Corrosion in Surface Preparation and its inhibition by Dehumidification

All types of material viz. Concrete, steel, Cast Iron, Aluminum, stainless alloys etc. need to be protected from the deformation and disintegration to their natural form. This need had led to the understanding of Corrosion and the development of Corrosion engineering. Corrosion is the deterioration of a material, because of its reaction with the environment. This disintegration process can be due to chemical oxidation, atmospheric affects, galvanic couple reaction etc.

Corrosion is a natural phenomenon or process that follows the laws of science. The atmospheric corrosion accounts for more failures on both a tonnage and cost basis than any other type of environmental corrosion. Tremendous amount of material in automobiles, bridges, ships, marine structures, tanks, pipelines…..are exposed to the atmosphere and attacked by " oxygen and water". The principal factors influencing atmospheric corrosion for a given metal are :

1.Moisture 2.Temperature 3.Atmospheric Contaminants

The critical factor in our discussion is the mechanism of atmospheric corrosion and hence the factors controlling the initial rate of deterioration of the bright surface.

There are 2 concepts of Metal corrosion, both effectively used by the corrosion engineers to design the protection and control methods.

Chemical Concept of Corrosion Cell in Metals

In the chemical concept of a corrosion cell the iron goes into solution at the anode, reacts rapidly with the negative hydroxyl ions, and precipitates. The electrons move through the metal or the exterior circuit to the cathode. AT this point , the electrons are neutralized by positive ions, e.g. the positive hydrogen ion on reacting with the electron becomes molecular hydrogen, leaving an

excess of OH- ions in the area or oxygen is removed by reaction with water and electrons to form hydroxyl ions as shown in Fig.1. In either case, the removal of hydrogen or removal of oxygen, hydroxyl ions are concentrated on the cathode.

The Electrical Concept of Corrosion Cell in Metals

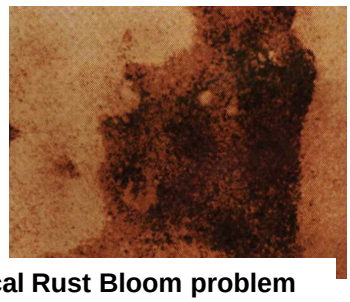
In contrast to the chem ical con cept, the electri cal or convent ional concept of current flow i s quite different, n onetheless very im portant. Here the flow of electric c urrent runs from the ano de throu gh t he soluti on to the cat hode. The anode is often described as the area of the metal surface from which the current leaves the metal and enters the sol ution. This is depicted in Fig 2. T he cathode is used to describe the area of the metal surface to which the current flows from the sol ution and then retur ns by way of the exte rnal circuit to the a node. The electrical current flow is then from the positive pole (Cathode) to the negati ve pole (Anode) and fr om the anod e, into and throu gh the sol ution to the pos itive pole, to complete the circuit.

Surface Preparation and Coating a Tool for Corrosion Prevention

Some of the most impor tant tools use d in corrosion eng ineering are painting and latel y high performance coa ting. This i ncludes pr oduct designed for the protection of the most costly and complex structures and material of the world. E.g. ultra la rge cargo carr iers, LNG ships, chemical transport equipm ent l ike ships, bar ges and tank cars, offshore drill ing, large con crete s ilos, concr ete tanks and structures, pro duction s tructures, petroleum r efineries, sewage systems and chemical nuclear and p aper plants. T he value of the se structures, economically and soci ally being so high, the cost of material and ap plication of the coat ings is negligib le considering the sa vings. Thus the most s ophisticated and m odern methods are emp loyed for the prote ction by high p erformance coatings of such structures.

The Problem :

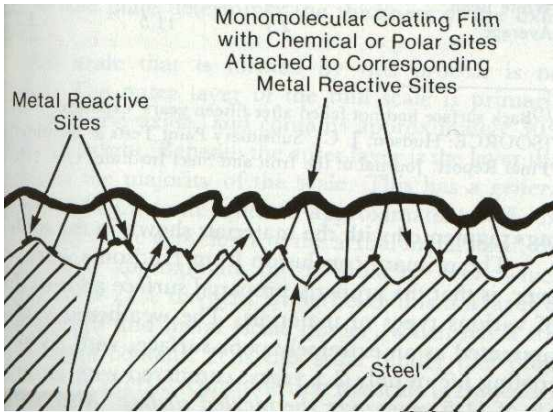
High humidity can allow blooming or flash rust between the time the surface is blasted visually clean and when the coating is applied, which may result in premature coating failure. This problem can occur on any surface but is most common when there is a large continuous surface as in the interiors of storage tanks, process piping and reaction vessels. In these circumstances, the practical logistics of coating operation prevent the immediate coating of the surface after cleaning. While the surface is waiting for the coating, small reductions in surface temperature or small increase in the humidity of the surrounding air can result in condensation, which causes immediate corrosion and defies negates the entire exercise.


A typical Rust Bloom problem

A typical example is when a large tank is blasted clean and sealed. It may show corrosion on reopening because the relative humidity at the metal surface can reach 100% because the metal cools at night, chilling the air in immediate contact with the surface to below the dewpoint causing moisture to condense on the surface. The condensation acts as an electro the corrosion reaction. Because the air n the middle of the tank remains warm, a relative humidity reading several inches away from the surface may be deceptively low, even when the moisture is condensing on the surface.

The problem is intensified by the surface temperature and the air dewpoint changing throughout the day as well as seasonal variations.

Most of the failures of coating are a result of poor or inadequate Surface Preparation. The objective of Surface Preparation is to create proper adhesion of a coat over the substrate. Adhesion is the key to coating effectiveness and it determines whether the coating is just a thin sheet of material lying on the substrate or it becomes the actual part of the substrate. Adhesion is even more critical for the coatings applied in corrosion prone areas, especially those subject to high relative humidity. Thus proper surface preparation is vital for the long life and effectiveness of a coating applied in corrosive.



Whatever the surface to be coated, from the preparation of the surface to the application of the first coat, the surface is subject to he environmental factors .The term "Hold the Blast" is commonly used and refers to the prevention of rust bloom from forming between the blasting and coating cycles. As a result general rules have been established which attempt to meet the specifications as set by NACE and SSPC to maintain a 5 degree differential between the air dew point and the surface to be coated in case of metals, and complete removal of dampness and moisture in the case of a non-metal like concrete, where even an apparently dry surface before coating can later show major blistering and de--lamination problems.

Dehumidification, an aid to Surface Preparation :

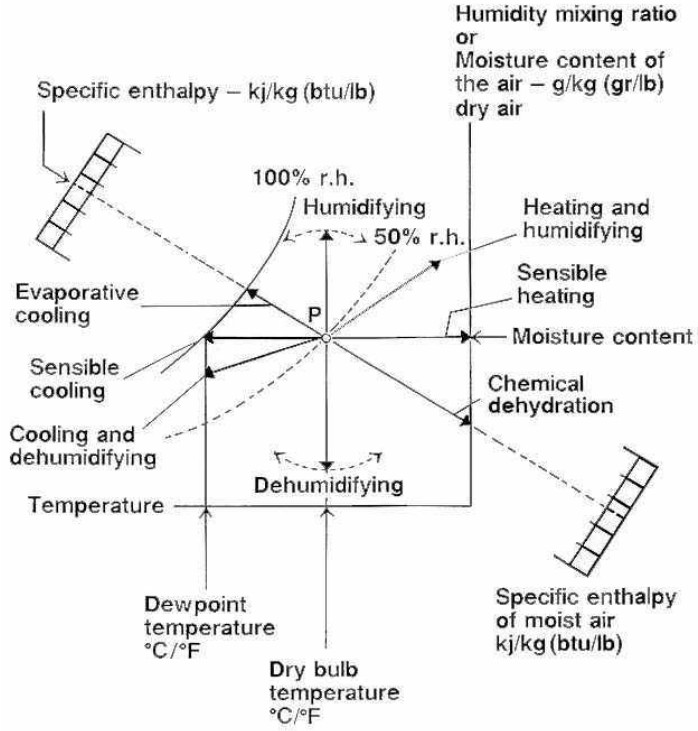
To avoid the above problems , a dehumidifier can be used to remove enough moisture from the air at the surface so that the air dewpoint is lowered sufficiently for the metal .To understand the role of dehumidification in the Surface preparation process an understanding of the psychrometric variable will be necessary. These include the surface temperature of the steel, air dewpoint and air temperature inside the tank; and the air temperature, air dewpoint and projected rate of change in ambient conditions outside the tank. The primary purpose of understanding the effect of these variables, is to determine the proper level of relative humidity that must be achieved and maintained inside the tank to prevent rust bloom from condensation.

-Inside Surface temperature of Steel. The temperature of the steel itself is affected by the inside temperature of the air during working conditions, outside air temperature, evaporative cooling that may take place during rain, and the radiational heating and cooling created by day/night cycle.

-Inside Air Dewpoint. The dewpoint is the temperature at which the air achieves 100% humidity. Additional cooling below the dewpoint will create condensation. The inside air dewpoint is likely to be uniform throughout an enclosed tank but

variations can occur in areas where air infiltrates in from the outside, standing water evaporates and in tall tanks where the moisture has a tendency to rise.

-Inside Air Relative Humidity . The inside air relative humidity is only useful to know at the surface of the material to be coated. At a constant moisture level in the air, the relative humidity varies widely with the temperature of the air.



-Outside Air Temperature. The outside air temperature will change with the day night transition. Additional changes can be caused by evaporative cooling effect of rainstorms. Various geographic areas may have wider swings in temperature depending on the time of the year.

-Outside Air Dewpoint. The outside air dewpoint will change if the temperature falls and the moisture has been condensed. It potentially increases during the day as rising temperatures create a re-evaporation.

-Outside Air Relative Humidity. The relative Humidity is a function of the amount of moisture and temperature As a given volume of air increases in temperature, the volume has a greater potential for holding more moisture…..thus a lower relative humidity. As the temperature decreases, the relative humidity increases to a point where the moisture will condense out of the air as the temperature continues to fall . The chart that follows displays the properties of air water mixture.

The Dehumidifier :

The Desiccant based Dehumidifier removes moisture from the air by chemical attraction rather than condensation. Humid air is directed across a desiccant material that acts as a drying agent. The moisture is collected on or in the desiccant rather than as a liquid. The moist desiccant is dried by a second hot air stream that heats the desiccant and releases the moisture. Then the desiccant is reused to dry more air. In a continuos process, the Air is dried by the desiccant at the same time that more desiccant is being dried in preparation for reuse, so that dry air is available at all times.

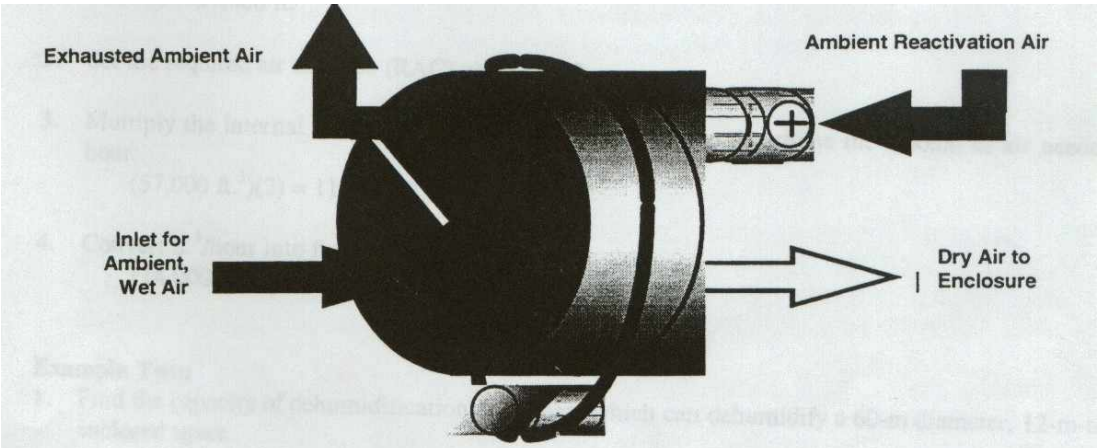


Figure 2: A Solid-Sorption Desiccant System

Rotating Honeycomb Dehumidifiers: In its latest configuration, solid desiccant is impregnated into a rotating wheel that contains structured air contact media in the form of a honeycomb. Air passes through the open flutes in the media and releases the moisture to desiccant contained in the media walls. The moist media then rotates into the reactivation air stream. It is separated from the process air by a partition. The heated desiccant releases its moisture and is ready to reuse on the process air side of the partition.

Application Considerations :

Dehumidification is used 24 hours per day until all the blasting and lining application is complete. Dehumidifiers are applied to the surface preparation operations in the following uncomplicated manner.

Air is taken from the outside environment dried and fed to the interior of the structure where coating is to be carried out. The dry air performs three primary functions :

Prevents condensation and high relative humidity at the surface

Prevents the build up of hazardous vapors inside closed areas to be blasted, during the operations

Provides ventilation air for the personnel at site

The dry, fresh air continuously purges the area or surface and is exhausted to the atmosphere.