
**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?
- One-tenth the tolerance or spread
 - One-hundredth the tolerance or spread
 - One-thousandth the tolerance or spread
 - 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. A measurement laboratory has a rule that requires a test uncertainty ratio (TUR) of 3:1 or better. On a hand operated mechanical gage, just received back from calibration, the lab has determined the TUR to be 3.5:1. Is this gage acceptable?
- No, the actual TUR must be 4:1 or higher
 - No, the actual TUR is worse than the requirement
 - Yes, the actual TUR just meets the requirement
 - Yes, the actual TUR is better than the requirement

Solution: The TUR was defined as an attempt to solve this limitation. The TUR is calculated as the ratio of the allowed measuring tolerance of the unit under test divided by the expanded uncertainty of the measurement process used in the calibration. This is then embodied in a decision rule (usually 4:1).

This rule is good in that it does take uncertainty into account. It is much stricter than TAR, and so many times the decision rule will fail - the TUR will be less than 4:1. In such a case, the laboratory will often report the result and the actual TUR and it will be up to the customer to develop and enforce a decision rule on what to do with small TURs. Usually, TUR values larger than 4:1 are not reported - just the fact of conformance is reported.

Answer d is correct.

Reference: *CQI Primer*, Section III - 30/31.

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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: Note that a negative response is requested. 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 require which of the following?
- A definable standard that is internationally accepted
 - Automatic calibration
 - A physical reference
 - A person to operate the equipment

Solution: A measurement requires answer **a**. A person to operate the equipment (answer **d**), is actually not necessary. Many measurements are automated and operators are not attended at all. Answer **b** is a distracter choice. Some references can be electronic (answer **c** is false)

Answer a 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. An example of electronic measuring equipment includes which of the following?
- Radius gages
 - Network analyzers
 - Vernier scales
 - Ring gages

Solution: There are hundreds of types of electronic measuring equipment available. However, radius gages, ring gages, and vernier scales are mechanical.

Answer b is correct.

Reference: *CQI Primer*, Section III - 10/11, 13, 17, and 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 - 41.

- 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/NCSL Z540.2 sets a 4:1 minimum ratio of measurement standard resolution.

Answer a is correct.

References: *CQI Primer*, Section III - 30/31. AIAG MSA-4(2010) Measurement Systems Analysis: Reference Manual. ANSI/NCSL 540.2 1997(R2007). American National Standard for Expressing Uncertainty.

- 3.13. An inspector would be surprised to find which of the following on an ordinary floor micrometer?
- a. An analog display
 - b. A nongraduated scale
 - c. A digital display
 - d. A graduated scale

Solution: 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.

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

Solution: 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 best use of an inspector is to verify problem boards identified by a 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?
- One third 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 that some blocks must be inverted to create some of the angles.

Answer c is correct.

Reference: *CQI Primer*, Section III - 40 (and logic).
