

W

WATERLINE ATTACK

When a metal is partially submerged in an aqueous system with air above the metal, it undergoes simultaneous differential aeration cell and crevice corrosion at the waterline junction. This is referred to as waterline attack.

WEATHERING

Weathering is the process of decomposition and disintegration from the chemical action of sunlight, frost, water, and heat resulting from exposure to the atmosphere.

It is also a method of removing mill scale from heavy structural steel members by exposing them outdoors for a period of several months to allow mill scale to crack off under the stress of expansion and contraction.

WEATHERING STEELS

When small amounts of copper, chromium, nickel, phosphorus, silicon, manganese, or various combinations thereof are added to conventional carbon steel, a low-alloy carbon steel results that has an improved corrosion resistance. These steels are known as weathering steels. The corrosion resistance of these steels is dependent upon the climatic conditions, the pollution levels, the degree of sheltering from the atmosphere, and the specific composition of the steel.

Upon exposure to most atmospheres, the corrosion rate becomes stabilized within 3 to 5 years. A dark brown to violet patina, or protective film, develops over this period. This patina is a rust formation that is tightly adhered to the surface and cannot be wiped off. In rural areas with little or no pollution, a longer period may be required to form this protective film. In areas that are highly polluted with SO_2 , the weathering steels exhibit a much higher corrosion rate, and loose rust particles are formed. Under these conditions, the film formed offers little to no protection.

These steels will not produce this protective film in marine environments where chlorides are present. Corrosion rates will be as high as for conventional carbon steels.

The formation of the patina is dependent upon a series of wet and dry periods, because periodic flushing followed by a period of drying is necessary. In areas where the steel is sheltered from the rain, the dark patina is not formed. In its place, a layer of rust in lighter colors forms, which has the same effect. With continued exposure to wetness, such as in water or soil, the corrosion rate for the weathering steels is equal to that of plain carbon steel.

Because the patina formed has a pleasant aesthetic appearance, the weathering steels can be used without the application of any protective coating of antirust paint, zinc, or aluminum. This is particularly true in urban or rural areas.

When employing these weathering steels, design consideration should be given to the elimination of possible areas where water, dirt, and corrosion products can accumulate. If pockets are present, the time of wetness will be increased, which will lead to the development of corrosive conditions. The design should make maximum use of exposure to the weather. Sheltering from rain should be avoided.

The designer should also be aware that during the period over which this protective film is forming, rusting will proceed at a relatively high rate, during which time rusty water is produced. This rusty water may stain masonry, pavements, and the like. In view of this, precautions should be taken to prevent detrimental staining effects, such as coloring the masonry brown so that any staining will not be obvious.

The weathering steels are used primarily for buildings, bridges, structures, and guard rails.

WELD RUSTING

Locally chromium depleted iron–nickel alloys are subject to slow rusting by mildly acidic liquids, such as the weld metal rusting of stainless steel by dew (containing dissolved carbon dioxide) condensing on the outside of a pipe. Even though this is primarily an aesthetic problem, in some applications it would be unacceptable. If chlorides are present, such corrosion could become aggressive because of the formation of ferric chloride.

WET STORAGE STAIN

Wet storage stain, or white rust, is a white, crumbly, and porous coating that forms on zinc. It occurs in storage where there is access for water but limited supply of oxygen and carbon dioxide. The presence of chlorides and sulfates accelerates wet storage stain formation. This coating of white rust is not protective and consists of $2\text{ZnCO}_3 \cdot 3\text{Zn(OH)}_2$ together with ZnO and voluminous $\beta\text{-Zn(OH)}_2$. The surface underneath the white products is often dark gray.

The coating is usually found on newly galvanized bright surfaces and particularly in crevices between closely packed sheets, angle bars, etc. if the surfaces come into contact with condensate or rain water and the moisture cannot dry up quickly. Zinc surfaces that have a normal protective layer of corrosion product are seldom attacked.

When zinc or zinc coatings corrode in open air, zinc hydroxide and zinc oxide are normally formed. When the supply of air to the surface is restricted, as in a narrow crevice, there is insufficient carbon dioxide to allow the formation of a zinc carbonate layer.

Zinc oxide and zinc hydroxide layers are voluminous and porous and adhere only loosely to the zinc surface. As a result, the zinc surface is not protected against oxygen in the water. Corrosion can therefore proceed as long as there is moisture on the surface.

When wet storage staining has taken place, the objects should be arranged to allow their surfaces to dry rapidly. The attack will stop, and since there is a free supply of air to the surfaces, the normal protective layer of corrosion products can be washed off.

Chromating or phosphating will supply short-term protection. Painting after galvanizing also provides protection. The most effective way to prevent wet storage stain is by

preventing new zinc surfaces from coming into contact with rain or condensate water during storage and transport. Materials stored outdoors should be arranged so that water can easily run off the surfaces. Refer to [Fig. Z.1](#).

Also refer to “White Rust.”

WHITE IRON

When cooled, the carbon in white iron forms a hard, abrasion-resistant, iron–chromium carbide, instead of forming free graphite. White irons are used primarily for abrasive applications. They are very brittle. There is very little difference in corrosion resistance between the white irons and gray irons. The high chromium content provides only slightly better corrosion resistance. See “[Cast Iron](#).”

See [Refs. 1 and 2](#).

WHITE RUST

White rust is the name applied to zinc corrosion products that appear as a white to dirty gray deposit found on galvanized steel surfaces below the waterline, when exposed to recirculated water. The deposit is zinc carbonate, which does not form a protective film on the galvanized surface. Because of this, the white rust corrosion will continue until all of the protective zinc is entirely removed from the base metal.

White rust occurs when galvanized steel or zinc is exposed to water having a pH value above 8.2. The alkalinity of the water and the presence of any accelerating agents such as phosphates or phosphonates will govern the rate of corrosion. Higher alkalinity and the presence of accelerating agents will increase the corrosion rate.

Prevention of white rust is possible by maintaining pH control to hold the alkalinity level below the critical 8.2 and by the use of inhibitors. See “[Wet Storage Stain](#).”

WOOD

Wood is a naturally formed organic material composed of cells arranged in a parallel manner. The chemical composition of the woody cell walls is approximately 40% to 50% cellulose, 15% to 30% lignin, less than 1% mineral, 25% to 35% hemicellulose, and the remainder extractable matter of various types. Softwoods and hardwoods contain approximately the same cellulose content.

Timber is classified as hardwood and softwood. Hardwood comes from the broad-leaved trees such as oak, maple, and ash. Softwood is the product of coniferous trees such as pines, birch, spruce, and hemlock. The terms hardwood and softwood have no relation to the actual hardness of the wood.

Sapwood is the living wood on the outside of the stem. Heartwood is the inner core of physiologically inactive wood in the tree. Heartwood is usually darker in color than sapwood.

Wood is relatively inert chemically but is readily dehydrated by concentrated solutions and consequently shrinks badly when subjected to the actions of such solutions. It is slowly hydrolyzed by acids and alkalies, particularly when hot. In tank construction, if sufficient shrinkage takes place to permit crystals to form between the staves, it becomes

very difficult to make the tank tight again. Wood can be impregnated to resist acids or alkalis and the effects of high temperatures.

Wood deteriorates from two principal causes, chemical and biological attack. The chemical resistance of the wood is dependent upon the ability of the wood's cell walls to resist chemical action, and the extent that the chemical penetrates into the wood.

Wood is most resistant to chemical attack in the pH range of 2 through 9, and in certain conditions can be used up to a pH of 11. Wood is resistant to weak acids, but concentrated mineral acids tend to hydrolyze the cellulose and hemicellulose constituents. The lignin in the wood that binds the fibers together is attacked by oxidizing agents such as ozone. Strong oxidizing agents such as nitric acid, chromates, potassium permanganate, and chlorinated water can also oxidize the cellulose. Aqueous solutions of sodium hydroxide, nitric acid, sulfuric acid, and hydrochloric acid can cause the most damage, since swelling and degradation are simultaneous.

Wood can be used to handle dilute hydrochloric acid (<5%) and sulfuric acids at ambient temperature, phosphoric acid up to 30% at ambient temperature, organic acids, aldehydes, alcohols, and acid salts.

Various types of wood are used depending upon the service. Cypress is used for general chemical service; redwood and fir are used for sulfite liquors from the pulp and paper industries; pine is used in acid mine waters, dilute mineral acids, and mildly alkaline solutions; maple because of its hardness is used for abrasive slurries; oak is used to store and age whiskey and wine; and redwood, red cedar, Douglas fir, and various pines are generally used for cooling towers and many chemical exposures.

Biological deterioration of wood is caused by aquatic organisms, insects, and fungi. This deterioration can be delayed or prevented by pressure treating the wood with creosote or some other preservative.

WORM TRACK CORROSION

This is another name for "Filiform Corrosion."

WROUGHT IRON

Wrought iron is a highly refined form of iron containing less than 0.03% carbon and with 1% to 3% slag which is evenly distributed throughout the material in threads and fibers so that the product has a fibrous structure quite dissimilar to that of crystalline cast iron. It is a mechanical mixture of slag and low-carbon steel. Wrought iron generally rusts less readily than other forms of metallic iron. See "[Cast Irons](#)."

REFERENCES

1. GW George and PG Breig. Cast alloys. In: PA Schweitzer, ed. Corrosion and Corrosion Protection Handbook. New York: Marcel Dekker, 1989, pp 289–290.
2. JL Gossett. Corrosion resistance of cast alloys. In: PA Schweitzer, ed. Corrosion Engineering Handbook. New York: Marcel Dekker, 1996, p 259.