steel quiz

LOOKING FOR A CHALLENGE? *Modern Steel Construction*'s monthly Steel Quiz tests your knowledge of steel design and construction. Most answers can be found in the 2005 *Specification for Structural Steel Buildings*, available as a free download from AISC's web site, **www.aisc.org/2005spec**. Where appropriate, other industry standards are also referenced.

This month's Steel Quiz was developed by the American Galvanizers Association, online at **www.galvanizeit.org**. Sharpen your pencils and go!

1 Overlaps, gaps, and holes must be designed at least ___ in size for the zinc in the galvanizing process to penetrate and fully coat the steel surface.

a. 3/32" **b.** 1/32" **c.** 1/4" **d.** 1/2"

2 Which ASTM specification covers the hot-dip galvanizing of fasteners and small parts?

a. A780 **b.** A123 **c.** A767 **d.** A153

3 **True/False**: Steel chemistry affects the appearance of the galvanized coating.

4 A good rule of thumb for cold bending steel prior to galvanizing is to make bends as large as possible, but the bend radius should be at least ___ times the thickness of the steel.

a. 1 **b.** 2 **c.** 3 **d.** 4

5 What will happen at joints of steel sections that differ considerably in thickness during hot-dip galvanizing?

6 Which of the following methods of repairing hot-dip galvanized steel are allowable according to ASTM A780:

a. Zinc-rich paint, zinc-based solder, and zinc flame spray metallizing
b. Zinc-based solder, zinc electroplating, and zinc-rich paint
c. Zinc-rich paint, zinc-flame spray metallizing, and cathodic protection
d. Zinc-based solder, zinc-flame spray metallizing, and zinc electroplating

7 When hot-dip galvanized steel is going to be painted, it is best to inform the galvanizer about the plans to paint so that the steel is not ___.

a. cleaned prior to galvanizing
b. quenched after galvanizing
c. stacked on wood spacers after galvanizing
d. galvanized at too high a temperature

8 The following method(s) of galvanized surface preparation are acceptable to obtain a Class A surface in slip critical connections.

a. wire brushing
b. quenching
c. applying zinc-silicate paint
d. a and c
e. all of the above

9 **True/False**: Salt-spray testing of hot-dip galvanized steel produces results that can be correlated to real-world performance and serves as a good comparative tool to other corrosion protection systems.

10 To avoid any potential for hydrogen embrittlement, steels that have a tensile strength greater than ___ should not be galvanized.

a. 90 ksi
b. 120 ksi
c. 150 ksi
d. 180 ksi

TURN PAGE FOR ANSWERS

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ANSWERS

1 The answer is **a**. After-fabrication, batch hot-dip galvanizing involves dipping steel in a bath of liquid zinc. The viscosity of zinc at galvanizing temperatures prevents it from entering gaps less than 3⁄32". The best practice is to ensure all gaps exceed this size so that a complete and consistent coating thickness can be achieved.

2 The answer is **d**. ASTM A153 includes a special provision that allows the galvanizer to use a spinner or centrifuge to remove excess zinc from critical sections of small parts such as threads. This specification is similar to ASTM A123 (the more common specification covering hot-dip galvanizing of steel) as it requires minimum coating thicknesses based on the thickness and type (bolt, casting, forged article) of steel.

3 **True**. The hot-dip galvanized coating is formed as a result of a metallurgical reaction between liquid zinc and solid iron. Other elements commonly found in steel, such as silicon, can act as a catalyst for this reaction, accelerating the rate at which the coating grows. It is suggested in ASTM A123 that the amount of silicon should be below 0.04% or between 0.15% and 0.22% to produce a well controlled coating structure. Levels outside of this range may produce a thicker than average coating and have a matte gray or dull appearance. Note that this is purely a visual matter—there is no effect on corrosion performance.

4 The answer is **c**. Strain-aging embrittlement of steels can occur as a result of cold working. At room temperature the aging proceeds relatively slowly; however, if strained steel is immersed in a galvanizing bath at 830 °F, aging is accelerated and can produce cracks after galvanizing in some isolated instances, especially in sharply bent steel.

5 Joining pieces of steel that differ considerably in thickness (e.g. No. 20 gage expanded metal to ¼"-thick wall tube frame) can potentially cause a distortion in the intended shape of the assembly. Different thickness steels expand and contract at different rates when exposed to the heating and cooling cycles associated with the hot-dip galvanizing process. The differing expansion and contraction rates can cause the metal to become stressed and alter its shape in order to balance out the thermal stresses.

6 The answer is **a**. Zinc-rich paint, zinc-based solder, and zinc-flame spray metallizing are all acceptable repair materials for galvanized steel. They differ in application methods, zinc concentration, cost, and service life. Zinc electroplating is not a field-applied coating, and cathodic protection does not repair a bare spot in a galvanized coating. A comparison of the characteristics can be found in AGA's "Inspection of Products to be Hot-Dip Galvanized after Fabrication" (www.galvanizeit.org/showContent,52,84.cfm).

7 The answer is **b**. Some galvanizers employ a quenching step in their process following galvanization. The quench tank may contain contaminants that can affect the adhesion of a top coat. Quenching can serve two purposes: first, to cool the steel rapidly; and second, if chromates are used in the quench bath, to apply a thin passivation layer to the surface of the coating to avoid premature corrosion during shipping and handling or to prevent reaction with fresh concrete.

8 The answer is **d**. Wire brushing, sand blasting, phosphating, and applying a zinc silicate paint will all achieve a mean slip coefficient of 0.35 or higher, the minimum slip coefficient for Class A surfaces (as defined in the 2005 AISC *Specification for Structural Steel Buildings*—ANSI/AISC 360-05). Quenching does not roughen the zinc surface enough to meet the Class A minimum slip coefficient. Not yet recognized but on the horizon, current theories surrounding hot-dip galvanizing and slip critical connections indicate contacting zinc surfaces build up resistance and will eventually achieve the necessary slip factor without any treatment. Studies are being developed to prove this phenomenon.

9 **False**. Salt spray tests of galvanized steel (or any metal) do not portray an accurate picture of how it will perform in actual service. The development of a series of corrosion products on the zinc surface combine to form the zinc patina, which is inherently corrosion resistant. Salt spray testing methods do not allow the zinc patina to form and thus inaccurately represent the corrosion process of galvanized steel.

10 The answer is **c**. Steels with tensile strengths higher than 150 ksi will not expel hydrogen absorbed during the pickling stage of the galvanizing process. The small grain boundaries of the steel at this strength trap atomic hydrogen that may cause hydrogen embrittlement when the steel is put under load. Steels of less than 150 ksi tensile strength expel hydrogen when the steel is heated to galvanizing temperatures 800 °F to 850 °F, eliminating any concern over hydrogen embrittlement.

Anyone is welcome to submit questions for Steel Quiz. If you are interested in submitting one question or an entire quiz, contact AISC's Steel Solutions Center at 866.ASK.AISC or at **solutions@aisc.org**.

Steel SolutionsCenter