
**THE
QUALITY INSPECTOR
SOLUTIONS TEXT**

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SECTION III

METROLOGY-- TEST QUESTIONS

- 3.1 A gage should be sensitive enough to discriminate differences in measurement based on the total tolerance specification or the process spread, whichever is smaller. What should the sensitivity be?
- a. One-tenth the tolerance or spread
 - b. One-hundredth the tolerance or spread
 - c. One-thousandth the tolerance or spread
 - d. One-ten-thousandth the tolerance or spread

Solution: Answers **b**, **c** and **d** are incorrect. A gage should be sensitive enough to detect differences in measurement as slight as one-tenth of the total tolerance specification or process spread, whichever is smaller. Inadequate discrimination will affect both the accuracy and precision.

Answer a is correct.

Reference: *CQI Primer*, Section III - 30.

- 3.2 According to the AIAG Measurement Systems Analysis Reference Manual the so called 10:1 rule can apply to which of the following?
- I. The calibration instrument
 - II. The process variability
 - III. The specification tolerance
- a. I only
 - b. I and III only
 - c. II and III only
 - d. I, II and III

Solution: The question pertains to increments of measurement not calibration. The measuring instrument should be able to divide either the product specification or process variability into ten parts.

In most cases, the process variability should be less than the tolerance. Potentially, this should be divided into ten parts. However, in the case of some electrical components, this may be cost prohibitive.

Answer c is correct.

Reference: *CQI Primer*, Section III - 30.

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- 3.3. A tracer type surface finish instrument, such as a profilometer, can be used to measure all of the following EXCEPT:
- Roughness on gear teeth
 - Depth of scratches on a metal surface
 - Roughness on mild steel plate
 - Surface roughness of a tapered hole

Solution: A profilometer measures the rise and fall of the stylus, calculates the data and displays the results as the standard deviation of a sample (rms). Profilometers are used to determine surface roughness. The depth of scratches are not determined because of the severity of the dimensional change.

Answer b is the correct, incorrect, choice.

References: *CQI Primer*, Section III - 43/44. Fargo, F. T. (1982), *Handbook of Dimensional Measurement*, 2nd ed. Chapter 13.

- 3.4. All measurements consist of at least which the following elements?
- An unknown
 - A reference standard
 - A means of comparing an unknown and a reference
 - A person to operate the equipment
- I and II only
 - I and IV only
 - I, III and IV only
 - I, II, and III only

Solution: The definition of a measurement includes the first three elements, but the fourth element, a person to operate the equipment, is actually not needed. Many measurements are automated and not attended at all.

Answer d is correct.

Reference: *CQI Primer*, Section III - 2 (and logic).

- 3.5. An electronic torque transducer with indicator is used to calibrate a click-stop type torque wrench. This is an example of:
- A traceable measurement
 - A direct measurement
 - An indirect measurement
 - A null measurement

Solution: This is a direct measurement because the reference standard measures the exact parameter, torque, that is required by the unit under test.

Answer b is correct.

Reference: *CQI Primer*, Section III - 28 (and logic).

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- 3.6. There's an old story about measuring the height of a building using a barometer. One of the suggested methods is to wait until late afternoon on a sunny day when shadows are clear and long. Measure the shadow of the building, the shadow of the barometer, and the height of the barometer, and calculate the height of the building. This is an example of:
- A traceable measurement
 - A direct measurement
 - An indirect measurement
 - A null measurement

Solution: This is an indirect measurement. Even though the parameter of the unit under test (UUT) and the parameter of the reference are the same, the reference is never compared to the UUT. Instead, it is compared to other objects (shadows, barometer) and the value of the UUT is calculated from that.

Answer c is correct.

Reference: *CQI Primer*, Section III - 28 (and logic).

- 3.7. Examples of electronic measuring equipment include all of the following EXCEPT:
- Acoustic level meters
 - Network analyzers
 - Vernier scales
 - Seismological monitors

Solution: Answers **a**, **b**, and **d** are just three of the hundreds of types of electronic measuring equipment that is available. Vernier scales do not have any electronic parts.

Answer c is the correct, incorrect, choice.

Reference: *CQI Primer*, Section III - 19.

- 3.8. The weight of an object is:
- Dependent on the location of the object
 - Equal to the object's resistance to acceleration
 - An increasing function as the altitude increases
 - Proportional to the number of atoms in a mole

Solution: Answer **b** is the definition of an object's mass, not weight. If all other things are held constant, the weight of an object decreases as the altitude increases.

Answer a is correct.

Reference: *CQI Primer*, Section III - 41.

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- 3.9. One unique advantage of electronic measuring equipment over mechanical equipment is the:
- Lower cost
 - Ease of repair
 - Minimal training required
 - Ability to provide remote sensing

Solution: In general, electronic measuring equipment compared to the corresponding mechanical equipment is higher cost, more difficult to repair, and requires more operator training. The unique advantage is the ability to provide remote sensing. Many types of electronic equipment have the ability to transmit data to the person reading the data anywhere in the world

Answer d is correct.

Reference: *CQI Primer*, Section III - 19/21.

- 3.10. The tolerances for weights used as references for balances and scales in the United States are:
- A defined percentage for a given weight class
 - Uniform for both laboratories and commercial applications
 - Defined by U.S. and international documents
 - Only given for the range from 1 mg to 1,000 kg

Solution: Each weight class has tolerances which are a function of the size of the weight. There are three sources of weight classifications used in the United States. The most common are:

NIST Handbook 105-1, Class F
ASTM E 617-97, Classes 0 through 7
OIML R111, Classes E1, E2, F1, F2, M1, M2, M3

Answer c is correct.

Reference: *CQI Primer*, Section III - 4.

- 3.11. Identify the true statement, regarding the basic types of measurements, from the options listed:
- Transfer measurements are more inaccurate than direct measurements
 - Some direct measurement tools are read indirectly
 - Differential and transfer measurements are both comparative
 - Transfer measurements are quicker to use than direct measurements

Solution: Transfer measurements, in many cases, take longer than direct measurements, but in some cases may be more accurate (answers **a** and **d** are false). Direct measurements are read directly (answer **b** is false).

Answer c is correct.

Reference: *CQI Primer*, Section III - 28/29.

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- 3.12. There is a 10:1 "rule of thumb" in measurement and the remnants of a 10:1 "rule of thumb" in calibration. Which of the following is a more accurate reflection of the current minimum requirements, assuming that a 10:1 capability in both areas is desirable?
- a. 10:3 in measurement, 4:1 in calibration
 - b. 10:1 in measurement, 5:1 in calibration
 - c. 10:2 in measurement, 3:1 in calibration
 - d. 10:3 in measurement, 10:1 in calibration

Solution: Note the key question phrase "minimum requirements". Obviously a 10:1 ratio of measuring instrument to part (by tolerance, during measurement) and a 10:1 ratio of standard to measuring instrument (by tolerance, during calibration) make sense. However, in the case of automotive suppliers, a 10:3 in measurement might be acceptable and ANSI/NCSS Z540-1995 sets a 4:1 minimum ratio of measurement standard resolution.

Answer a is considered correct.

References: *CQI Primer*, Section III - 30/31. AIAG (1995) Measurement Systems Analysis: Reference Manual. ANSI/ASQ Z540-1-1995.

- 3.13. An ordinary floor "mike" could have all of the following EXCEPT?
- a. An analog display
 - b. A nongraduated scale
 - c. A digital display
 - d. A graduated scale

Solution: Note that a negative response is requested. The display on a micrometer (even at floor level) could be either analog or digital. If analog, the micrometer would contain a graduated scale.

Answer b is correct, incorrect, choice.

Reference: *CQI Primer*, Section III - 5 and 18.

- 3.14. To check a dimension using a small hole gage:
- a. The part bore diameter is read on a scale in the fiber-optic end
 - b. The gage is inserted in the hole, and then spread apart to fit
 - c. The part is inserted in the smallest diameter in which it will fit
 - d. Calibrated pins are inserted until the largest diameter is found

Solution: Small hole gages or split sphere gages are used for hole diameters from about 1/8 inch to 1/2 inch. The gage consists of two hemispherical contact surfaces that are spread apart by an adjustable wedge. An outside micrometer is used to measure the diameter.

Answer b is correct.

Reference: *CQI Primer*, Section III - 13.

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- 3.15. A circuit board manufacturer wants to verify that all components are inserted on the 3,000 boards they produce each day. One effective way to perform this inspection is using:
- Machine vision gaging
 - Automated weighing systems
 - Hi-pot testers
 - Trained inspectors

Answer choices **a**, **b** and **d** are potential options. Depending upon the size of the components, the weighing systems may not have the resolution to detect a missing component. Inspectors could very easily miss seeing an omitted component. The better use of the inspector is to verify problem boards identified by the machine vision gaging system.

Answer a is correct.

Reference: *CQI Primer*, Section III - 23.

- 3.16. When setting up automated vision gaging equipment:
- Color correction is made for part reflectance properties
 - A black body light source is desirable
 - Angles are calibrated using angle blocks
 - Images of good parts are first captured

Solution: Automated vision gaging equipment typically uses computer analysis of the image versus stored images of good parts. Parameters can be set for threshold values of differences allowed.

Answer d is correct.

Reference: *CQI Primer*, Section III - 23.

- 3.17. Using the available angle blocks of 1', 3', 5', 20', 30', 1°, 3°, 5°, 20°, 30°, which of the following statements is correct regarding the angles that can be created?
- Angles of approximately 1/3 of the possibilities up to 60°
 - Odd value angles below 20° and even values of 20° up to 50°
 - All angles from 1' to 59° 59' in 1' increments
 - All angles from 0' to 59° 59' in 1' increments

Solution: Using the blocks given, all angles from 1' to 59° 59' in 1' increments is a true statement. Note some blocks are inverted to create some of the angles.

Answer c is correct.

Reference: *CQI Primer*, Section III - 40.

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- 3.18. A method which can be used to provide a quick, but only approximate indication of surface finish is a:
- Fingernail comparator
 - Profilometer
 - Wavinometer
 - Profile tracer

Solution: Profilometers, profile tracers and surface profiler are descriptions of surface roughness testers. They all provide more accurate information than does using a fingernail comparator, although the fingernail method is quicker. The word "wavinometer" is not a real word.

Answer a is correct.

Reference: *CQI Primer*, Section III - 45.

- 3.19. Rapid verification of hole diameters with accuracies of 0.0001" or better is often done using:
- Bore scopes
 - Water gauges
 - Inside calipers
 - Air gages

Solution: Pneumatic comparators or air gages are often used for measuring bore diameters with accuracies of 0.0001" or better. In fact, some air gages have accuracies of 0.000002".

Answer d is correct.

Reference: *CQI Primer*, Section III - 45/46.

- 3.20. In a conventional roundness tester:
- The probe follows a computer controlled path
 - The part is rotated while in contact with the probe
 - Air bearings permit non-contact measurements
 - Part centering must be done manually

Solution: Air bearings in a roundness tester allow the part to be rotated with very little error due to the axis of rotation. Automatic part centering and leveling is available on some units.

Answer b is correct.

Reference: *CQI Primer*, Section III - 45/46.

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3.21. An oscilloscope can be used to display all of the following EXCEPT:

- a. Electrical waveforms
- b. Voltage versus time
- c. Frequencies above 10 kHz
- d. Weight versus lot number

Solution: Note that a negative response is requested. Oscilloscopes display voltage versus time over a wide range of frequencies. The patterns are representations of the electrical waveforms.

Answer d is the correct, incorrect, choice.

Reference: *CQI Primer*, Section III - 20.

3.22. An instrument used for measuring high temperatures is a:

- a. Rheostat
- b. Piezoelectric recorder
- c. Pyrometer
- d. Manometer

Solution: A pyrometer is an instrument used for measuring high temperatures. An optical pyrometer is based on the black body color emitted from heated objects, which is a function of temperature. The light is captured by a lens system, filtered, and then visually compared with a heated wire, or analyzed electronically. Optical pyrometers can measure temperatures from about 500 °C to 4,000 °C (932 °F to 7,232 °F).

Answer c is correct.

Reference: *CQI Primer*, Section III - 22.

3.23. A digital vision system can be used for all of the following quality inspection activities EXCEPT:

- a. Verifying color content of surfaces
- b. Dimensional measurements
- c. Electrical measurements
- d. Sorting defectives from acceptable items

Solution: The digital vision system can be used for dimensional measurements, but not electrical measurements. The vision system can be used for the other items listed.

Answer c is the correct, incorrect, choice.

Reference: *CQI Primer*, Section III - 55.

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3.24. Gage blocks wring together because of:

- a. The high quality of material used
- b. The combination of surface finish and flatness
- c. The carbide content of the material
- d. The ferrous capability of the material

Solution: Gage blocks wring together by a combination of molecular attraction and the adhesive effect of a very thin oil film. The molecular attraction is made possible by exacting surface finish and flatness.

Answer b is correct.

Reference: *CQI Primer*, Section III - 8.

3.25. A scale graduated in hundredths of an inch also shows:

- a. Eights
- b. Tenths
- c. Thirty-seconds
- d. Sixty-fourths

Solution: A vernier scale graduated in hundredths of an inch would routinely show tenths divisions. The English divisions of eights, thirty-seconds, and sixty fourths are inconsistent with hundredths graduations.

Answer b is correct.

Reference: *CQI Primer*, Section III - 5 and 14/15 (and logic).

3.26. Identify the type of microscope most appropriate for determining the approximate grain size in a common heat treated metal alloy:

- a. Stereoscope
- b. Scanning probe microscope
- c. Confocal microscope
- d. Metallograph

Solution: The question implies that a fairly quick approximation of grain size is desired. The least exotic and most widely available tool is the metallograph. Normally, the metal specimen is etched and polished.

Answer d is correct.

Reference: *CQI Primer*, Section III - 49.

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3.27. A two inch micrometer has barrel markings measuring from:

- a. Zero to one half inch
- b. Zero to one inch
- c. Zero to one and one half inch
- d. Zero to two inches

Solution: A traditional two inch micrometer has a fixed one inch opening and measures dimensions from zero to one inch (which indicates readings between one and two inches). It may be possible to have a "special order" micrometer that would measure more than one inch but in most cases they are unnecessary and very expensive.

Answer b is correct.

Reference: *CQI Primer*, Section III - 5.

3.28. What is a surface analyzer used to measure?

- a. Surface roughness
- b. Surface temper
- c. Surface brightness
- d. Surface tension

Solution: A surface analyzer measures surface roughness. Answers **b**, **c** and **d** are weak choices.

Answer a is correct.

References: *CQI Primer*, Section III - 43/44. Farago, F.T. *Handbook of Dimensional Measurement*, 2nd ed., Chapter 15.

3.29. One full revolution of the hand on a dial indicator always equals:

- a. 0.2500 inch
- b. 0.5000 inch
- c. 1.0000 inch
- d. None of the above

Solution: Different dial indicator manufacturers and models offer a variety of scales. The word always in the question indicates that answer **d** is the proper choice.

Answer d is correct.

Reference: *CQI Primer*, Sections III - 14.
