U.S. General Services Administration
Historic Preservation Technical Procedures

Galvanized Iron And Steel: Characteristics, Uses And Problems

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GALVANIZED IRON AND STEEL: CHARACTERISTICS, USES AND PROBLEMS

This standard includes general information on the characteristics and common uses of galvanized iron and steel and identifies typical problems associated with these materials along with common causes of its deterioration.

INTRODUCTION

Galvanizing is a process of coating iron or steel with zinc in order to provide greater protection against corrosion for the iron or steel base. The process of galvanizing sheet iron was developed simultaneously in France and England in 1837. Both of these methods employed a "hot dipping" process to coat sheet iron with zinc. Like tinplate, early galvanized metals were hand dipped. Today almost all galvanized iron and steel is electroplated.

The following are the most common methods for applying protective coatings of zinc to iron and steel:

1. Hot-dip Galvanizing: The immersion of iron or steel in molten zinc, after the surface of the base metal has been properly cleaned.

    a. This process gives a relatively thick coating of zinc that freezes into a crystalline surface pattern known as spangles.

    b. During the process, a multiple layered structure of iron- or steel-zinc alloys is formed between the inner surface of the zinc coating and the iron or steel. **These middle layers tend to be hard and brittle and may peel or flake if the iron or steel element is bent.**

2. Electrogalvanizing: The immersion of iron or steel in an electrolyte, a solution of zinc sulfate or cyanide. Electrolytic action deposits a coating of pure zinc on the surface of the iron or steel.

    Advantages:

    a. The thickness of the coating can be accurately controlled using this process.

Limitations:

a. The thick coatings provided by the hot-dip galvanizing process are not usually possible with this method.

3. Sherardizing: The placing of a thoroughly cleaned iron or steel element in an air-free enclosure where it is surrounded by metallic zinc dust. The architectural element is then heated and a thin, zinc alloy coating is produced.

Advantages:

a. The coating will conform to the configurations of the element.

Limitations:

a. **<u>This process is usually limited to relatively small objects.</u>**

Spraying Zinc Rich Primer

4. Metallic Spraying: The application of a fine spray of molten zinc to a clean iron or steel element. The coating can then be heated and fused with the surface of the iron or steel to produce an alloy.

Advantages:

a. Coating is less brittle than those produced by some of the other processes.

b. Coating will not peel or flake on bending.

Limitations:

a. **<u>The coating is more porous and becomes impermeable with time as products of corrosion fill in the pores</u>**.

5. Painting: Paint containing zinc dust pigments may be applied as a protective coating to galvanized iron and steel.

Advantages:

a. The paint may be applied in situ.

Limitations:

a. This is a less effective method of zinc coating than the others listed above.

b. **<u>Paint does not adhere well to pure zinc, nor to galvanized iron or steel.</u>**

c. **<u>When paint peels from galvanized iron and steel, it usually comes off completely along with the primer, exposing a clean metal surface.</u>**

d. If sheetmetal features are well-painted, it is difficult to identify whether they are zinc or galvanized iron or steel.

1) **If the metal is galvanized, it will have a spangled appearance and may show some rust or rust stains from the iron or steel base metal. Both galvanized iron and steel are magnetic.**

2) If the metal is cast or pressed zinc, it will have a grayish-white appearance. Pure zinc is not magnetic so a magnet will not stick.

3) A magnet test will also reveal whether a painted sheetmetal feature is zinc or galvanized iron or steel. Both galvanized iron and steel are magnetic, pure zinc is not.

TYPICAL USES

Typical historical uses for galvanized iron and steel included:

- Cornices and other wall ornaments

- Door and window hoods

- Decorative formed shingles and pantiles designed to imitate other materials

- Roof ornaments such as crestings and finials

Typical uses today include:

- Sheetmetal for flashing, and gutters and downspouts.

- Hot-dipped galvanized steel nails.

PROBLEMS AND DETERIORATION

Problems may be classified into two broad categories: 1) Natural or inherent problems based on the characteristics of the material and the conditions of the exposure, and 2) Vandalism and human-induced problems.

Although there is some overlap between the two categories, the inherent material deterioration problems generally occur gradually over long periods of time, at predictable rates and require appropriate routine or preventive maintenance to control. Conversely, many human induced problems, (especially vandalism), are random in occurrence; can produce catastrophic results; are difficult to prevent, and require emergency action to mitigate. Some human induced problems, however, are predictable and occur routinely.

NATURAL OR INHERENT PROBLEMS

CORROSION:

Galvanized iron and steel's resistance to corrosion depends largely on the type and thickness of the protective zinc coating and the type of corrosive environment.

The zinc coating on galvanized iron and steel **may be corroded by:** Acids, strong alkalis, and is particularly vulnerable to corrosion by sulfur acids produced by hydrogen sulfide and sulfur dioxide **pollution in urban atmospheres**.

1. Natural Corrosion:

    a. **The zinc coating on galvanized iron and steel develops a natural carbonate on its surface by exposure to the atmosphere and by the action of rainwater. This coating, however, is usually not thick enough to protect the metal from further corrosion.**

    b. **The carbonate can become brittle and crusty and eventually split, exposing fresh zinc for corrosion. Since the zinc coating on the iron or steel is very thin, it can corrode up to the base metal exposing the base to the atmosphere as well.**

    c. In industrial atmospheres, the zinc carbonate coating can be broken down by the same acids that attack zinc. These acids convert the carbonate to zinc sulfate, which is water soluble and washes away with rainwater, often staining the adjacent building elements.

2. Chemical Corrosion:

    a. Galvanized iron and steel have good corrosion resistance to: Concrete, mortar, lead, tin, zinc and aluminum.

    b. Galvanized iron and steel have poor corrosion resistance to: Plasters and cements (especially Portland cements) containing chlorides and sulfates, acidic rainwater run-off from roofs with wood shingles (redwood, cedar, oak, and sweet chestnut), moss, or lichen, condensation on the underside of zinc plates and ponded water on the exterior surfaces of the zinc features

3. Galvanic (Electrochemical) Corrosion: **This type of corrosion is an electrolytic reaction between the zinc coating and dissimilar metals when in the presence of an electrolyte such as rain, dew, fog or condensation.**

    a. To prevent the corrosion of the zinc coating due to galvanic action, contact between galvanized items and copper or pure iron or steel should be avoided.

    b. **Galvanized iron and steel are corrosive to all metals** except lead, tin, zinc and aluminum.

c. Applying a protective coating such as paint to galvanized iron and steel will alleviate the problems caused by corrosion of the protective zinc coating.

VANDALISM OR HUMAN-INDUCED PROBLEMS

Mechanical or Physical Deterioration:

1. **Abrasion: Causes removal of the protective metal surface. The soft zinc coating on galvanized iron and steel make it vulnerable to abrasion damage, especially at roof valleys and gutters where the coating can be worn paper-thin by the scouring of rainwater.**

2. Fatigue: A type of deterioration caused by cyclical expansion and contraction of sheet metal features, especially roofs, without adequate provisions for this movement.

   a. **Zinc is very vulnerable to fatigue failure because it has a relatively high coefficient of thermal expansion.**

   In hot climates, the zinc cannot expand and will crack and then corrode.

   b. Fatigue failure may also occur when the metal sheets are too thin to resist buckling and sagging. It results in the bulging and tearing of the zinc coating and resembles a cut or a crack.

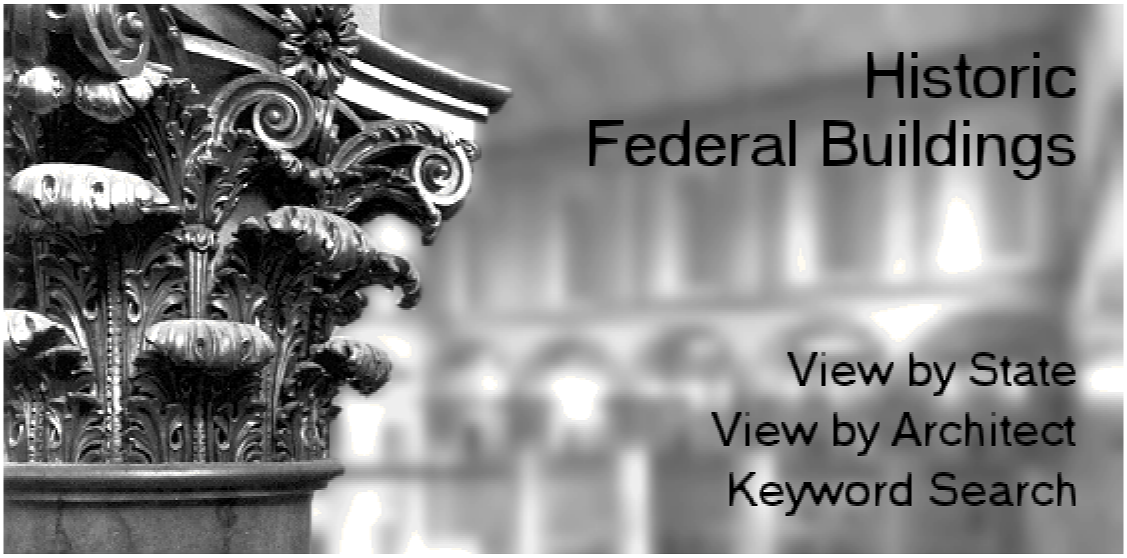
3. Creep: The permanent distortion of a soft metal which has been stretched due to its own weight. **Thin areas of the metal are especially prone to failure.** Creep may be prevented by the use of properly sized individual sheets and bays, properly designed joints, and an adequate number of fasteners.

   Cracks are prone to corrosion.

4. Distortion: **Permanent deformation or failure may occur when a metal is overloaded beyond its yield point because of increased live or dead loads, thermal stresses, or structural modifications altering a stress regime.**

Connection Failure:

1. Wind and thermal stress can damage a roof by pulling joints apart and loosening fasteners.



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