# AVIATION MAINTENANCE TRAINING

# MOS 6492 LESSON GUIDES

# AVIATION MAINTENANCE TRAINING

| | |
|---|---|
| A.01 (F) | Thermohumidigraphs |
| A.02 (A-1) | Performs First Aid Procedures |
| A.02 (A-2) | Performs Hazardous Material/Waste Disposal Procedures |
| A.02 (A-3) | Demonstrates Safety Procedure Near Electricity |
| A.02 (A-3A) | Demonstrates Safety Procedure Near High Pressure Air (Pneumatic) Sources |
| A.02 (A-4) | Utilizes Personal Protective Equipment, (Gloves, Eye Protection Goggles, etc.) |
| A.02 (A-5) | Complies With Safety Markings |
| A.03 (C) | Naval Aviation maintenance program, (NAMP) |
| A.03 (D) | Avionics Cleaning & Corrosion Control Manual |
| A.03 (F) | Aviation Hydraulics Manual |
| A.03 (Q) | Metrology Automated System for Uniform Recall and Reporting (MEASURE) Users Manual |
| A.03 (U) | Naval Aviation Metrology and Calibration (METCAL) Program |
| A.03 (X) | Calibration Facility Requirements for Navy Field Calibration Activities |
| A.03 (Y) | Metrology Requirements Lists |
| A.03 (Z) | Technical Requirement for Calibration of Test and Monitoring Systems (TAMS) |
| A.03 (GG) | Instrument Calibration Procedures |
| B.01 (A) | AC/DC Voltage Standards |
| B.01 (D) | Current Shunts & Measuring Systems |
| B.01 (E) | Electronic Counters |
| B.01 (G) | Flow meters |
| B.01 (N) | Oscilloscopes |
| B.01 (P) | Pressure Gages |
| B.01 (Q) | Resistance Standards & Measuring Systems |
| B.01 (S) | RF Power Measurement Devices |
| B.01 (V) | RF Spectrum Analyzer |
| B.01 (W) | Signal Generators |
| B.01 (BB) | Torque Devices |
| B.01 (FF) | Meter Calibrator |
| B.01 (GG) | Oscilloscope Calibrator |
| B.01 (HH) | Signal Generator Calibrator |
| B.01 (II) | Frequency Counter Calibrator |
| B.01 (JJ) | Pressure Gage Calibrator |
| B.01 (LL) | Pulse Generator |
| B.01 (SS) | Power Meter/Sensor |
| B.01 (TT) | Peak Power Meter/Sensor |
| B.01 (XX) | Vibration Calibrator |

# MOS 6492 Lesson Guides

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 A.1 (F)

## Support/Special Equipment

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**A. LECTURE NUMBER:** MOS 6492 A.1.F

**B. TIME:** 30 Minutes

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Support/Special Equipment

**F. OBJECTIVES:** To instruct the technician on the correct procedures used with thermohumidigraphs.

**G. INSTRUCTIONAL AIDS:** 56912 series thermohumidigraphs

**H. REFERENCES:**

1. OPNAVINST 4790.2H
2. NAVAIR 17-35FR-06

**I. PRESENTATION:**

1. INTRODUCTION

2. BODY:

   a. Since environmental conditions of temperature and humidity are of such importance to calibration, continual monitoring, and recording of the temperature and relative humidity of each laboratory area is a facility requirement. Thermohumidigraphs and/or sensors used to monitor environmental conditions shall be placed within the working volume of the calibration area to represent accurately the area of coverage, i.e. out of drafts and away from heat sources, doors, windows, and vents.

   b. Calibration facility environmental conditions shall be monitored on a qualitative routine basis at the local level. This requirement applies to all calibration, special purpose or hazardous areas defined within. The environmental parameters of temperature and humidity shall also be monitored on a

quantitative basis. These parameters shall be continuously monitored, recorded and verified to be within the limits specified in NAVAIR17-35FR-06. Maintain all recorded thermohumidigraph charts on file for a minimum of one year. Charts and/or logbooks should be clearly marked and annotated with any relevant information when environmental conditions are out-of-tolerance.

c. Portable hand-held devices having a sufficient accuracy may be used to monitor and record the temperature and humidity within the working volume. These devices may be preferred over conventional thermohumidigraphs or sensors, particularly if they cannot be located within the working volume or when the temperature of the TI is required such as during artifact calibrations.

d. Measurement accuracy is dependent upon the ambient temperature of the environment. Maintain a spatially uniform temperature, such that the deviation between any two points in the working volume of a laboratory does not exceed the specified value for stability or temperature tolerance limits or 4 degrees/hour if no stability requirement is given. The working volume is defined as any point where measurements are conducted or sensitive equipment located, or within +/- 3ft. elevation from the workbench level. Humidity below 20% relative humidity (RH) can result in static buildup, which is hazardous to sensitive electronics, while humidity above 90 to 95%, can create condensation. In the presence of falling temperatures, or when equipment is moved from cooler to warmer areas, condensation can occur at a much lower ambient humidity levels. To protect electronics from static discharge and condensation, humidity limits of 20 to 60% RH are listed for most areas. However, humidity above 50% RH can also cause rusting of steel and iron items, such as gage blocks and other dimensional standards. Therefore, limits of 20 to 45% RH are listed in areas where such standards are used.

e. The maximum acceptable conditions have been established in order to maintain a maximum level of safety in all calibration areas. There are some instances when calibrations may need to be performed

outside of the prescribed area parameters. This must be evaluated in order to identify potential safety hazards and possible damage to measurement standards. For example, static discharge becomes a potential problem when humidity drops below 20%. This may cause problems with some measurements and pose shock hazards when working with electronic equipment. Conversely, high humidity may accelerate corrosion and condensation can cause possible shorts. Therefore, appropriate SYSCOM approval must be obtained prior to performing measurements outside of the requirements.

**J. SUMMARY:** Observation of environmental factors is an essential part of the calibration process. Therefore, a thorough understanding of thermohumidigraphs and environmental conditions is mandatory for all hands. Proper record keeping and practices will ensure a quality product and guarantee safe TI and standard protection.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 A.2 (A-1)

## Safety Precautions and Procedures

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**A. LECTURE NUMBER:** MOS 6492 A.2 (A-1)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Safety Precautions and Procedures

**F. OBJECTIVES:** To instruct the technician on First Aid Procedures and the steps required to perform life saving techniques.

**G. INSTRUCTIONAL AIDS:** Pictures

**H. REFERENCES:**

1. MCCS Handbooks 1A, 1B
2. www.ou.edu/oupd/choke.htm

**I. PRESENTATION:**

1. INTRODUCTION: The purpose of this First Aid lesson guide is to provide all laboratory personnel with the necessary skills to perform life-saving techniques and utilize safety precautions while performing these techniques. The four-lifesaving steps are:

   a. Start the breathing.

   b. Stop the bleeding.

   c. Protect the wound.

   d. Treat for shock.

2. BODY: The information contained herein discusses the steps to apply basic first aid to start the breathing.

   a. The Heimlich maneuver is the best-known method for removing an object from the airway of a person who is choking. You can use it on yourself or someone else. These are the steps:

(1) Stand behind the choking person and wrap your arms around the victim waist. Bend the person slightly forward.
(2) Make a fist with one hand and place it slightly above the person's navel.
(3) Grasp your fist with the other hand and press hard into the abdomen with a quick, upward thrust. Repeat this procedure until the object is expelled from the airway.
(4) If you must perform this maneuver on yourself, position your own fist slightly above your navel. Grasp your fist with your other hand and thrust upward into your abdomen until the object is expelled.

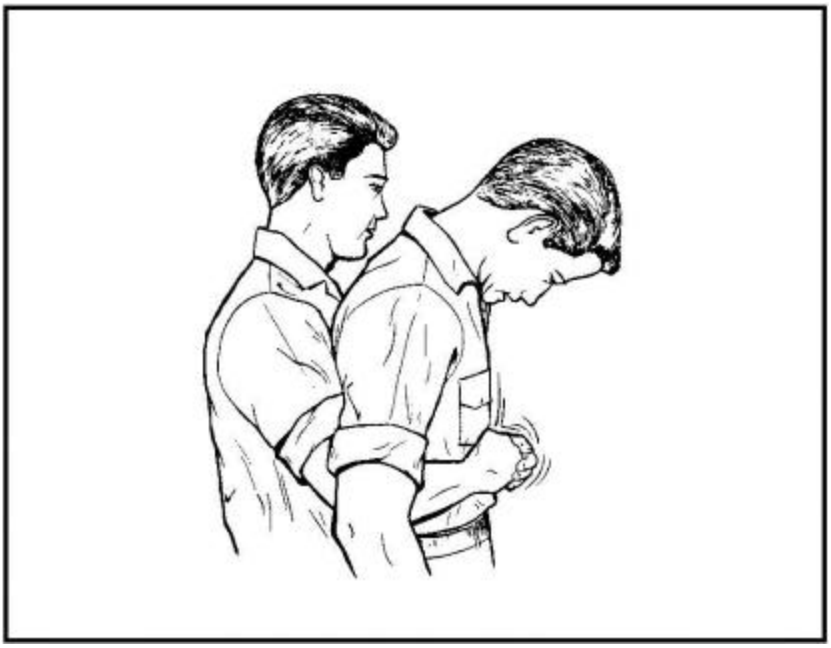

**FIGURE 5-3. ADMINISTERING AN ABDOMINAL THRUST (STANDING PERSON)**

b. An upper airway obstruction (blockage) occurs when a piece of food or some other object enters the person's trachea (windpipe). When a person has suffered a facial injury, blood clots, or loose teeth that have become lodged in the person’s throat may cause blockage. Blockage may also occur when the contents of the stomach are regurgitated (vomited) and some of the vomit is inhaled. The blockage must be removed and full breathing restored. A blockage that greatly reduces the amount of air that can be inhaled and exhaled or that stops all air exchange

can quickly lead to unconsciousness and death. A person with an airway obstruction will automatically begin to cough or at least try to cough. In addition, the person may clutch his or her or her throat. This clutching action is natural, but it has also been adopted as the universal distress signal for choking. This sign alerts other people that the problem is an airway obstruction rather than another problem such as a heart attack or nausea.

**FIGURE 5-1. UNIVERSAL DISTRESS SIGNAL FOR CHOKING**

(1) **Partial Blockage With Good Air Exchange:** If the person with an obstruction can speak or cough forcefully, the person is said to have a partial blockage with good air exchange. (A partial blockage means that the airway is not completely blocked and air can still get to and from the person's lungs. Good air exchange indicates that the person can still inhale and exhale enough air to carry on all life processes.) A person may have good air exchange even though he makes a wheezing sound between coughs.

(2) **Partial Blockage With Poor Air Exchange**: A partial blockage with poor air exchange is indicated by a weak cough, high-pitched noises (like crowing) while inhaling, and signs of shock (bluish tint of the fingernail beds and the lips). A person with poor air exchange is not inhaling sufficient air to continue carrying on all life processes. If the person is not

helped, he or she may become unconscious and die.

**CAUTION:** If you cannot decide whether a conscious person has good or poor air exchange, tell them to speak to you. If the person does not speak, assume the he or she has poor air exchange.

(3) **Complete Blockage:** If the person's airway is completely blocked, he can neither speak, breathe, nor cough at all (no air exchange occurring) and may be clutching his or her neck. Quick action is needed to clear the airway.

c. **DETERMINE WHAT ACTIONS ARE NEEDED**

(1) **Partial Blockage With Good Air Exchange**: If the person has good air exchange, encourage the person to continue his or her or her efforts to cough up the obstruction. Don’t interfere with the person’s efforts. Do not leave the person since "good" air exchange can rapidly deteriorate to "poor" air exchange or complete blockage, either of which can result in unconsciousness and death. Be prepared to administer manual thrusts should his or her condition worsen.

(2) **Partial Blockage With Poor Air Exchange/Complete Blockage**: If the person has poor air exchange or a complete blockage, call for help and begin administering manual (abdominal or chest) thrusts. If possible, send someone to seek medical help.

(a) Abdominal Thrusts. If manual thrusts are required, abdominal thrusts are normally used to expel whatever is blocking the airway.

(b) Chest Thrusts. If the person has abdominal injuries, is noticeably pregnant, or has a waist that is too large to encircle, chest thrusts are used instead of abdominal thrusts.

**CAUTION:** The manual thrusts presented in This lesson are used with a conscious person who is sitting or standing. If the person becomes unconscious or is lying down, start rescue breathing

d. The following procedures are used to restore respiration (breathing) to an unconscious person who is not breathing. These procedures are also used for a person who becomes unconscious (passes out or faints) while you are attempting to remove an upper airway blockage. The modified abdominal and chest thrusts can be used with a conscious person who is lying on his or her back.

**WARNING:** Do not perform mouth-to-mouth resuscitation in a chemical environment.

(1) **CHECK FOR RESPONSIVENESS**: If you come upon a person who appears to be unconscious, check for responsiveness by gently shaking the person's shoulder and calling out, "Are you okay?" If the person does not respond, assume that mouth-to-mouth resuscitation is needed. If possible, send someone to get medical help.

**CAUTION:** If you come upon a person who is in a dangerous area (under hostile fire, near a burning vehicle, etc.), remove the person (and yourself) from the danger before beginning mouth-to-mouth resuscitation.

(2) **POSITION THE PERSON FOR MOUTH-TO-MOUTH RESUSCITATION**: If the person is not lying on his or her back, position the person face up on a firm surface. Straighten the person's legs. Take the person's arm that is nearest to you. Move it so that it is straight and above his or her head. Repeat the procedure with the other arm. Kneel beside the person with your knees near his or her shoulders (leave space to roll

the body). Place one hand behind the head and neck for support. With your other hand, grasp the person under the far arm (armpit area). Roll the person toward you using a steady and even pull. The head and neck should stay in line with the back. Return the person's arms to his or her sides. Straighten the person's legs. Reposition yourself so that you are now kneeling at the level of the person's shoulders.

**CAUTION:** The person should be carefully rolled as a unit so that his or her body does not twist. If a spinal injury is suspected and assistance is available, support the person's head and neck while one or more helpers gently turn the person's trunk and legs.

(3) **OPEN THE PERSON'S AIRWAY**: Many times an unconscious person's tongue may be blocking his or her airway. The muscles of the tongue relax when a person loses consciousness. The tongue may slide to the back of the mouth and cover the opening to the trachea (windpipe). Moving the tongue away from the trachea may result in the person resuming breathing on his or her own. Even if the person has not stopped breathing, the procedures for opening the airway will allow him or her to breathe easier. The two preferred methods of opening the person's airway are the head-tilt/chin-lift method and the jaw thrust method. The jaw thrust method is used if you suspect that the person has suffered a neck injury or severe head injury (deformed-look, major wounds, etc.). The jaw thrust keeps movement of the neck to a minimum.

e. D) **Head-Tilt/Chin-Lift**

**CAUTION:** Do not use the head-tilt/chin-lift method if a spinal or neck injury is suspected.

(1) Kneel at the side of the person's head. Place one of your hands on the person's forehead and apply firm, backward pressure with your palm. This will cause the person's head to tilt back. Place the fingertips of your other hand under the bony part of the person's lower jaw and lift to bring the chin forward. The fingertips should not press deeply into the soft tissues under the chin since the pressure could make breathing difficult. Use your fingertips, not your thumb, to lift the chin.

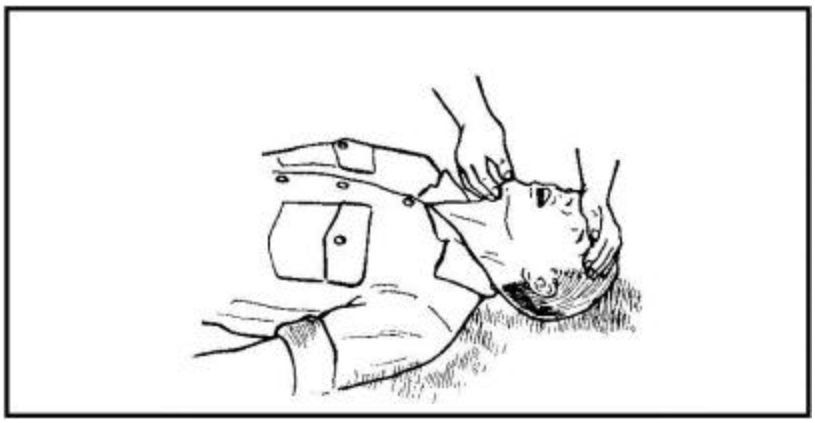

**FIGURE 6-1. HEAD-TILT/CHIN-LIFT**

(2) Lift the chin forward until the upper and lower teeth are almost brought together. The mouth should not be closed as this may block the airway. If needed, the thumb may be used to depress the person's lower lip slightly to keep his or her mouth open.

f. **Jaw Thrust**: Kneel at the top of the person's head (looking toward the person's feet). Rest your elbows on the ground or floor.

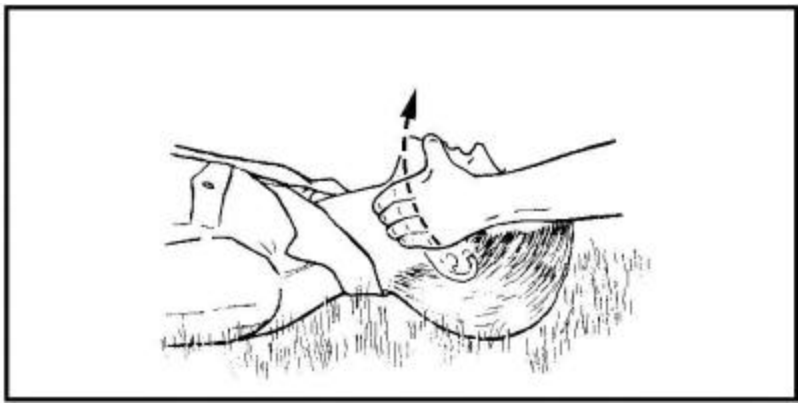

**FIGURE 6-2. JAW THRUST**

(1) Place one hand on each side of the person's head and place the tips of the index and middle fingers under the angles of the person's lower jaw. Place your thumbs on the jaw just below the level of the teeth. Raise your fingertips to lift the jaw forward (upward). This action will also cause the person's head to tilt backward somewhat. If the person's lips are still closed after the jaw has been moved forward, use your thumbs to retract the lower lip and allow air to enter the person's mouth.

g. **CHECK FOR BREATHING**: Place your ear over the person's mouth and nose with your face toward the person's chest. Maintain the open airway (head-tilt/chin-lift or jaw thrust) during your check.

(1) Look for the rise and fall of the person's chest and abdomen.

(2) Listen for sounds of breathing.

(3) Feel for his or her breath on the side of your face.

(4) If the person is breathing and has good air exchange, keep his or her airway open and proceed to look for life-threatening injuries (massive bleeding, etc.). If he is not breathing or breathing weakly, start mouth-to-mouth resuscitation. The examination process should not take more than five seconds.

**FIGURE 6-3. CHECKING FOR BREATHING WHILE OPEN AIRWAY (HEAD-TILT/CHIN-LIFT)**

h. **INITIATE MOUTH-TO-MOUTH RESUSCITATION**

(1) **Maintain Open Airway**: Keep the person's airway open during the rescue breathing process. Keeping the person's lower jaw forward prevents the tongue from blocking the airway.

(2) **Close Person's Nose**: If you are using the head-tilt/chin-lift, use the thumb and index finger of your hand on the person's forehead to gently pinch the person's nose closed. Let the same hand, pinching the nose closed, exert pressure on the person's forehead to maintain the backward head tilt and maintain an open airway. With the other hand, lift the chin while keeping your fingertips on the bony part of the lower jaw near the chin. If you are using the jaw thrust technique (due to head, neck, spinal injury), close the person's nostrils by placing your cheek tightly against them. Do **not** tilt the person's head backward or side-to-side.

(3) **Administer Two Full Breaths**: Open your mouth wide and take a deep breath. Place your mouth over the person's mouth. Make sure that your mouth forms a good seal so that air will not escape when you blow air into the person's mouth. Maintaining the open airway will keep the person's mouth open slightly. Blow into the person's mouth. As you blow, observe the

person's chest. If air is getting into the person's lungs, his or her chest will rise.

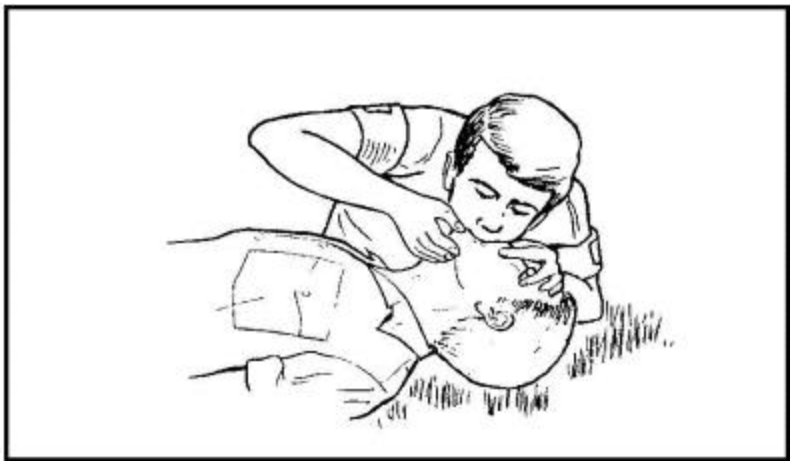

**FIGURE 6-4. ADMINISTERING MOUTH-TO-MOUTH RESUSCITATION (HEAD-TILT/CHIN-LIFT)**

(4) After blowing into the person's mouth, quickly break the seal and take another deep breath. Seal your mouth over the person's mouth again and blow. Administering the two breaths (ventilations) should take about two to three seconds. Break the seal over the person's mouth and release his or her nose. This will allow the person's body to exhale.

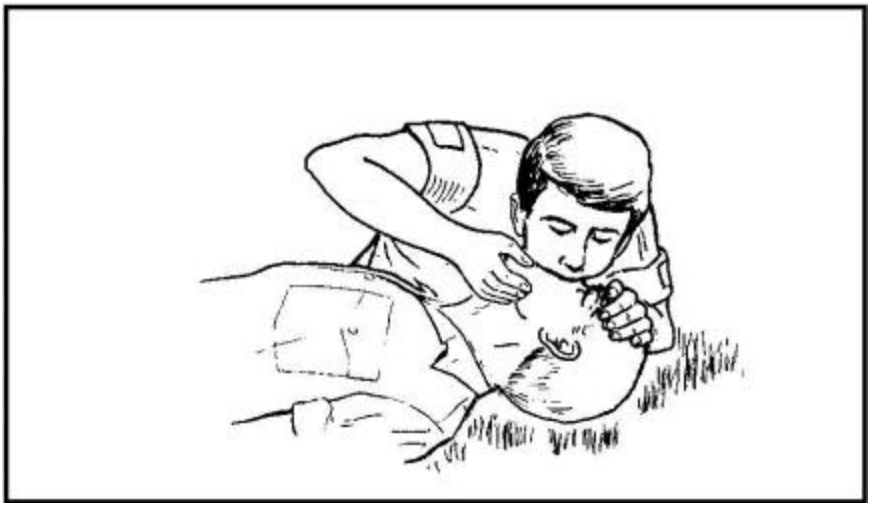

**FIGURE 6-5. ADMINISTERING MOUTH-TO-NOSE RESUSCITATION (HEAD-TILT/CHIN-LIFT)**

**CAUTION:** If you cannot seal off the person's nose or if the person has injuries to his or her mouth area that prevent you from administering mouth-to-mouth resuscitation, administer mouth-to-nose resuscitation. Close the person's mouth, seal your mouth over the person's nose, and blow two breaths into his or her nostrils.

(5) **Evaluate Effectiveness of the Ventilations**: If the person begins breathing again on his or her own, look for injuries. Then evacuate the person to a medical treatment facility. Do not leave the person alone since his or her breathing may stop again. The person may still require help to keep his or her airway open. If air goes in and out of the person's lungs but he does not start breathing on his or her own, check his or her pulse. (Pulse beats mean that the heart is still pumping blood.) You will normally check for a pulse using one of the two major arteries in the neck. One artery is in the groove on the left side of the windpipe; the other is in the groove on the right side of the windpipe. (The grooves are located between the windpipe (trachea) and the large strap muscles of the neck). The arteries are called the carotid (kah rot' id) arteries; therefore, the pulse taken using either artery is called the carotid pulse. Either artery may be used to check the person's pulse. Continue to maintain the person's airway. If the head-tilt/chin-lift method is being used, keep one hand pressing on the person's forehead. Use the index and middle fingers of your free hand to feel for the artery in the groove next to the person's Adam's apple (larynx).

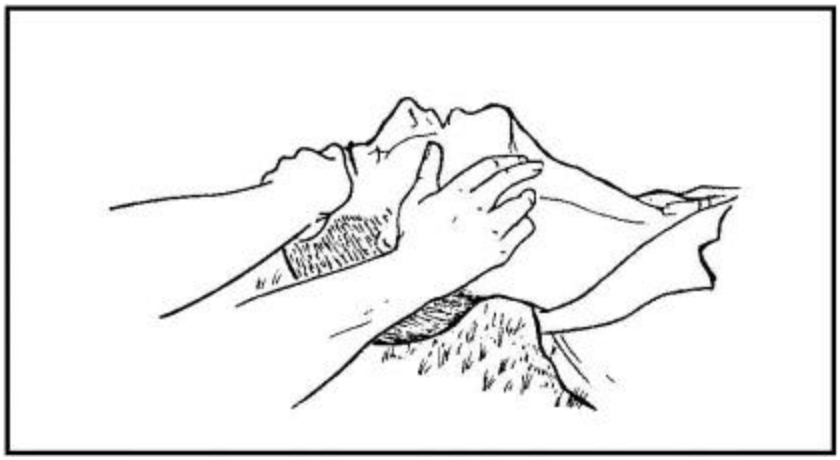

**FIGURE 6-6. FEELING FOR CAROTID PULSE**

(6) Once the artery is located, press on the pulse area gently with your two fingers for five to ten seconds and feel for a pulse. Look for signs of spontaneous breathing (rising and falling of the person's chest, etc.) while checking the pulse.

**CAUTION:** Do not use your thumb to feel for the person's pulse. If you use your thumb, you may feel the pulse in your thumb instead of the person's pulse.

**i. Evaluate the situation and perform needed actions.**

(1) If the person has no pulse, seek medical help immediately. If a person is without a pulse (heartbeat) for more than six minutes, he or she probably cannot be revived.

(2) If the person has a pulse but is not breathing on his or her own, continue mouth-to-mouth resuscitation.

(3) If the person resumes breathing on his or her own, check for bleeding and other injuries. Continue to monitor the person's breathing and be prepared to resume mouth-to-mouth resuscitation if needed. (NOTE: If a person is breathing on his or her own, he will also have a pulse.)

(4) If the person's chest did not rise and fall, then fresh air is not getting into his or her lungs. Try to open the person's airway more. (If the head-tilt/chin-lift method is being used, lift the chin more. If the jaw thrust method is being used, tilt the head backward slightly.) Then administer two full breaths again. If the person's chest still does not rise, a foreign object is probably blocking his or her airway. Administer finger sweeps (see Perform Finger Sweep) and manual thrusts (see Perform Abdominal Thrusts or Perform Chest Thrusts) as needed in order to unblock his or her airway. Once the airway is unblocked, administer two full breaths again and reevaluate.

j. **PERFORM FINGER SWEEP, IF NEEDED**: If you can see a foreign object in an unconscious person's mouth or if you strongly suspect the presence of a foreign object in an unconscious person's mouth, a finger sweep should be performed.

**WARNING**

**Do not use the finger sweep technique if the person is conscious. The finger sweep can trigger the person's "gag reflex" and cause him to vomit.**

(1) Open the person's mouth. If the person's mouth does not open readily, cross your finger and thumb and push his or her teeth apart. Lift the person's jaw using the tongue-jaw lift. Grasp the person's tongue and lower jaw between your thumb and fingers and lift the jaw. Moving the tongue and jaw makes foreign objects easier to locate. Look inside the person's mouth to see if you can locate the obstruction. Insert the index finger of your free hand down along the inside of the person's cheek to the base of his or her tongue. Sweep the throat with a "hooking" motion. Many foreign objects can be dislodged by using a hooking action when moving your finger from the side of the person's mouth toward the

center. You may need to push the object to the side of the person's throat before you can secure the object to be removed.

**CAUTION:** Take care to avoid forcing the object deeper into the person's airway.

(2) Pull the object out of the person's throat. Remove the object with your fingers. Try to ventilate the person again (mouth-to-mouth or mouth-to-nose) and check for breathing. If the person is breathing on his or her own, treat any major injuries and evacuate the person. If the person's chest rises and falls but he does not breathe on his or her own, check the person's pulse. If you are unable to ventilate the person (chest does not rise), perform manual thrusts (see Perform Abdominal Thrusts, Fig. 6.8 or Perform Chest Thrusts, Fig. 6-10).

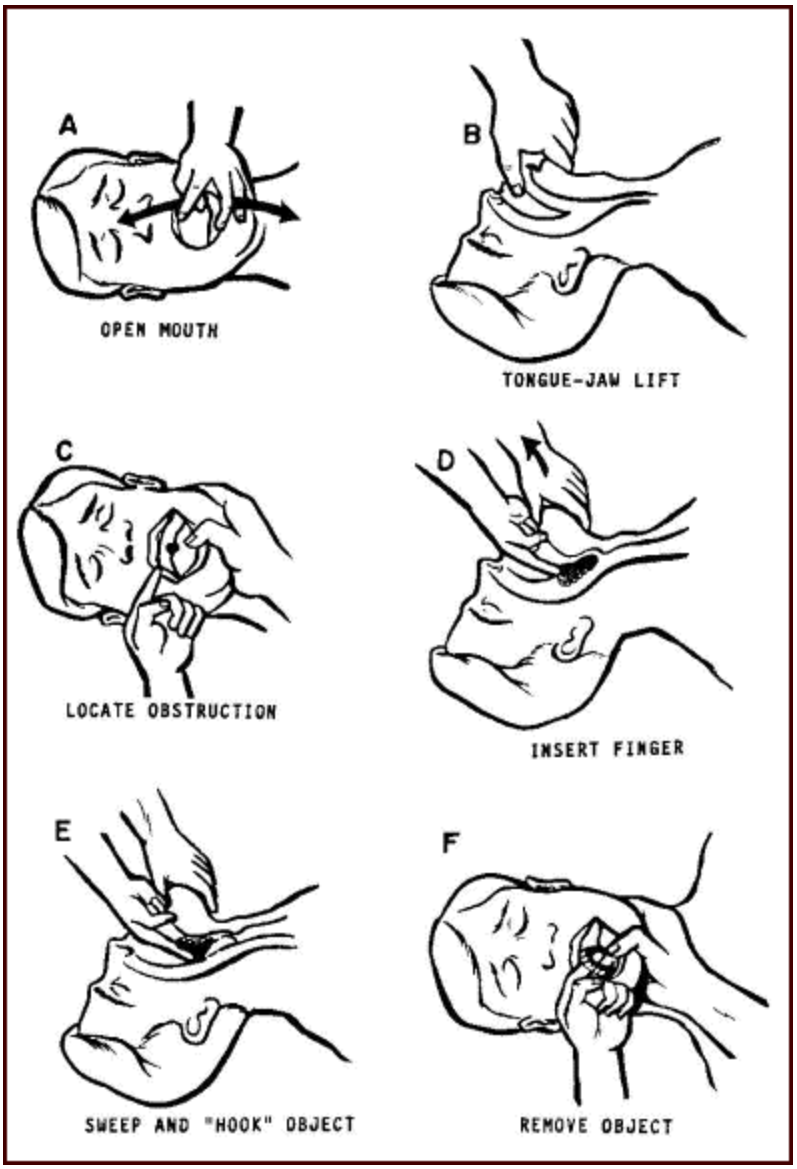


**FIGURE 6-7. PERFORMING A FINGER SWEEP**

**PERFORM ABDOMINAL THRUSTS, IF NEEDED**

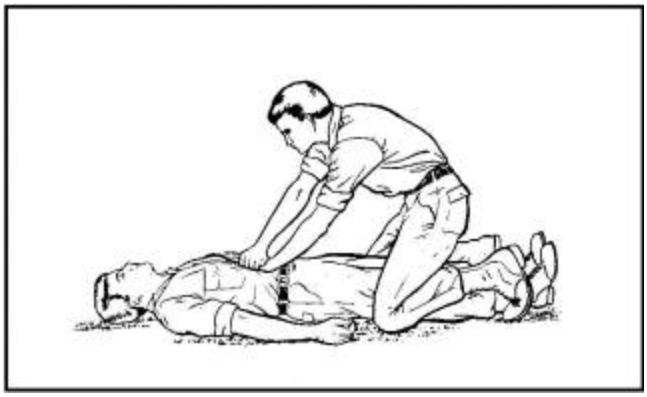

**FIGURE 6-8. ADMINISTERING AN ABDOMINAL THRUST (PERSON IN SUPINE POSITION)**

(3) A manual thrust acts like an artificial cough. Each thrust is performed with the intent of dislodging the obstruction without having to perform additional thrusts. The abdominal thrust is usually the preferred method of administering a manual thrust.

**WARNING**

**If the person has an abdominal wound, is noticeably pregnant, or is extremely overweight, use the chest thrust method.**

(4) Kneel astride the person's thighs. Place the heel of one hand against the middle of the person's abdomen. The heel should be slightly above the navel (belt buckle) and well below the tip of the breastbone (xiphoid process) with your fingers pointing toward the person's head. Do not make your hand into a fist. Place the heel of your other hand on top of the heel of the hand on the person's abdomen. Press into the abdomen using a quick forward (inward) and upward thrust. Locking your elbows and shifting your body weight forward can deliver the thrust. Release the pressure on the person's abdomen (shift your body weight backward). Quickly evaluate the effectiveness of the thrust.

(5) If the obstruction has been dislodged, perform a finger sweep to remove the obstruction, administer two full breaths, and evaluate their effectiveness.

(6) If the obstruction was not dislodged, administer additional thrusts (up to five). If the obstruction is not expelled, call for help again. Then repeat the procedures for initiating resuscitation, perform a finger sweep, and administer abdominal thrusts again. Continue until the object is expelled and the person's

airway is open (chest rises during ventilations).

**CAUTION:** If the person vomits, turn him onto his or her side and use a quick finger sweep to remove vomitus from his or her mouth.

k. **PERFORM CHEST THRUSTS, IF NEEDED**: The chest thrust is used to remove an airway obstruction in an unconscious person if the person has an abdominal wound, is noticeably pregnant, or is extremely overweight. Kneel close beside the person's chest. Locate the lower edge of the person's rib cage.

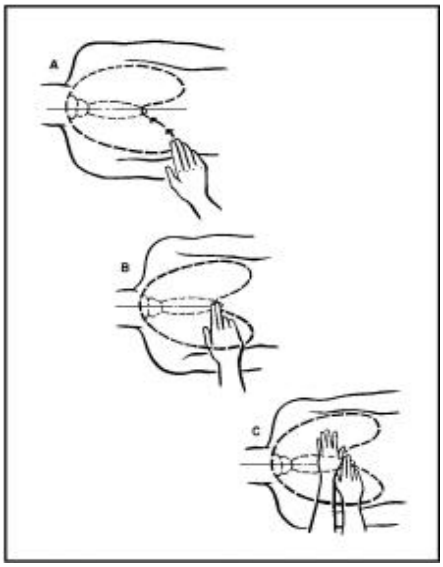


**FIGURE 6-9. LOCATING COMPRESSION SITE FOR CHEST THRUST**

(1) Run the fingers of one hand (usually your dominant hand) along the lower edge of the rib cage until you come to the notch where the rib meets the breastbone at the middle of the person's chest. Place your middle finger on the notch. Then place your index finger next to your middle finger. Your index finger should now be on the lower end of the person's breastbone. (NOTE: This step assumes that your index finger is closer to the person's head than your middle finger. If not, put your index finger on the notch and your middle finger on the breastbone.) Place the heel of your other hand next to your

two fingers and over the person's breastbone. Do not form a fist. The heel of your hand is on the compression site.

**CAUTION:** Make sure that your heel is on the breastbone and not resting on the ribs.

(2) Remove your fingers from the notch area and place that hand on top of the hand on the compression site. Either extend or interlace your fingers. Straighten your arms and lock your elbows. Position your shoulders directly above your hands.

FIGURE 6-10. ADMINISTERING A CHEST THRUST (PERSON IN SUPINE POSITION)

(3) Using the weight of your body, apply enough pressure straight down to depress the person's breastbone 1 to 2 inches.

**CAUTION:** Do not bend your elbows, rock, or allow your shoulders to sag while delivering the thrust. If the thrust is not delivered properly, it will lose some of its effectiveness and could result in additional injury.

(4) Release the pressure by shifting the weight of your body from your arms. Do not remove your hands from the compression site. If you remove

your hands from the site, repeat the procedures for locating the compression site. Delivering a thrust at the wrong compression site can injure the person.

(5) Quickly evaluate the effectiveness of the thrust.

(6) If the obstruction has been dislodged, perform a finger sweep to remove the obstruction, administer two full breaths, and evaluate their effectiveness.

(7) If the obstruction was not dislodged; administer additional chest thrusts (up to five). If the obstruction is not expelled, call for help again. Then repeat the procedures for initiating resuscitation, perform a finger sweep, and administer chest thrusts again. Continue until the object is expelled and the person's airway is open (chest rises during ventilations).

l. **CONTINUE MOUTH-TO-MOUTH RESUSCITATION**

(1) Open the person's airway.

(2) Take a breath.

(3) Close the person's nostrils.

(4) Seal your mouth over the person's mouth.

**CAUTION:** If the person has face injuries that prevent you from administering mouth-to-mouth resuscitation, close his or her mouth, seal your mouth over his or her nose, and administer mouth-to-nose resuscitation.

(5) Blow the breath into the person's lungs. Observe the rising of the person's chest to ensure that the ventilation is effective.

(6) Break your seal over the person's mouth and release his or her nose. Observe the person's chest fall and listen for exhalation.

**CAUTION:** If the chest does not rise and fall, reposition his or her airway (tilt head back more or lift jaw more) and try again until the chest rises and falls.

(7) Repeat mouth-to-mouth (or mouth-to-nose) ventilations at the rate of about 10 to 12 ventilations per minute. Observe the chest to make sure that it is rising and falling.

(8) After about one minute (12 ventilations), stop ventilating the person and check the person's carotid pulse. Observe the person's chest for spontaneous breathing (breathing on his or her own without your help) as you feel for the pulse. The procedure should take 3 to 5 seconds.

(9) Evaluate the situation and determine needed action.

(10) If the person has no pulse and you are not qualified to administer CPR, seek medical aid for the person. If you are qualified to administer CPR, administer CPR and send someone to seek medical help.

(11) If the person has a pulse and is breathing on his or her own, check for other injuries while continuing to monitor the person's breathing and pulse.

(12) If the person has a pulse but is not breathing on his or her own, continue to administer mouth-to-mouth (or mouth-to-nose) resuscitation at the rate 10 to 12 ventilations per minute. Check the person's pulse at the end of 12 ventilations to ensure that his or her heart is still beating. When checking the person's pulse, also observe the person's chest to see if he is breathing on his or her own. Continue administering rescue breathing until spontaneous breathing occurs, you are relieved, you must seek medical help, or you are too exhausted to continue.

m. **MONITOR THE PERSON**: Once you have established that the person is breathing on his or her own (breathing

spontaneously), continue to monitor the person's breathing. Ensure that the person's airway remains open. If breathing difficulties arise, call for help and repeat the steps for clearing the airway and performing rescue breathing, as needed.

(1) The information contained herein discusses the steps to apply basic first aid to stop bleeding.

(2) After you have established that the individual is breathing or that it has been restored, you should check for any wounds that may be bleeding. Look for both an entry and an exit wound.

(3) Once you identify the wound, you want to identify the pressure points of the body and apply a pressure dressing, or use your hand, to prevent the wound from further bleeding.

**Warning:** Do not try to remove objects from the wound.

(4) If the wound is in an arm or leg, elevate the injured limb above the level of the heart.

**Warning:** Do not elevate a limb with broken bones unless it is properly splinted.

(5) In the event that the wound does not stop bleeding once pressure has been applied, apply a tourniquet.

(6) Tie the tourniquet between the wound and the body trunk or between the wound and the heart.

(7) Never place the tourniquet directly on the wound.

(8) Mark the person with a visible capital “T” on his or her forehead, write the time and date to identify when the tourniquet was applied.

(9) Seek immediate medical attention.

(10) The information contained herein discusses the steps to apply the basic first aid to protect the wound.

(11) Securely cover wound and organs with a bandage but do not try to replace organs that are outside the body.

(12) Act quickly but remain calm, reassure the person, and seek medical assistance as soon as possible.

(13) The information contained herein discusses the steps to apply the basic first aid to treat for shock.

**Warning:** Unless shock is prevented or treated, death may result even though the injury is not fatal.

n. Identify the symptoms of shock.

(1) Restlessness, thirstiness, pale skin, and rapid heartbeat.

(2) Sweating, and cool, clammy skin.

(3) Gasping breath or shallow, rapid breathing.

(4) Staring blindly into space.

(5) Blotchiness or bluish color around the mouth.

o. Keep the person warm; reassure the person by remaining calm yourself, and assure the victim her or she will be taken care of.

p. Place the person in a comfortable position and continue monitoring until relieved by medical personnel.

**J. SUMMARY:** This lesson guide has covered the 4 life saving techniques. When these techniques are performed properly, the likelihood of saving the individual will be improved significantly.

## K. QUESTIONS?

1. What should you do after you apply a tourniquet?

   a. Mark the person with a visible capital “T” on his or her forehead, write the time and date to identify when the tourniquet was applied.

2. If a person is choking, should you continue to let them cough before attempting First Aid?

   a. **T** or F

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 A.2 (A-2)

## Safety Precautions and Procedures

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**A. LECTURE NUMBER:** MOS 6492 A.2 (A-2)

**B. TIME:** 1 hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Safety Precautions and Procedures

**F. OBJECTIVES:** To assure that minimal harm to people, other organisms, and the environment will not result from the disposal of waste laboratory chemicals.

**G. INSTRUCTIONAL AIDS:** None

**H. REFERENCES:** MSDS

**I. PRESENTATION:**

1. INTRODUCTION: Hazardous waste disposal is the most costly and most regulated method of managing expired or unneeded hazardous materials. The cost of disposal is often more than the purchase cost of the material, thus every effort should be made to avoid disposal as a hazardous waste. In the next 30 minutes I will be discussing with you the proper way to perform hazardous material/waste disposal. The purpose of this lesson is to assure that minimal harm to people, other organisms, and the environment will not result from the disposal of waste laboratory chemicals.

2. BODY:

   a. If a hazardous material is determined to no longer be suitable for its intended purpose and all other routes of utilization have been attempted, the last management alternative is disposal as a regulated waste. The waste disposal program should specify how waste is to be collected, segregated, stored, and transported and include consideration of what materials can be incinerated. The following are general steps in performing hazmat disposal:

b. Discarding Chemical Stocks: unlabeled containers of chemicals and solutions should undergo prompt disposal; if partially used, they should not be opened. Before workers leave the area, chemicals for which that person was responsible should be discarded or returned to storage.

c. Frequency of Disposal: Waste should be removed from laboratories to a central waste storage area at least once per week and from the central waste storage area at regular intervals.

d. Method of Disposal: Incineration in an environmentally acceptable manner and is the most practical disposal method for combustible laboratory waste. Indiscriminate disposal by pouring waste chemicals down the drain or adding them to mixed refuse for landfill burial is unacceptable. Hoods should not be used as a means of disposal for volatile chemicals. Disposal by recycling or chemical decontamination should be used whenever possible.

**J. SUMMARY:** Everyone is responsible for performing proper hazardous material and waste disposal so that the least amount of damage is done to people, other organisms, and the environment. This can be accomplished through properly identifying waste that has out lived its shelf live and, through the proper procedures, disposing of it frequently. By doing this we are providing a safe working environment.

## K. QUESTIONS?

1. Who is responsible for ensuring hazardous waste is disposed of properly?

2. What is a method of disposal?

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 A.2 (A-3)

## Safety Precautions and Procedures

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**A. LECTURE NUMBER:** MOS 6492 A.2 (A-3)

**B. TIME:** 1 hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Safety Precautions and Procedures

**F. OBJECTIVES:** To familiarize technicians on electrical safety. The main objective of this course is to ensure safety procedures are followed at all times.

**G. INSTRUCTIONAL AIDS:** None

**H. REFERENCES:** NAVOSH ASTM F 496-85

**I. PRESENTATION:**

1. INTRODUCTION: Technicians, quite often, do not place sufficient emphasis on electrical safety within calibration laboratories. Complacency while performing safety procedures cause potentially hazardous circumstances to be overlooked. Most technicians have respect – or even fear – of electricity when first introduced to it. But, over time many technicians fail to identify and/or avoid potentially hazardous situations. The majority of shock victims are not new technicians, rather experienced technicians who are comfortable working around electricity. Technicians do not have to fear electricity to avoid personal injury due to electrical shock, but electricity should always be respected. The most important concept to remember is this to **BE CAUTIOUS**.

2. BODY:

   a. **Identifying electrical hazards at home and at the work center.** This is basically what the Marine Corps is about; identifying the problem before it becomes a problem. At home, it should be noted if too many power cords are connected to an extension cord it might cause a short. Also, look for water around

outlets as well as burned or aged cords/outlets. Remember that electricity produces heat and may cause fires. If you notice corrosion, alert a technician who has the proper training to correct the deficiency. More importantly, pay attention to high voltage signs and labels. If a hazard, without a warning label, is identified ensure that a label is placed over the hazard promptly. A basic guideline for identifying hazards is, “If it does not look right, it is a hazard.”

b. **Precautions and Procedures**. All work or repair of electrical circuits or equipment will be performed by authorized and qualified technicians/electricians. Personnel working within 4 feet of electrical equipment/circuits shall remove rings, wristwatches, bracelets, and other metal objects. Work will not be performed with wet hands, while wearing wet clothing, or while standing on wet/damp surfaces. Rubber electrical gloves shall be worn if the technicians likely to come in contact with live wires, conductors, or current carrying parts. Electrical gloves shall be checked, as per ASTM F 496-85. The two-person concept should always be applied when working on live equipment. All metal hand tools shall be properly insulated with plastic handle grips, dip coating, or rubber insulated tape. The shanks of screwdrivers used inside of electrical equipment shall be insulated with insulating sheaths leaving only 3/16$^{th}$ inch exposed. Fuse boxes and panel covers will be closed at all times unless work is being conducted. All circuit breakers shall be properly labeled and all circuits identified and revalidated annually. Power panels shall be identified as to the power panel number/source supply; amps, volts, cycle, and phase actually in use and each circuit uniquely identified. Check resistance between the metal bases and frames of electrical equipment and ground.

c. **Tool inspection & equipment inspection.** This is very important when it comes to safety; the condition of tools may save a life. Make sure that electrical tools do not have frayed wires or any exposed circuits. Ensure that electrical tools are not wet or damp. Pay attention to the equipment for maximum

inputs and capabilities and use PPE as required. Check tools and equipment for rust and corrosion.

d. **Effects of current types of shock (mild or sever) and how to identify a shock victim.** The severity of injury from electrical shock depends on the amount of electrical current and the length of time the current passes through the body. For example, 1/10 of an ampere (amp) of current passing through the body for just 2 seconds is enough to cause death. The amount of internal current a person can withstand and still be able to control their arm or hand muscles can be less than 10mA. Currents above 10mA can paralyze or "freeze" muscles. When this "freezing" happens, a person is no longer able to release a tool, wire, or other object. In fact, the electrified object may be held even more tightly, resulting in longer exposure to the shocking current. For this reason, hand-held tools that conduct electricity can be very dangerous. If the technician cannot let go of the tool, current continues through his/her body for a longer time, which can lead to respiratory paralysis (the muscles that control breathing cannot move). Usually, it requires about 30mA of current to cause respiratory paralysis. Currents greater than 75mA may cause ventricular fibrillation (very rapid, ineffective heartbeat). This condition may cause death within a few minutes unless a special device called a defibrillator is used to save the victim. Heart paralysis occurs at 4 amps, which means the heart does not pump at all. Currents greater than 5 amps burn tissue. A severe shock can cause far more damage to the body than what is visible. An individual may suffer internal bleeding and destruction of tissues, nerves, and muscles. Sometimes the hidden injuries caused by electrical shock result in a delayed death. Electrical shock is often only the beginning of a chain of events. Even if the electrical current is too small to cause injury, reaction to the shock may cause an individual to fall. This may result in bruises, broken bones, or even death. The electrical shock duration greatly affects the amount of injury. If the shock is short in duration, it may only be painful. A longer shock (lasting a few seconds) could be fatal if the level of current is high enough to cause the heart to go into ventricular fibrillation. A small power drill

uses 30 times more current than required to kill a human being. At relatively high currents, death is certain if the shock is long enough. However, if the shock is short and the heart has not been damaged, a normal heartbeat may resume if contact with the electrical current is eliminated. The amount of current passing through the body also affects the severity of an electrical shock. Higher voltages produce higher currents. So, there is greater danger from higher voltages. Resistance hinders current. The lower the resistance (or impedance in AC circuits) the higher the current will be. Dry skin may have a resistance of 100,000 ohms or more. Wet skin may have a resistance of only 1,000 ohms. Wet working conditions or broken skin will drastically reduce resistance. The low resistance of wet skin allows current to pass into the body more easily. When more force is applied to the contact point or when the contact area is larger, the resistance is lower, causing stronger electrical shocks. The path of the electrical current through the body affects the severity of the shock as well. Currents passing through the heart or nervous system are most dangerous. If a live wire contacts with a head, the nervous system could be permanently damaged. Contacting a live electrical part with one hand-while grounded at the other side of the body will cause electrical current to pass across the chest, possibly injuring heart and lungs. Once a victim is no longer in contact with electricity, call for medical help and check the following:

(1) Shock: Signs include cold or clammy skin, weakness, shallow breathing and a rapid pulse.
(2) Burns: Cool minor burns with cold, running water. Don't touch the burn, break blisters, or remove burned clothing. Get medical help; electrical burn damage may not be immediately apparent.
(3) Shut off the electricity if the victim is still in contact with the energized circuit. At the same time, have someone else call for help. If getting to the power shut off switch quickly is a problem, pry the victim from the circuit with something that does not conduct electricity such as dry wood. Do not touch the victim if he or she is still in contact with an electrical circuit! Do not become a victim! Do not leave the victim

unless there is absolutely no other option. Stay with the victim while Emergency Medical Services (EMS) is contacted. The caller should return afterwards to report that the call was made. If the victim is not breathing, does not have a heartbeat, or is badly injured, quick response by a team of Emergency Medical Technicians (EMTs) or Paramedics provide the best chance for survival. Once it is clear that electrical current is no longer flowing through the victim, call out to the victim to see if he or she is conscious. If the victim is conscious, tell the victim not to move. It is possible for a shock victim to be seriously injured but not realize the severity of his or her injuries. Quickly examine the victim for signs of shock, which include cold or clammy skin, weakness, shallow breathing, and a rapid pulse. Check for burns. Cool minor burns with cold, running water. Do not touch the burn, break blisters, or remove burned clothing. Get medical help; electrical burn damage may not be immediately apparent. Also, look for major bleeding. If there is a large amount of bleeding, place a cloth (such as a handkerchief or bandanna) over the wound and apply pressure. If an arm or leg is wounded and the bleeding does not stop, gently elevate the injured area while keeping pressure on the wound. Keep the victim warm and talk to him or her until help arrives. If the victim is unconscious, take the necessary steps to ensure he/she is breathing. While this is happening, move the victim as little as possible. If the victim is not breathing, someone trained in CPR should begin artificial breathing and then check to see if the victim has a pulse. Quick action is essential! To be effective, CPR must be performed within 4 minutes of shock setting in.

e. **How to perform CPR.**

# 1. CALL

**Check the victim for unresponsiveness. If there is no response, Call 911 and return to the victim. In most locations the emergency dispatcher can assist you with CPR instructions.**

# 2. BLOW

**Tilt the head back and listen for breathing. If not breathing normally, pinch nose and cover the mouth with yours and blow until you see the chest rise. Give 2 breaths. Each breath should take 2 seconds.**

# 3. PUMP

**If the victim is still not breathing normally, coughing or moving, begin chest compressions. Push down on the chest 11/2 to 2 inches 15 times right between the nipples. Pump at the rate of 100/minute, faster than once per second.**

**CONTINUE WITH 2 BREATHS AND 15 PUMPS UNTIL HELP ARRIVES**

**NOTE: This ratio is the same for one-person & two-person CPR. In two-person CPR the person pumping the chest stops while the other gives mouth-to-mouth breathing**

**J. SUMMARY:** electrical safety is very important. Safety should be the first and last thought technicians should have while working. They need to be familiar with their surroundings (circuit breakers, PPE, and signs). Continually check for misuse and abuse of electrical instruments, proper labeling of hazardous environments, and

personal care to avoid shock or bodily harm. This will ensure injury due to electrical shock is avoided.

## K. QUESTIONS?

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 A.2 (A-3A)

## Safety Precautions and Procedures

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**A. LECTURE NUMBER:** MOS 6492 A.2 (A-3A)

**B. TIME:** 1.0 Hours

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Safety Precautions and Procedures

**F. OBJECTIVES:** Students shall be well informed and skilled in the application of safety procedures near high-pressure air sources within the work center.

**G. INSTRUCTIONAL AIDES:** Local work center safety board, signs, and Personal Protective Equipment (PPE).

**H. REFERENCES:**

1. OPNAVINST 5100
2. Series NAVSEA OD 55147
3. Rev 2 NAVSEA 48930

**I. PRESENTATION:**

1. INTRODUCTION: The purpose of the following period of instruction is to instruct students on safety procedures near high-pressure pneumatic sources. This instruction contains several safety guidelines that must be followed to ensure operator safety and to prevent damage to any high-pressure equipment being used. Please refer to the manufacturers' equipment operation manual for any equipment-specific safety procedures.

2. BODY: The following is a list of safety precautions that should be followed to ensure your own personal safety while operating high-pressure pneumatic equipment:

   a. Be knowledgeable of the pressure system under test.

   a. Always wear a face shield and/or safety goggles when operating pressurized test equipment.

a. Post a "Danger-High Pressure" sign near your work area.

a. Double-check all pressure and unit selections.

a. Check the condition of all high-pressure fittings and connectors prior to each use.

a. Always open air valves slowly, paying close attention for leaks.

a. Observe the instrument while increasing pressure.

a. Never apply twisting force to a pressure gage or test instrument case.

a. Use properly fitting wrenches on the instruments wrench flats.

a. Never leave any pressurized system unattended.

**J. SUMMARY:** This instruction was a brief overview of several guidelines that must be considered when working on or near high-pressure pneumatic sources. These, and other steps, are necessary to protect the operator, other people in the area, and the equipment itself. Always remember to exercise extreme caution when using high-pressure pneumatic sources and remember to refer to the manufacturer’s publication for answers to any question about the proper set-up, operation, and breakdown of high-pressure systems.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 A.2 (A-4)

## Safety Precautions and Procedures

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**A. LECTURE NUMBER:** MOS 6492 A.2 A-4

**B. TIME:** 30 Minutes

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Safety Precautions and Procedures

**F. OBJECTIVES:** To familiarize technicians on the correct employment and maintenance of Personal Protective Equipment (PPE).

**G. INSTRUCTIONAL AIDS:** Face Shield, Goggles, Electrical Gloves, Hazardous Material Gloves and Apron, Earmuffs, Cranial, and Safety Boots

**H. REFERENCES:** OPNAVINST 5100.23E

**I. PRESENTATION:**

1. INTRODUCTION: For proper protection, one needs to determine the correct PPE for the task being performed. When the correct PPE is selected and used properly the risk of a job-related injury or illness is dramatically reduced. Many protective devices, through misapplication or improper maintenance, can become ineffective and can have potentially serious consequences. Therefore, proper equipment selection, maintenance, employee training (including equipment limitations), and mandatory enforcement of equipment use are key elements of an effective PPE program.

2. BODY:

   a. Any technician required to wear PPE shall receive training in the proper use and care of PPE. OSHA shall offer periodic retraining to both the employees and the supervisors as needed. This training shall include, but not necessarily be limited to, the following subjects:

(1) When PPE is necessary to be worn.
(2) What PPE is necessary?
(3) How to properly don, doff, adjust, and wear PPE.
(4) The limitations of the PPE.
(5) The proper care, maintenance, useful life, and disposal of the PPE.

b. Types of and use of PPE:

(1) Face Shield – used for entire face protection.
(2) Goggles – used for eye protection from liquids.
(3) Electrical Gloves – used for high voltage/current tasks.
(4) HazMat Gloves – used for hydraulic fluid, synthetic lubrication oil.
(5) Apron - used for hydraulic fluid, synthetic lubrication oil.
(6) Earmuffs – used anytime 100 psi or greater is present.
(7) Cranial – used anytime overhead hazards or fall hazards exist.
(8) Safety Boots – Need to be worn at all times in production, storage, and inspection areas of the work center.

c. It is important that all PPE be kept clean and properly maintained. Cleaning is particularly important for eye and face protection where dirty or fogged lenses could impair vision. PPE should be inspected, cleaned, and maintained at regular intervals so that the PPE provides the requisite protection.

**J. SUMMARY:** The three most important things to remember are:

1. Choose the correct PPE for the task; PPE is specifically designed for the hazard you will face.
2. Understand how to use the equipment; PPE must be used correctly to protect you effectively. It is designed for <u>your</u> benefit. For your sake and for your fellow Marines, learn how to use PPE. If you don’t know, ASK!
3. Clean and maintain the PPE; dirty or malfunctioning PPE could result in serious injury or death.

4. PPE is an all hands responsibility. Know the hazards present in your work area. Inform anyone entering the area of the hazards they may face.

## K. QUESTIONS?

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 A.2 (A-5)

## Safety Precautions and Procedures

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**A. LECTURE NUMBER:** MOS 6492 A.2 (A-5)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Safety Precautions and Procedures

**F. OBJECTIVES:** Students will know and understand how to comply with safety markings in the work center and know where to find references on safety and related areas.

**G. INSTRUCTIONAL AIDS:** Local work center safety board, NAVAIR publications, and NAVOSH publications

**H. REFERENCES:**

1. OPNAVINST 4790.2H
2. OPNAVINST 5100.23
3. MCO 3500.27A/OPNAVINST 3500.39
4. OPNAVINST 5100.8G

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY:

   a. Safety is all about preventing accidents. Personal injury typically occurs because safety precautions are either not learned or they are not practiced.

   b. Standard safety markings are used in all areas of the shop as aids to communicate information on hazards, the need for personal protective equipment, and the location of safety equipment and emergency facilities, such as the eye wash stations, first aid kits, and fire extinguishers. Furthermore, they provide guidance and instruction in emergencies.

c. One reason for safety markings is to remind Marines to use Personal Protective Equipment (PPE). PPE is required in many areas both in and out of the work center. Safety markings pertaining to PPE are established to be a reminder to utilize earplugs, gloves, and face shields as well as other necessary protection. Adhering to such markings saves marines from hearing loss, eye loss, and any other personal injury.

d. Safety markings also pertain to HAZMAT. There are often signs posted which direct Marines to where the HAZMAT business plan and MSDS binder can be found. This is important because it gives Marines information, contacts, and instructions on how to deal with mishaps. This provides the location of the binder and MSDS information in case of a HAZMAT incident.

e. Examples of safety signs are:

(1) Danger signs indicate an imminently hazardous situation, which, if not avoided, will result in death or serious injury. This signal work is to be limited to the most extreme situations.

(2) Warning signs indicate a potentially hazardous situation, which, if not avoided, could result in death or serious injury.

(3) Caution signs indicate a potentially hazardous situation, which, if not avoided, could result in minor or moderate injury. It may also be used to avoid unsafe practices.

3. Activity:

a. At this time proper safety procedures for the shop should be demonstrated to include the correct procedure in case of an electrical accident, the proper P.O.C. to notify in case of any emergency, and what to do and what not to do in case of electrical fires.

**J. SUMMARY:** Safety is something that should always be practiced, rather than learned from an incident or experience. By following all of the proper markings posted,

many dangers can be avoided. The biggest safety lesson one can learn and always practice is to be vigilant and aware of ones surroundings.

## K. QUESTIONS?

# AVIATION MAINTENANCE TRAINING

**LESSON GUIDE NUMBER: Aviation MOS 6492 A.3 (C)**

**Publications, Diagrams, Sketches, and Drawings**

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**A. LECTURE NUMBER:** MOS 6492 A.3 (C)

**B. TIME:** 1 hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Publications, Diagrams, Sketches, and Drawings

**F. OBJECTIVES:** To instruct the technician on the Naval Aviation Maintenance Program (NAMP), specifically Vol. V Ch. 19 concerning the METCAL program.

**G. INSTRUCTIONAL AIDS:** 4790.2H

**H. REFERENCES:** 4790.2H Vol. V Ch. 19

**I. PRESENTATION:**

1. INTRODUCTION: The NAMP section addressing the Metrology and Calibration (METCAL) program is Vol. V Ch. 19 and covers the procedures and responsibilities at the Intermediate level. There are six sub-sections and each cover a different aspect of calibration. Also included in this chapter are illustrations of labels, tags, and sample formats for invoices and discrepancy reports.

2. BODY:

   a. Section 19.1 covers the introduction to the METCAL program and lists all references that the NAMP draws from to create I-level policy concerning calibration.

   b. Section 19.2 provides requirements of calibration, explains measure formats, and outlines calibration stickers and their different uses. This section is a good quick reference, which defines various aspects of the METCAL program. Along with defining items it also lists the reference and, in most cases, who is responsible for that aspect of calibration, i.e. TYCOMs.

c. Section 19.3 lists all pertinent information and duties of all personnel involved in the METCAL Program. It lists responsibilities for the Field Calibration Activity (FCA), Aircraft Maintenance, Avionics Division Officer (AMO), Intermediate Maintenance Activity METCAL Program Manager (PME Chief), Organizational Level (I-Level) METCAL Program Manager, Quality Assurance (QA) Officer, Program Manager, Individual Material Readiness List (IMRL) Manager, Work Center 67A, and the Work Center Supervisor.

d. Section 19.4 covers deployment-operating procedures. This section outlines the responsibilities of the squadron and the FCA during two different deployment lengths. (Less than 90 days and greater than 90 days.

e. Section 19.5 address the METCAL extension policy. This section entails who has the authority to extend an interval and tags used for the extension. The AMO is authorized to extend calibration intervals for support equipment (SE), except for flight or safety of personnel SE. Safety of flight and personnel extension requests can only be approved by the responsible TYCOM. Radiac SE calibration extensions can only be approved by the responsible SYSCOM. When extending the calibration interval a special calibration label shall be affixed to the SE next to, but not over, the previous cal sticker. It shall list the approving authority and the length of the extension. Also, this sub section provides guidance on how to designate safety of flight and personnel in measure formats. This is done with the (#) symbol next to the last character in the sub custodian field.

f. Section 19.6 addresses embedded calibration standards and pool site functions, as well as I-level procedures for acquiring new standards from pool sites. These are standards embedded into automated benches that allow self-calibration before each use. Further, the listing of all embedded standards is found in 19.6. There are only 5 in the 4790.2H revision of the NAMP.

**J. SUMMARY:** The NAMP covers all Naval Aviation Maintenance functions. As calibrators, our primary focus is the METCAL

program covered in Vol. V Ch. 19. This section defines who is accountable for calibratable items and outlines procedures and policies that provide the foundation for the METCAL Program.

## K. QUESTIONS?

# AVIATION MAINTENANCE TRAINING

**LESSON GUIDE NUMBER: Aviation MOS 6492 A.3 (D)**

**Publications, Diagrams, Sketches, and Drawings**

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**A. LECTURE NUMBER:** MOS 6492 A.3 (D)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Publications, Diagrams, Sketches, and Drawings

**F. OBJECTIVES:** To instruct the technician on the purpose of avionics cleaning and corrosion control manual.

**G. INSTRUCTIONAL AIDS:** None

**H. REFERENCES:**

1. OPNAV 4790.2
2. NAVAIR 17-1-125
3. NAVAIR 16-1-540
4. NAVAIR 01-1A-509

**I. PRESENTATION:**

1. INTRODUCTION: A successful corrosion prevention program is the result of concentrated efforts by all operating, maintenance, and other support personnel involved with Support Equipment (SE). An organized and vigilant preventive maintenance effort will reduce maintenance time spent repairing corrosion damage, reduce the number of maintenance actions, and increase SE reliability, availability, and longevity. In accordance with OPNAVINST 4790.2 series, activities responsible for the maintenance of SE will establish a maintenance schedule for each piece of equipment. Completed Visual Information Display System/Maintenance Action Forms (VIDS/MAFs) and OPNAV Form 4790/60 are used to schedule and record maintenance actions for each piece of equipment. When properly documented, this form provides valuable past, present, and future preventive maintenance information. The preventive maintenance schedule, in conjunction with the Maintenance Requirements Cards (MRCs), shall be developed with regards to the type of equipment, its intended use, its

service environment, its storage location, and this lesson.

2. BODY:

a. The major concern in corrosion control is “PREVENTION”. The detection and treatment of corrosion are important skills and all maintenance personnel should be familiar with these methods to ensure the integrity of all aircraft systems, components, and equipment.

(1) Types of corrosion:

(a) Direct surface attack.

(b) Galvanic or dissimilar metal corrosion.

(c) Inter-granular corrosion.

(d) Pitting.

(e) Exfoliation.

(f) Crevice attack or concentrated cell corrosion.

(g) Fretting corrosion.

(h) Stress corrosion.

(i) Corrosion fatigue.

b. Prevention of corrosion should be completed on a scheduled basis. This will insure the integrity and safety of the equipment being used. Intervals are designated for equipment that requires corrosion control to promote long-term quality. Intervals may vary due the climate or conditions in which the equipment is being used. All preventive maintenance should be done in accordance with the references listed and/or that equipment MRCs.

(1) Only qualified personnel that are trained in the preparation of surfaces, application of materials, and removal of corrosion will perform treatment of corrosion. This will ensure that

proper procedures are followed to prevent continued corrosion of the affected material.

(2) Safety in corrosion cannot be overemphasized. It is the responsibility of each individual to ensure a safe work environment for workers, as well as all other personnel located in or near the immediate area. Extreme caution should be used when handling hazardous material. For example: paints, solvents, carbon fibers, paint removers, resins, and epoxy adhesives.

**J. SUMMARY:** Corrosion control impacts all aspects of maintenance as well as the environment. However, with adherence to existing instructions it can be a safe well-managed program that will greatly reduce the deterioration of aircraft, systems, components, and the equipment used in maintaining these assets. This program saves lives and assets when personnel actively participate.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

**LESSON GUIDE NUMBER: Aviation MOS 6492 A.3.F**

**Publications, Diagrams, Sketches, and Drawings**

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**A. LECTURE NUMBER:** MOS 6492 A.3.F

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Publications, Diagrams, Sketches, and Drawings

**F. OBJECTIVES:** To instruct technicians on the procedures and policies of the Aviation Hydraulics Manual (AHM).

**G. INSTRUCTIONAL AIDS:** Aviation Hydraulics Manual

**H. REFERENCES:** Aviation Hydraulics Manual (NA 01-1A-17)

**I. PRESENTATION:**

1. INTRODUCTION: This lesson will cover Aviation Hydraulics Manual procedures and policies. The manual will be thoroughly dissected to include its key components.

2. BODY:

   a. The purpose of the Aviation Hydraulics Manual is to provide general maintenance requirements for aircraft hydraulic systems and related support equipment (SE). The manual pertains to all naval aircraft hydraulic systems, airborne hydraulic equipment, and related hydraulic servicing and test equipment.

   b. All modern naval aircraft contain hydraulic systems used for operating various mechanisms. The average operational aircraft has numerous hydraulically operated units. There are several different types of hydraulic fluids with various specifications.

      (1) **MIL-PRF-5606:** This was the principal hydraulic fluid used in naval aircrafts prior to the introduction of hydraulic fluid MIL-PRF-83282. 5606 consists of petroleum products with additive materials to improve viscosity

temperature characteristics, inhibit oxidation, and act as an anti-wear agent.

(2) **MIL-PRF-83282:** This is the principal hydraulic fluid currently used in military aircrafts. This fluid is a fire-resistant type fluid developed to replace hydraulic fluid 5606. The fluid consists of a synthetic hydrocarbon base and contains additives to provide the required viscosity and anti-wear characteristics to inhibit oxidation and corrosion. It is used in hydraulic systems that have a temperature range of -40 degrees F to +401 degrees F. There are many different fluids; these are just two that are most commonly used.

c. Hydraulic fluid contamination may be described as any foreign material or substance whose presence in the fluid is capable of adversely affecting system performance or reliability. It may assume many different forms including liquids, gases, solid matter of various composition, sizes, and shapes. Solid matter is the type most often found in aircraft hydraulic systems and is generally referred to as particulate contamination.

(1) Organic Contamination:

(a) Organic solids or semi solids found in hydraulic systems are produced by wear, oxidation, or polymerization. Minute particulates of O-rings, seals, gaskets, and hoses are present due to wear or chemical reactions.

(b) Metallic Solid: Metallic contaminations are commonly present in hydraulic systems and will range in size from microscopic particles to particles readily visible to the naked eye. These particles are the result of wearing and scoring of bare metal parts and plating materials, such as silver and chromium.

(c) Effects: Contamination of hydraulic fluid with particulate matter is one of the

principal causes of wear in hydraulic pumps, actuators, valves, and servo valves.

(2) Air Contamination:

(a) Hydraulic fluids are adversely affected by dissolved, entrained, or free air. Air may be introduced through improper maintenance or as a result of system design. Any maintenance action, such as disconnecting or removing a line or component, will invariably result in some air being introduced into the system.

(b) Effects: Free or entrained air affects the system in many ways. If the fluid supplied to a pump has high air content, resulting cavitation can cause sever mechanical damage within the pump and partial or complete loss of output pressure.

(3) These are just two of the contaminations that affect the hydraulic system.

d. Electronic Particle Counter: Two common particle counters are the 8011-3 and the CM20.9090. Both units use the principle of light extinction to determine particle size. Light shines through sample fluid to a photo detector. As the fluid from the sample flows past the photo detector at a constant rate, particles in the fluid block the light creating a shadow that reduces intensity of light shining on the photo detector. The bigger the shadow is, the larger reduction in intensity. The photo detector converts intensity to an electrical impulse whose amplitude is then converted to particle sizes. The fluid from the sample is drawn past the sensor at a constant flow rate by use of a motor controlled syringe pump.

(1) Differences:

(a) The CM20.9090 (CM20) is portable and has a smaller sample size, thus it is more critical in obtaining and preparing a good sample.

(b) The CM20 requires operator presence to turn the dial to start test and perform a few runs of clean hydraulic fluid to clean out lines in the sensor after processing dirty samples.

(c) The CM20 particle counter uses white light verses a laser.

(2) Operators should be trained and qualified to use the particle counters. NATEC representatives provide training for all personnel.

(3) Section 4 provides a discussion of decontamination methods, contamination sequence control, and decontamination procedures.

(4) The purpose of section 5 is to outline the Navy Hydraulic Contamination Control Program.

(5) Section 6 is servicing the hydraulic system. Such service will usually fall into one of the following categories:

(a) Fluid Servicing: consists of adding new filtered hydraulic fluid to the system to replace fluid lost through leakage or as a result of system maintenance or malfunction.

(b) Filter Servicing: some aircraft and SE are equipped with indicating devices (buttons or pins), which will extend when the differential pressure across the filter exceeds a predetermined value indicating a loaded element.

(6) Section 9 addresses the controlled environment work center. In order to establish this control, depot and intermediate maintenance activities shall establish programs, which ensure that dirty components will not contaminate hydraulic systems.

<u>INSTRUCTOR NOTE:</u> Have Marines browse through the Hydraulics Manual to gain a familiarization of the Aviation Hydraulics Manual.

**J. SUMMARY:** The majority of the Aviation Hydraulics Manual was covered in this lesson. Section 3 is the main section that pertains to calibration technicians. It explains what the particle counters do and how they work. The other information given is tools to help the technician understand how important aviation hydraulics is to aircraft operation.

**K. Questions?**

# AVIATION MAINTENANCE TRAINING

**LESSON GUIDE NUMBER: Aviation MOS 6492 A.3 (Q)**

**Publications, Diagrams, Sketches, and Drawings**

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**A. LECTURE NUMBER:** MOS 6492 A.3 (Q)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Publications, Diagrams, Sketches, and Drawings

**F. OBJECTIVES:** Metrology Automated System for Uniform Recall and Reporting (MEASURE) Users Manual

**G. INSTRUCTIONAL AIDS:** (MEASURE) Manual and Meter Card

**H. REFERENCES:** OPNAV Manual OP43P6B

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY:

   a. MEASURE provides information and technical data commonly required by system commands to administer the Navy Metrology and Calibration Program in accordance with NAVELEXINST 4355.3.

   b. The procedures prescribed in OP Manual OP43P6B apply to all Navy calibration laboratories/activities, all activities obtaining services there from, and to other Navy activities whose use of MEASURE has been approved or directed by its cognizant authority.

   c. MEASURE is designed to provide participating activities with a standardized system for the recall and scheduling of metrology assets into calibration laboratories/activities, documentation of data pertaining to calibration actions and related transactions performed by those calibration laboratories/activities, as well as for reporting all actions performed on those assets. MEASURE also provides collection, correction, analysis and collation of technical data, as well as distribution

of data and products/formats to calibration laboratories/activities and customer activities. In addition, MEASURE has the following functions:

(1) Develop and support Navy MetCal Program resource budgets.

(2) Plan/analyze calibration laboratory/activity workload.

(3) Record/document configuration changes and update database files.

(4) Provide technical data to the Metrology Engineering Center for TAMS reliability, analysis, and calibration interval assignment.

(5) Document traceability of measurements to standards maintained by the National Institute of Standards and Technology.

d. **CHANGES AND REVISIONS** - Navy activities having proposed changes or revisions to MEASURE, procedures/disciplines, or related documentation shall forward them via appropriate chains of command to the appropriate SYSCOM field activity in that geographic area.

e. **SYSTEM OPERATION** - The initial cycle of MEASURE begins with the completion of the inventory forms for equipment held by each customer activity. The cognizant MOCC or CDBF will establish the database. The customer activity is then provided with a printed inventory and a set of preprinted METER cards. The Cognizant MetCal Representative ensures recall schedules of equipment due for calibration in the following month are provided to customer activities and calibration laboratories/activities. Output formats are provided to management personnel by MOCC. As METER cards are processed, the database is updated and the system continues to cycle.

f. **Performance** - In accordance with recall schedule, the customer activity submits equipment for calibration, accompanied by a METER card, to the calibration laboratory/activity. The calibration laboratory/activity performs the required service,

completes the METER card, and enters the data via remote terminal, if available. Otherwise, the FCA forwards the WHITE copy to the appropriate data entry site and returns the equipment and the PINK copy of the METER card to the customer activity. The data entry site updates the database, which produces operational documents and management reports. The operation documents are distributed to customer activities and calibration laboratories/activities. The management reports are distributed to system commands, type commanders, aircraft controlling custodian activities, MetCal Reps, customer activities, and calibration laboratories/activities.

g. **Appendix Features** - The OP43P6B appendixes contain a wealth of information for personnel required to complete METER cards and for data entry via E-Term.

(1) **Appendix A:** Completion of Inventory Form. This section of the publication outlines the completion of the MEASURE TMDE INVENTORY form. Though this form is no longer used, (superceded for most applications by other inventory forms) it remains useful as a guide for information required to be collected when adding an item to the MEASURE inventory.

(2) **Appendix B:** Completion of MEASURE METER Card. Appendix B contains detailed instructions and regulations on the individual blocks that make up the METER Card. This section includes information on the purpose and uses for the different colored copies that make up the METER Card. Information on the blocks of include: Block #, Title, Alpha/Numeric entries, Completion instructions, Field Size (characters), and an example.

(3) **Appendix C:** Completion of Equipment Identification and Receipt Tag. This section contains detailed instructions on the appropriate completion of the “bottom section” of the METER Card and includes information on the use of the colored copies of the receipt tag.

(4) **Appendix D:** Examples of METER Card Transactions. This appendix provides quick reference examples of common METER Card transactions including: addition to inventory, calibration transaction, delay status documentation, deletion from inventory/change of sub-custodian, placing equipment in inactive status, placing in NCR status, rejecting items, and repair only documentation.

(5) **Appendix E:** Required Customer Activity Functions. This section outlines the responsibilities for the customer activity and program manager to perform. These include format distribution, METER Card handling, etc.

(6) **Appendix F:** Required Calibration Laboratory/Activity Functions. This section outlines the responsibilities assigned to the calibration laboratory for the upkeep of the METCAL program.

(7) **Appendix G:** Management Functions. This appendix describes the responsibilities of SYSCOMS and their METCAL personnel.

(8) **Appendix H:** Central Database Facility/MEASURE Operational Control Center Functions. Appendix H contains information on the operation and responsibilities of the METCAL database and its' management.

(9) **Appendix I:** MEASURE Operating Procedures. This section contains instructions for such special cases as non-MEASURE customers, sub-custodian ownership of equipment, classified equipment, etc.

(10) **Appendix J:** MEASURE Formats. This appendix details the MEASURE product formats (310, 350, 311, 802, etc.) including their layout and function. Also includes examples of these formats.

(11) **Appendix K:** Glossary

(12) **Appendix L:** Operating Supplements. Operating supplements are information that is issued upon request when a need arises to meet specific requirements. These requests are submitted via the chain of command.

**J. SUMMARY:** In an effort to ensure all equipment requiring calibration/servicing is maintained at maximum dependability, the scheduling of equipment and reporting of management data is automated under MEASURE. The system goal is to provide a uniform management information system for the Navy METCAL Program. This system applies to all Navy Calibration Laboratories/Activities and their supported activities as directed by cognizant authority. Test equipment custodians, customer activities, and calibration laboratories/activities are provided with periodic information on the status of test equipment requiring calibration. The outputs obtained from MEASURE are essential to the cost effective operation and management of the METCAL Program.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

**LESSON GUIDE NUMBER: Aviation MOS 6492 A.3 (U)**

**Publications, Diagrams, Sketches, and Drawings**

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**A. LECTURE NUMBER:** MOS 6492 A.3 (U)

**B. TIME:** 1 hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Publications, Diagrams, Sketches, and Drawings

**F. OBJECTIVES:** To give an overview of the METCAL Program and to enhance the Technician's knowledge on the usage of the MEASURE program, METPRO, and the METRL. The main objective of this course is continuous Calibration Program training.

**G. INSTRUCTIONAL AIDS:** None

**H. REFERENCES:**

1. OP43P6B Measure Manual
2. METPRO, MEASURE MANUAL
3. NAVAIRINST 13640.1A

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY:

   a. The Naval Aviation Metrology and Calibration Program, also known as the METCAL Program, is the authority for all policies and procedures pertaining to calibration Support Equipment (SE) utilized by the Department of the Navy (DON) and Marine Corps Calibration Activities. The METCAL Program provides policies and procedures for implementation and management of the Naval Aviation Maintenance Program (NAMP) including Support Equipment calibration requirements, level of support, and procedures for management of calibration and rework at the three levels of maintenance. It also directs the Naval Air Systems Command (NAVAIR) to implement and maintain a complementing METCAL program as part of the NAMP.

   b. The Metrology Automated System for Uniform Recall and Reporting (MEASURE) is the data system for the Navy's

Metrology and Calibration METCAL Program. This manual outlines the procedures that apply to Navy Calibration Laboratories/ Activities utilizing the system, ship and shore activities obtaining services there from, and other military activities whose use of MEASURE has been directed. MEASURE will be used to report data for fleet and shore activities as directed by the Naval Sea Systems Command (NAVSEASYSCOM) and Naval Air Systems Command (NAVAIRSYSCOM). In addition MEASURE is designed to provide participating activities with a standardized system for the recall and scheduling of metrology assets. MEASURE also provides for the collection, correction, analysis and collation of technical data, as well as distribution of data and formats. Some of the benefits of MEASURE to the fleet are:

(1) Calibratable equipment status indicator.
(2) Identification of calibration problems.
(3) Equipment reliability based on usage, environment, and percent short cycle.
(4) Automated recall.
(5) Automatically updated TAMS and standards inventory.

c. The MEASURE manual is divided into several different sections.

(1) **Section 1** contains general information about the MEASURE program. In section 1 you will find the purpose of the MEASURE Uses Manual, the MEASURE policy, and a description of the MEASURE Program.

(2) **Section 2** System Summary – In an effort to ensure all equipment requiring calibration/servicing is maintained at maximum dependability, the scheduling of equipment and reporting of management data is automated under MEASURE. The system goal is to provide a single, uniform management information system for the Navy METCAL program.

(3) **Section 3** Staff Functions Related to Technical Operations- This section contains details necessary to provide staff inputs to MEASURE. Additionally, this section will explain the characteristics and meaning of the information the system produces as outputs.

(4) **Appendix A** Completion of Inventory Form - The information entered on these inventory forms by each

customer activity is the initial input source of all data for MEASURE.

(5) **Appendix B** Completion of Measure Meter Card – The Metrology Equipment Recall and Report (METER) Card is the source of all data within MEASURE subsequent to the submission of the Initial Inventory Forms. The METER card will be completed in accordance with the instructions of OP43P6.

(6) **Appendix C** – Completion of Equipment Identification and Receipt Tag. A five-part receipt that is attached to the METER card.

(7) **Appendix D** – Examples of METER Card Transactions. A series of figures that provide examples of the various transactions for which the METER Card is used.

(8) **Appendix E** – Required Customer Activity Functions. Each Customer Activity must ensure that the TAMS and Standards, for which that activity has been assigned primary responsibility, are submitted in a timely manner to a Calibration Laboratory/Activity for required calibration.

(9) **Appendix F** – Required Calibration Activity Functions. It is the responsibility of each calibration activity to ensure that required calibration is performed on equipment submitted in accordance with the MEASURE Recall Schedule and as directed by the cognizant METCALREP.

(10) **Appendix G** – Management Functions. The METCAL groups perform the management functions for the Navy METCAL program.

(11) **Appendix H** – Measure Operational Control Center Functions. Under MEASURE, the MOCC will produce certain MEASURE formats and preprinted METER cards.

(12) **Appendix I** – MEASURE Operating Procedures. Standard MEASURE operation procedures will be promulgated jointly by the METCAL groups to the users of MEASURE.

(13) **Appendix J** – MEASURE Formats. The data collected from the inventory forms, and from METER card inputs.

Provides the information required for the formulation of various types of program outputs.

(14) **Appendix K** – Glossary. Definitions are presented in this Appendix for the terms, some of which are abbreviated, which appear in the various blocks of the METER card and on the Receipt Tag.

(15) **Appendix L** – METCAL MEASURE Operational Supplements. Operational supplements are issued when there is a needed to tailor the use of MEASUE to meet specific requirements of a Systems Command or when cognizant activities require further guidance and direction in the implementation of MEASURE operating procedures.

d. Customer activities of NAVAIR calibration facilities, including Naval Sea Systems Command (NAVSEASYSCOM) activities receiving support from NAVAIR facilities, will complete form OPNAV 4790/58 Metrology Equipment Recall and Report (METER) Card, per the OP43P6B users manual. The METER card is a five-part form, which has been color-coded to assist in its use and for ease of handling. The five color-coded parts or copies of this document are to be used as follows.

(1) **White Copy**: Forwarded to MEASURE operational control center (MOCC) via mail or remote terminal by the customer activity when an action occurs which requires update of the customer’s database or when calibration or servicing is completed. This copy will be forwarded on the same day that any transaction is completed.

(2) **Green Copy**: Used by NAVAIR type IV calibration and Forwarded to AIMD data analyst for processing.

(3) **Yellow Copy:** Calibration activity personnel use this copy to advise MOCC of a delay status and to indicate the cause of the delay.

(4) **Pink Copy:** This copy, when completed, is forwarded by activity to the customer activity to provide a report of the data collected during calibration/servicing.

(5) **Buff Copy:** This copy is to be utilized by the calibration activity as a permanent record of work performed.

e. Given the Aviation 3M interface Handbook the technician will accurately provide 3M data for the METER card.

(1) The Aviation 3M system is the current program for providing the Navy with a standardized management tool for maintenance and material support of aviation weapon systems and their related equipment.

(2) This system provides information to local AIMD's upper level management and the Naval Aviation Maintenance Support Office (NAMSO) via the input source documents referred to as the Maintenance Action Forms (MAFs)

(3) The feedback system of aviation 3M information is the Maintenance Data Systems (MDSs), which provide various reports that reflect:

(a) Expended man-hours.
(b) Identification of maintenance trends.
(c) Readiness Posture.
(d) Equipment failures.
(e) Material support requirements.
(f) Technical directive compliance.

f. Section 1 General – Gives detailed procedures for filling out the 3M data in block 20 of the meter card.

(1) The 3M data elements will only be preprinted in this block for those workload items normally calibrated by the FCA as indicated by block 7 (scheduled cal lab) of the METER card.

(2) The 3M elements must be manually inserted when it is not preprinted and maintenance is to be performed at an FCA.

(3) Most of the interface is nothing more than an interpretation of MEASURE data, which already is or will be recorded on the METER card.

(a) Job Control Number (JCN) – A three part, 9 or 11-character number assigned to each item submitted for maintenance.

<u>1</u> Most Important of the data elements.

2 It identifies the supported aviation or non-aviation activity.

3 It is assigned by the supported activity Production Control.

4 Correlated with the activity in block 5 or 6 of the METER card.

5 Consists of organization code, Julian date and serial number.

(b) Work Center (WC):

1 A three-letter code that identifies the AIMD work center performing the maintenance as designated by OPNAVINST 4790.2 (series) volume V appendix.

2 Corresponds with block 21 of the METER card.

(c) Work Unit Code (WUC) – A five or seven digit alphanumeric code, which identifies a system, subsystem, and/or a component part of an end item.

1 This element identifies the item in block 1 of the METER card.

2 For items or components with no WUC assigned, always use the Not Otherwise Coded (NOC) number of the group of equipment most closely related to the TI.

3 Can be annotated in block 14.

(d) Organization Code (ORG) – A three-character alphanumeric code that identifies the activity performing the maintenance.

(e) Transaction Code (TR):

1 A two character numeric code that identifies the type of data being reported.

2 TR-31 will normally be used since 3M data was developed for VIDs/MAFs and not METER cards.

(f) Maintenance Level (ML) - A one-character numeric code representing the level at which the maintenance is performed.

1 This element is preprinted.

2 Indicates the maintenance level of the activity in block 21 of the METER card.

(g) Action Taken Code (AT):

1 A one character numeric or alpha code that describes what action has been performed on the item.

2 Relates to information found in block 59 and 63 of the METER card.

(h) Malfunction Code (MAL):

1 A three character numeric code used to describe the malfunction occurring on/in the equipment.

2 Relates somewhat with block 61 of the METER card.

(i) Items Processed (IP) – A two-character numeric code indication the number of items processed under this JCN.

1 Will always be “01” except during work center assist.

2 Relates to block 15 of the METER card.

(j) Man-hours (M/HRS):

1 The total man-hours expanded by assigned work center personnel on this maintenance action.

2 The sum total of all man-hours performed under the JCN related to blocks 40, 42, and 44 of the METER card.

(k) Elapsed Maintenance time (EMT) - The actual clock time, which elapsed during the maintenance action.

(l) Type Equipment Code (TEC):

1 A four character alphanumeric code that identifies an end item or equipment category.

2 This code has a basic relationship to block 60 of the METER card.

(m) Serial Number (SER) - This is the serial number of the item in block 1. If the number consists of six characters, it will be identical to block 4.

1 If less than six characters, precede the number with zeros.

2 If greater than six characters, use only the last six characters.

(n) When Discovered Code (DISC):

1 A one character alphabetic code that identifies when the need for maintenance was discovered.

2 No associated MEASURE block.

(o) Type Maintenance Code (TM):

1 A one character alphabetic code that identifies the type of maintenance performed.

2 Relates to blocks 18 and 23 for scheduled and unscheduled maintenance and/or calibration.

(p) Removed/Received Date:

1 The four-digit Julian date the equipment was received for service.

2 Relates to block 23 of the METER card.

(q) In Work Date:

1 The four-digit Julian date the equipment was received for service.

2 Relates to block 23A except for work center assist METER cards.

(r) Completion Date- the four digits Julian date on which maintenance was completed.

b. **Appendix A** When Discovered Codes-Contains the When Discovered Codes used by Calibration activities.

c. **Appendix B** Type Maintenance Codes - Contains the Type Maintenance Codes used by calibration activities.

d. **Appendix C** Action Taken Codes - Contains the Action Taken Codes used by calibration activities.

e. Metrology Requirements List (METRL) - an authoritative reference document that contains data applicable to calibration for Navy TAMS and standards. The information is used as a ready reference to determine authorized calibration intervals, approved calibration procedures and related technical data.

f. Navy Calibration Equipment List (NCE) - An authoritative reference document containing data applicable to Navy calibration standards, equipment, and lab locations.

g. METPRO – Designed to allow easy access to the Naval Warfare Assessment Division (NWAD) Metrology data. The METPRO allows users to query data in the METRL, NCE, NCA, and company information such as cage codes and name searches. The METPRO is divided into two different categories used to access calibration data. These are the Query and the publications databases. First let’s talk about the Query database.

(1) The Query database is sub-divided further into six more categories listed as: METRL Model Standards, ICP, Lab, Manufacturers, and METRL Sect. 5.

(a) METRL Model – this feature is used to look up part numbers and corresponding approved ICPs. It also lists cage codes and special instructions such as remarks or NCR items.

(b) Standards Query - Contains part numbers for standards with corresponding cage codes. This section also contains approved substitutions for standards.

(c) ICP - This section of the METRL contains all NAVAIR approved Instrument Calibration Procedures (ICPs)

(d) Lab - This section of the query contains updated lab codes and information specific to their activities.

(e) Manufacturers - This section of the METRL contains a listing of cage codes and corresponding company manufacturers.

(f) METRL section 5 - This section of the METRL contains the most current NAVAIR supported publications on SE and operating procedures.

(2) The Publications database is sub-divided further into categories listed as: METRL (sections 1,2,5,and 6) NCA (sections 1 and 7) and the NCE (sections 1 and 8)

(a) **METRL section 1** General Information - This document has been prepared for use by personnel concerned with the Navy Metrology and Calibration (METCAL) program. It is an authoritative reference document and contains data applicable to the information contained within section 1. It is to be used to determine authorized calibration intervals, approved ICPs, and related technical data.

(b) **METRL section 2** Generic Intervals – This information has been prepared for use by personnel concerned with the METCAL program. It is an authoritative document and contains generic calibration procedures that encompass blanketed test equipment with a generic ICP.

(c) **METRL section 5** Cal Related Documents – This section contains calibration related documentation pertaining to the METCAL program.

(d) **METRL section 6** Navy METCAL policy – These policies are the “who”, “what”, “where”, “how”, and “why” of calibration. Policy issuances are written orders, which must be followed unless you have a specific waiver from your commanding officer or from the policy-issuing agency. Deviation from established policy may jeopardize

proper operations, technical integrity, safety, and the ability to accomplish missions. Conflicting or unworkable requirements should be brought to the attention of all responsible parties for proper resolution.

(e) **NCA section 1** General Information – The NCA is an authoritative reference document describing authorized standards and calibration laboratories, field calibration activities, and contractor calibration facilities, which support the METCAL program.

(f) **NCA section 7** Glossary – The NCA glossary provides definitions pertinent to calibration activities and standards. It is a description of METCAL terminology and nomenclature.

(g) **NCE section 1** General Information – The NCE is an authoritative reference document containing data applicable to Navy Calibration Standards and Equipment.

(h) **NCE section 8** Glossary – The NCE glossary provides definitions pertinent to calibration activities and standards. It is a description of METCAL terminology and nomenclature.

**B. SUMMARY:** Student should now have a good overview of the METCAL program. During this period of instruction the METCAL programs policies, procedures, and doctrine were discussed. The MEASURE program, the METER card, and how to utilize the METPRO to access calibration data such as specific ICPs, standards, authorized substitutions, calibration activities, terms, and definitions were discussed as well.

**C. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

**LESSON GUIDE NUMBER: Aviation MOS 6492 A.3 (X)**

**Publications, Diagrams, Sketches, and Drawings**

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**A. LECTURE NUMBER:** MOS 6492 A.3 (X)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Publications, Diagrams, Sketches, and Drawings

**F. OBJECTIVES:** Students will know and be able to demonstrate/apply knowledge of calibration facility requirements for Navy Field Calibration Activities (FCAs).

**G. INSTRUCTIONAL AIDES:** 4790.2H, NAVAIR 17-35FR-06

**H. REFERENCES:**

1. 4790.2H
2. NAVAIR 17-35FR-06

**I. PRESENTATION:**

1. INTRODUCTION: The following lesson on Navy Calibration Facility Requirements was derived primarily from NAVAIR 17-35FR-06. It is an extremely informative document containing information necessary for the calibration of precision measurement equipment, as well as the calibration of test equipment (electrical, physical/dimensional, etc.).

2. BODY:

   a. Many factors must be considered when designing and preparing a calibration laboratory. These factors include:

      (1) Site location.

      (2) Building.

      (3) Facility work areas.

      (4) Electrical services.

(5) Heating, Ventilation, and Air Conditioning (HVAC).

b. Site location considerations should include factors such as vibration from railroad lines or aircraft landing areas.

c. These factors can be met unless the facility is shipboard. Building factors may include isolation from weather and other harmful effects from outside the laboratory. Also, due of the nature of the equipment and publications contained inside, security of the installation should be a high priority.

d. When designing an FCA, one should take into account the layout or facility work areas within the laboratory. The laboratory should be separated into several general areas. These general areas include, but are not limited to:

(1) Electrical/Electronic Calibration.

(2) Physical/Mechanical Calibration.

(3) Optical/Dimensional Calibration.

(4) Electro-Optical Calibration.

e. After the general calibration areas have been considered, Special Purpose or Hazardous Areas should be identified. These areas include, but are not limited to:

(1) Electrostatic Discharge Areas (ESD).

(2) Liquid Flow Calibration.

(3) Oxygen-Clean Calibration.

f. Electrical Services is the next topic that should be discussed since they play a major role in almost every aspect of a calibration laboratory. All electrical services must meet the National Electric Code, National Fire Protection Association Standard No. 70. All power outlets, connectors, or receptacles in calibration areas shall be properly labeled to

provide a technical description of the type of power source (voltage, power rating, and phase) or connection scheme as applicable.

g. Basic laboratory electrical service shall consist of a 480 V, 3-phase, and 60Hz supply. The following stepped down or converted sources shall be required with respect to the calibration facility workload:

| PHASE | | FREQUENCY | VOLTAGE |
|---|---|---|---|
| 1 | 60Hz | 120/220 | +/- 5% |
| 3 | 60Hz | 120/208 | +/- 5% |
| 1 | 400Hz | 120/220 | +/- 5% |
| 3 | 400Hz | 115/220 | +/- 5% |
| DC | ----- | ------- | 28 +/- 1 Volt |

(1) Heating, Ventilation and Air Conditioning (HVAC) Systems control the primary parameter **CLIMATE**.

h. The HVAC system controls the heating, cooling, and filtration of airborne particles in the laboratory. The following is a summary of general facility environmental conditions that must be maintained to ensure the stability of high-accuracy calibration standards and equipment.

| **PARAMATER** | **ACCEPTABLE RANGE** |
|---|---|
| TEMPERATURE | 60-85 F |
| HUMIDITY | 20-60%RH |
| AIRBORNE PARTICLES | >2.4 X 100,000,000,000. particles per cubic meter > .5 micro-meters |
| VIBRATION | .032 in/s or less and .046g or less for 8 – 100Hz |
| BACKGROUND NOISE | 55dB(A) or less |
| ILLUMINANCE | 50 ft-c or less |

**J. SUMMARY:** This lesson guide described many necessary calibration laboratory facility requirements. For answers to

further questions regarding this topic refer to NAVAIR 17-35FR-06, and 4790.2H, VOL 5, Chapter 19.

## K. QUESTIONS?

1. What is the voltage level and tolerance of the dc power receptacle?

Answer: 28 Volts +/- 1 Volt

2. Name three important factors to consider when designing and preparing a laboratory for use with precision measuring equipment?

Answer: Site location, electrical service, HVAC

# AVIATION MAINTENANCE TRAINING

**LESSON GUIDE NUMBER: Aviation MOS 6492 A.3 (Y)**

**Publications, Diagrams, Sketches, and Drawings**

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**A. LECTURE NUMBER:** MOS 6492 A.3 (Y)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Publications, Diagrams, Sketches, and Drawings

**F. OBJECTIVES:** To familiarize the technician with the Metrology Requirement List, it's functions and uses, and its relevance to the calibration field.

**G. INSTRUCTIONAL AIDS:** METPRO

**H. REFERENCES:** 17-35MTL-1

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY: What is the METRL (Metrology Requirements List)? The METRL is "an authoritative reference document and contains data applicable to calibration of Navy Test and Monitoring Systems (TAMS) as well as calibration standards." The METRL is a document that provides all information calibration technicians need to perform calibration procedures. The METRL contains calibration intervals and procedures as well as other technical data. The METRL is divided into 6 sections, each covering a different aspect of the Navy Metrology and Calibration (METCAL) program.

   a. **Section 1** provides general information about the METRL such as the arrangement of the METRL as well as different METCAL policies. Also, it includes requirements for the calibration of certain categories or types of TAMS.

   b. **Section 2** of the METRL lists TAMS by type as well as the recommended calibration interval for each asset. Section 2 is to be used only when the model number and manufacturer are not listed in Section 3. It should be noted that the presence of an interval for a model number in Section 2 does not necessarily mean

that item requires calibration. Ensure NCR (No Calibration Required) criteria is checked before submitting items from Section 2.

c. **Section 3** is one of the most important sections of the METRL. Section 3 contains all calibration requirements of Navy and Marine Corps TAMS and standards. Divided into 5 sections, Section 3 lists model numbers, CAGE codes, descriptions, calibration interval, and approved calibration procedure. There is also a remarks column where maintenance manuals or supplemental data is shown when applicable. The first section, Model Number, merely list the test equipment with an alphabetic, numeric, or alphanumeric identifier. Section 2 is a five-digit code (CAGE Code) signifying the manufacturer. The next section is simply the nomenclature of the test equipment as assigned by the manufacturer. The next section encompasses Calibration Intervals. It lists the maximum number of months the test equipment is allowed before submitting for calibration. The final section lists all Approved Calibration Procedures. Like the other sections, this section provides the procedure number to be used during the calibration.

d. **Section 4** list calibration procedures. They are listed with the procedures publishing/revision date as well as the date of the latest change. This is to ensure that procedures are current.

e. **Section 5** lists various calibration documents, which include Engineering Circles, Engineering Reports, Fabrication Instructions, Modification Instructions, Training Manuals, and other similar publications. They are listed by date of publication/revision.

f. **Section 6** lists METCAL policies.

**J. SUMMARY:** The METRL is a useful tool in the field of calibration. A technician can utilize the resources of the METRL to ensure the highest quality of calibration performance is being obtained. Through the METRL, the technician can guarantee that the test equipment information is correct, the procedure is up to date, and access the latest publications.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

**LESSON GUIDE NUMBER: Aviation MOS 6492 A.3 (Z)**

**Publications, Diagrams, Sketches, and Drawings**

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**A. LECTURE NUMBER:** MOS 6492 A.3 (Z)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Publications, Diagrams, Sketches, and Drawings

**F. OBJECTIVES:** To instruct the technician on the purpose of the TAMS program and use of the TAMS publications.

**G. INSTRUCTIONAL AIDS:** None

**H. REFERENCES:**

1. NAVAIR 17-35TR-1
2. NAVELEX P4734-3
3. NAVSEA TT700-AA-CAL-010/TR-1
4. OD 56732 (SSPO)
5. USMC TI-4733-45/13

**I. PRESENTATION:**

1. INTRODUCTION: The Purpose of the Technical Requirements for Calibration of Test and Monitoring Systems (TAMS) publications is to set guidelines on technical requirements for the Navy Metrology and Calibration (METCAL) Program. It has been prepared by the Metrology Engineering Center on behalf of the Chief of Naval Material and for the METCAL Lead Systems Command, Naval Electronic Systems Command, and the Commandant of the Marine Corps in executing the center’s role as scientific and technical authority for the Navy METCAL Program as delineated in NAVMAT Instruction 4355.67B, and Marine Corps Order MCO 4733.1. The TAMS manual consists of 9 sections that cover an introduction to TAMS, TAMS calibration support requirements and approaches, calibration test requirements, calibration procedures, calibration equipment and standards, calibration intervals, laboratory environmental/facility

requirements, personnel capabilities and training, and measurement process control.

2. BODY:

a. The information contained herein discusses the needs of metrology, objectives of calibration, measurement traceability, and elements of a calibration system.

b. The need for metrology support within the Navy and Marine Corps is growing with technology. As more modern weapons and systems are being used there is also a need for increased accuracy and increased performance to test those weapons and systems.

c. In order to maintain readiness, the objective of calibration is to ensure the overall measurement integrity and traceability of TAMS. Proper calibration methods should guarantee TAMS are returned to the user within tolerance and operable.

(1) Traceability is mandatory for all TAMS supported by the Navy METCAL Program. Traceability is defined as follows: “The process by which the assigned value of a measurement is compared directly or indirectly through a series of calibrations to the value assigned to the U.S. national standard or to natural physical constants.”

d. TAMS calibration support requirements and approaches revolve around reliability.

(1) In general, a reliability target of 85% average over-the-period is applied to General Purpose Test Equipment (GPTE) and 92% to Special Purpose Test Equipment (SPTE). The 85% and 92% targets are also used as TAMS reliability requirements unless other specific reliability requirements are required. Reliability of TAMS can be affected by factors such as handling, environment, operating personnel, utilization, location, and maintenance practices. TAMS reliability is controlled through assignment of calibration intervals.

(2) For the most part, any item that is used to make quantitative measurements or provide accurately known outputs must be calibrated at certain intervals to maintain the accuracy of the item. A criterion for determining if a device requires calibration is provided in Section 1 of the METPRO.

(3) TAMS should always be calibrated to their actual use requirements. Situation dictating, TAMS users can identify limited use requirements for any TAMS dictated to support specific applications. This type of calibration would receive a “Special Calibration” label or tag attached to the TAMS identifying performance limitations.

e. General Purpose Test Equipment (GPTE) is equipment that is used to support two or more operational systems of different design. GPTE is calibrated at authorized calibration facilities to manufacturer’s specifications. Special Purpose Test Equipment (SPTE) is equipment that is used to support a single or peculiar operational system or equipment. Approved calibration documentation and calibration intervals are listed in METRL for GPTE and SPTE. Embedded Test and Monitoring Capabilities (ETMC) are test and monitoring capabilities that are considered to be an integral part of an operational system or equipment. Automated TAMS (or automated test equipment (ATE)) is TAMS where the testing process is under some form of preprogrammed control, where the test steps, equipment set-ups, and tolerance decisions are embedded into a computer or microprocessor rather than a technical manual. Metrology and Calibration Standards in the Navy METCAL Program are listed in the Navy Calibration Equipment publication (NAVAIR 17-35NCE-1).

f. TAMS out-of-tolerance evaluators and performance criteria are generally defined two ways, “perform satisfactorily” and “significant out-of-tolerance”. TAMS are considered to perform satisfactorily when its performance meets all prescribed calibration criteria. When TAMS performance can adversely affect product quality, measurement integrity, or ability to

provide valid test data it is considered significantly out-of-tolerance.

g. In general, each parameter that is directly related to Test Instrument accuracy or specified performance shall be tested periodically to verify it meets the specified requirements.

(1) Tests are separated into two categories; tolerance tests and functional checks. Tolerance tests are intended to verify that the Test Instrument is performing within the specified tolerance limits or other applicable criteria at the time of calibration. Tolerance tests are usually quantitative. Functional checks are intended to ensure that the Test Instrument is in satisfactory operational condition and is functioning adequately at the time of calibration, as opposed to tolerance tests, which assess the specified performance of the Test Instrument.

(2) The tolerances used as pass-fail criteria for calibration are generally those used by the manufacturer to specify the published performance of the Test Instrument. Calibration tolerances are usually given in the general description section of the applicable operation and maintenance manual. Tolerances shall be included in the applicable calibration procedure in a form compatible with the measurement system to be used. If the Test Instrument indications are to be compared with those of a standard, the tolerances should be expressed as upper and lower limits in terms of measurement units.

(3) There are four factors that shall be considered in establishing the calibration test sequence of functional checks and tolerance tests. The first, dependence or interaction, is where the measurement of one parameter is dependent on the prior calibration of another, or where circuits or corrective adjustments interact, a test sequence shall be adopted which satisfies the dependence or minimizes the effects of the interaction. The next factor is test efficiency. Tests should be grouped so that the tests

requiring the same calibration equipment setup are performed consecutively. Third, minimum retesting (test of parameters or functions which, when out of tolerance the corrective adjustment or repair could affect a number of other tests) should be performed early to minimize the need for retesting. Lastly, logical grouping occurs after all other factors have been satisfied. The remaining tests should be arranged in functionally related groups. For example, all tests relating to an oscilloscope vertical amplifier should be grouped as much as possible, consistent with the foregoing requirements.

h. METCAL includes hundreds of calibration activities which use in excess of 4,000 model numbers or types of calibration standards following the methodology of approximately 5,500 authorized Instrument Calibration Procedures (ICPs) to support more than 19,000 model numbers of test equipment.

(1) Uniformity of calibration standards and equipment within the Navy METCAL program is managed by the Navy Metrology Engineering Center through the semi-annual publication of the Navy Calibration Equipment List (NCE) NAVAIR 17-35NCE-1, NAVELEX 0969-LP-170-5010, and NAVSEA OD 48939. The NCE is the authoritative reference document that contains information applicable to Navy Calibration Standards and equipment.

(2) The purpose of the NCE is to provide a uniform list of calibration equipment and standards to facilitate uniformity throughout the Navy METCAL Program. Navy and contractor personnel use this information to determine what specific model numbers are known to be available for use in writing calibration procedures.

(3) Equipment performance must meet the minimum requirements of the Navy METCAL Program including parameters, accuracy, range, environment, portability, etc. The evaluation of potential standards and the thorough preparation of procurement documentation and first article/acceptance testing are necessary to ensure new standards meet the required

performance specification. Reliability and maintainability are primary factors in the acceptability of new standards.

i. Calibration Intervals are necessary to ensure that equipment maintains a required reliability level.

(1) These calibration intervals are maintained and revised as calibration data becomes available. To ensure calibration intervals are optimum, a computerized candidate selection system is used to identify equipment with apparently non-optimum intervals, which become candidates for interval changes.

(2) The calibration data is analyzed as required to determine proper calibration intervals for equipment on a model number basis. The intervals are published in METPRO. METPRO is updated every month. When sufficient calibration data is available, it is analyzed to determine the correct calibration interval. When data is either not available or is not of sufficient quantity, an interval based on similar equipment, engineering recommendation, or generic category is used. A generic interval is an interval representing equipment of a similar class.

j. The environment in which that calibration is preformed is a significant factor in the quality of the calibrations that directly affect the reliability of TAMS.

(1) Environmental factors to be considered include temperature, humidity, vibration, line power, lighting, etc. The acceptable limits associated with the factors vary depending upon the nature of the workload supported and location of the facility.

(2) An effective environment for a calibration facility must consider the various elements of the total process. Typically, the five critical elements are equipment, the calibration process, personnel performance, safety and operations, and elements not affecting technical calibration. The equipment element evaluates the operating

specifications of the calibration standards and the TAMS submitted for calibration. The calibration process sometimes depends on controlling the power input or the temperature and humidity in order to produce valid and meaningful calibrations. The work environment directly affects the personal performance of calibration technicians. During the workflow process, the safety of both the technician and the equipment are paramount. Also, environmental factors such as storage space, adequate administration space, overall cleanliness, and general guidelines should be considered.

**J. SUMMARY:** The Navy Test and Monitoring System (TAMS) is a baseline for technical decisions being applied in analysis of calibration requirements, determination of calibration approaches, selection and application of calibration equipment, preparation and review of calibration procedures, and related requirements for calibration support.

## K. QUESTIONS?

1. What is the purpose of TAMS?

2. Name some environmental factors to consider that ensure quality calibration?

# AVIATION MAINTENANCE TRAINING

**LESSON GUIDE NUMBER: Aviation MOS 6492 A.3 (GG)**

**Publications, Diagrams, Sketches, and Drawings**

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**A. LECTURE NUMBER:** MOS 6492 A.3 (GG)

**B. TIME:** 30 Minutes

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Publications, Diagrams, Sketches, and Drawings

**F. OBJECTIVES:** To give the technician background information on and illustrate the proper format of instrument calibration procedures (ICPs).

**G. INSTUCTIONAL AIDS:** Any 17-20 or 17-50 ICP

**H. REFERENCES:**

1. NAVAIR 17-35POP-01
2. 17-35TR-4 Or 17-35TR-50

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY:

   a. Calibration of support equipment (SE), including TAMS, and calibration standards used to make quantitative measurements is mandatory, and shall be performed with approved Instrument Calibration Procedures (ICPs). The primary purpose of ICPs is to provide information that enables calibration personnel to determine whether the SE and standards being calibrated are operating within prescribed tolerances or performance criteria. ICPs also serve the following purposes: establish and maintain uniformity of calibration test methodology and agreement of calibration results among NAVAIR calibration laboratories; provide detailed instructions concerning calibration equipment setup and connections, required standards/ancillary equipment, test instrument connections, control adjustments, tolerance values, test criteria, performance of the various tests, and interpretation of the results; and they serve as training and reference material.

b. Approved ICPs are listed in METPRO, and are, typically, NAVAIR 17-20 series ICPs that have been developed and approved for use by the Navy METCAL Program. These ICPs may have been developed for METCAL sponsors other than NAVAIR. The NAVAIR 17-20 series ICPs, developed for different sponsors, do not necessarily utilize standards available to NAVAIR laboratories. The recently introduced NAVAIR 17-50 series ICPs maintain NAVAIR configuration control and fully utilize NAVAIR modernization standards. Modernization standards are NAVAIR preferred calibration standards that have been carefully selected to support a wide range of requirements, to be compatible with and use modern calibration techniques, to replace several model numbers presently in inventory, and to have a program-wide utilization. The NAVAIR 17-50 series is specifically written for NAVAIR, and its use is preferred over 17-20 series ICPs for NAVAIR workload. The driving force behind this series is the use of modern equipment in harmony with new measurement techniques to provide a quality-based engineering process. As appropriate, ICPs shall be written following the guidelines of NAVAIR 17-35TR-4 or NAVAIR 17-35TR-50.

c. ICP Format:

(1) **Title Page -** This page provides the model number and nomenclature of the SE/TAMS being calibrated. Information such as what ICP this ICP supercedes (if any), revision date, destruction notice.

(2) **List Of Effective Pages -** The purpose of this list is to identify the pages in the ICP affected by any technical content changes made since the previous release of the document.

(3) **Table Of Contents -** This page provides a quick reference to the contents of the ICP; i.e. different sections of the procedure, tables, and illustrations.

(4) **Section 1 (Introduction And Description) –** It provides an overview of the performance specifications and test methods used to calibrate certain characteristics of the SE/TAMS (herein referred to as the Test Instrument or TI).

(5) **Section 2 (Equipment Requirements) -** This section has a list of standards needed to calibrate assets which have been verified to be 4 times more accurate than the

asset it is calibrating (minimum test accuracy ratio= 4:1). This section also has a list of non-standard items needed such as shielded leads, binding posts, etc.

(6) **Section 3 (Preliminary Operations) -** This section informs the technician of any preliminary steps that must occur prior to starting the calibration i.e., TI control settings, test equipment control settings, and self calibration for certain standards being used.

(7) **Section 4 (Calibration Process) -** This section describes the calibration of the TI. Be sure to pay special attention to the notes and warnings in this section because they can be very helpful to the technician. This section may contain many subsections, depending on how many parameters of the TI are being tested.

(8) **Calibration Checklist -** This checklist correlates with the calibration process. When the calibration process is asking for certain tolerance limits, they can be found here. This checklist explains the function being tested by a particular step number, the nominal value being tested, the lower and upper tolerance values, and a space to fill in the first and second measured values.

(9) **Appendix -** This section provides such information as, adjustments, wiring diagrams for test jigs that need to be constructed for the calibration process, and test point locations.

**J. SUMMARY:** Throughout this lesson we discussed the importance of ICPs and the uniformity they provide. ICPs provide guidance to calibration personnel to ensure the SE and standards being calibrated are operating within prescribed tolerances or performance criteria. We discussed the two types of ICPs (17-20 and 17-50). Knowing the format of ICPs is important. It makes it easier for the technician to quickly reference critical information throughout the calibration process.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (A)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (A)

**B. TIME:** 30 Minutes

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To instruct the technician on the correct procedures for the operation and use of AC/DC Voltage Standards.

**G. INSTRUCTIONAL AIDS:** 5700AN

**H. REFERENCES:** 5700AN Instruction Manual

**I. PRESENTATION:**

1. INTRODUCTION:

   a. FEATURES

      (1) Internal environmentally-controlled references
      (2) Automatic meter error calculation
      (3) Keys that multiply and divide the output value
      (4) Programmable entry limits to restrict levels
      (5) Offset and scaling modes that simplify linearity testing
      (6) Extensive automatic internal self testing and diagnostics of analog and digital functions

2. BODY: The Fluke Model 5700A Calibrator has the ability to calibrate a wide variety of electrical instruments. The 5700A has the capability of calibrating voltage, current and resistance. For the following class we will cover AC and DC voltage calibration.

   **a. DC MEASUREMENTS:**

      (1) The 5700A's DAC assembly generates DC voltages in six ranges:

220mV
2.2V
11V
22V
220V
1100V

(2) The DAC assembly generates the 11V and 22V ranges and its output is routed to the Switch Matrix. The Switch Matrix resistively divides the 11V range by five and ten, which creates the 220mV and 2.2V ranges. Amplifying the 11V range through the Power Amplifier Assembly generates the 220V range and amplifying the 11V range through the High Voltage/High Current assembly generates the 1100V range. Reference Amplifiers maintain DC accuracy and stability. Depending on which range the 5700A is in the resolution can vary from 10nV to 100uV.

(3) To set a DC voltage output, make sure the 5700A is in standby, connect the Test Instrument (TI), and set it to measure DC voltage on the appropriate range. Press up to eight numeric keys to select a voltage, which can be changed between negative and positive. Select micro (u), Milli (m), or kilo (k) if necessary. The Control Display now shows the amplitude of the selected entry. If there are mistakes made when making the entry, press the clear key (CE) and reenter the value. Press (ENTER) clears the entry from the Control Display and copies it into the Output Display. No voltage is available at the output terminals until pressing Operate/Standby (OPER/STBY). After pressing the Operate/Standby key, the TI will respond to the applied voltage.

**b. AC MEASUREMENTS:**

(1) The Oscillator Output assembly is the AC signal source for the 5700A. AC voltages are generated in the following ranges:

2.2mV
22mv
220mV
11V

22V
220V
1100V

(2) The 2.2V and 22V ranges are generated by the Oscillator Output assembly and routed to the Switch Matrix. The Switch Matrix resistively divides the 2.2V range by ten to create the 220mV range and divides the 2.2V range or 22V range by 1000 to create the 2.2mv and 22mV ranges respectively. Amplifying 22V range through the Power Amplifier Assembly generates the 220v range and amplifying the 22V range through the High Voltage Control Assembly generates the 1100V range. The frequency range for all AC voltage outputs are from 10Hz to 1MHz. The 5700A achieves its exceptional AC voltage accuracy by using a Fluke RMS sensor to make real-time AC/DC comparison measurements.

(3) To set an AC voltage output, make sure the 5700A is in standby, connect the TI, and set it to measure AC voltage on the appropriate range. Select a voltage output by entering up to seven numeric values, which can be changed between negative and positive. Select micro (u), milli (m), or kilo (k) if necessary. Now enter up to five numeric values to select a frequency, followed by kilo (k) or Mega (M) if necessary. The Control Display now shows the amplitude of the selected entry. Pressing (ENTER) clears the entry from the Control Display and copies it into the Output Display. No voltage is available at the output terminals until pressing the Operate/Standby (OPER/STBY) key. Press the Operate/Standby key and the TI will now respond to the applied voltage.

**J. SUMMARY:** The 5700A is configured internally as an automated calibration system with process controls and consistent procedures. Internal microprocessors control all functions and monitor performance using a switching matrix to route signals between modules. AC/DC voltages produced from the 5700A are extremely accurate over a wide range.

**K. QUESTONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (D)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (D)

**B. TIME:** 1 HOUR

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To instruct the technician on the correct use of current shunts, as well as the proper use of the 242D Resistance Measuring System and its capabilities.

**G. INSTUCTIONAL AIDS:** 242D/AND CURRENT SHUNT

**H. REFERENCES:** Equipment manufactures manuals

**I. PRESENTATION:**

1. INTRODUCTION: This lesson will teach the proper usage of current shunts as well as the 242D Resistance Measuring Device and its calibration parameters.

2. BODY:

a. CURRENT SHUNTS

(1) A current shunt is a known, low valued resistor that is placed in a circuit so as not to cause any imbalance within that circuit. The voltage drop measured across the shunt (resistor) is used to determine the current. The current is determined by using Ohms law I = E/R. For example, if the shunt resistance is .01 ohms and a current of 100 amps is applied, the voltage drop would equal 1 volt. In a 120-v circuit, 1-volt would not be significant and the current measurement would be very precise. The proper use of current shunts allows the technician to exceed the current capability of the measuring device by using its voltage-measuring capability.

(2) SR-15, SR-100, and the SR-300 are current shunts commonly used in calibration laboratories. Primarily, these low resistance standards or shunts are used in accurate measurements of large currents utilizing the potentiometer method. These standards may be used as comparison standards by either the adjustable ratio Kelvin Bridge or the potentiometric method. Resistance measurements are measured between the potential contacts. These shunts are designed to provide ample radiating surfaces in air at ordinary room temperature at their maximum current capacities. A resistor of this type may be used in place of a Reichsanstalt type if a +\- 0.04% limit error is satisfactory.

(3) The next model is the Fluke Y5020 current shunt. It is a precision, four-terminal, current shunt designed for calibrating ac/dc current sources at ranges from 0 to 20 amps, and dc to 5 kHz. The shunt is housed in a forced-air cooled case that enhances the accuracy of the standard.

Ranges of the 240C:

| | |
|---|---|
| Nominal resistance | 0.01 ohms +/- 1% |
| Accuracy | +/- .01% |
| Stability | (30ppm per 6 months) |
| Maximum current | 20A dc or RMS ac |

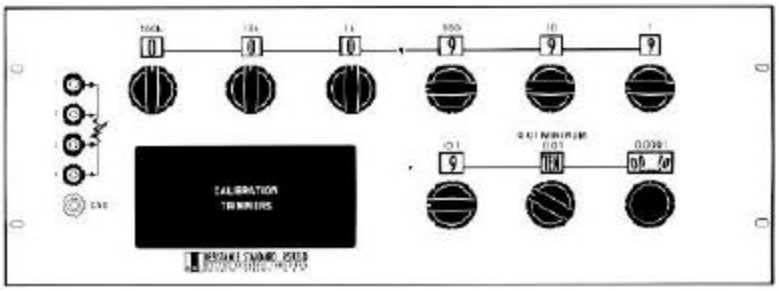
INSTRUCTOR NOTE: Refer to manufacturer’s manual and demonstrate the proper setup and operation to the students.

b. MEASURING DEVICES

(1) The 242D Resistance Measuring System is a highly accurate, reliable measuring system ranging from 10Mohms to 120M ohms with an operational speed ideal for production and quality control. The direct reading accuracy is 10 ppm, which is maintained over a wide range without the need for correction tables or computations of any sort. The 242D Resistance Measuring System consists of the model 801B DC Generator Detector, model 240C Kelvin Ratio Bridge, and model RS925D Decade Resistance Standard.

INSTRUCTOR NOTE: Demonstrate, to the students, the correct operational procedures and set up IAW the manufacturer's manual.

(2) The RS925D Decade Resistance Standard is a four terminal, continuously variable 1.2 M ohm resistance standard, which simplifies resistance measurements. Its' decade capacity ranges from 100K ohms per step to 10m ohms per step. A continuous rheostat with 100 micro-ohms per division provides resolution down to 20 micro-ohms. The first four decades may be individually trimmed for increased accuracy.

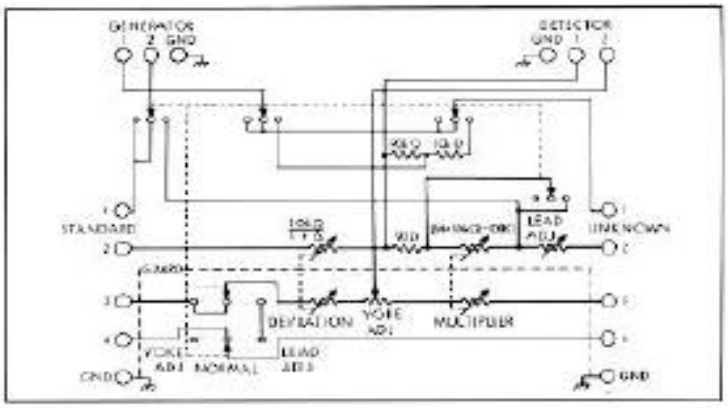


RS925D DECADE RESISTANCE STANDARD

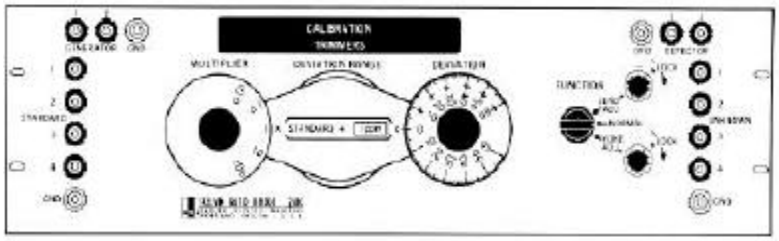
(3) The model 240C Kelvin Ratio Bridge used in the model 242D system allows comparison of resistors to 0.5 ppm either by interchanging the units or reading their values directly. Direct readout is possible to an accuracy of .001% using the model RS925D resistance standard. This bridge can also be used to determine deviation of an unknown resistor from a standard.

Ranges of the 240C:

| | |
|---|---|
| 0.1ppm/dial division | +/- 6ppm |
| 1.0ppm/dial division | +/- 60ppm |
| 0.001%dial deviation | +/-0.06% |
| 0.01%dial deviation | +/-0.6% |

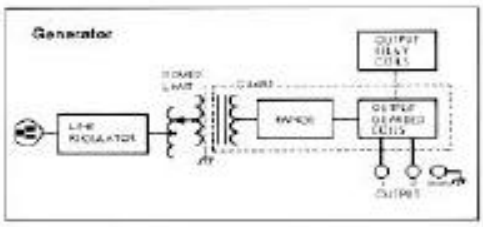



**240C**

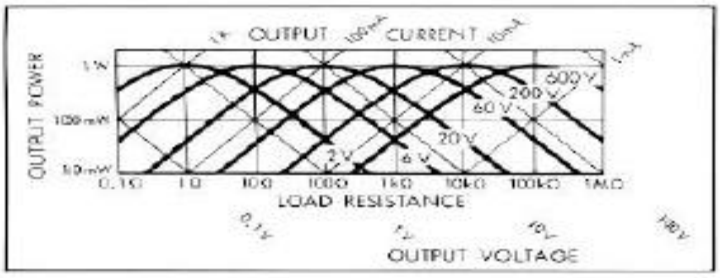



**240c KELVIN RATIO BRIDGE**

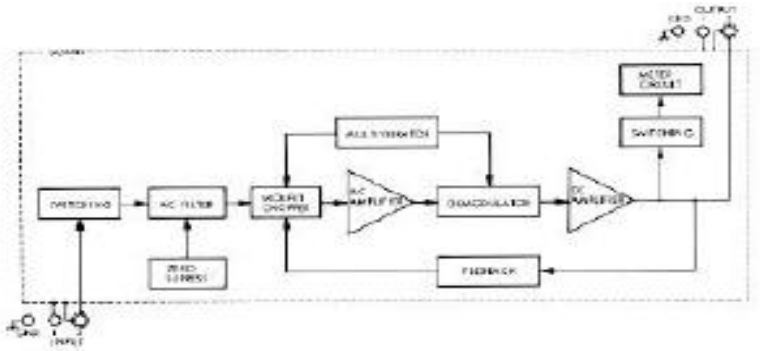
(4) The model 801B is an integral part of the Model 242D Precision Resistance measuring System. The DC generator has six different ranges. The six ranges are continuously variable from 0 – 600v. Its’ power is limited to 1W.




**801B GENERATOR**




**OUTPUT CAPACITY**



**BLOCK DIAGRAM 801B**

**J. SUMMARY:** This lesson covered current shunt theory and capability, as well as resistance measuring devices. Current shunts are low-valued resistors that provide a measurable voltage drop. Its voltage measuring capability can exceed current measuring capabilities of current measuring devices such as a 34401A. Specifications of the 242D were covered. This measuring device is incredibly accurate and resilient because its system components may be used individually. Knowing the parameters of these test sets will ensure smooth operation and error free measurements.

**K. Questions?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (E)

## Precision Measuring Equipment

| | YR/MO/DAY | | NAME/RANK |
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**A. LECTURE NUMBER:** MOS 6492 B.1 (E)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To provide the technician with basic knowledge of electronic counters.

**G. INSTRUCTIONAL AIDS:** HP 53132A Universal Counter and its manufacturer's manual. Application Note 200 Electronic Counters Series from Agilent Technologies web site.

**H. REFERENCES:** 53131A/53132A

**I. PRESENTATION:**

1. INTRODUCTION: There are many types of frequency-measuring devices. During this period of instruction we will discuss the specifications of models 5335A, 5345A, and 5351B frequency counters. Further, we will discuss the specifications and operation of the model 53132A.

2. BODY:

**a. 5335A Universal Counter, 200MHz**

(1) The 5335A Universal Counter is capable of measuring signals up to 200 MHz. If option 030 is installed, this counter will measure signals from 150 MHz to 1.3 GHz on channel C.

(2) This counter's basic functions include frequency, period, time, ratio, and totalize. Also, it has the capability to create user-defined measurement function keys for statistical data, math functions, pulse width, rise/fall time, slew rate, duty cycle, and phase relationship.

**b. 5345A Universal Counter, 500MHz**

(1) The 5345A Universal Counter is capable of measuring signals from 50 µHz to 500 MH and 2ns to 20,000s.

(2) The counter's basic functions include frequency, period, period average, single-shot time interval, time interval average, and ratio. It also provides a totalize function whereby two signals can be simultaneously totalized.

**c. 5351A Universal Counter, 500MHz**

(1) The 5351B Universal Counter is capable of measuring signals from 500 MHz to 26.5 GHz applied to the channel 1 input and 10 Hz to 525 MHz applied to the channel 2 input.

(2) It has exceptional sensitivity down to –40 dbm, 1 GHz/s tracking speed, 60 ms acquisition time in automatic mode and 20 ms in manual mode, 100 measurements/s (HP-IB) in automatic mode, and selectable resolution from 1 Hz to 1 MHz.

(3) Built in features include a self-check, diagnostics, display and keyboard lockout, and an overload indicator.

(4) Math functions are scale, offset, and smooth (exponential averaging).

**d. 53132A Universal Counter, 225 MHz**

(1) The 53132A Universal Counter is a high performance counter, which is capable of giving fast and precise frequency measurements. It measures frequencies as high as 225 MHz on channels 1 and 2. An optional channel 3 (option 030 or 050) extends this capability to 3.0 or 5.0 GHz respectively. This counter features an intuitive user interface and one-button access to frequently used functions for quick and easy measurements. The 53132A is equipped with 3 different manuals; operating, programming, and assembly-level service guides.

(2) Its’ basic measurement functions include frequency, period, pulse width, duty cycle, rise/fall times, time interval, frequency ratio, totalize, phase, and peak voltage.

(3) Frequency and time interval resolution is 12 digits in 1 second and 150 Pico seconds.

(4) Operating the counter: the counter presets the menus to default states and values at power up. Cycling the power key presets the counter. The counter automatically displays measurement(s) shortly after a measurement function is selected. For a detailed description of how to operate the HP 53132A, refer to the manufacturer’s manual.

(5) Calibrating the 53132A: hold the Scale & Offset key and cycle the power key to access the calibration menu. All calibration factors and security settings are stored in non-volatile memory and do not change when power is not applied.

(6) The security code is set to 53132 when the counter is shipped from the factory. If the code is changed and by chance forgotten, resetting all of the non-volatile memory to a default state will reset it to the model number default.

(7) While in the calibration menu, the technician can initiate the counter’s calibration routines. It also allows the technician to view the calibration count. This indicates the number of times that the counter has been calibrated. It counts to a max of 32,767 before wrapping around to 1. A calibration count of 0 indicates that the counter is completely uncalibrated.

**e. Fundamentals of Conventional Counters**

(1) Functions of the Conventional Counter

(a) Frequency measurement: the frequency (f) of repetitive signals may be defined by the number of cycles of that signal per one unit

of time. It may be represented by the equation: $f = n / t$. Where n is the number of cycles of the repetitive signal that occurs in time interval (t). If $t = 1$ second, the frequency is expressed as n cycles per second or n Hertz. As suggested by the equation, the frequency (f) or a repetitive signal is measured by the conventional counter by counting the number or cycles and dividing it by the time interval.

(b) Period measurement: the period (p) of an input signal is the inverse of its frequency ($p = 1 / f$). The period of a signal is therefore the time taken for the signal to complete one cycle of oscillation. If the time is measured over several input cycles the average period of the repetitive signal is determined. This is often referred to as multiple period averaging.

(c) Frequency Ratio of two input signals: the ratio of two frequencies is determined by using the lower-frequency signal for gate control while the higher frequency signal is counted by the counting register. Accuracy of the measurement may be improved by using multiple averaging techniques.

(d) Time Interval measurement: time interval is the measurement of elapsed time between two events. This requires two independent inputs; the start input opens the gate and the stop input closes it. During the elapsed time clock pulses are accumulated. The accumulated count represents the time interval between the start event and the stop event. Time interval averaging is a technique used for reducing measurement errors of a random nature by taking the statistical average of a large number of measurements.

(2) Important Basic Considerations that Affect Performance of the Conventional Counter.

(a) Sensitivity: the sensitivity of a counter is defined as the minimum specified input signal that can be counted. Sensitivity is usually specified in terms of the RMS value of a sinusoidal input.

(b) AC-DC Coupling: AC coupling of the input is commonly provided to enable signals with a DC content to be counted.

(c) Trigger Level: the function of the trigger level control is to shift the hysteresis levels above or below electrical ground to enable positive or negative pulse trains respectively, to be counted. Counters provide a continuously adjustable trigger level control, adjustable over the whole dynamic range of the input and signal amplitude that is consistent with the counter's sensitivity.

(d) Dynamic Range: the dynamic range of the input is defined as the input amplifier's linear range of operation.

(e) Attenuators: it is not good practice to exceed the dynamic range of the input. To avoid this on larger level signals, attenuators are provided. Inputs with wide dynamic ranges usually employ step attenuators with attenuation positions such as X1, X10, and X100. Another variation is a variable attenuation scheme. This is mandatory for low dynamic range inputs, but it also provides the additional advantage of variably attenuating noise signals to minimize the noise while maintaining maximum signal amplitude.

(f) Input Impedance: for frequencies up to 10 MHz, a 1 MΩ input impedance is usually recommended. Beyond 10 MHz, however, the inherent shunt capacity of high impedance inputs rapidly reduces input impedance. For this reason 50Ω impedance levels, which can be provided with low shunt capacity, are preferred. While sensitivities of 10 mV are

technologically feasible, because of noise and related problems, 20 mV to 25 mV are considered optimum with 50Ωinputs.

(3) Sources of Measurement Error

(a) ±1 Count Error: when an electronic counter makes a measurement a ±1 count ambiguity can exist in the least significant digit or quantization error. This occurs because of the non-coherence between the internal clock frequency and the input signal.

(b) Time Base Error: any error resulting from the difference between the actual time base oscillator frequency and its' nominal frequency is directly translated into a measurement error.

(c) Trigger Error: trigger error is a random error caused by noise on the input signal and noise from the input channels of the counter.

(d) Systematic Error: for time interval measurements, any slight mismatch between the start channel and the stop channel amplifier rise times and propagation delays results in internal systematic errors. Mismatched probes or cable lengths introduce external systematic errors.

**J. SUMMARY:** During this period of instruction we discussed the specifications of the model 5335A, 5345A, 5351B, and the 53132A frequency counters. Also, we discussed some of the basic fundamentals and important considerations that affect performance and sources of measurement errors using electronic frequency counters.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (G)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (G)

**B. TIME:** 30 Minutes

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To teach the technician the operational principles of a flow meter and its applications.

**G. INSTRUCTIONAL AIDS:** AN series flow meter

**H. REFERENCES:** Instructors discretion

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY:

   a. Flow meters are designed with exceptionally wide application in the areas of testing and control. They measure the rate at which a fluid passes through a medium, such as a hose or hard line. With a wide range of sizes, AN fittings meet the requirements for most applications with a accuracy of +/- .25% of reading.

   b. The flow meter meets many calibration needs with its' wide flow range and fast response to rate changes. The simplicity of construction with few parts makes it cost effective and traceable to N.I.S.T.

   c. With most liquid flow measurement instruments, the flow rate is determined by measuring the liquid's velocity or the change in kinetic energy. Velocity depends on the pressure differential that is forcing the liquid through a pipe or conduit. There are three basic types of flow sensors and flow meters. Mass flow meters measure flow rate in terms of the mass of the fluid substance and have units such as lbs/min. Volumetric flow meters measure flow rate in terms of how much of the material is flowing and use units

that measure mL/min. Velocity flow sensors and flow meters measure flow rate in terms of how fast the material is moving and measure  ft/sec. Any of these sensors can handle liquid or gas.

d. Critical specifications for flow sensors and flow meters are the measuring range, what type of medium and measurement is to be used, and the operating temperature and pressure ranges. Analog outputs can include voltage, current, frequency, or a pulsed signal. Digital output can be a computer signal such as serial or parallel, or another digital signal, such as TTL. Turbine flow meters measure the rate of flow in a pipe or process line via a rotor that spins as the media passes through its blades. The rotational speed is a direct function of flow rate and can be sensed by a magnetic pick-up, photoelectric cell, or gears.

e. Test cell and hydraulic generators are examples of test equipment that require calibration using flow meters. Ensure fittings are tight when using flow meters. Do not over tighten, as it will strip the fitting, create F.O.D., and lead to bad fit and leaks.

f. Important parameters to consider when specifying turbine flow meters include velocity flow rate range, liquid volumetric flow rate, operating pressure, fluid temperature, material density, and material viscosity.  Velocity flow rate range applies only to those turbine flow meters that are velocity flow sensors or meters.  It is the range of flow in distance/time. Liquid volumetric flow rate applies only to those turbine flow meters that are liquid volumetric flow sensors or meters.  It is expressed as the range of flow in volume/time.  The operating pressure is the maximum head pressure of the process media the meter can withstand.

**J. SUMMARY:** Flow meters are highly reliable for calibration when they are properly used and maintained. The measurements made when using a flow meter can save a corporation, as well as the Marine Corps, an enormous amount of money.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (N)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (N)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To instruct the technician on the correct procedures for the operation and use of oscilloscopes.

**G. INSTRUCTIONAL AIDS:** TDS620A, Oscilloscope probe, BNC cable and the 33120A

**H. REFERENCES:** TDS620A and HP54602B user manuals

**I. PRESENTATION:**

1. INTRODUCTION: Oscilloscopes are instruments used for two purposes in the 6492 MOS, calibration of support equipment/standards and troubleshooting. The oscilloscope is a useful instrument to the METCAL field due to the fact that it can measure and graphically display a voltage. One reason to use an oscilloscope vice a multimeter is that it can display the voltage across time instead of a single reading, therefore allowing the user to see wave shapes. Through triggering an oscilloscope can provide a small number of periods of an oscillating signal so that even high frequencies may be displayed.

2. BODY:

   a. When setting up measurements on an oscilloscope, it is best to set all dial and buttons to their highest setting before taking a measurement of a signal to avoid damaging any internal components. When using an oscilloscope probe, always remember to conduct a probe compensation test, allowing the oscilloscope to adjust to the specific probes electrical properties.

After these preliminary operations are accomplished, the oscilloscope is ready to make measurements.

b. Once a signal is applied to channel 1 or channel 2, the technician has three options to obtain a stable signal on the oscilloscope (four when dealing with digital oscilloscope, i.e. auto scale).

(1) The vertical menu allows the technician to manipulate the volts-per-division aspect of the oscilloscope, also known as the amplitude of the signal. If the signal were off screen the technician would increase the volts-per-division displayed bringing the signal onto the screen. Inversely, if the signal is too small reduce the amount of volts-per-division for an onscreen waveform. There are three types of voltage measurements commonly made with AC signals on an oscilloscope: volts peak, voltage peak to peak, and volts RMS. Volts peak is the number of divisions a waveform crosses above the zero graticule multiplied by the volts-per-division selection. (4 div x .5 volts/div= 2 volts) Volts peak-to-peak is just the same formula but adding on the negative half of the signal. Volts RMS is just volts peak times .707, so 2vp would be 1.414 VRMS.

(2) The horizontal menu allows a technician to control how many periods of a signal is displayed. If a technician was looking at a waveform and he or she did not have enough periods of the signal to make a measurement, the technician could reduce the amount of seconds-per-division to achieve the right amount. If too many periods are displayed on the screen to the display looks like a straight bar, the technician could increase seconds per division and stretch out the signal across the screen. To measure the frequency, count the number divisions covered by one period and multiply by the seconds-per-division, i.e. If the oscilloscope is set for 100uS-per-division and the period is 5 divisions the period is 500uS. Since period and frequency are reciprocals of each other, (1/frequency=period and 1/period=frequency) a 500uS period would be a frequency of 2kHz.

(3) The triggering menus function allows a technician to stabilize repeating waveforms and capture single-shot waveforms. There are a couple of controls to remember on the triggering menu, first is the slope function. This allows a technician to decide where the waveform will be triggered. Positive slope will follow rising edge and a negative slope is the falling edge. Also, there is AC/DC coupling, which in DC mode allows all components of the signal to pass, while in AC mode a capacitor is added to the circuit that will block all DC components of the signal. A technician can also trigger a channel 1 signal with a signal applied channel 2, Some calibration procedures occasionally require this process and usually explain it in detail. There is also an auto-triggering mode for most new oscilloscope.

c. Another measurement that can be accomplished using an oscilloscope is the timing in pulses or pulse trains. Measuring the amount of pulses in a time frame, measuring how long a pulse is, or measuring the time between pulses are a few examples. This can be accomplished by enlarging the pulses with the sec/div switch to where a viable reading of the graticules can be achieved, or if using a digitizing oscilloscope use the cursor functions. With the cursor functions a technician can set one cursor to the beginning of a pulse and set the other cursor to the point where he/she needs to make a time measurement. There will be a delta symbol with the time difference displayed at the top or bottom of the screen.

**J. SUMMARY:** During this period of instruction the basic functions of scopes were discussed that are utilized to make measurements during calibration or troubleshooting. We discussed how to set up voltage and time measurement on the scope while using the trigger function to stabilize the signal, which also allows a technician to make basic measurements of voltage i.e. volts peak, volts peak to peak, and volts RMS. Time measurement also was discussed was discussed as well. During this portion of the lesson we learned how to make frequency and period measurements and learned that the two were reciprocals of each other. We discussed pulses and pulse trains and measuring their

timing. The oscilloscope is a versatile instrument in both calibration and in troubleshooting and should be utilized often.

## K. QUESTIONS?

1. What is the formula for volts RMS?
   a. Volts peak times .707.

2. How does one convert frequency to period?
   a. Use the reciprocal of frequency 1/frequency.

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (P)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (P)

**B. TIME:** 30 Minutes

**C. DATE PREPARED:** 14 September 04

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To familiarize technicians with the different types and uses of pressure gages.

**G. INSTRUCTIONAL AIDS:** (1) Bourdon-tube Gage (1) Bellows Gage, and (1) Diaphragm Gage

**H. REFERENCES:** NAVAIR 17-35QAL-2

**I. PRESENTATION:**

1. INTRODUCTION: The types of pressure gages used in the Aviation calibration field are bourdon-tube gages, bellows, and diaphragm gages. Bourdon-tube gages are generally used for measuring pressures above and below atmospheric pressure. Bellows and diaphragm gages and manometers are generally used to measure pressure levels below 15 pounds-per-square-inch (psig). They are also used for low vacuum pressure. Low vacuum pressure is slightly less than 14.7 pounds-per-square-inch absolute. Often, pressure-measuring instruments have scales calibrated in inches-of-water (in H2O) to allow greater accuracy.

2. BODY

   a. Bourdon-tube Gages: The device usually used to indicate temperature changes by its response to volume changes or to pressure changes is called a bourdon tube. A bourdon tube is a C-shaped, curved or twisted tube that is open at one end and sealed at the other (fig. 11-1). The open end of the tube is fixed in position and the scaled end is free to move. The tube is more or less elliptical in cross section; it does not form a true circle. The tube becomes more

circular when there is an increase in the volume or the internal pressure of the contained fluid or gas. The spring action of the tube metal opposes this action and tends to coil the tube. Since the open end of the bourdon tube is rigidly fastened, the sealed end moves as the pressure of the contained fluid or gas changes. There are many types of bourdon-tube gages used in the Navy. The most common are the simplex, duplex, vacuum, compound, and differential pressure gages. They operate on the principle that pressure in a curved tube has a tendency to straighten out the tube. This curved tube is made of bronze for pressure under 200 psi and of steel for pressures over 200 psi.

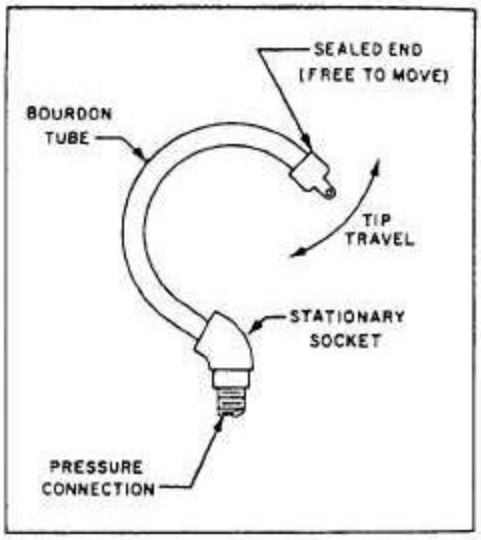


Fig 11-1

b. Simplex Bourdon-tube Gauge: Figure 11-2 displays a simplex bourdon tube installed in a gauge case. Notice that the bourdon tube is in the shape of the letter C and is welded or silver-brazed to the stationary base. A linkage assembly connects the free end of the tube to the indicating mechanism. The threaded socket, welded to the stationary base, is the pressure connection. When pressure enters the bourdon tube the tube tends to straighten out. The tube movement through linkage causes the pointer to move proportionally to the pressure applied to the tube. The simplex gage is used for measuring the pressure of steam, air, water, oil, and similar fluids or gases.

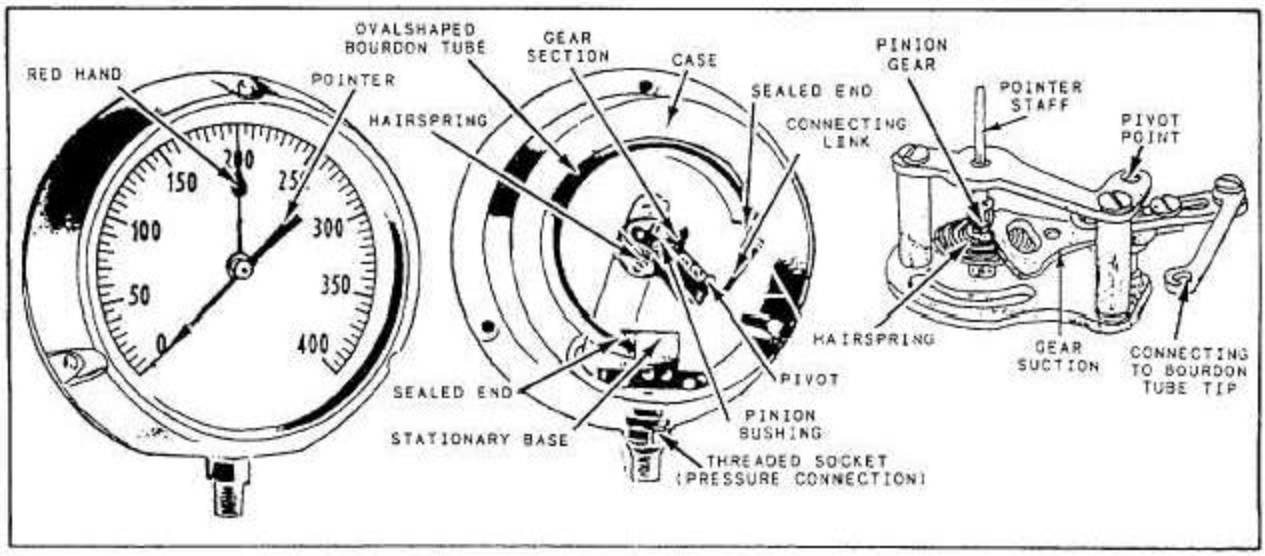


Fig 11-2

c. Duplex Bourdon-tube Gauge: The duplex bourdon-tube gage (fig. 11-3) has two tubes and two separate gear mechanisms within the same case. As shown in view B, a pointer is connected to the gear mechanism of each tube. Each pointer operates independently. Duplex gages are normally used to show pressure drops between the inlet and outlet sides of lube oil strainers. If the pressure reading for the inlet side of a strainer is much greater than the pressure reading for the outlet side, one may assume that the strainer is likely to be dirty and is restricting the flow of lube oil through the strainer.

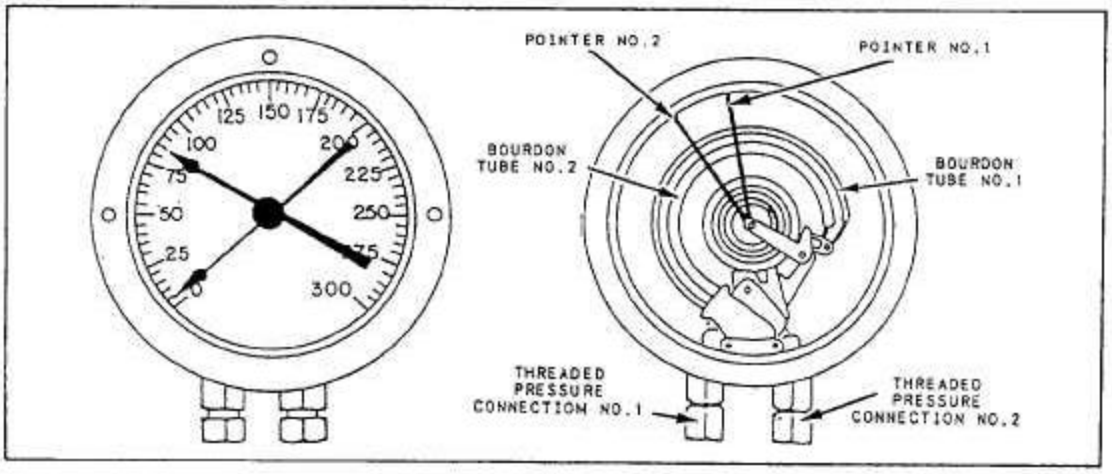


Fig 11-3

d. <u>Bourdon-tube Vacuum Gauge, Compound Gauge, and Differential Pressure Gauge</u>:

(1) Bourdon-tube vacuum gages are marked off in inches-of-mercury (fig. 11-4).

(2) When a gage is designed to measure both vacuum and pressure, it is called a compound gauge. Compound gages are marked off both in inches-of-mercury (in Hg) and in psig (fig. 11-5).

(3) Differential pressure may also be measured with bourdon-tube gages. One kind of Bourdon-tube differential pressure gage is shown in figure 11-6. This gauge has two bourdon tubes, but only one pointer. The bourdon tubes are connected in such away that they are the pressure difference of the two, rather than either actual pressures indicated by the pointer.

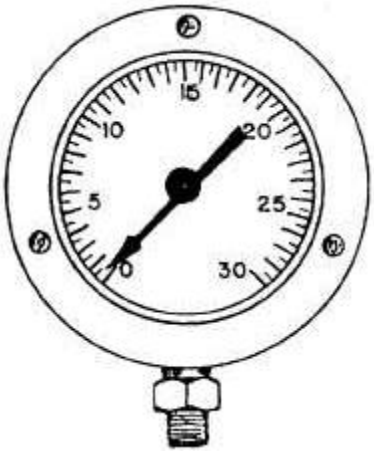


Fig 11-4

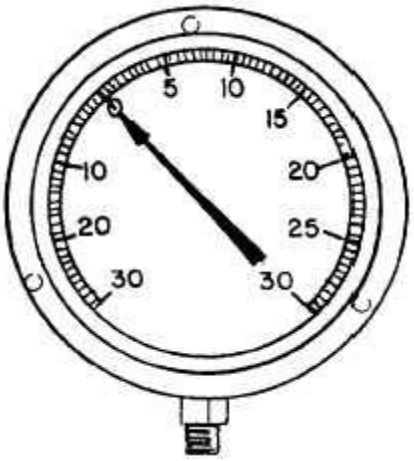


Fig 11-5

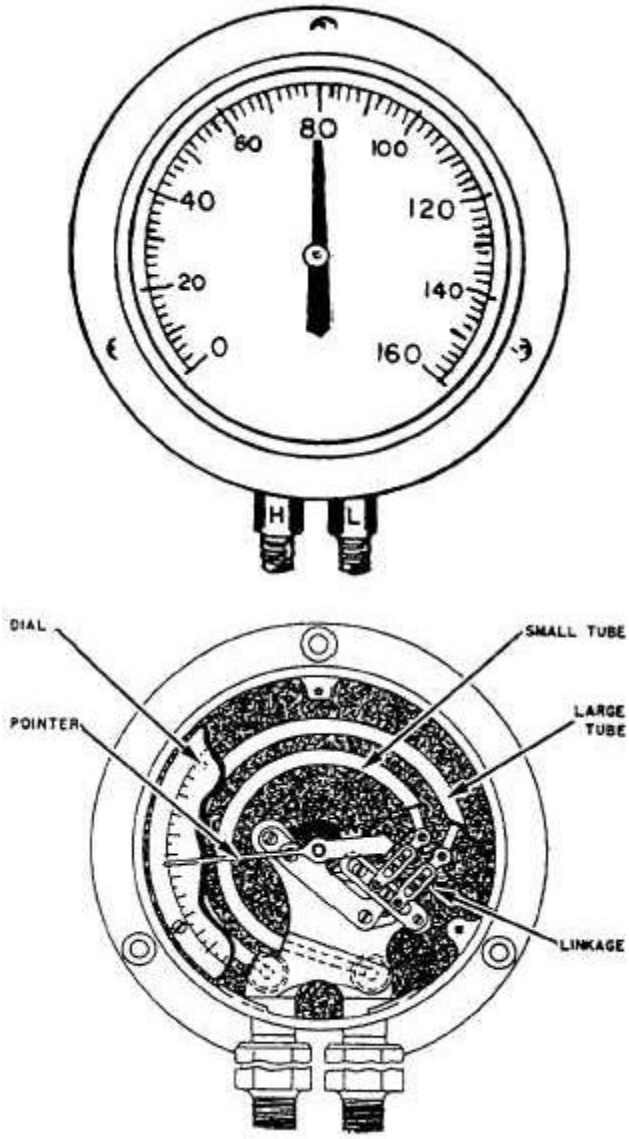


Fig 11-6

e. <u>Bellows Gages</u>: A bellows gage contains an elastic element that is a convoluted unit that expands and contracts axially with changes in pressure. The pressure to be measured can be applied to the outside or inside of the bellows. However, in practice, most bellows measuring devices have the pressure applied to the outside of the bellows (fig 11-7). Like bourdon-tube elements, the elastic elements in bellows gages are made of brass, phosphor bronze, stainless steel, beryllium-copper, or other metal that is suitable for the intended purpose of the gage. Most bellows gages are spring-loaded; that is, a spring opposes the bellows, thus preventing full expansion of the bellows. Limiting the expansion of

the bellows in this way protects the bellows and prolongs its' life. In a spring-loaded bellows element the deflection is the result of the force acting on the bellows and the opposing force of the spring. Although some bellows instruments can be designed for measuring pressures up to 800 psig, their primary application is in the measurement of low pressures or small pressure differentials. Many differential pressure gages are of the bellows type. In some designs, one pressure is applied to the inside of the bellows and the other pressure is applied to the outside. In other designs, a differential pressure reading is obtained by opposing two bellows in a single case. Bellows elements are used in various applications where the pressure-sensitive device must be powerful enough to operate not only the indicating pointer but also some type of recording device.

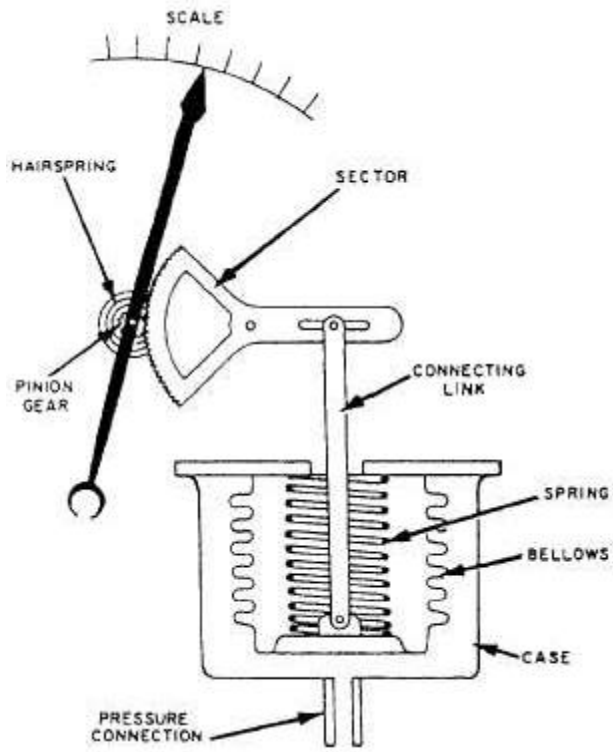


Fig 11-7

f. DIAPHRAGM GAGES: Diaphragm gages are very sensitive and give a reliable indication of small differences in pressure. Diaphragm gages are generally used to measure air pressure in the space between the inner

and outer boiler casings. Figure 11-8 shows the indicating mechanism of a diaphragm gage. This mechanism consists of a tough, pliable, neoprene rubber membrane connected to a metal spring that is attached by a simple linkage system to the gage pointer. One side of the diaphragm is exposed to the pressure being measured while the other side is exposed to the atmosphere. When pressure is applied to the diaphragm, it moves and, through a linkage system, moves the pointer to a higher reading on the dial. When the pressure is lowered, the diaphragm moves the pointer back toward the zero point.

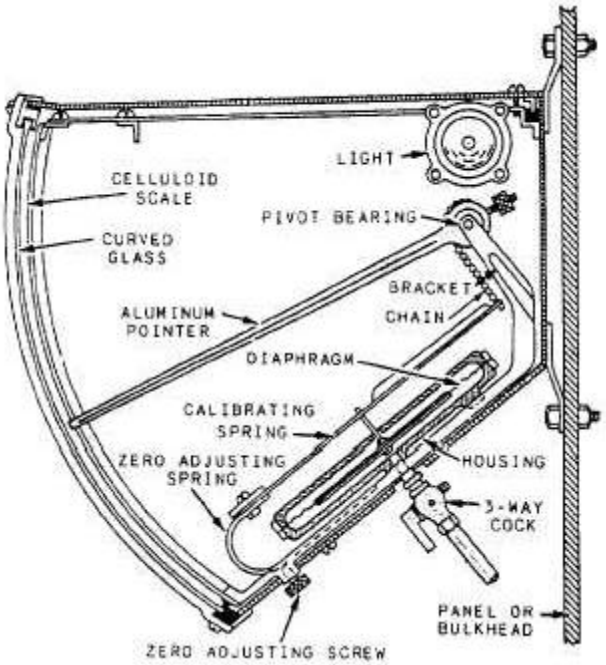


Fig 11-8

**J. SUMMARY:** There are several different types of gages, which have unique roles in the Aviation Calibration field. Understanding how to operate and identifying the differences between gages will prolong the life of gages and ensure maximum accuracy when using gages for calibration.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (Q)

## Precision Measuring Equipment

| | YR/MO/DAY | | NAME/RANK |
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**A. LECTURE NUMBER:** MOS 6492 B.1 (Q)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** **Precision Measuring Equipment**

**F. OBJECTIVES:** To provide training on the use of resistance standards and measuring systems.

**G. INSTRUCTIONAL AIDS:** 3458A, and decade resistor

**H. REFERENCES:**

1. 3458A Manufactures Pub
2. NAVAIR 16-45-1829

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY:

   a. The multimeter measures resistance by supplying a known current through unknown resistance being measured. The current passing through the resistance generates a voltage across it. The multimeter measures this voltage and calculates the unknown resistance (resistance = voltage/current).

   b. Two-wire OHMS is most commonly used when the resistance of the test leads is much less than the value being measured. If the lead resistance is large compared to the resistance to be measured, readings will be inaccurate.

   c. The 4-wire OHMS mode eliminates the measurement error caused by test lead resistance. In 4-wire OHMS mode the voltage is measured across the unknown resistance only, not the combined resistance. This is important

when the test lead resistance is high in comparison to the resistance being measured.

d. Decade resistors are primarily used for precision measurement applications that require higher accuracy, greater stability, and low zero resistance. They are convenient standards for checking the accuracy of resistance measuring devices and are often used for components in DC and low frequency AC bridges and other precision measuring circuits. Many models can be used in the RF frequency range. All models are easily rack-mounted for use during precision adjustments in measurement and control systems.

(1) **Overall accuracy -** the resistance difference between any setting and at the zero setting is equal to the indicated value +-(.02%+2mohm).

(2) **Zero resistance (Ro) -** .001 ohms per dial at DC; .04 ohms per dial at 1Mhz; proportional to square root of frequency at all frequencies above 100 KHz.

(3) **Temperature coefficient of resistance** - Less than +-10 ppm per degree C for values above 100 ohms and +-20 ppm per degree C for 100 ohms and below, at room temperatures. For the 1433s, the box wiring will increase the over-all temperature coefficient of the .1 and .01 ohms decades.

3. DEMONSTRATION:

a. Students receive a demonstration of the two-wire resistance measurement/mode of operation.

b. Students receive a demonstration of the four-wire resistance measurement/mode of operation.

4. PRACTICAL APPLICATION:

a. Student demonstrates the two-wire resistance measurement/mode of operation.

b. Student demonstrates the four-wire resistance measurement/mode of operation.

**J. SUMMARY:** Resistance is measured using a known current applied through an unknown resistance. The increase in accuracy required of today's instrumentation tends to increase the complexity and cost of maintaining calibration of these instruments. The 3458A multimeter measures DC and AC as well as resistance with unmatched accuracy, precision, and speed in a cost-effective manner. The calibration of all resistance ranges for the 3458A requires only a single resistance standard. All adjustments are done electronically with the 3458A. Standard decade resistors are simply a collection of rotary switches with precision resistors in series used in steps to provide an unknown and accurate resistance.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (S)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (S)

**B. TIME:** 2 HOURS

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** Student will be capable of performing RF power measurements using the 8902A RF Measuring Receiver.

**G. INSTRUCTIONAL AIDS:** 8902A Measuring Receiver Manufacturers Publication

**H. REFERENCES:** HP 8902A Operation And Calibration Manual

**I. PRESENTATION:**

1. INTRODUCTION: This lesson is designed to provide students with the knowledge necessary to perform basic RF power measurements. There are several methods and various pieces of equipment that can be used to make these measurements. For this period of instruction, the 8902A Measuring Receiver will be utilized.

2. BODY:

   a. To begin using the 8902A, several steps must be taken by the operator to ensure the measuring receiver is in an operational state. Perform the following steps:

      (1) Check the system and cables for proper connection and setup.

      (2) Check the main line fuses and apply the appropriate power source to the 8902A.

      (3) Turn on the 8902A and allow for proper warm-up time.

b. To begin making an RF power measurement, the sensor head must be zeroed and calibrated. This ensures the specified measurement accuracy. Perform the following steps:

(1) Enter the calibration factors of the sensor head into the 8902A.

(2) Zero the power sensor

(3) Setup the 8902A to measure its' 1mw RF power reference.

(4) Scale the subsequent power measurement to the 1mw calibration.

c. To make an RF power measurement:

(1) Ensure the sensor head has been properly zeroed and calibrated.

(2) In this case, select RF Power.

(3) Connect the sensor head or the microwave cable to the signal source.

(4) Turn on the RF power source. The 8902A Measuring Receiver should automatically self tune and begin displaying a reading.

(5) If the 8902A Measuring Receiver does not display a reading within a few seconds, or it displays an error code, consult the manufacturer's publication.

## J. SUMMARY:

1. This lesson was a brief overview of the steps necessary to make a simple RF measurement using the 8902 Measuring Receiver. Make note that the 8902A has many different functions and options the operator should be familiar with prior to operating this system. There are also several different techniques of making RF power measurements that the technician should be familiar with as well.

2. As with any type of electrical equipment or device, safety is the most important issue and should always be considered. Also, the applicable manufacturer’s publication should be readily accessible to answer any questions that might arise during equipment operation.

## K. QUESTIONS?

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (V)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (V)

**B. TIME:** 30 Minutes

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To instruct the technician on the correct procedures of the operation and use of the 8562A RF Spectrum Analyzer.

**G. INSTRUCTIONAL AIDS:** 8562A Spectrum Analyzer

**H. REFERENCES:** 8562A Manufactures manual

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY:

   a. The 8562A is a portable spectrum analyzer capable of measuring signals from –119.9dBm to +30dBm over a frequency range of 1kHz to 22GHz. It has a warm up time of 5 minutes from ambient temperature, 30 minutes to meet frequency response specifications without preselector peaking, and a 2-hour warm up for conditions of internal condensation.

   b. The trace alignment procedure and the reference level calibration should be preformed after the spectrum analyzer is warmed up. To perform the trace alignment procedure, press the PRESET key, the RECALL key, [MORE], and [CRT ADJ]. Adjust the rear-panel TRACE ALIGN until the leftmost line of the test pattern is parallel with the CRT bezel. Adjust the rear-panel X PONS until the leftmost “@” characters and the soft key labels appear just inside the left and right edges of the CRT bezel. Adjust the rear-panel Y PONS until the soft key labels align with their appropriate soft keys. Press the PRESET key to return the analyzer to normal operation.

c. To perform the reference level calibration, connect a 50-ohm coaxial cable between the front-panel CAL OUTPUT and the RF INPUT 50ohm connector. Set the center frequency to 300 MHz by pressing the FREQUENCY key, enter 300 on the keypad and then press the MHz key. Set the span to 20 MHz by pressing SPAN, 20 on the keypad, and the MHz key. Press the PEAK SEARCH key, set the reference level to –10dBm by pressing AMPLITUDE key, and then –10 on the key pad followed by the dBm key. Press [MORE] and [REF LVL CAL]. Rotate the cursor knob until the marker reads –10dBm +/-.17db. Press [STORE REF LVL] and then press the PRESET key.

d. The 8562A uses the frequency, amplitude, and span functions for most measurements. The frequency function can allow you to set a center frequency, and a start and stop frequency. The amplitude function enables one to set the reference level. The span function enables one to set the span width and set the sweep time. The 8562A also has a marker function, which enables one to read single peaks, or find the difference in frequency or amplitude between two peaks.

e. It is extremely important not to exceed the limits of the spectrum analyzer. The RF input range is 1kHz to 22GHz with 0V max, and +30dBm with a minimum of 10dBm input attenuation. The Probe powers max input is +15V, -12V (150mA max). The calibrator output has a frequency range of 300MHz with-10dBm max. The IF input has a frequency range of 321.4MHz with 0V max. The Lo output has a frequency range of 3GHz to 6.81GHz with 16dBm max.

**NOTE:** Applying DC power to the RF input can destroy the internal attenuators!

## J. SUMMARY:

The 8562A spectrum analyzer is designed to read frequency and amplitude through a range of 1kHz to 22GHz and –119.9dBm to+30dBm. It is important to understand its functions to improve test accuracy and prevent damage.

## K. QUESTIONS?

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (W)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS/6492/B.1 (W)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** **Precision Measuring Equipment**

**F. OBJECTIVES:** To instruct the technician on the use of the HP83630A Synthesized Sweeper, HP8648B Signal Generator, and the HP33120A Arbitrary Waveform Generator.

**G. INSTRUCTIONAL AIDS:** The HP 83630A, 8648B, and 33120A

**H. REFERENCES:** HP 83630A Manufacturers User Guides

**I. PRESENTATION:**

1. INTRODUCTION:

   a. This lesson will discuss the following topics:
   b. Specifications and options.
   c. Common workloads for each item.
   d. Correct setup and operation *(demonstrate to students as noted)*.

2. BODY:

   a. The HP 83630A is a versatile instrument. It can generate CW, swept, AM, FM, and pulse-modulated signals. It has a broad range of uses and workload. Some examples are: Spectrum Analyzers, Weapon and Radar test equipment, RF voltmeters, etc. The 83630A may also be used in conjunction with a Scalar Network Analyzer, for example the 8003, to calibrate or check VSWR of microwave attenuators and various other components.

   b. The HP83630A's specifications are as follows:

      (1) **Range:** 10MHz to 26.5GHz.

(2) **Output power:** *max~* +13dbm @ < 20GHz, +10dbm @ >20GHz *min~* -20dbm, OPT001 –110dbm.

(3) **Frequency Resolution:** 1KHz, OPT008 1Hz.

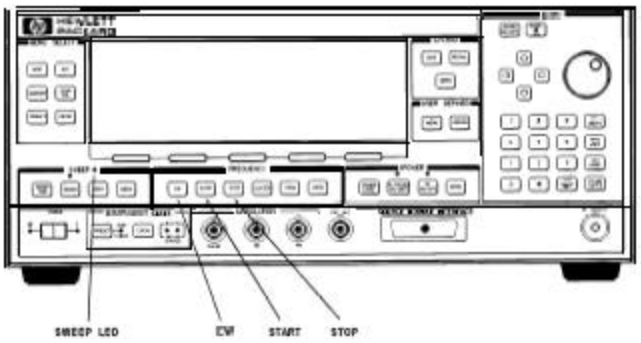
(4) **Modulation:**

(a) *Pulse:* minimum PW – 1us; search or ALC off mode 50us

(b) *AM:* Bandwidth – DC to100kHz Depth – -20dBm to 1dB below max output power; Deep and Unleveled modes – 50dB below max output power.

(c) *FM:* Max Deviation – +/- 8MHz. Rates – 100kHz to 8MHz.

c. The 83630A should be connected to a power source for at least 24 hours to ensure time base accuracy and warm up for 30 minutes after turning the instrument on. *(The instructor will demonstrate the following series of keystrokes)*




(1) **For CW operation:** press CW key, 12.345678 keys, and then the GHz key. The 83630A should display →cw: 12345.678000 MHz. You can alter this entry with the rotary knob and arrow keys.

(2) **For a Swept frequency:** press Start key, 4.56 keys, GHz key, then press Stop key, 7.89 keys, GHz key. The start and stop frequencies should be displayed, and both may be altered in the same manner as a CW signal.

(3) **To adjust the Power Level:** press Power Level key, -11 keys, and dBm key. –11 dBm should be displayed. The power level may also be altered in the same manner as the frequency, utilizing the arrow keys and rotary knob.

(4) **Modulation:** All modulation parameters are set via soft key menus.

d. These are just a few simple operations, for more complex operations, consult the user manual available online at www.agilent.com.

e. The **HP 8648B** is another example of a signal generator. It is capable of generating CW, and modulated CW signals. You can use this instrument to calibrate modulation meters, power sensors, radio test equipment, universal counters, etc.

f. The specifications of the HP 8648B are:

(1) **Range:** 9kHz to 2GHz.

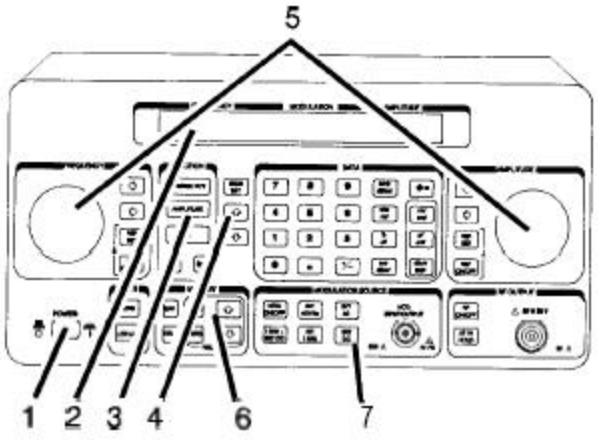
(2) **Output power:** +13dBm max; -136dBm min.

(3) **Frequency resolution:** .001 Hz

(4) **Modulation:**

(a) *AM:* Bandwidth – DC to 25kHz; Depth – 0 to100%.

(b) *FM:* Deviation – 0 to 400kHz; Rate – DC to 150kHz. *(The instructor will now demonstrate the following)*




(5) Power Key: Toggles power on/off
(6) Display: Interface between user and instrument
(7) Function and Data Keys: Allows user to select parameters to be set
(8) Increment Set Keys: Allows user to modify an active function
(9) Knobs: Work the same as Increment Set Keys
(10) Memory: Allows user to save a current setting
(11) Modulation Source: Allows user to select a modulation source

g. For correct use, consult the user manual available at www.agilent.com

**J. SUMMARY:** Technicians should now have a better understanding of the use of Signal Generators, and are better prepared to utilize them during calibration and troubleshooting procedures.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (BB)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (BB)

**B. TIME:** 30 Minutes

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITTLE:** Precision Measuring Equipment

**F. OBJECTIVES:** Instruction the technician on the correct procedures for the operation and use of torque devices.

**G. INSTRUCTIONAL AIDS:** 3695 Torque and Force Calibrator

**H. REFERENCES:** 3695 Torque and Force Calibrator Technical Manual.

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY:

a. SPECIFICATIONS

(1) Model 3695 Torque and Force Calibrator is self contained, semi-automated, multi-functional calibrator that provides a means for rapid, safe, and highly accurate calibration of torque and force measuring instruments.

(2) The Model 3695 has the capability to calibrate various wrenches, torque multipliers, force gauges, cable tensiometers, and cable testers throughout the standard ranges from in-ozs to 20,000 ft-lbs (torque) and 5,000 lbs force with accuracies up to ± 0.5% for torque and ± 0.125% for force.

(3) The Model 3695 has been tested and complies with the requirements for shipboard equipment as defined in MIL-T-28800.

**PHYSICAL CHARACTERISTICS**

| | |
|---|---|
| Dimensions | 44.2"L x 25"D x 54.5"H |
| Weight | 760 lbs |
| Input Power | |
| Voltage | 115VAC, 50-60Hz |
| Current Drain (max) | 5 Amp |
| Fuses | 3AG style, 2 Amp, (Main power)<br>3AG style, 7 Amps (Stepper motor) |
| Operating Temperature Range | 10° C to 40° C |
| Non-Operating Temperature Range | -40° C to 75° C |
| Humidity | 85% RH |

**FUNCTIONAL FEATURES**

| | |
|---|---|
| Display | 40 Character, alphanumeric, vacuum fluorescent |
| Printer | Dot matrix, in-line, electrostatic |
| Operator Input Device | Keypad with 10 digits and 6 function keys |
| Units of measure | ft-lbs, in-lbs, in-oz, N-m, kg-m, lbs, oz, kg, GM, N |
| Interface Compatibility | IEEE-488 GPIB, RS-232 |

**PERFORMANCE**

| | |
|---|---|
| Range | |
| Torque Testing (Motor Driven) | 0-5000 ft-lbs |
| Torque Testing (Test Item Driven) | 5000-20000 ft-lbs |
| Force Gauge Testing | 0-500 lbs |
| Cable Tensiometer Testing | 0-2400 lbs |
| Cable Tester Testing | 0-5000 lbs |
| Accuracy | *(the greater of)* |
| Torque Testing (Motor Driven) | ± 0.5% IV or ± 0.005 ft-lbs |
| Torque Testing (Test Item Driven) | ± 0.5% IV or ± 5 ft-lbs |
| Force Gauge Testing | ± 0.125% IV or ± 0.005 lbs |
| Cable Tensiometer Testing | ± 2.5% IV or ± 0.75 lbs |
| Cable Tester Testing | ± 0.75% IV or ± 2.1 lbs |
| Resolution | |
| 0 to 10 | 0.001 |
| 10 to 100 | 0.005 |
| 100 to 1,000 | 0.05 |
| 1,000 to 5,000 | 0.5 |
| 5,000 to 20,000 | 1 |
| Setability | *the greater of* |

| | |
|---|---|
| Force | ± 0.03% IV or ± 0.001 lbs |
| Tension | ± 0.6% IV or ± 0.2 lbs |
| Cable Tension | ± 0.2% IV or ± 0.52 lbs |
| Torque (bidirectional) | ± 0.1% IV or ± 0.001 ft-lbs |

b. OPERATION

(1) For torque wrench calibration, select a transducer that has a full-scale range equal to or greater than the range of the test instrument.

(2) For dual range instruments calibrate the lowest range first.

(3) For torque multiplier calibration, select the 500ft-lb, 5000ft-lb, or the 20000ft-lb transducer as specified for the applicable test instrument:

(4) When calibrating force instruments with units of measure in pounds of force, the output value of the transducer is automatically converted from ft-lbs to lbs (f) by the control console based on the data entered during the programming procedures.

(5) For cable tensiometer calibration, select either the 500ft-lb or the 5000ft-lb transducer as specified for the applicable test instrument.

(6) For force gage calibration, select the 50ft-lb transducer for ranges up to 50 lbs and 500ft-lb transducer the ranges up 500 lbs.

**J. SUMMARY:** The 3695 will measure several different types of torque instruments. The key to correct and proper calibration is to use the correct transducers, and attachments. By following procedures and adhering to safety, the 3695 is a valuable calibration asset.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (FF)

## Precision Measuring Equipment

| | YR/MO/DAY | | NAME/RANK |
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**A. LECTURE NUMBER:** MOS 6492 B.1 (FF)

**B. TIME:** 30 Minutes

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To instruct the technician on the correct procedures for the operation and use of the 5700 Meter Calibrator.

**G. INSTRUCTIONAL AIDS:** 5700A Meter Calibrator and digital multimeter

**H. REFERENCES:** 5700A Operators Instruction Manual

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY:

   a. The 5700A is a precise instrument used to produce a variety of outputs utilized to calibrate multimeters and other precision measuring instruments. The 5700A is capable of maintaining high accuracy over a wide ambient temperature range, when combined with its' highly variable modes of output it is a very versatile instrument.

   b. Features:

      (1) Automatic meter error calculation using an output adjust knob with a display that shows linearity, offset, and scale errors.

      (2) Functions that multiply/divide the output value by 10.

      (3) Variable phase reference signal output and phase-lock input.

(4) IEEE-488 (GPIB) interface.

(5) Selectable normal remote mode or emulation of the Fluke 5100B Series Calibrators.

(6) Automatic internal self-testing and diagnostics of analog and digital functions.

c. Specifications:

(1) DC Voltage to 1100 Volts:

| Range | Resolution |
|---|---|
| 220 mV | 10 nV |
| 2.2 V | 100 nV |
| 11 V | 1 uV |
| 22 V | 1 uV |
| 220 V | 10 uV |
| 1100 V | 100 uV |

(2) AC Voltage to 1100 Volts, with output available from 10 Hz to 1.2 MHz.

| Range | Resolution |
|---|---|
| 2.2 mV | 1 nV |
| 22 mV | 10 nV |
| 220 mV | 100 nV |
| 2.2 V | 1 uV |
| 22 V | 10 uV |
| 220 V | 100 uV |
| 1100 V | 1 mV |

(3) AC and DC current up to 2.2 Amps with an output frequency available from 10 Hz to 10 kHz.

(a) DC Current

| Range | Resolution |
|---|---|
| 220 uA | .1 nA |
| 2.2 mA | 1 nA |
| 22 mA | 10 nA |
| 220 mA | .1 uA |
| 2.2 A | 1 uA |

(b) AC Current

| Range | Resolution |
|---|---|
| 220 uA | 1 nA |
| 2.2 mA | 10 nA |
| 22 mA | 100 nA |
| 220 mA | 1 uA |
| 2.2 A | 10 uA |

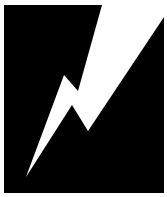
(4) Resistance in values of 1x10n and 1.9x10n from 0 to 100 MOhms.

(5) Optional wideband AC voltage from 300 uV to 3.5 V (-57 dBm to +24 dBm), 10 Hz to 30 MHz.

| Range | | Resolution |
|---|---|---|
| **Volts** | **dBm** | |
| 1.1mV | -46 | 10nV |
| 3mV | -37 | 10nV |
| 11mV | -26 | 100nV |
| 33mV | -17 | 100nV |
| 110mV | -6.2 | 1uV |
| 330mV | +3.4 | 1uV |
| 1.1V | +14 | 10uV |
| 3.5V | +24 | 10uV |

d. Operation:

***WARNING***



***HIGH VOLTAGE***

Is used in the operation of this equipment.

# LETHAL VOLTAGE

May be present on the terminals. Observe all safety precautions!

e. Warm-up: A 5700A requires a 30-minute warm up.

f. Setup Menu: Allows access to the Calibration menu, Self Test & Diagnostics, Instrument Setup, Instrument

Configuration and Special Functions. Refer to the Operators Instruction Manual for more info.

g. Operate and Standby Modes: When the OPERATE annunciator is lit the output value and function shown on the Output Display are active at the selected terminals. When the STANDBY annunciator on the Output Display is lit all 5700A binding posts except GROUND are open-circuited.

*Note: using the arrow keys and variable knob can vary all functions described below.*

h. DC Voltage Output:

(1) Make sure the 5700A is in STANDBY mode.
(2) Connect the test instrument.
(3) Set the test instrument to measure DC voltage.
(4) Press up to eight numeric keys to select voltage.

(5) To change the polarity of the entry, press [+/].

(6) Press [u], [m], or [k] if necessary.

(7) Press [V].

i. The Control Display now shows the amplitude of the entry. If an error occurs, press [C] to clear the display and re-enter the value.

j. Press [ENTER] and the entry moves from the Control Display to the Output Display. No voltage is available at the output terminals until pressing [OPR/STBY]

k. Press [OPR/STBY] to activate the 5700A output.

l. AC Voltage Output: It is similar to DC Voltage Output, with the addition of having to enter a frequency after the voltage desired.

**Note:** *When switching between output terminals and the Wideband AC output, keep in mind that the value will change. The reason for this is the output*

*terminals are a 600-Ohm load and the Wideband AC output is 50 Ohms.*

*Note: The 5700A stays in the AC function after entering a non-zero frequency. If choosing to change back to DC, simply enter a frequency of 0 Hz or a signed voltage.*

m. Wideband AC Voltage Output: This option provides a high-accuracy, low noise, extremely flat AC voltage source with a frequency range of 10 Hz to 30 MHz. It is useful for the calibration of RF voltmeters. The output is provided through a Type "N" coaxial connector into a 50-Ohm load.

n. DC Current Output: Entry is same as above, except for pressing the [A] after entering the desired value.

o. AC Current Output: It is the same as above, with the addition of entering desired frequency.

p. Resistance Output: Use the numeric keys along with appropriate function keys to enter desired value. The “List Table Values” soft key can be used to display available resistance values.

**J. SUMMARY:** The 5700A is a vital standard to calibration laboratories. Its various functions enable technicians to calibrate several different types of equipment at one station. It is highly recommended that all technicians become familiar with the 5700 Meter Calibrator.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (GG)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (GG)

**B. TIME:** 30 Minutes

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To instruct the technician on the correct procedures for the operation and use of the Oscilloscope Calibrator.

**G. INSTRUCTIONAL AIDS:** 9500B Oscilloscope Calibrator

**H. REFERENCES:** 9500B Instruction Manual

**I. PRESENTATION:**

1. INTRODUCTION: Over the last several years due to advancements in technology, oscilloscopes have gone from two channels to four channels. The calibration of more complex oscilloscopes demand the technician has the proper equipment to do the job. The Fluke 9500B Oscilloscope Calibrator has the capability to calibrate most modern-day oscilloscopes. It provides true, full automation through the use of its active heads. From the mainframe, detachable heads produce all the signals needed to calibrate an oscilloscope.

2. BODY:

   a. The 9500B has a variety of features; for example, its' mainframe upgrades ability from 600MHz to 1.1GHz, 3.2GHz, or even 6GHz. The four active heads 9510,9530,9560, and 9550 also have the 1.1, 3.2, 6GHz ranges and an ultra-fast head with a pulse capability of 25PS range respectively. With the active head connected the technician is able to produce precise DC voltage levels up to +/- 220V, square waves with amplitudes of 210V pk-pk from 10Hz to 100KHz, and leveled sine waves from 0.1Hz to 6GHz depending on the active head attached. The 9500B has many

capabilities, such as the calibration of the vertical and horizontal deflection bandwidth. The fast return to ground edges with amplitudes ranging between 4.44mV to 3.1V and rise/fall times of 70PS, 150PS or 500PS ensure the accuracy of the pulse response and bandwidth of an oscilloscope's vertical deflection/acquisition amplifiers. Also with the high level edges up to 210 V pk-pk, it checks the performance of the input attenuators. The leveled sine wave of up to 600 MHz, 1.1, 3.2 or 6GHz with an amplitude ranging from 4.44mV to 5.56 V pk-pk into 50 ohms allows direct calibration of the oscilloscope bandwidth. With the 9560 active head the amplitude range changes from 8.88mV to 5.56 V pk-pk into 50 ohms. Also calibrated are the Z-axis and horizontal deflection bandwidth. The dual sine outputs calibrate the trigger sensitivity and other functions that normally require the insertion of a splitter. The calibration of the vertical deflection gain can be done with the 9500B. With the dc levels and 10Hz to 100KHz square wave that is adjustable to 220V, it is sufficient to calibrate the vertical deflection ranges of 12 bit digitizing and 14 bit interpolation oscilloscopes. Another useful feature of the 9500B is that it checks the oscilloscope's input impedance before applying high voltages to protect the 50 ohm input terminations. With the automatic switching function, it provides the same waveforms at amplitudes up to 5.56V. The calibration of the time base accuracy is done with timing markers ranging form 0.2ns to 50s per division. There are four different styles of time marker to choose from; sine, square, pulse, or narrow triangle. The square and pulse markers can be use to calibrate time base jitter as well.

b. The 9500B also has auxiliary functions that may be used when calibrating an oscilloscope. For example, the DC and square wave currents up to 100mA calibrate the current probes. The TV sync separator function is tested by the composite video signals. The high current 5V to 20V pulses test the 50-ohm terminator protection. The resistance and capacitance functions of the 9500B directly measure the oscilloscope's input impedance. The short/open circuit outputs allow the testing of an oscilloscope's input leakage current. Other characteristics of the 9500B are the

general operating parameters and physical dimensions. The operating temperature is 5 to 40 degrees Celsius. The non-condensing humidity is <90% over 5 to 30 degrees Celsius or <75% over 30 to 40 degrees Celsius. The power requirements are 95V to 132V rms with a frequency of 48 to 63Hz. It has a power consumption of 400VA. The physical dimensions of the 9500B 5.24 x16.8 x 17.3 INs. It weights approximately 27 pounds.

**J. SUMMARY:** The calibration of more complex oscilloscopes demands that the technician has the proper equipment. One oscilloscope calibrator is the Fluke 9500B Oscilloscope Calibrator. The 9500B oscilloscope calibrator provides technicians with a more precise way to calibrate. For the correct settings and test equipment setup, follow the steps in the ICP and always be electrically safe.

## K. QUESTIONS?

1. How many active heads does the 9500B have?

2. What is the maximum frequency the 9500B can test?

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (HH)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (HH)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To instruct the technician on the correct procedures of the operation and use of the 8902A Signal Generator Calibrator.

**G. INSTRUCTIONAL AIDS:** 8902AOPT E04/E41/E51 Signal Generator Calibrator and a signal generator.

**H. REFERENCES:** 8902A User's Manual, 8902A Quick Reference Guide, Agilent 8902A Product Notes, Agilent.com Library

**I. PRESENTATION:**

1. INTRODUCTION: Signal Generators produce signals over a wide range of frequencies. They also produce modulated signals. Today's technologies require signal generators to provide stable leveled signals. Hewlett Packard developed a solution, the 8902A Signal Generator Calibrator, to test all characteristics of a signal.

2. BODY:

   a. The 8902A Signal Generator Calibrator is capable of measuring signals between 150 KHz and 1300 MHz. The 8902A is used to measure signals up to 18 GHz. This is accomplished by using the 11793A Microwave Converter, 11792A Power Sensor Module, and one of three oscillators.

   b. The 8902A measures RF power, AM, FM, FM, RF Frequency, Audio Distortion, and RMS Levels. The power meter in the 8902A can accommodate any 8480 series power sensor. It uses thermocouple, thermistor, or diode detector power sensors. Each sensor has a 50 dB range with various high and low

limits. The 8902A uses IF Substitution to produce a wider range. When used with one of its two power sensor modules, the 8902A can measure power levels between -127 dBm and +30 dBm.

c. The 11792A Power Sensor Module is an 8485A power sensor, microwave switch, and 10 dB input attenuator. It has two paths by which the incoming signal travels. The first path is used for making RF frequency and modulation measurements. It bypasses the power sensor module's power sensor and goes undisturbed into the 11793A Microwave Converter. The down converted signal then enters the 8902A. The second path goes directly through the power sensor and a dc voltage goes into the 8902A. This two-in-one system makes it possible to make all measurements through one connector.

d. The 11722A Power Sensor Module is an 8482A power sensor, microwave switch, and 10 dB input attenuator. When used, it is not connected to the 11793A Microwave Converter. Its N-type male connector is attached to the 8902A's INPUT 50Ω N-type female connector.

e. The 11793A Microwave Converter down converts RF signals to an IF that can be used by the 8902A Signal Generator Calibrator.

f. The LO (8672A, 8671B, 83711B) provides a +8dBm leveled signal for the 11793A Microwave Converter to mix with the incoming signal. It also provides a stable 10 MHz time base for the 8902A Signal Generator Calibrator.

g. <u>Setting up the 8902AOPT E04/E41/E51</u>

(1) Rear

(a) Connect the Local Oscillator (L.O.) 10MHz OUT to the TIME BASE 10MHz INPUT of the 8902A. The 11793A is connected to the 8902A by an IEEE cable. The FREQ OFFSET INPUT 10V MAX of the 11793A is connected to the 8902A FREQ OFFSET TTL OUT. The power cord from the wall is connected to the 11793A Line Power in connector. There is an identical connector

on the back of the 11793A that says LINE OUTPUT TO 8902A. **Do not** apply line power to this connector. This connector is an output used to supply line power to the 8902A.

(2) Front

(a) The L.O. is connected by its female N-type RF OUT connector to the 11793A's LO INPUT on the lower left (when looking at the front) side of the microwave converter. The INPUT 50Ω connector on the right side of the 8902A will be connected to the IF OUTPUT connector on the top right of the microwave converter. The 11792A Power Sensor Module will be connected to the 8902A's SENSOR connector and the 11793A's RF INPUT.

h. <u>Entering Calibration Factors</u>

(1) To make an RF measurement one must enter the Calibration Factors from the Power Sensor Module into the 8902's non-volatile calibration factor tables. The 8902A has two internal non-volatile calibration factor tables.

(2) Table #1 (primary table) holds up to 16 pairs of calibration factors plus the Reference Calibration Factor Table #2(frequency offset): 22 pairs plus the Reference Calibration Factor.

(3) Perform the following to enter calibration factors:

(a) 37.9 SPCL (clears all calibration factor storage tables)
(b) RF POWER (Error 15 displayed indicating no calibration Factors are stored)
(c) 37.3 SPCL
(d) Enter the reference calibration factor value.
(e) BLUE MHz (The reference calibration factor is now set)
(f) 37.3 SPCL.
(g) Enter Frequency of first calibration factor in MHz.
(h) MHZ key.
(i) Enter value of calibration factor.

(j) BLUE MHZ (first pair is now stored.
(k) Repeat this sequence for every calibration factor up to 1300 MHz on the label of the power sensor module (The primary table does not have space to hold the 22 cal factor pairs on the 11792A label).
(l) 27.3 SPCL (this enables the Frequency Offset mode and opens the second table for calibration factors).
(m) RF POWER (Error 15 displayed).
(n) 37.3 SPCL.
(o) Enter reference calibration factor value.
(p) BLUE MHz (The reference calibration factor is now set).
(q) 37.3 SPCL.
(r) Enter Frequency of calibration factor in MHz key.
(s) MHz key.
(t) Enter value of calibration factor.
(u) BLUE MHz.

(4) Repeat the previous step for each following Frequency and related calibration factor shown on the sensor head.

i. <u>Verification of the calibration factor tables</u>

(1) Perform the following to verify calibration factors:

(a) BLUE AUTOMATIC OPERATION (presets instrument).
(b) RF POWER (If Error 15 appears cal factors will have to be re-entered).
(c) 37.5 SPCL (starts table from beginning).
(d) BLUE MHz (displays reference calibration factor).
(e) 37.6 SPCL (to go to the next calibration factor).
(f) BLUE ?kHz (to display next frequency).
(g) BLUE MHz (to display related calibration factor).

(2) Repeat the previous step to view all entered frequencies.

(3) To correct any calibration factor % error, perform the calibration factor entry instructions only for the frequency and calibration factor in error. If a frequency is entered incorrectly, perform calibration factor entry instructions and enter the frequency in error with a calibration factor of zero (0). This will erase the frequency from the table.

j. Zeroing and Calibrating Power Sensor Module

(1) The power sensor needs to be re-calibrated when environmental conditions change or every 8 hours. To zero and calibrate the sensor module perform the following:

(a) Connect the sensor to the RF POWER CALIBRATION connector on the 8902A.
(b) Press ZERO (after a few seconds 0.00W is displayed).
(c) Press CALIBRATE (this turns on the reference oscillator).
(d) Press the BLUE key then CALIBRATE (1.000 mW is displayed).
(e) Press CALIBRATE (this turns off the ref. oscillator).

k. Tuning the 8902A to a test frequency

(1) Preset the 8902A.

(2) If the signal is <1300 MHz the 8902A will automatically tune to the frequency with the largest amplitude. To lock on to a frequency enter the frequency and then press MHz.

(3) If the signal to be measured is >1300 MHz, an IF frequency must be supplied to the 8902A.

(4) It is recommended to set the LO to a frequency that is 120.53 MHz higher than the input signal. 120.53 is the ideal IF frequency for measurement accuracy.

(5) For example, if the input signal to be measured is 3000 MHz, set the LO to 3120.53 MHz.

(6) If the external LO cannot be set 120.53 MHz higher than the input signal due to a minimum LO frequency range of 2000 MHz, add one of the following frequencies to the test frequency for optimum performance: 240.53, 480.53, 600.53, or 680.53 MHz. Choose the lowest frequency from this list for optimum performance. Any IF frequency between 10 MHz and 700 MHz can be used.

(7) The 11793A requires the LO to be set for a +8 dBm level. Turn the LO RF on.

(8) On the 8902A, press 27.3 SPCL to enable the frequency offset mode.

(9) Enter the frequency as it appears on the LO.

(10) MHz key (the test frequency should appear on the 8902A).

l. Making Low-Level RF Power Measurements

(1) Make sure that calibration factors have been entered and the sensor module has been zeroed and calibrated. Turn OFF all modulation (Low-level power measurements can only be done with an unmodulated CW signal).

(2) Set the TI to the desired test frequency and set the amplitude to at least -5dBm.

(3) Tune the 8902A to the test frequency as listed above.

(4) Perform the following to make low-level RF power measurements:

(a) Press GOLD.
(b) TUNED RF LEVEL.
(c) (Press BLUE ?kHz to view the TIs frequency at any time).
(d) LOG/LIN (to display either dBm or watts).
(e) 1.9 SPCL (to improve mismatch uncertainty by insuring that 10 dB of attenuation is always inserted).
(f) 39.9 SPCL (this clears cal factors for the 3

tuned RF ranges)

(5) The display should show a power reading, the RECAL and UNCAL annunciators should be lit. If the UNCAL comes on but not the RECAL increase the test instrument's (TI's) amplitude until RECAL appears. The UNCAL annunciator light indicates that the current tuned RF level absolute power measurement is uncalibrated. The RECAL light prompts the user to calibrate.

(6) Press the CALIBRATE key. DO NOT continue until a reading is displayed and the RECAL light is off.

(7) Reduce the TI's signal level in 10 dB steps. Each time wait for a reading. If the RECAL and UNCAL annunciators light press CALIBRATE. Keep reducing the signal until you reach about -100 dBm. There are 3 ranges so the RECAL light should come on about 3 times.

(8) You can now take a calibrated measurement at that frequency between 0 dBm and -100 dBm.

**J. SUMMARY:** The Basic Setup and Operation of the 8902A Signal Generator Calibrator have been covered. The technician should now be able to perform the initial setup and make tuned RF and frequency measurements with the 8902A.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (II)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (II)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To provide training on the use of frequency counter calibrator model 9390-6000 ExacTime GPS time code and frequency generator.

**G. INSTRUCTIONAL AIDS:** 9390-6000 publication and gear, oscilloscope

**H. REFERENCES:** 9390-6000 Users guide revision B

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY:

   a. The GPS timing unit operates on the civilian L-band (1575.42 MHZ) utilizing C/A (Course Acquisition) code transmissions to monitor time and frequency data from the NAVstar Satellite constellation. Time and frequency is determined from satellite transmissions and calculations referenced to USNO (United States Naval Observatory) through the GPS Master Clock System. This linkage provides traceability to USNO and all international time scales through the use of publications from the National Institute of Standards and Technology, USNO and BIPM in Servres. France.

   b. The unit automatically acquires and tracks satellites based on health status and elevation angle. Time and Frequency monitoring requires only 1 satellite, once accurate position data has been acquired or entered. In auto mode, the 4-SV requires 4 satellites for the GPS timing unit to do 3D position fixes. In the 3-SV

mode, only 3 satellites are required to do 2D position fixes.

c. The basic GPS timing unit includes the GPS main module, and antenna/pre-amp and a coaxial cable for interconnection. A corrected 1pps output signal and a 10 MHz sine wave are provided in the basic GPS timing unit configuration. An RS-232 I/O port is also provided in the basic configuration, which can be used to control the unit as well as to get data from the unit. The basic unit has an LCD display and keyboard. It generates IRIG B serial time code and has the capability of measuring time interval difference between the GPS 1pps and externally input 1pps. Optional features such as additional output codes and/or frequencies, RS-232 printer port, and external frequency input or signal or triple event log are available to meet specific requirements.

d. GPS SUBSYSTEM:

(1) **Time accuracy** - better than 100ns relative to UTC with 6 or more satellite averaging with 95% confidence.

(2) **Position accuracy** - less than a 100 feet latitude, 100 feet longitude, and 250 feet altitude with current SA. Accuracy improved to better than 30 feet after 24 hr of automatic position averaging in static position.

(3) **Maximum velocity** - 400 meters/second.

(4) **Tracking Channels** - 6 parallel.

(5) **Receiver frequency** - L1 1.575GHZ, C/A code.

(6) **Acquisition time** - Time to first fix is less than 2 minutes with outputs operational less than 5 minutes with time and accuracy better than 2 microseconds and frequency accuracy better than 1 E-8. Full system accuracy (100ns) provided within one hour.

(7) **GPS Solution Modes** - The user may select one of three modes for position solutions.

(8) **The 3-SV mode,** which is two-dimensional (latitude and longitude).

(9) **The AUTO mode**, which is three-dimensional (latitude, longitude, and altitude).

(10) **The 4-SV** mode, which is three-dimensional) latitude, longitude, and altitude). The AUTO mode, used when the unit is initially turned on, uses the three-dimensional solution. A fourth mode is also available for single satellite tracking, which does no position solutions and is used for time-keeping and frequency measurements.

3. DEMONSTRATION:

a. Student receives demonstration of the modes of operation and method to change between these modes.

b. Student receives demonstration of the frequency outputs utilizing an oscilloscope to view the signals.

4. PRACTICAL APPLICATION:

a. Student demonstrates of the modes of operation and method to change between these modes.

b. Student Demonstrates use of the frequency outputs utilizing an oscilloscope to view the signals.

**J. SUMMARY:** The model 9390-6000 ExacTime GPS Time Code and Frequency Generator operates on the civilian L-band (1575.42) utilizing C/A code transmissions to monitor time and frequency data from the Navstar satellite constellation. Time and Frequency is determined from satellite transmissions and calculations referenced to USNO through the GPS Master Clock System. The unit automatically acquires and tracks satellites based on health status and elevation angle. Time and freq monitoring requires only one satellite, once accurate position data has been acquired or entered.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (JJ)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (JJ)

**B. TIME:** 30 Minutes

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** **Precision Measuring Equipment**

**F. OBJECTIVES:** To instruct the technician on correct procedures of the operation and use of the 3712 Portable Pressure Gage Calibrator.

**G. INSTRUCTIONAL AIDS:** 3712 with Master Gages

**H. REFERENCES:** 3712 Instruction Manual

**I. PRESENTATION:**

1. INTRODUCTION: The King Nutronics Model 3712 is a portable, self-contained pressure gage calibrator that calibrates pneumatic pressure gages by comparison to reference master gages. The pressure is manually generated through the use of a hand pump. Hydraulic oil is used as the pressure medium. Test gages, which are filled with oil, can be installed directly onto the calibrator. For applications where the test gage contains a different type of fluid, such as water, a fluid separator is installed to act as a physical barrier between the two fluids.

2. BODY:

   a. Hand Pump Case Assembly:

      (1) Arrange the components of the hand pump case assembly on a stable, level surface so they are easily accessible. Set up the hand pump case assembly for operation in accordance with the following procedures.

      (2) Unlatch the eight latches and remove case lid. Remove the reservoir fill port plug. Place the

hand pump case assembly in a vertical position with the fill port up. Fill the pump reservoir with hydraulic oil, (MIL-H-5606). After filling the reservoir, install and tighten the plug. Remove the dust plugs from quick-disconnect couplings on pump manifold assembly. Fill and bleed the pump manifold assembly as follows:

(a) Install any two-test gage adapters in the pump manifold quick-disconnect couplings.
(b) Set the range selector to high-volume, low-pressure position (pulled out).
(c) Operate the hand pump until oil flows out of the adapters.
(d) Remove the test gage adapters.
(e) Select and install the appropriate master gage in one of the pump manifold quick-disconnect couplings.
(f) Exercise the master gage IAW Section 2.A.1-8.
(g) Fill the test gage with appropriate fluid (water or hydraulic oil) in accordance with guidelines above.

(3) The full-scale value of the master gage must be equal to or greater than the full-scale value of the test gage. Use of a master gage with a full-scale value less than that of the test gage could result in over-pressurization, which could cause a calibration shift or permanent damage to the master gage.

(4) If a water system gage is to be calibrated, install the fluid separator and open vent valve. Remove the fill plug from gage end of separator. Using WATER liquid charger filled with distilled water, force the diaphragm, inside the separator to the pump end by filling gage end with distilled water. Keep the spout of liquid charger firmly pressed in port to prevent spillage. After filling, install and tighten the fill plug.

(5) If a panel mounted gage is to be calibrated, install the appropriate test gage adapter on test gage inlet port and connect the fluid separator, if required, to test gage adapter. Connect the high-pressure test hose assembly to manifold quick-disconnect coupling and bleed the air by

pumping hydraulic oil through the hose. Connect the test hose to fluid separator or the test gage adapter, as appropriate.

(6) Install the test gage in the pump manifold quick-disconnect coupling or the fluid separator, as appropriate. Operate the hand pump assembly as described above.

(7) Note: The selected master gage must be exercised prior to connecting test gage to manifold.

b. Master Gage Exercising:

(1) Exercise the master gage in accordance with the following:

(a) Set the pointer of master gage to zero.
(b) Screw and vent the plug two turns to vent the pump.
(c) Set the selector valve to high-volume, low-pressure position (pulled out).
(d) Close the vent valve by rotating handle fully clockwise.
(e) Turn the displacement valve handle to position valve midway between extremes of travel.
(f) Operate the pump handle until pressure indicate on master gage is 1000 pound-per-square-inch. Then push in the selector valve to the low-volume, high-pressure position.
(g) Operate the pump until pointer is just below the full-scale pressure point.
(h) Rotate the vent valve fully counter clockwise, allowing master gage to vent to 0 psig.
(i) Repeat steps 1 through 8 two more times for a total of three exercise cycles.

c. Test Gage Calibration:

(1) To perform gage calibration tests, operate the hand pump assembly as follows:

(a) Perform the pre-operating procedures described in 3.5.2. of the operators manual.
(b) Set the master gage needle to zero.

(c) Unscrew the fill and vent plugs two turns to vent the pump.
(d) Set the selector valve to high-volume, low-pressure position (pulled out).
(e) Close the vent valve by rotating handle fully clockwise.
(f) Turn the displacement valve handle to position the valve midway between extremes of travel.
(g) Operate the pump handle until the pressure indicated on master gage is 1,000 PSI. Then push in the selector valve to low-volume, high-pressure position.
(h) Operate the hand pump until pointer on test gage is just below the first calibration point.

**Note:** If the gage dial pointer goes beyond the calibration point, slowly rotate the vent vale handle counterclockwise until the pointer is significantly below the calibration point, then rotate the vent valve handle fully clockwise and reapply hand pump pressure.

(i) Slowly rotate the displacement valve clockwise until the pointer on the test gage is exactly on first calibration point.
(j) Lightly tap the test gage and readjust displacement valve, if required.
(k) Record the master gage pressure indication and fluid head correction factor, if applicable.
(l) Repeat steps 1 through 11 for all increasing pressure calibration points, including the full-scale point.
(m) For decreasing pressure calibration, slowly rotate the vent valve handle counterclockwise until the test gage pointer is slightly above the calibration point. Then rotate the vent valve handle fully clockwise.
(n) Slowly rotate the displacement valve counterclockwise until the pointer on test gage is directly on the calibration point. Lightly tap the test gage and readjust the displacement valve, if required.
(o) Record the master gage pressure indication and fluid head correction factor, if applicable.

(p) Repeat steps 13, 14 and 15 for all remaining down scale calibration points.
(q) Perform the post-operating procedures described below

d. Post operating procedures:

(1) After completion of the calibration, perform the following post-operating procedures:

(a) After the last calibration point has been verified, rotate the vent valve handle fully counterclockwise. Verify that the master gage indicates 0 psig.
(b) Remove the master gage from the pump manifold assembly quick-disconnect coupling, install the dust cover, and place in the master gage case assembly.
(c) Remove the test gage from the pump manifold assembly quick-disconnect coupling or fluid separator, as applicable.
(d) Drain all water or hydraulic system gages in accordance with 3.4.3.1.H in the manufacturer publication.
(e) Flush and dry the pneumatic system gages in accordance with 3.4.3.2 in the manufacturer publication.
(f) Install the dust covers on the pump manifold assembly quick-disconnect couplings.
(g) If used, clean the fluid separator and store in the accessory case assembly.
(h) Tighten the fill and drain plug.
(i) Install the lid and latch it in place.

## J. SUMMARY

## K. QUESTIONS?

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (LL)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (LL)

**B. TIME:** 30 Minutes

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To teach the technician the principles of operation and proper use of a pulse generator.

**G. INSTRUCTIONAL AIDS:** 33120A

**H. REFERENCES:** HP 33120A Users Guide

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY:

   a. The HP 33120A is a high performance, 15 MHz, synthesized function generator with built-in arbitrary waveform capability. Its combination of bench-top and system features makes this function generator a versatile solution for testing requirements during calibration.

   b. The 33120A has many convenient features; it comes with 10 standard waveforms readily accessible by the mean, built-in 12-bit 40 Ms/s arbitrary waveform capabilities, and an easy-to-use knob input.

   c. Specifications for the 33120A can be found in Chapter 8 of the HP 33120A manufactures manual. Specifications that allow the 33120A to stand out are as follows:

      (1) Waveforms such as sine, square, triangle, ramp, noise, dc volts, sine x/x, negative ramp, exponential rise, exponential fall, and cardiac.

(2) Frequency range of 100 MHz to 15 MHz with a 10 MHz resolution with an accuracy of 10 parts-per-million in 90 days and 20 ppm in a year.

(3) Output characteristics such as amplitude of 50 mvpp-10 vpp with a 50ohm termination are available.

**J. SUMMARY:** The 33120A is a reliable calibration standard that is easy-to-use and has versatile specifications. Technicians should become familiar with this calibration standard.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (SS)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (SS)

**B. TIME:** 60 Minutes

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To instruct technicians on the correct procedures during operation and use of power meters/sensors.

**G. INSTRUCTIONAL AIDS:** 436A or 438A, any 8480 series sensor, and the 83630A.

**H. REFERENCES:** 436A, 438A, and 8480 series sensor manuals

**I. PRESENTATION:**

1. INTRODUCTION: Power meters and sensors play a vital role in calibration. The power meter and sensor are versatile calibration standards due to their ability to offer high accuracy and high resolution through the switching of power sensors for different power ranges. In fact a technician has the ability to monitor power from a signal sources' output on the front panel or, if necessary, in circuit tracing power through a TI with the help of adapters. This instrument can also be an effective tool for troubleshooting.

2. BODY:

   a. The power meter has a frequency range of 100kHz to 33GHz and a power range of –70dBm to +44dBm. This range span is achieved through changing out the sensors fir a particular frequency range and power range. This allows for greater resolution and accuracy. The power meter can compensate for the different frequencies through the use of a calibration factor table located on each sensor.

These cal factors can be anywhere along a percentage scale, but generally are between 80 and 100 percent.

b. Prior to using a power sensor, verify the sensors' frequency and power ranges. First, zero and calibrate the sensor to the meter allowing each to compensate for the others electrical components, as well as the power sensor cable. This is accomplished by attaching the sensor to the meter input via a power sensor cable, and then attaching the sensor to the "N" type output on the front panel. Adjust the calibration factor selector to the value designated by the sensor and then depress the zero button and wait for the display to zero out. After this is accomplished, depress the calibration reference button and wait for a stable indication. Proceed to adjust the calibration adjust screw for a 1mw display on the front panel meter display. Once this is accomplished, disconnect the power sensor from the "N" type output. The power meter is now ready to measure power.

c. It is very important that the correct calibration factor is selected and all external power sources are set to their minimum power settings. Power levels below –20dBm will ensure sensors are not damaged. So always set the signal source to minimum or RF off and then double check the power sensor to make sure it is capable of handling the power level for the next setting in the ICP. Taking this extra step before each new power level reading will prevent over-powering the sensors.

d. Unless a technician has a 100 percent air dielectric set-up he or she will not be able to measure power above 18GHz. Various Test Instruments have output frequency ranges above 18 GHz, but without air dielectric connectors a technician cannot measure above 18GHz.

**J. SUMMARY:** A power meter, used in conjunction with different power sensors, gives laboratories the ability to make power measurements with high accuracy and increased resolution. It is imperative to have a

general knowledge of the intended measurement theory and use of power meters/sensors because of their extreme sensitivity to power and to avoid damage to the power meter.

## K. QUESTIONS?

# AVIATION MAINTENANCE TRAINING

## LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (TT)

## Precision Measuring Equipment

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**A. LECTURE NUMBER:** MOS 6492 B.1 (TT)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 04

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To instruct the technician in making more accurate peak power measurements and on the correct procedures for the operation and use of the 8991.

**G. INSTRUCTIONAL AIDS:** 8991A

**H. REFERENCE:** HP 8991 QUICK START GUIDE & OPERATING MANUAL

**I. PRESENTATION:**

1. INTRODUCTION:

2. BODY:

   a. Although there are various models of peak power analyzers, most calibration activities have 8991As. This model will be used as an example throughout this lesson. One might ask, “What is peak power, and what is a peak power analyzer?” Peak power is defined as follows: Output power averaged over a cycle of an electromagnetic wave having the maximum peak value that can occur during transmission. At RF and microwave frequencies, the parameters of voltage and current become difficult to measure. Power measurements are the fundamental parameter for characterizing components and signals at RF or microwave frequencies. A peak power analyzer is an electronic measuring device that provides complete and accurate characterization of complex pulsed signals. The 8991A provides complete pulse characterization ranging from 50 MHZ to 40 GHZ, depending upon which sensor is utilized.

b. As with any measurement, there are errors involved, But there are certain things a technician must understand in order to make accurate measurements, such as:

   (1) Understanding the characteristics of the signal under test and how the signal interacts with the power sensing process.

   (2) Understanding power measurement uncertainties and traceability to a primary power standard at a national laboratory such as NIST.

   (3) Understanding characteristics and performance of available sensor technologies and operating features of various power meters.

   (4) Making the performance comparison and selecting the right product for the application.

c. Pulse parameters are: peak power, average peak power, rise-time, fall-time, frequency (pulse repetition rate), pulse period (pulse repetition interval), pulse width, pulse off-time, duty cycle, delay, statistically defined pulse top and bottom, overshoot, and average power. The 8991A can measure and display these parameters with no calculations required from the technician. For the most accurate results when using the 8991A, measurements should be made at the fastest possible sweep time. Below are tips for making more accurate measurements:

   (1) At least one complete cycle must be displayed for PRI (Pulse Repetition) or PRF (Pulse Repetition Frequency) measurements.

   (2) The rising edge followed by the negative edge must be displayed for pulse width measurements.

   (3) The falling edge followed by the rising edge must be displayed for off-time measurements.

   (4) The leading edge of the waveform and enough of the pulse to define the top and the base must be displayed for rise-time and all other edge measurements.

(5) The trailing edge of the waveform must be displayed for fall-time measurements and all other edge measurements.

(6) The top, base, and peak of waveform must be displayed for overshoot measurements.

(7) If more than one waveform, edge, or pulse is displayed, the measurements are made on the first (leftmost) portion of the displayed waveform that can be used. If there are not enough data points, the analyzer will display $\leq$ with the measurement results. This annotates that the results may not be as accurate as possible. It is recommended that the technician re-scales the displayed waveform and performs the measurement again.

(8) When any of the standard measurements are requested, the Peak Power Analyzer first determines the top amplitude level. From this information, it can determine the other important amplitude threshold values (lower, upper, and mid) needed to perform the measurements. For example, the 10% threshold value is found by measuring 10 DB down from the top of the pulse. The 10%, 50%, and 90% amplitude values are used in the rise-time and fall-time measurements as well as all other edge measurements.

(9) Automatic Top-Base: top is the heart of most automatic measurements. It is used to determine Vtop and Vbase. The top or base of the waveform is not necessarily the maximum or minimum linear amplitude present on the waveform. Consider a pulse that has a slight overshoot. It would be incorrect to select the highest point of the waveform as the top since the waveform normally rests below the perturbation.

**J. SUMMARY:** Peak Power Meters are extremely versatile and accurate measurement devices. It is important to fully understand what type of signal is being measured as well as how to most accurately perform the measurement with a given power meter. Refer to the manufacture’s manual for additional guidance.

**K. QUESTIONS?**

# AVIATION MAINTENANCE TRAINING

**LESSON GUIDE NUMBER: Aviation MOS 6492 B.1 (XX)**

**Precision Measuring Equipment**

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**A. LECTURE NUMBER:** MOS 6492 B.1 (XX)

**B. TIME:** 1 Hour

**C. DATE PREPARED:** 14 September 2004

**D. DATE REVIEWED:** On separate sheet

**E. TITLE:** Precision Measuring Equipment

**F. OBJECTIVES:** To instruct the technician on the correct procedures for the operation and use of the 680 Calibration System.

**G. INSTRUCTIONAL AIDS:** 680 Calibration System

**H. REFERENCES:**

1. 680 Manufactures manual
2. NAVAIR 17-50A346
3. NAVAIR 17-50A347
4. NAVAIR 17-50A348
5. NAVAIR 17-50A349
6. NAVAIR 17-50A350
7. NAVAIR 17-50A351

**I. PRESENTATION:**

1. INTRODUCTION:

   a. The UDWIN Transducer Calibration System provides an integral collection of components necessary to provide a quick and accurate calibration of accelerometers and velocity transducers over a wide range of frequency and vibration amplitudes. The UDVWIN/C Calibration Systems contain the following components:

      (1) UD model 8B6 Laboratory Standard Accelerometer.
      (2) UD model 8B6 Working Standard Accelerometer.
      (3) UD model TSC-3 Calibration Signal Conditioner.
      (4) UD model VGN-4 (or VGN-8) Variable Gain Amplifier Card.

(5) UD model DSP-4 (or VGN-8) Digital Signal Processor Card.
(6) Host computer with Windows 98, NT Ver4, or Windows 2000.
(7) Operating Systems (The VGN-4 and DSP-4 are mounted in the host computer).
(8) Power Amplifier.
(9) Vibration Exciter with Accelerometer Bridge and Ceramic Insert for Base-to-Base mounting of Working Standard Accelerometer and the Device Under Test (DUT).

b. For the UD model 660 System, the UD model TA30 Power Amplifier and model 5PM Shaker is supplied. The model 680 System provides the model TA100CL Power Amplifier and model S032-C Shaker. The model S032 Shaker moving element is designed to provide a recess for integral mounting of the ceramic insert and the Working Standard Accelerometer. Both shaker systems are completely air-cooled.

c. Existing UD transducer calibration systems prior to the model 660 or 680 may be upgraded by adding the control components listed above. Minor changes to power amplifier control circuits may be needed to be compatible with the model UDVWIN/C system.

d. A customer’s general vibration test system may also be used for calibration purposes by adding the control components listed above together with the Accelerometer Bridge and ceramic insert. However, the frequency and amplitude testing range may be limited by the specifications for the test system.

2. BODY:

a. For specifications, refer to the manufactures publication or ICP.

b. The information contained herein discusses the use of the Keithley 2000 multimeter, which is a part of the 680 Vibration Calibration System. Some accelerometers and velocity transducers require a resistance check before calibration. The Keithley 2000 will always be used.

(1) To turn on the 2000, press the POWER button in the lower left hand side of the digital multimeter. Next, press the OHMS2 key. Make sure that when connecting the test leads with the TI's pins, good contact is made without touching any other surface of the TI, inside or out. Grounding the signal to the system's casing could produce inaccurate calibration results. Connect only to a pin and casing when designated by the calibration procedure. If either of the resistance tests fails, the TI must be rejected. When finished, press the POWER button once again to turn off the Keithley and disconnect the test leads.

(2) Disregard the statement above for TIs that do not require a resistance check.

c. The vibration system parameters are entered or edited by using the keyboard and mouse. Normal test setups will include the type of transducer; sensitivity, frequency response, and the vibration test level as a function of frequency, sweep direction, and sweep time.

**NOTE:** *Before starting the system, ensure single-phase power and three-phase power to the power cabinet is turned on and the power switch on the front of the amplifier is turned on. (These two switches are located in the front on the 680 beneath the oscilloscopes and left of the vent).*

(1) Turn the Amp Gain rotary pot to full CCW, position (reset); you will feel a click that confirms the required reset position. (If you do not turn it to reset, when you try to start another TI and press the OPERATE button, nothing will happen, no signal will start, and the OPERATE key will not light up).

(2) Press the ON key on the power cabinet and wait approximately 30 seconds for the STANDBY key to light. (The STAND BY key usually takes about 5 seconds to light and the system is ready).

(3) Press the BLOWER key and ensure it is toggled to the in position and the key lights up. This

selects the blower mode of operation allowing maximum shaker output. (The BLOWER key should never be set to off or unlighted for use at MCCs).

(4) Press ROCKER switch on the 120-volt power strip on the necessary cabinet to power on the TSC-3 signal conditioner and VWIN Controller. (The ROCKER switch should never be turned off, always leave in the ready position).

(5) Turn the computer on and the VWIN software will load and display the VWIN CONTROLLER HOME window. If the VWIN software did not automatically execute, find the VWIN HOME icon on the desktop of the computer and double-click on the icon.

(6) Set the controls of both the oscilloscopes as follows:

| OCSILLOSCOPE CONTROL | SETTING |
|---|---|
| POWER button | ON |
| Volts/Div knob | 0.5 |
| Time/Div knob | 10ms |
| Trigger Mode knob | x-y |
| TRIGGER SOURCE Button | EXT (pushed in) |
| AC Button | OUT |
| GND Button | OUT |
| Trigger Level | Centered |
| Vertical Var. knob | Clockwise Max |
| Vertical Position knob | Adjust Necessary |
| Horizontal Position knob | Adjust as Necessary |
| SWP. VAR. knob | Clockwise Max |

(7) (The oscilloscope settings should never be changed after setting them the first time; so don’t touch or move them, just check to see if they are in the correct positions, as they should be already.

d. In order to mount the TI, you will need to determine the correct mounting adapter needed to mount the TI to the shaker table. Refer to the Test Specification Sheet. You will be able to find out what cables and screws, along with the amount of torque the is required to safely secure the TI on the Test Specification Sheets. If the correct mounting

adapter is installed then leave as is. If the correct adapter is not installed then replace it with the correct mounting adapter:

(1) Remove the socket head cap screws from the installed mounting adapter and lift the mounting adapter and working standard accelerometer out of the shaker.

(2) Disconnect the microdot cable from the working standard accelerometer; remove the working standard accelerometer and mounting stud from the bottom of the mounting adapter.

(3) Install the mounting stud on the bottom of the replacement-mounting adapter.

(4) Apply petrolatum to both of the mounting surfaces of the working standard accelerometer and the mounting adapter.

(5) Screw the working standard accelerometer into the bottom of the replacement-mounting adapter. Torque the working standard to 18in-lb.

(6) Connect the microdot cable from the working standard accelerometer to the REFERENCE CHARGE INPUT connector on the TSC-3 signal conditioner.

(7) Install the working standard accelerometer, microdot cable, and mounting adapter assembly in the shaker armature. Route the microdot cable through the indentation with the same bend as it had before. This will keep the cable in better condition and lesson the chances of the bending back and forth to wear and break it down. Torque the mounting adapter screws to 9in-lb.

(8) Taping the cable to the shaker to minimize cable movement during calibration is the minimum that you can do. You can also use a foam pad and place it underneath the cable to even further nullify movement. Also, the threaded holes on the shaker are a perfect match with the temperature stands. Use a rod from the temperature stand and screw it into the hole on the front of the shaker. Then, use the clamp that is made for the thermometers

and place it on the rod. This clamp can be tightened to hold the cable in the air so that it never touches the shaker. The foam may still be used to aid in minimizing any further cable movement.

**NOTE:** *The ECU of the van in which calibration is being performed, can also be turned off during calibration to reduce the vibration that it makes and once again further minimize external vibrations. Be sure to turn the ECU back on after calibration and in between TI's so the van will not go out of tolerance. Also, take precautions to not let anyone in or out of the van when calibrating so that pounding of the feet does not shake the TI.*

(9) Be sure to leave sufficient slack in the microdot cable to allow for the ¾ inch travel of the shaker table and accelerometer.

(10) If the mounting adapter was removed or replace in any way be sure to perform a Transfer Standard Test in accordance with Appendix A of the manufacture's manual.

(11) Apply petroleum to both the mounting surfaces of the TI and the mounting adapter to improve the coupling and the preserve the mounting integrity. (Errors may occur from improper coupling if the petroleum is not applied prior to every test).

(12) Mount the TI to the shaker adapter using the appropriate mounting hardware for the TI; refer to the Test Specification Sheet of the TI. Use the torque wrench to torque the transducer down to the proper torque; refer to the Test Spec. Sheet of the TI.

(13) Ensure that the CURR (Constant Current Power Source) button on the TSC-3 signal conditioner is in the out, or off position. There are only a select few TIs that will ever need the CURR on. Pay close attention to ensuring this switch in the correct position, or the TI and/or 680 Calibration System may be damaged.

(14) From this point on, the procedure will dictate the required procedures depending on the type of TI you are using.

**WARNING**

**When placing any TI on the mounting surface or removing and replacing an adapter or TI, follow required procedures. Do not attempt to perform calibrations without the correct torque amounts, screws, cables, etc. Damage to the plate, ceramic insert, cables, or TI may occur from failure to properly follow spec. sheets. Requirements for proper operation of system are located on the Test Spec. Sheets.**

**J. SUMMARY:** The 680 Calibration System is a highly accurate vibration system that can measure frequency from 2-10000Hz, at 0.1 to 5000pc/g or mv/g and 0.2 to 5000mv-s/in. It is very sensitive to placement of adapter, tightness of screws, and movement outside of the system. Take precautions to limit all outside interference and damages. Follow the calibration procedure.

## K. QUESTIONS?

1. Where do you look to find what cables are needed, along with mounting adapter, screw, and how many?
   a. Answer: Test Specification Sheet.

2. What would be a reason that the OPERATE key when pushed would not light up?
   a. Answer: Failing to turn the Amp Gain rotary pot to full CCW.