UNITED STATES MARINE CORPS
Logistics Operations School
Marine Corps Combat Service Support Schools
Training Command
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AIM 5201

STUDENT OUTLINE

PRECISION MEASURING TOOLS

LEARNING OBJECTIVE

1. TERMINAL LEARNING OBJECTIVE: Given appropriate precision measuring tools, various automotive components and a student handout entitled "Precision Measuring Tools", per information contained in the reference, use the precision measuring tools in conjunction with automotive component repair. (5.1.1)

2. ENABLING LEARNING OBJECTIVES: Given appropriate precision measuring tools, various automotive components and a student handout entitled "Precision Measuring Tools", per information contained in the reference:

a. measure with a micrometer, (5.1.1a)

b. measure with a caliper, (5.1.1b)

c. measure with a telescoping gauge, (5.1.1c)

d. measure with a dial indicator, (5.1.1d)

e. measure with a depth gauge, and (5.1.1e)

f. torque bolts to specifications with a torque wrench. (5.1.1f)

OUTLINE

1. MICROMETERS

a. Types and Purpose. Micrometer caliper is the correct name for what we commonly call a micrometer or a "mike." Micrometers are made in various shapes and sizes, depending upon the purpose for which they are to be used. Some micrometers are graduated to measure in thousandths of an inch and others will measure as close as ten thousandths of an inch. Others are metric and measure in hundredths of a millimeter. There are two basic types of micrometers, with two distinct jobs. One is the outside micrometer, used to measure outside dimensions and the other is the inside micrometer, used to measure inside dimensions. Let's first take a look at the outside micrometer.

(1) Outside micrometers. Outside micrometers are widely used in the automotive field to measure such components as crankshaft journals, piston pins, and valve stems to determine if they are within serviceability specifications.

(a) The first thing I want to do is identify some of the micrometer parts so when they are mentioned later on you will understand what part I am talking about. The parts you should be able to identify are the frame, anvil, spindle, barrel, thimble, ratchet, and clamp ring.

(b) Most outside micrometers have a chrome plated or enameled steel frame to resist corrosion or tarnish, a ratchet for applying a constant measuring pressure, a special vernier scale for reading ten thousandths of an inch, a clamp ring or locknut for clamping the spindle to hold a setting, and cemented carbide tips on the measuring anvils to reduce wear.

(c) The shape of the frame may be varied to adapt to different types of work. The type we will use most often is the U-shape.

(d) The spindle and anvil may vary to accommodate special physical requirements. For example, a ball shaped anvil is used in measuring the thickness of a pipe section or a friction bearing.

(e) The part called the thimble is rigidly attached to the spindle. Turning the thimble clockwise screws the spindle towards the anvil to tighten the micrometer and turning the thimble counterclockwise moves the spindle away from the anvil to loosen it.

(f) Some micrometers have a ratchet on top of the thimble cap that will slip when the correct measuring pressure is reached. The purpose of this ratchet is to reduce the possibility of error by eliminating any difference in personal touch due to a difference in measuring pressure. It also prevents damage to the micrometer by preventing overtightening of the spindle.

(g) Some micrometers are also equipped with a clamp ring or locknut located where the spindle passes through the frame. This makes it possible to lock the spindle in position to preserve a setting.

(h) Most micrometers are sized as follows: zero to one inch, one to two inches, two to three inches, three to four inches, and so forth. The size indicates the minimum and maximum thickness of an object that a particular micrometer can measure. Therefore, the scale range is only one inch.

(i) Although not very common, there are zero to one-half inch micrometers for special applications. These have a scale range of one-half inch.

(j) A micrometer can be adjusted by the user to compensate for wear or misuse. It is adjusted by using a spanner wrench and gauge blocks or standards.

(2) Inside micrometers.

(a) A common inside micrometer is constructed to measure in increments of thousandths of an inch, with the smallest models having a range of one quarter inch and the largest with a one inch range. However, some inside micrometers will measure in increments of ten-thousandths of an inch.

(b) The measuring capability is extended by use of the various length extension rods.

(c) Some inside micrometers are equipped with a detachable handle that attaches to the micrometer to permit reaching into a deep bore or cavity to obtain a measurement.

(d) This is an example of an inside micrometer in use.

(e) This is an example of an outside micrometer in use.

b. <u>Procedures For Using a Micrometer</u>

(1) The piece to be measured is placed between the anvil and the spindle or the micrometer is held over and around the piece and the spindle screwed down until it touches the piece with the lightest of pressure. The spindle is screwed down only enough to take up the clearance and get an accurate reading. You should be able to slide the micrometer across the piece being measured to indicate that there is no clamping action.

(2) There are twenty-five equal spaces around the tapered edge of the thimble. Each space represents one thousandth of an inch. Turning the thimble one space changes the opening between the end of the spindle and the anvil by one thousandth of an inch.

(3) There are also graduations on the part called the barrel, with the graduations being marked by vertical lines. Through these lines is a line running lengthwise of the barrel called a reference or a datum line.

(a) The smallest division on the barrel graduations represents twenty-five thousandths of an inch, which is one complete turn of the thimble.

(b) Every fourth cross line is numbered and represents four complete turns of the thimble or four times twenty-five thousandths, which is one-hundred thousandths. The figures on the barrel, therefore, represent one-hundred thousandths of an inch. Figure 1 is one-hundred thousandths, figure 2 is two-hundred thousandths, and so on.

(4) The first step in reading the micrometer is to determine the size of the micrometer, since the first number of our reading depends on the size of the micrometer. For example, if the micrometer we are using is a 3 to 4 inch micrometer, the first number in our reading will be 3, because three inches is the smallest measurement we can get with a 3 to 4 inch micrometer.

(5) The next step in to read the highest figure visible on the barrel, which represents hundred thousandths.

(6) We then multiply the number of unmarked lines visible between the numbered line and the edge of the thimble by .025, as each of these lines represents twenty-five thousandths of an inch.

(7) We would then add the thimble reading, which is obtained by reading the number on the thimble that coincides with the reference or datum line on the barrel.

(8) To get a reading to within one ten-thousandth of an inch, we must have a vernier micrometer which has a vernier scale. The vernier scale divides the scale on the thimble by ten. The vernier scale is located on top of the barrel and is numbered from 0 to 10. To read the vernier scale, you locate the line on the thimble that lines up with the line on the vernier scale. For example, if it lines up with the 2nd line of the vernier scale, that equals two ten-thousandths of an inch. Add that to our previous reading to get a total reading to within ten-thousandths of an inch.

(9) The scale on an inside micrometer is read in the same manner as the one on an outside micrometer.

c. Care of Micrometers. To maintain a micrometer in good condition and preserve accuracy, a few simple rules should be followed:

(1) Always store the micrometer in a case or box to protect it, if one is available.

(2) Never store the micrometer with its anvil and spindle closed, as this may cause corrosion.

(3) Oil the micrometer in only one place. Use a light oil on the screw. If storing for a long period of time, cover the micrometer with a light film of oil and wrap it in an oiled paper.

(4) Never hold the micrometer by the thimble and twirl the frame around to open or close it; this may cause excessive wear on the screw.

(5) Always keep the micrometer clean and dry.

(6) The micrometer requires calibration by the calibration lab every six months.

2. **CALIPER**

a. Design, Purpose, and Construction

(1) The caliper is a very versatile measuring tool in that this one tool is designed to perform inside, outside, and depth measurements.

(2) There are three basic designs of calipers. Some have a vernier scale much like a micrometer, some have a scale and dial, and others are digital. Most calipers are graduated in one-thousandths of an inch if they are in U.S. measurements and two-hundredths of a millimeter if they are metric. Some are graduated in both U.S. and metric.

(3) The inside jaws are designed to measure the distance between inside surfaces. However, the depth that can be measured is restricted by the length of the jaws. For example, you can measure the diameter of a cylinder bore at the top of the cylinder, but you cannot measure the diameter of that bore at the middle or the bottom of the bore.

(4) The outside jaws are designed to measure distances over and around adjacent surfaces. For example, the diameter of a wrist pin or a crankshaft journal can be measured, using the outside jaws of a caliper.

(5) The caliper can also be used to measure depth. Such things as the depth of a bolt hole or the distance a seal sets below a surface can readily be measured with the caliper. (OFF SLIDE NO. 31)

b. <u>Advantage and Disadvantages of the Caliper</u>

(1) Advantages.

(a) One advantage that a caliper has over the micrometer is that calipers are available that will measure a large area; as much as ten feet or more.

(b) Another advantage that we've already discussed is the fact that three types of measurements can be made with the one tool.

(2) A disadvantage of the caliper is that it will measure only to thousandths vice ten-thousandths of an inch, as a vernier micrometer is capable of.

c. <u>Using the Calipers</u>. A caliper is used in much the same way as the micrometer. Usually the caliper is set by measuring the work and then comparing that reading with the desired measurement or the caliper is set to the desired measurement on the scale and then the work is checked to see if it is the correct size.

(1) Outside measurements are made by placing the work between the jaws of the caliper or placing the caliper jaws around the work and adjusting the caliper. To obtain a correct measurement, the caliper should be placed onthe axis of the work and the caliper adjusted just tight enough to make good contact and still be able to slide on the work. Do not overtighten, as this will give an incorrect reading and damage the caliper.

(2) Inside measurements are made by placing the inside jaws into the work and adjusting the caliper. Be sure to hold the caliper parallel to the work to obtain a correct reading.

(3) To measure the depth of a hole, extend the caliper depth gauge into the hole and seat the caliper beam against the lip of the hole. Be sure to hold the caliper perpendicular to the work to obtain a correct reading.

(4) As we mentioned earlier, there are three basic types of calipers, with three methods for reading the measurements.

(a) The U.S. vernier caliper is read by first reading the numbers on the stationary beam, which are graduated into inches, hundred-thousandths and twenty-five thousandths of an inch and then adding the number on the vernier scale, which is graduated into thousandths.

(b) The dial type caliper has inches and hundred-thousandths on the beam like the vernier type and the dial is graduated in thousandths. Simply add the beam reading and the dial reading.

(c) The digital type takes any guesswork out of measuring. Simply place the caliper on the work and look at the digital display for the correct reading.

(5) A sense of feel must be acquired to use calipers properly. This comes through practice.

d. Care of Calipers. The caliper is a precision tool and should be handled with care. Don't throw it around or pile things on it. A caliper should be kept clean and lightly lubricated on the threads, and when stored, a light coat of oil should be applied to keep it from rusting. The caliper requires calibration every six months, which is done by the calibration lab.

3. TELESCOPING GAUGES

a. Design, Purpose and Construction. Telescoping gauges (T-gauges) are used somewhat like inside micrometers. The telescoping gage has no scale graduations to obtain direct readings. Therefore, a micrometer or caliper must be used to measure the gauge itself. Then, by reading the mike or caliper, you will know the dimensions of the part you measured.

(1) Telescoping gauges can be used when measuring odd sizes and shapes of holes, such as slots. A lot of times a T-gauge will be used in smooth bores, such as in a cylinder bore or something of that nature, when you don't have any other tool to make an inside measurement.

(2) Telescoping gauges are made of metal and are "T" shaped. Each gauge consists of two plungers under spring pressure, fitting inside a rod which is attached to the head. The handle has a locking screw to lock the plungers in place at a desired measurement.

(3) A common set of gauges would contain six gauges with a measuring capacity of 5/16 inch to 6 inches.

(4) Here is an example of the telescoping gauge in use.

b. Using the Telescoping Gauge

(1) To use the telescoping gauge, loosen the lock screw, compress the plungers in the top of the "T" and lock them by turning the hand screw.

(2) Next, insert the gauge in the hole to be measured and release the plungers slowly to prevent damage to the work piece and gauge. The plungers will expand to the exact size of the hole.

(3) Make sure the gauge is straight, lock the plungers by turning the hand screw, tilt the gauge, and then carefully remove it.

(4) Now measure the gauge with an outside micrometer or caliper to obtain the correct dimension.

c. Care of the Telescoping Gauge

(1) Keep the gauge clean and lightly lubricated.

(2) Store the gauge in a dry area and do not throw other tools or items on top of it.

4. **DIAL INDICATORS**

a. Design, Purpose and Construction

(1) Dial indicators are one of the world's most widely used precision measuring tools. They are used extensively in layouts, inspection, and quality control operations.

(2) Dial indicators are designed with varying degrees of accuracy ranging from thousandths of an inch to fifty millionths of an inch. Some measure in hundredths of millimeters and still other measure in both English and metric measurements.

(3) The dial indicator is a gauge that uses a dial face and one or more pointers or "hands," somewhat like a clock, to register measurements. The dial indicator has a movable contact arm and when the arm is moved, the pointer rotates on the dial face to indicate the amount of movement in thousandths of an inch or smaller increments, depending on the dial indicator used.

(a) A typical U.S. measurement dial indicator has two scales or pointers; one small, inner and one large, outer. The outer scale is usually marked in measurements of one-thousandths of an inch and the small or inner scale counts the revolutions of the outer pointer and indicates one-hundred thousandths of an inch.

(b) The small inner scale is usually marked from 0 thru 9, often in a counterclockwise pattern. One revolution of the large outside pointer will move the small pointer one-hundred thousandths or one number space on the small scale.

(c) The measuring capacity of the dial indicator is normally one inch.

(4) They range in size from approximately 1 inch to 4 1/2 inches in diameter. Various sizes are made to be used for different applications.

(5) The dial indicator is used to measure such things as end play of a shaft; out-of-round and taper of a cylinder; shaft or gear runout; and gear backlash.

(6) Dial indicators are available with various holding devices and fixtures that will allow a wide range of measurements from different positions.

(7) Many of the fixtures and holders have a magnetic base that permits a positive clamping action to metal components such as an engine block, a housing, or a cover.

(8) To use the dial indicator, set it up to perform a desired test. Dial indicators come with clamps and rods that are used to adapt to different setups. Next, set the contact point lightly on the work, turn the dial to zero on the gauge, and perform the test in accordance with the instructions contained in the technical manual.

b. Care of the Dial Indicator. Care of the dial indicator is simple. Keep it clean, handle it with care, and do not lubricate the shaft. The dial indicator requires calibration every six months; this is accomplished at the calibration lab.

5. DEPTH GAUGE

a. Design, Purpose and Construction. The depth gauge or depth micrometer is a tool used for measuring the depth of small holes, slots, recesses, counterbores, and the distance from one surface to another.

(1) There are various designs and types of depth gauges to include the micrometer type, often called a depth micrometer; the vernier, or rule type; the dial type; and the digital type.

(a) The micrometer type consists of a flat base attached to a device similar to an inside micrometer.

(b) The vernier type depth gauge is similar to a vernier caliper but has a flat base instead of jaws.

(c) The dial type closely resembles the dial caliper, but has a flat base instead of jaws.

(d) Although there are four distinct types of depth gauges, only one type will be discussed and used; the micrometer type.

(2) Like the micrometers that we studied earlier, the range of the micrometer depth gauge is one inch; however, the measuring capacity is extended by adding various size extension rods. The rod lengths increase in increments of one inch; for example: one, two, three, four, five and so forth.

(a) A micrometer depth gauge kit usually contains a spanner wrench and three to twelve extension rods. The number and length of the rods determine the depth that can be measured.

(b) Various gauges are equipped with different length bases. Use of the gauge is limited by the width of the base. For example, you could notmeasure the depth at the center of a six inch diameter hole if the length of the depth gauge base was four inches.

b. Using the Micrometer Type Depth Gauge

(1) First, position the measuring rod so that it will not touch the bottom of your work when the gauge flat base is resting on the top edge.

(2) Place the gauge shoulder on the top of the work.

(3) Choose the appropriate extension rod and extend the measuring rod down until it comes in contact with the bottom of the work.

(4) Remove the gauge and check the reading.

(5) To read the micrometer type depth gauge, we read the gauge exactly the same way as with the outside micrometer, EXCEPT WE READ FROM RIGHT TO LEFT. The graduations on the hub run in the opposite direction from the micrometer, with the small numbers to the right and larger numbers to the left. In other words, **YOU READ THE NUMBERS YOU CANNOT SEE RATHER THAN WHAT YOU CAN SEE.** Be sure to remember this when you are reading the micrometer depth gauge.

c. Care of the Micrometer Depth Gauge. The depth gauge is cared for the same way as the micrometer. Keep it clean and dry, handle it with care, and store it in a protective case. The depth gauge requires calibration every six months. This is accomplished by the calibration lab.

6. TORQUE WRENCHES

a. Design, Purpose and Construction

(1) The purpose of a torque wrench is to apply a specified amount of torque to a nut, bolt or other fastener.

(2) There are four major types of torque wrenches.

(a) Dial type.

(b) Needle type.

(c) Clicker type.

(d) Digital type.

(3) Torque wrenches are made of hardened metal, have a straight bar handle, and a dial or scale that reads in inch-pounds, foot-pounds, or Newton meters if it is metric. Torque wrenches are available in a number of drive sizes that range from one quarter of an inch to one inch drive.

(4) Most torque values are based on clean, dry threads. However, some applications require lubricants, sealants or locking compounds. The technical publications will so specify if one of these is to be used and the torque specification will take this condition into account.

b. Using the Torque Wrench

(1) The first step is to select the proper torque wrench. Remember, we just said they measure in inch-pounds, foot-pounds, or Newton meters. Some torque wrenches are calibrated in both pounds and Newton meters.

(a) If you have a torque specification in inch-pounds and a foot-pound torque wrench or a specification in foot-pounds and an inch-pound torque wrench, you can still apply proper torque by converting inch-pounds to foot-pounds and vice versa.

1 To convert inch-pounds to foot-pounds, you simply divide the inch-pounds by twelve. For example, if you have a specification of 120 inch-pounds, you divide 120 by twelve and get ten foot-pounds.

2 To convert foot-pounds to inch-pounds, you multiply the foot-pounds by twelve. For example, if you have ten foot-pounds, multiply ten by twelve and get 120 inch-pounds.

3 Some torque wrenches have a conversion chart to convert Newton meters to inch-pounds or foot-pounds. If there isn't a chart on the wrench, look at one in a technical manual.

(b) Be sure to use a wrench that is within the range of the torque specification. Do not use a wrench that is too small.

(c) Another thing to bear in mind is that most wrenches, and especially those you will see in the Marine Corps, are calibrated only for tightening right-hand threads. This is because most of the bolts we deal with are right-hand thread.

(2) Then you need to select the proper size socket and attach it to the square drive.

(3) The next thing you would do is to adjust the dial to zero, if using a dial type torque wrench. If a scale type torque wrench is to be used, you must check the pointer to make sure it is on zero.

(4) Once you are sure the indicator is on zero, fit the socket on the item to be torqued.

(5) Torque the item with a steady pressure to the required specification, then check again.

c. Care of the Torque Wrench

(1) To take care of the torque wrench:

(a) keep it clean and dry,

(b) never drop it or throw it around, and

(c) always store it in a protective case.

(2) The torque wrench requires calibration every six months.

7. PRACTICAL APPLICALTION EXERCISES AND PERFORMANCE TEST

a. Measure with a Micrometer

(1) Perform the following measurements, using the micrometer set, and record each reading in the space provided.

(a) Measure a piston crown.

(b) Measure a piston skirt.

(c) Measure a piston pin.

b. Measure with a Caliper

(1) Perform the following measurements, using a caliper, and record each reading in the space provided.

(a) Perform inside measurement.

(b) Perform outside measurement.

(c) Perform a depth measurement.

(2) Notify your instructor when you have finished.

c. Measure with a Telescoping Gauge and outside Micrometer

(1) Perform the following measurements, using the telescoping fauges and outside micrometer, and record each reading in the space provided.

(a) Measure the piston pin bushing bore.

(b) Measure the cylinder bore.

(c) Measure the piston pin bore.

(2) Notify your instructor when you have finished.

d. Measure with a Dial Indicator

(1) Using a dial indicator, measure the discharge valve travel and record the readin in the space provided.

(2) Notify your instructor when you have finished.

e. Measure with a Depth Gauge

(1) Perform the following measurements, using a depth gauge, and record each reading in the space provided.

(a) Measure the unloader bore bushing.

(b) Measure the inlet valve seat.

(2) Notify your instructor when you have finished.

f. Torque Bolts to Required Specification with a Torque Wrench

(1) Torque a bolt to a specified torque.

(2) Torque a bolt to the required fort-pounds using an inch-pound torque wrench. Record required inch-pounds.

(3) Torque a bolt to the required inch-pounds using a foot-pound torque wrench. Record required foot-pounds.

(4) Notify your instructor when you have finished.

REFERENCE:

Student handout "Precision Measuring Tools"