COATING ADHESION AND SUBSTRATE CONTAMINATION

There are two main reasons for carrying out surface preparation. Firstly, it removes contamination, so that coatings can properly adhere to their intended substrates, rather than the contamination itself. Secondly it can increase the surface roughness of the substrate by producing a 'key' or 'anchor pattern' or 'surface profile'.

Removing contaminants and increasing surface roughness will allow the maximum bond strength and adhesion to develop between a coating and its substrate. This is critical, because marine coatings are subject to a large variety of hostile service conditions which can include abrasion, impact, flexure, moisture, moisture vapor transmission, humidity, salt and a whole range of corrosive chemicals. If the coatings have been applied over properly prepared surfaces, they will have strong adhesion to the substrate and they will have a good chance of withstanding these conditions. On the other hand, coatings which have been applied over poorly prepared surfaces will have weak adhesion to the substrate and may fail prematurely from a variety of causes including underfilm corrosion, blistering or chipping and flaking. Coating performance is therefore directly related to surface preparation.

This section will describe the types of adhesive bonds which bind a coating to its substrate and the types of contamination which must be removed for these bonds to be fully effective.

1. ADHESIVE BONDS

Basically, coatings adhere to substrates through a combination of different types of chemical bond and the frictional or mechanical bond produced by substrate surface profile. Chemical bonding is either the strong type produced by the sharing of electrons, or a weaker type produced by the attraction of oppositely charged particles.

1.1 PRIMARY VALENCE BONDING

This is the strongest type of bonding and occurs when chemical groups on the coating react across the interface with complementary groups on the substrate, forming a chemical compound. An example of this is the oxygen bonding of the silicate matrix to the steel substrate in an inorganic zinc silicate coating, as shown in Figure 1.

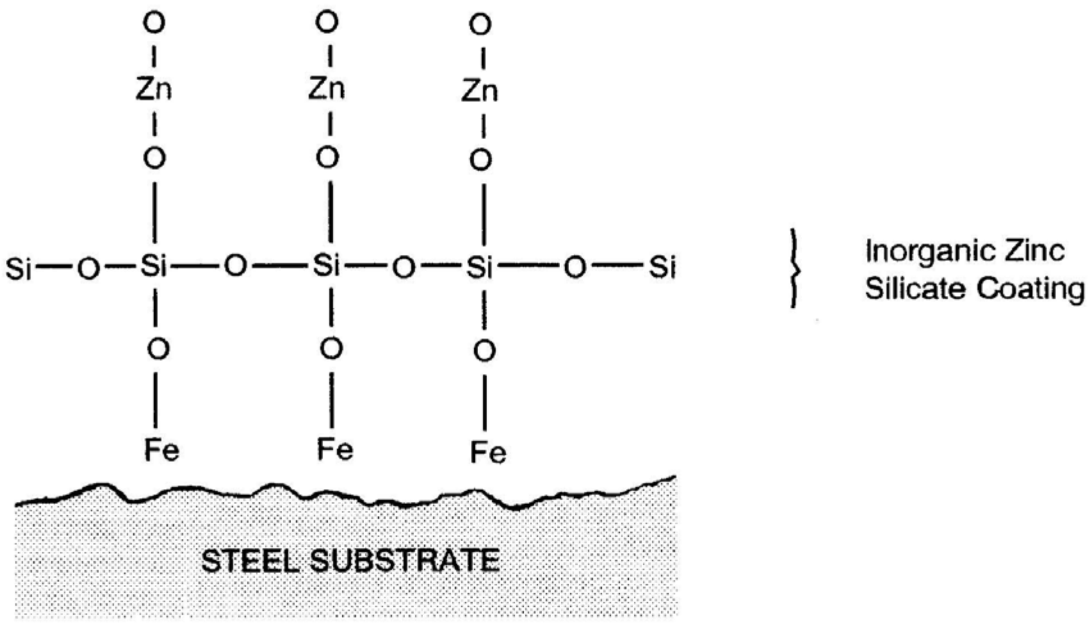

Figure 1 – Primary Valence Bonding Showing Oxygen Bonding of the Substrate with the Coating

In this type of bond the outer electrons are shared between the oxygen and iron atoms giving a strong directional bond, as shown in Figure 2.

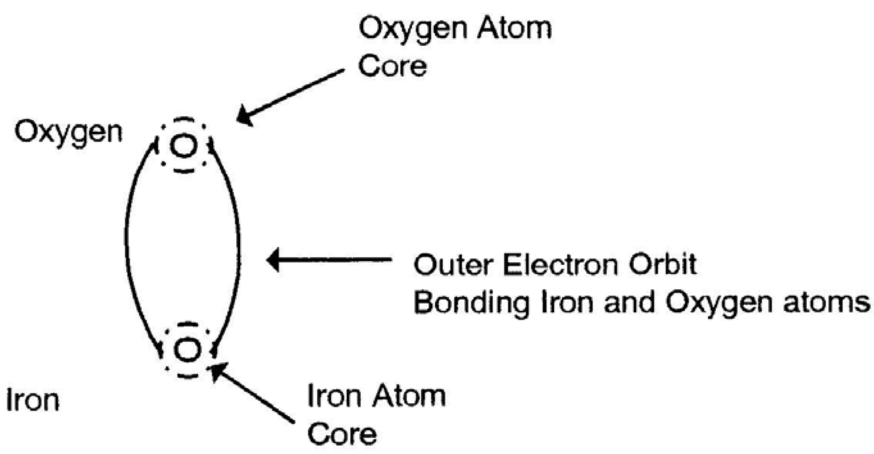

Figure 2 – Outer Electron Orbit Penetration of Iron and Oxygen Atom Cores

Zinc silicates are partially bonded to the substrate in this manner and it is one of the reasons they have such good performance and can be so difficult to remove if reblasting is required.

1.2 POLAR OR SECONDARY BONDING

This is the attraction of positively or negatively charged parts of the coating molecule to oppositely charged areas of the substrate, as shown in Figure 3. In this example the oxygen atom has high electro-negativity or greed for electrons which results in unequal sharing of electrons with the hydrogen atom. This means that the Hydroxyl (OH) molecule acts as a dipole and has a positive bias at one end, which is attracted to negatively biased sites of the substrate.

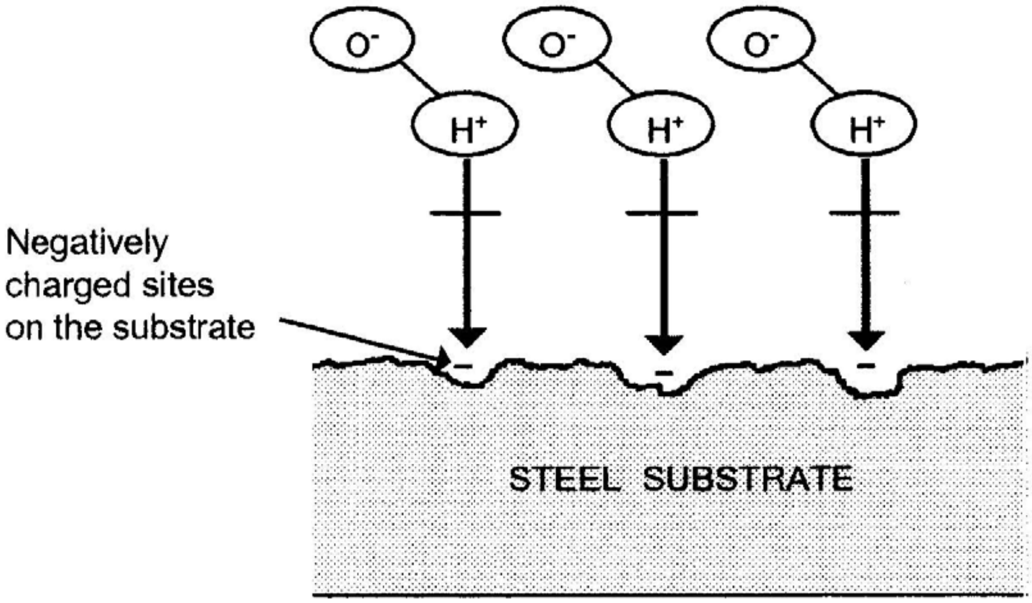

Figure 3 – Polar or Secondary Bonding

Secondary bonding is much weaker than primary bonding and is most common with organic coatings such as vinyls and chlorinated rubbers.

There are also weaker types of bonds such as Van-der Waals forces in place in most coatings, and adhesion is usually by a combination of all different types of chemical and electrical bonds.

There are two main points to remember with regard to adhesive bonds, as follows:

1 All types of primary and polar bonds require close contact between the coating and substrate to be effective. The contact distance should be less than three times the diameter of an oxygen atom. Coatings must therefore properly 'wet' the surface in order to bond, and any contamination between the paint film and the substrate will obviously prevent coating adhesion.

2 The coating can chemically bond to the contamination itself. However, most contaminants are themselves loosely bonded to the substrate, so coating failure will be inevitable if the contamination detaches from the substrate.

1.3 MECHANICAL ADHESION

Mechanical adhesion is associated with physical surface roughness, or profile. This is the distance measured between the peaks and valleys of the substrate and it affects coating adhesion in two ways, as follows:

1.3.1 Prevention of Slumping

The actual roughness produces frictional drag which helps coatings adhere to the surface. This is particularly important for thick film coatings, or coatings which have relatively poor internal cohesion, because it helps them stand up and avoids 'slumping'. Most heavy duty marine paints require a profile in the 50 to 75 micron range for this reason.

1.3.2 Increasing Surface Area

Roughening a surface to produce a profile can double or treble the surface area. This doubles or trebles the number of surface reactive sites to which the coating can chemically bond and it greatly increases the total adhesive bond strength. See Figure 4.

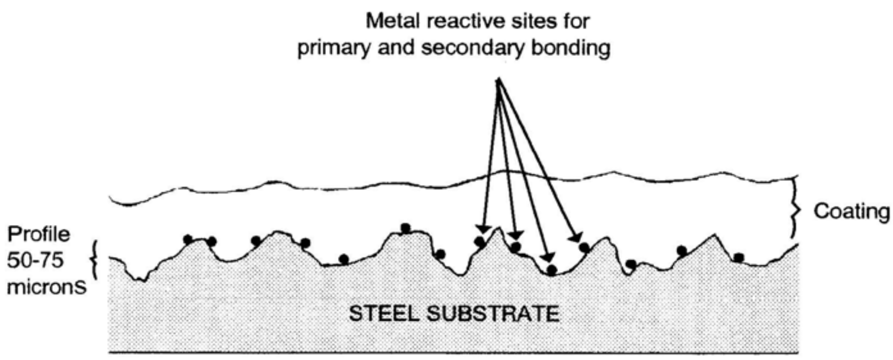

Figure 4 – Mechanical and Chemical
Adhesion increased by Surface Profile

출처 : International Paint " TSTM – Module 3 : Surface Preparation " 내용

상기 내용은 개인의 상업적 목적에 의한 게시가 아니라 지식공유의 차원에서 인용하였음을 밝힙니다.