remove the shavings from the catch tray.

**Step 9: Inspect threads.**

- 9.1. Visually inspect the threads and check for proper threads by hand tightening the section of pipe into a fitting. If it threads into the fitting with ease your threads are good.

**Step 10: Clean Area and place tools in proper areas.**

**5. Soldering/Sweating.** Of the many ways to make copper joints, we commonly use sweat-soldered joints. Sweat soldering (called sweating) is a method of joining two metals by allowing molten solder to run between the tubing and fittings. The law of capillary action governs the force responsible for the bonding in solder joints.

- 5.1. There are four major steps to sweating tubing: clean it, coat it, heat it, and solder it. The tubing must be cut to length and reamed before you are ready to solder the joint. The amount of solder required for a connection depends upon the diameter of the tube to be sweated.
- 5.2. To produce the necessary heat, use an air-acetylene torch or a propane torch. A high-temperature concentrated flame that quickly brings the fitting to the melting point of solder is required for "sweating" fittings onto copper tubing. Ninety-five/5 solder (95% tin and 5% antimony or any solder with a lead content of 0.20% or less) melts at 425 degrees \*F. To prevent the joint from overheating, apply the heat evenly back and forth across the connection. Overheating the joint could cause the flux to burn out, oxidation to occur, and the flux to spread unevenly.

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**SAFETY:**

**BEFORE SOLDERING IN HAZARDOUS LOCATIONS, YOU SHOULD HAVE THE FIRE DEPARTMENT INSPECT THE AREA AND ISSUE AN AF FORM 592, *WELDING, CUTTING AND BRAZING PERMIT*. MAKE SURE YOU FOLLOW ANY INSTRUCTIONS THE INSPECTOR PLACES IN BLOCK 12 OF THE PERMIT TO REDUCE THE HAZARD OF FIRE. MAKE SURE AN APPROPRIATE FIRE EXTINGUISHER IS WITHIN REACH.**

**5.3. To perform the task, follow these steps for soldering:**

**Step 1: Measure tubing.**

1.1. Measure the tubing to appropriate length to accomplish job using a standard tape measure.

**Step 2: Cut tubing.**

2.1. Cut the tubing with a tubing cutter, or a hacksaw keeping the cut as straight and square as possible.

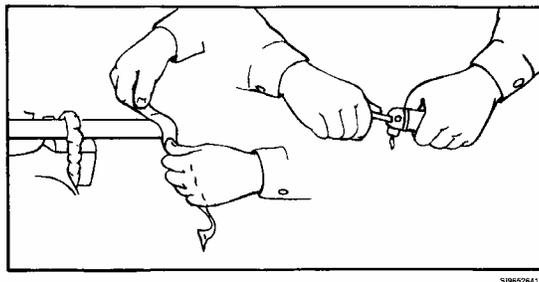
**Step 3: Ream tubing.**

3.1. Ream the interior of your tubing with the reamer provided on the tubing cutter or a hand reamer.

**Step 4: Clean tubing.**

4.1. Clean the tubing and the fitting using a fitting brush, emery cloth, or steel wool.

4.2. Cleaning the surfaces will ensure a good bond between the base metal and the solder. (See Figure 1.)

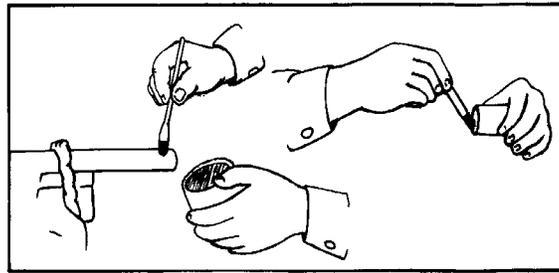


**Figure 1. Clean tubing and fitting**

**Step 5: Coat tubing and fitting.**

5.1. Flux must be applied to the inside of the fitting and onto the outer surface of the tubing to prevent oxidation and to promote fusion in the soldering process. (See Figure 2.)

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**Figure 2. Application of Flux**

**Step 6: Join fittings.**

6.1. After fittings have been fluxed, slide tubing into fittings.

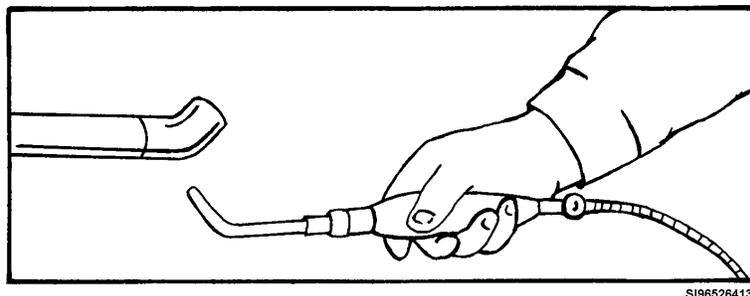
**Step 7: Heat fitting.**

7.1. Apply heat evenly around the fitting.

7.2. Do this by moving the flame back and forth.

7.3. This procedure also keeps you from over heating the tube fitting or burning out the flux.

7.4. When soldering small diameter tubing you can apply the heat to one area of the fitting. (See Figure 3.)



**Figure 3. Heating the Fitting**

**SAFETY:**

**IF A TORCH IS NOT USED, TURN OFF THE GAS AND SET ASIDE. IF THE PIPE IS IN AN ENCLOSED AREA WHERE A FIRE COULD EASILY BE STARTED USE A HEAT SHIELD.**

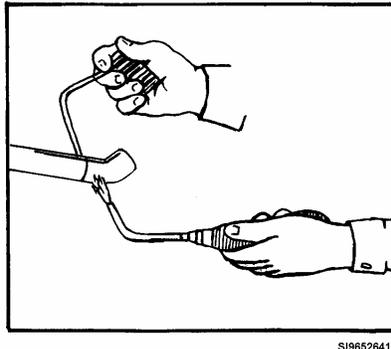
**SAFETY:**

**WHEN SOLDERING FITTINGS, LONG SLEEVE SHIRTS, AND LEATHER GLOVES MUST BE WORN AT ALL TIMES TO PREVENT BURNS!**

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**Step 8: Solder joint.**

- 8.1. Touch the solder to the fitting while applying heat.
- 8.2. As soon as the connection is hot enough to melt the solder, remove the flame and apply the solder to the edge of the fitting.
- 8.3. The solder will then be drawn into the fitting by capillary action. (See Figure 4.)



**Figure 4. Application of Solder**

**Step 9: Re-heat it.**

- 9.1. Re-heat the fitting slightly to help the solder penetrate the metal.

**Step 10: Remove heat.**

**Step 11: Continue to feed solder.**

- 11.1. When a bead of solder appears at the edge of the fitting the joint has all the solder it will take.

**HINT:**

Applying flux to the fitting prior to cooling the joint will remove some of the excess solder.

**Step 12: Allow the joint to cool.**

- 12.1. Use a wet rag to help cool the joint.

**Step 13: Remove excess solder.**

- 13.1. Remove excess solder with a small brush or fine emery cloth.

**Step 14: Slowly open water valve and check for leaks.**

- 14.1. If leaks are found, close valve, drain the system, and remove line by re-heating fitting with torch.

- 14.2. Use slip joint pliers to remove the fitting and repeat steps 3 thru 12.

**Step 15: Clean area and place tools in proper areas.**

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**REVIEW QUESTIONS  
FOR  
MEASURE, CUT, REAM, THREAD, SWEAT**

| QUESTION   | ANSWER  |
|--|---|
| 1. There are how many major steps to sweating pipe?  | a. One.<br>b. Two.<br>c. Three.<br>d. Four.   |
| 2. What governs the bonding process in sweating?   | a. Gravity.<br>b. Pressure.<br>c. Capillary Action.<br>d. Bonding Action.   |
| 3. 95/5 solder melts at ____degrees F.   | a. 300<br>b. 325<br>c. 400<br>d. 425  |
| 4. The amount of solder required for a connection depends upon the diameter of the tube to be sweated.   | a. True.<br>b. False.   |
| 5. What causes the flux to burn out, oxidation, and the flux spreading unevenly?   | a. Overheating the joint.<br>b. Too much solder.<br>c. Too little solder.<br>d. Too much flux.                                |
| 6. Before soldering in a hazardous location, you should have the Fire Department inspect the area and issue an AF Form 591, WELDING, CUTTING AND BRAZING PERMIT. | a. True.<br>b. False.   |
| 7. When a bead of solder appears at the edge of the fitting, what does this indicate?  | a. The joint has all the solder it will take.<br>b. Too much solder.<br>c. An overheated connection.<br>d. None of the above. |
| 8. What is used to remove excess solder?   | a. A small brush or emery cloth.<br>b. Steel wool or sand paper.<br>c. A rasp file.<br>d. None of the above.                  |
| 9. What is used to restore the inside diameter of the pipe by removing any burrs?  | a. Hand reamer.<br>b. Power threader.<br>c. File.<br>d. All of the above.   |
| 10. What equipment should be inspected to ensure that they are sharp and free from excessive wear prior to threading pipe?                                       | a. Cutter.<br>b. Oilier.<br>c. Die segments.<br>d. Segment holder.  |

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**REVIEW QUESTIONS (Continued)**

| <b>QUESTION</b>  | <b>ANSWER</b>   |
|--|---|
| 11. What is used to keep the dies cool when threading pipe?  | a. 10W-30.<br>b. 40 weight.<br>c. Linseed oil.<br>d. Cutting oil.               |
| 12. How often should you apply cutting oil to the dies when using the manual pipe threader?                                      | a. 1 to 2 strokes.<br>b. 2 to 3 strokes.<br>c. 4 to 5 strokes.<br>d. 6 strokes. |
| 13. When using a power threader you should lift the die release lever when ___ newly cut threads extend beyond the die segments. | a. 4<br>b. 3<br>c. 2<br>d. 1  |
| 14. What should be used to clean the die segments?   | a. Rag.<br>b. Fitting brush.<br>c. Emery cloth.<br>d. Wire brush.               |

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## MEASURE, CUT, REAM, THREAD, AND SWEAT PIPE

### PERFORMANCE CHECKLIST

#### INSTRUCTIONS:

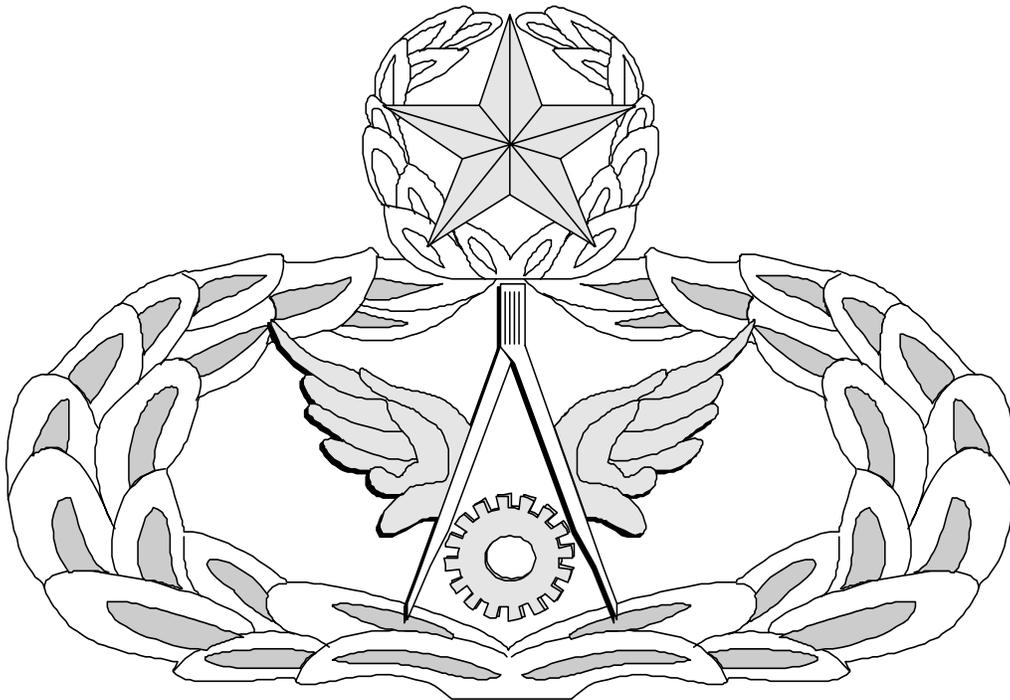
The trainee must satisfactorily perform all parts of the task without assistance. Evaluate the trainee's performance using this checklist.

| DID THE TRAINEE....?  | YES | NO |
|---|-----|----|
| 1. Complete the AFQTP video and CD-ROM  |     |    |
| 2. Understand how to properly measure, cut, ream, and thread pipe   |     |    |
| 3. Plan the work:<br>3.1. Sketch out the work<br>3.2. Determine the types of fittings   |     |    |
| 4. Did trainee identify all the equipment needed for measuring, cutting, reaming, and sweating:<br>4.1. Tape measure<br>4.2. Tubing cutting<br>4.3. Hacksaw<br>4.4. Hand reamer<br>4.5. Fitting brush<br>4.6. Emery cloth<br>4.7. Steel wool<br>4.8. Flux<br>4.9. Propane/Air-acetylene<br>4.10. Solder |     |    |
| 5. Properly thread pipe:<br>5.1. Measure<br>5.2. Cut<br>5.3. Ream<br>5.4. Thread pipe   |     |    |
| 6. Properly sweat tubing:<br>6.1. Measure<br>6.2. Cut<br>6.3. Ream<br>6.4. Clean<br>6.5. Coat<br>6.6. Heat<br>6.7. Apply solder<br>6.8. Cool  |     |    |
| 7. Take proper safety precautions:<br>7.1. Obtained an AF Form 592<br>7.2. Fire extinguisher was in reach<br>7.3. Long sleeve<br>7.4. Gloves worn   |     |    |

**FEEDBACK:** Trainer 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.

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**Air Force Civil Engineer**  
**QUALIFICATION TRAINING PACKAGE (QTP)**  
**REVIEW ANSWER KEY**



FOR  
**UTILITIES SYSTEMS**  
**(3E4X1)**

**MODULE 14**  
**UTILITIES FUNDAMENTALS**

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**Key-1**

**MEASURE, CUT, REAM, THREAD, AND SWEAT PIPE  
(3E4X1-14.6.1./14.6.2./14.6.3./14.6.4./14.6.5.)**

| QUESTION   | ANSWER  |
|--|---|
| 1. There are how many major steps to sweating pipe?  | d. Four.                                      |
| 2. What governs the bonding process in sweating?   | c. Capillary Action.                          |
| 3. 95/5% solder melts at ____ degrees F.   | d. 425  |
| 4. The amount of solder required for a connection depends upon the diameter of the tube to be sweated.   | a. True.                                      |
| 5. What causes the flux to burn out, oxidation, and the flux spreading unevenly?   | a. Overheating the joint.                     |
| 6. Before soldering in a hazardous location, you should have the Fire Department inspect the area and issue an AF Form 591, WELDING, CUTTING AND BRAZING PERMIT. | b. False.                                     |
| 7. When a bead of solder appears at the edge of the fitting, what does this indicate?  | a. The joint has all the solder it will take. |
| 8. What is used to remove excess solder?   | a. A small brush or emery cloth.              |
| 9. What is used to restore the inside diameter of the pipe by removing any burrs?  | d. All of the above.                          |
| 10. What equipment should be inspected to ensure that they are sharp and free from excessive wear prior to threading pipe?                                       | c. Die segments.                              |
| 11. What is used to keep the dies cool when threading pipe?  | d. Cutting oil.                               |
| 12. How often should you apply cutting oil to the dies when using the manual pipe threader?  | b. 2 to 3 strokes.                            |
| 13. When using a power threader you should lift the die release lever when ____ newly cut threads extend beyond the die segments.                                | c. 2  |
| 14. What should be used to clean the die segments?   | d. Wire brush.                                |

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

FROM:

SUBJECT: Qualification Training Package Improvement

1. Identify module.

Module # and title \_\_\_\_\_

2. Identify improvement/correction section(s):

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

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

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4. You may choose to call in your recommendations to DSN 523-6392 or FAX DSN/Commercial 523-6488 or (850) 283-6488 or email [ceof.helpdesk@tyndall.af.mil](mailto:ceof.helpdesk@tyndall.af.mil).

5. Thank you for your time and interest.

YOUR NAME, RANK, USAF  
Title/Position