UNIT 2

MARINE CORROSION AND PREVENTION HULL PLATE PREPARATION

PLATE PREPARATION DURING SHIP BUILDING

- ships basic hull design may be the same, the dimensions, capacity and systems used in one ship may be very different from another.
- Once the steel plates are procured by the shipyard, they are stored in the stockyard.
- Plates of different thicknesses and grades are available in standard dimensions (4 meter x 6 meter or 8 meter x 10 meter, and so on).
- There are usually two positions of stowing plates- Vertical Stowage and Horizontal Stowage.

- Vertical stowage of plates is more preferred because it enables the mill scale to fall of naturally due to gravity. This reduces the time required for blasting in later stages.
- Vertical stowage also consumes less space than that required by horizontal stowage. Picking individual plates using cranes becomes easier.
- Many modern shipyards carrying out multiple projects at the same time also practice methods of plate stowage scheduling.
- In this, each plate is marked with the project it has been designated to, and they are stored in an order that is synchronous with the working schedule or the master plan of the shipyard.

Stowage of Rolled Sections

- Rolled sections (Flat bars, Tee sections, Bulb bars, Equal Angles, Unequal angles) are used as stiffening members for shell and deck plating.
- They are ordered by the tendering department based on the scantlings provided by the structural drawings of every project.
- Rolled sections are stored in the stockyard, mostly in the same stockyard in which steel plates are stored.

Plate Preparation or Surface Preparation:

- When a plate is brought to a shipyard from a steel plant, it is not ready to be used for construction.
- Before a steel plate is used for construction, it needs to be prepared for the same. That includes two major processes:

Straightening and Removal of Residual Stress:

- The plate obtained by rolling in the steel plant is not completely straight, though it may visually appear to be so.
- Plates may also be mangled during transit from plant to the shipyard.
- In order to prevent misalignment of two such plates during welding in a later stage, they need to be straightened.

This is carried out by passing the plate through a series of rollers, also called mangles Under the rollers, the plate undergoes multiple cycles of bending until it is straightened.

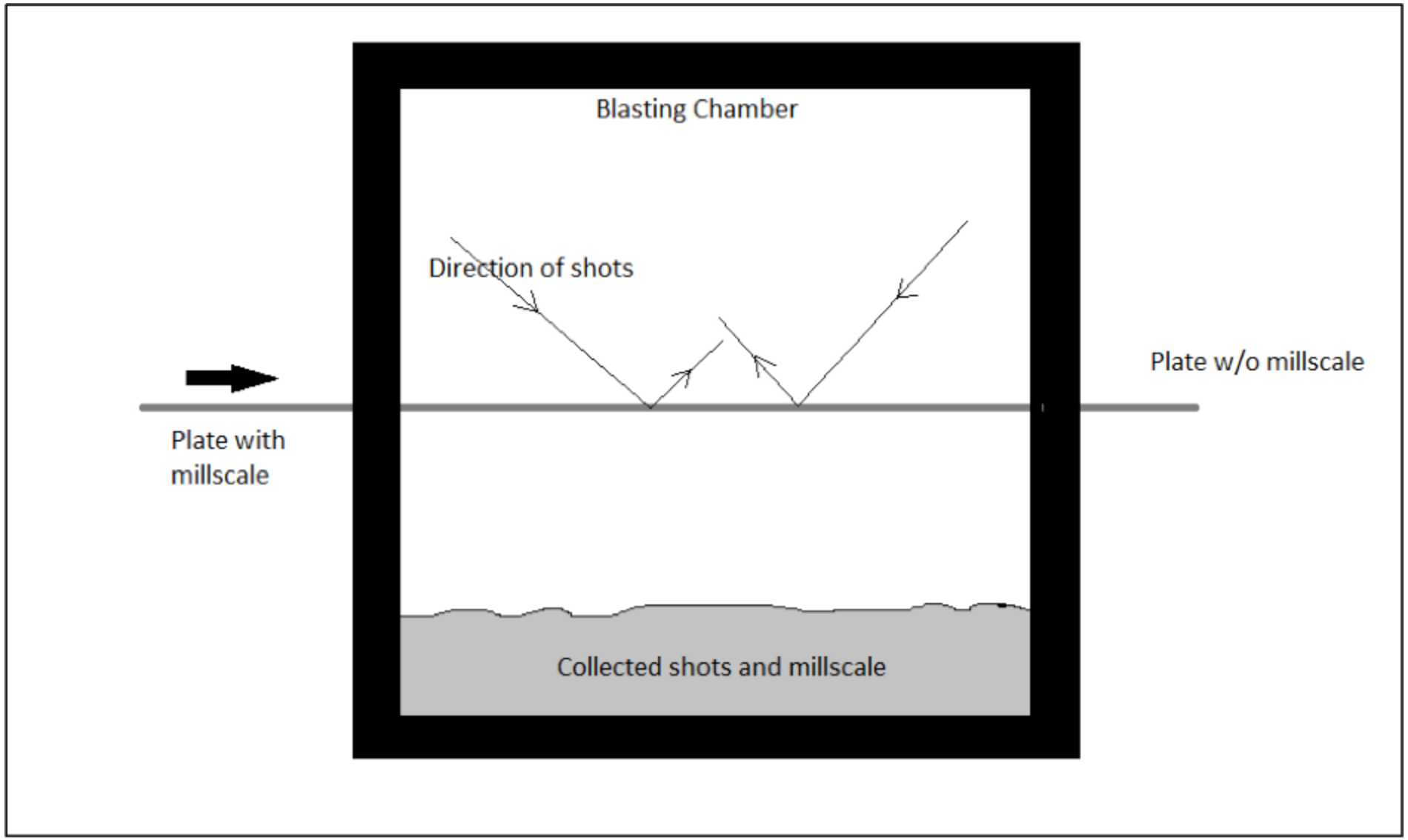
- Less number of rollers (five) are used for thicker plates (thickness above 10 mm).
- Whereas, in case of thinner plates (up to 10 mm thickness) the number of rollers are usually twenty-one.
- The hot work and cold work carried out on the steel in the steel plant leaves *residual stress* in the steel plates.
- If these stresses are not removed, the added loads experienced by the hull girder may subject the plate to stress levels higher than predicted values when the ship is at sea.
- Straightening of plates by repeated bending cycles also removes these residual stresses.

Mill Scale Removal

- Mill scale is a brittle layer of iron oxides on the steel plate. It must be removed from the plate surface because:
- It does not contribute to the strength of the plate.
- If plates are painted without the removal of mill scale, the adhesion of paint is insufficient.
- As a result, with time when the mill scale scrapes off the plate surface, the paint falls off along with it, exposing the steel plate to sea environment which will result in corrosion.
- Presence of mill scale contaminates the weld, reducing weld quality.

- The presence of mill scale also acts as an advantage when the steel plates are stocked in the yard. They form a protective oxide layer on the metal, thus preventing rusting of the plate surface when stowed for longer time in the yard.
- Mill scale is loose, but not loose enough to completely fall off the metal surface without application of external force. Some methods used by shipyards to remove mill scale are:
- **Natural Removal**: Vertical stacking of plates results is natural removal of mill scale. But this method is not reliable because the removal is non uniform and results in local corrosion.
- **Flame Treatment:** The steel plate is heated to a certain temperature. Since the coefficient of expansion of mill scale is different from that of steel, heating results in removal of mill scale.
- **Shot Blasting:** In this process, the plate is passed through an enclosed chamber within which, steel shots are blasted at high velocity on the steel plate. Each shot incident on the plate scrapes away the mill scale.

- It is very important to control some of the parameters of this process, in order to ensure that the amount of material scraped is neither less nor more than desired.
- The incident mass, size and velocity of the shots are pre-decided to ensure that the mill scale is completely removed, but at the same time the scraping should not be such that it removes steel from the surface.
- The plate feed speed is controlled based on the thickness of mill scale layer.
- Too much feed rate might result in insufficient removal, and excessively less feed rate might result in removal of steel.


Blasting Chamber
Direction of shots
Plate w/o millscale
Plate with millscale
Collected shots and millscale

- Shot blasting has certain disadvantages too.
- The incidence of high velocity shots exert stress on the surface of the plate.
- If stress levels are more than the yield strength of the material of the plate, then it enters into the plastic region.
- *A unique behaviour is observed at this stage*.
- When steel is subjected to stress levels within the proportional limit, removal of the load does not leave any deformation in the specimen.
- But if the stress levels go up to the plastic region, there is certain amount of permanent deformation even after the removal of stress. So, when subjected to stress again, the material would actually have less capacity to yield that before.
- ***In other words, its reserved plasticity has now reduced.***
- It is the above phenomenon that takes place in case of shot blasting. This reduction of plasticity is also called cold hardening. However, this effect can be prevented by controlling the parameters of the blasting chamber.
- Once the plate is completely free of mill scale, the supervisor checks the roughness of the plate surface. In case the plate it too rough, it would be unfavourable for proper welding. And if too smooth, it would not provide enough surface roughness for proper adhesion of paint. Hence, the surface of the plate at the exit of the blasting chamber is compared with a standard specimen which has the required roughness

PLATE PREPARATION

1. Shearing:

- In this method, the plate is rested on the edge of a flat surface, and a high velocity shearing surface (usually made of high strength steel) is used to shear the plate from the section lying on the edge of the flat surface.
- The advantages of this method are as follows:
- Cuts a long length of plate at one stroke.
- Smooth cut surface is produced, which provides better alignment during welding.
- Since it is a cold work, there are no thermal stresses or deformations in this process.
- shearing does have a major disadvantage, that is, intricate shapes like brackets, scallops, small radiuses, and bends cannot be cut out by shearing.

2. Thermal Cutting Methods:

- These methods use a movable cutting tool, which makes it possible to cut out complicated shapes.
- since these are hot works, they result in work hardening in the cut edges.
- since every cut edge will be welded in future stages, the cut edges lose the work hardened property and offset this effect.

There are two methods of thermal cutting:

Oxidation or Burning: This is basically oxy-acetylene or oxy-fuel type of cutting method where the metal along the cut edge is converted into oxide and the molten oxide is then thrown off.

Fusion Cutting:

- Plasma cutting is a type of fusion cutting which is used to cut plates for which melting point of the oxide is less than that of the metal.
- In plasma cutting a plasma gun shoots a plasma flame coated with a layer of inert gas, on the region of the plate supposed to be cut *(It is this inert gas layer that prevents the oxidation of aluminium).*
- The torch is then propagated along the cutting curve to complete the process.

SAND BLASTING

- Sandblasting is used to remove paint and rust from the ship hull.
- Sandblasting is a general term used to describe the act of propelling very fine bits of material at high-velocity to clean or etch a surface.
- Sand used to be the most commonly used material, but since the lung disease silicosis is caused by extended inhalation of the dust created by sand, other materials are now used in its place
- Sandblasting is frequently used in the ship cleaning industry to remove paint and to prepare surfaces for painting.

- It has shown that this is not a healthy environment which have lead to the fact that there are voices that would like to stop the use of sandblasting.
- The cost, in many countries, is far higher for the deposit of the sand as it is contaminated than it is to purchase the sand. the sand creates a lot of dust.
- So much that, in most cases, the repair and maintenance on the engines can not take place during the sandblasting operation.
- An alternative to sandblasting is the use of high pressure water, which is far superior from an environmental perspective.
- The paint residuals can be collected in a controlled way by vacuuming it directly during the removal process.

SAND BLASTING OPERATION AND MACHINE

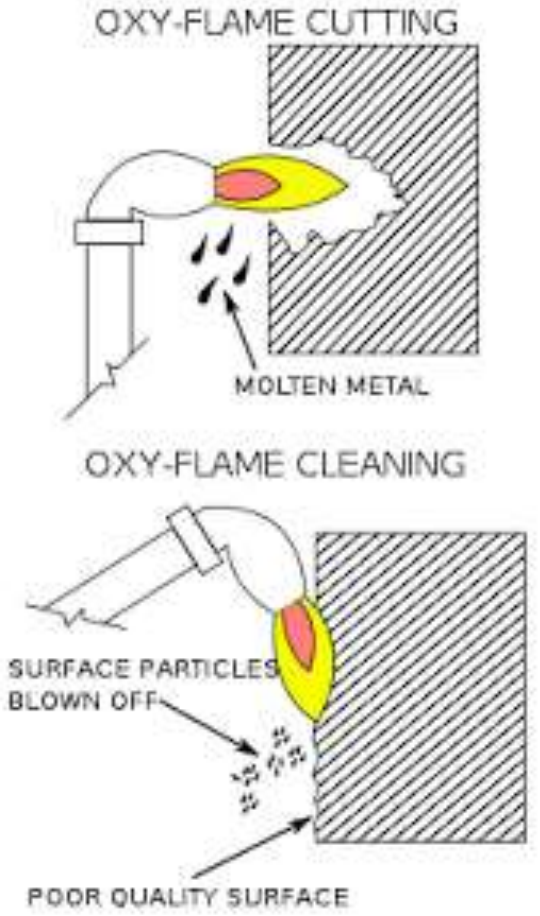
- The abrasive is stored in the pressure vessel then sealed.
- It is metered into the blast hose and conveyed by the compressed gas through the blast nozzle.
- It is typically used to create a surface profile when the frictional heat of dry blasting would damage the part.

ATMOSPHERIC CORROSION MILL SCALE

- **Mill scale**, often shortened to just **scale**, is the flaky surface of hot rolled steel, consisting of the mixed iron oxides iron(II) oxide (FeO), iron(III) oxide (Fe_2O_3), and iron(II,III) oxide (Fe_3O_4, magnetite).
- Mill scale is formed on the outer surfaces of plates, sheets or profiles when they are being produced by rolling red hot iron or steel billets in rolling mills.[1] Mill scale is bluish-black in color. It is usually less than 0.1 mm (0.0039 in) thick, and initially adheres to the steel surface and protects it from atmospheric corrosion provided no break occurs in this coating.

- Because it is electrochemically cathodic to steel, any break in the mill scale coating will cause accelerated corrosion of steel exposed at the break.
- Mill scale is thus a boon for a while until its coating breaks due to handling of the steel product or due to any other mechanical cause.
- Mill scale becomes a nuisance when the steel is to be processed. Any paint applied over it is wasted, since it will come off with the scale as moisture-laden air gets under it.
- Thus mill scale can be removed from steel surfaces by flame cleaning, pickling, or abrasive blasting, which are all tedious operations that consume energy.
- This is why shipbuilders and steel fixers used to leave steel and rebar delivered freshly rolled from mills out in the open to allow it to 'weather' until most of the scale fell off due to atmospheric action.
- Nowadays, most steel mills can supply their product with mill scale removed and steel coated with shop primers over which welding or painting can be done safely.

FLAME CLEANING

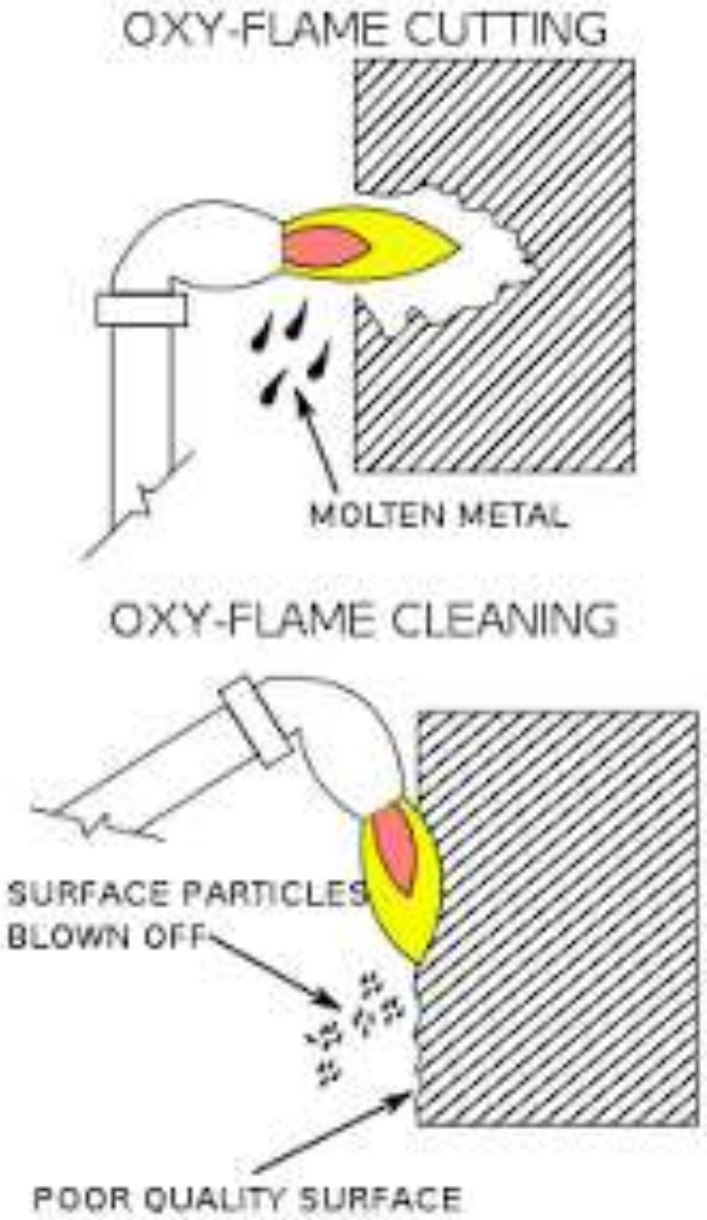


WHAT IS FLAME CLEANING ?

- **Flame cleaning**, also known as **flame gouging** is the process of cleaning a structural steel surface by passing an intensely hot oxyacetylene flame over it.
- Mill scale and rust are removed by the reducing effect of the flame and the action of the heat, leaving the surface in a condition suitable for wire brushing and painting.

- There are many uses for flame cleaning rather than just to remove rust and mill scale.
- It is also used as a removal tool for paints, bad welds, burrs, mechanical wear (scraping, cuts, gouges and more) along with other surface imperfections.
- The process of flame cleaning is not anything new and does not require any extra equipment than what would be found in a typical metal shop.

- It is just an oxygen-fuel torch that is used parallel with the surface to melt and blow off any blemishes that the operator wants to eliminate.
- Shown in the adjacent diagram, the surface is blasted with the oxygen-fuel torch across the surface versus the orthodox use of the flame as a cutting or gouging tool.
- Though the equipment is the same, the flame used in cleaning is drastically reduced to prevent excess removal of the surface. Various kinds of fuel can be run with the oxygen, for example acetylene.



- Various surfaces can be cleaned using this process.
- The oxy-flame can work on assorted surface qualities and remove some of the hardest to clean substances such as lubricants and grease.
- Ceramics, steel constructions, offshore systems and even concrete elements can all be cleaned.
- The function of cleaning can be thoroughly accomplished, the general aesthetic look is damaged due to the burn marks by the oxy-flame.
- The surface is then ready for further processing such as painting, grinding or any other further operation

AIR HAMMER & HIGH PRESSURE WATER BLASTING

ACID PICKLING

What Is Pickling?

- Pickling is a metal treatment process that removes superficial impurities from metal.
- It’s called “pickling” because it involves the use of an acidic solution known as pickle liquor.
- The exact composition of the pickle liquor varies depending on the type of metal on which it’s used.
- For low-carbon steel, pickle liquor typically consists of hydrochloric or sulfuric acid. For high-carbon steel, on the other hand, pickle liquor typically contains additional acids like phosphoric and/or nitric acid.

ACID PICKLING PROCESS

- Pickling is performed by submerging metal in pickle liquor. After working a piece of metal, the manufacturing company will submerge it in the acid solution.
- The pickle liquor will then eat away at any oxide or other impurities lingering on the surface of the metal.
- In addition to pickling, there are other ways to descale and clean metal. Smooth clean surface is an alternative treatment process that offers similar benefits.
- With smooth clean surface, metal is exposed to an abrasive compound that physically removes surface imperfections and impurities.
- There’s also abrasive blasting, which involves blasting metal with a pressurized stream of an abrasive solution to create a clean and smooth surface.

What is air hammer?

- An air hammer, also known as an air chisel, is a pneumatic hand tool used to carve in stone, and to break or cut metal objects apart. It is designed to accept different tools depending on the required function

How does an air hammer works?

- The **air hammer** utilizes an internal piston (or **hammer**) that is actuated by the compressed **air** (or other gas) flow inside the drill string. The internal piston moves up and down in a chamber under the action of **air** pressure applied either below or above the piston through ports in the inside of the **air hammer**.

ADVANTAGES OF PICKLING

- The presence of this oxide prevents the steel from obtaining a smooth and clean surface.
- Although there are numerous ways to remove oxide from steel, manufacturing companies often prefer pickling because of its simplicity.
- When pickled, the acidic pickle liquor eats away at the oxide layer without harming or otherwise disturbing the underlying steel.
- Even if a piece of metal doesn’t have oxide on its surface, it probably still contains some impurities.
- It’s not uncommon for newly produced metal to contain inorganic compounds like trace metals.
- Depending on the application for which the metal is intended, these impurities may hinder its performance.
- Pickling, however, can remove most impurities thanks to the acidic properties of pickle liquor.

Applications

- **Air Hammer** is light weight, strong impact, can make it competent for a variety of operations, whether it is cutting, punching, chiseling, or rust. Applicable to the sand industry, playing sand, removal of burr, iron thieves, building drilling, auto repair and maintenance industries.

HIGH PRESSURE WATER BLASTING

- **Water blasting**, commonly known as **hydro blasting**, is a widespread abrasive water discharge operation.

- As such, it is very successful because of its powerful blasting effect. In most cases, because of its efficiency, **water blasting** will require only one operator for a given application.

- Pressure and Flow both play key roles in efficient **high pressure water blasting machines**, and applications respond differently to each variable.

Construction

- **High pressure water blasting equipment** consists of bare pump, electric motor and starter, pressure regulating valve, safety valve and pressure gauge.
- Other accessories include suction hose, delivery hose, foot valve/gun, nozzles, rigid lance and flexible lance.

APPLICATIONS

- Paint removal from ships
- Water jet cutting
- Concrete surface preparation
- Surface preparation
- Tank cleaning
- Heat exchanger tube cleaning & pipe cleaning
- Vessel cleaning
- Deburring
- Ship hull cleaning
- Cleaning of rotary kiln, agitators, riser ducts, turbines, cooling towers, pump impellers filters and hoppers, mixers, ship hulls, conveyers, etc.

Advantages

- Reduction of plant downtime,
- Labor saving,
- Plant protection,
- Water conservation,
- No need of chemicals and non hazardous.

Shipboard paint system-Boot top and Corrosive paint

What is corrosion?

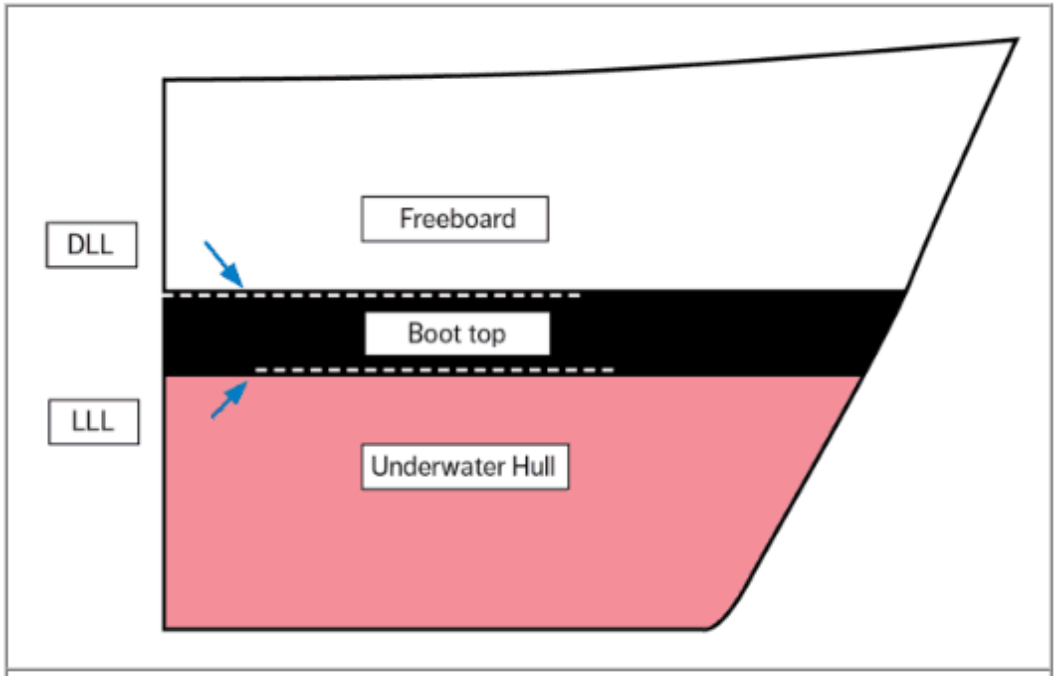
Corrosion is a natural process that converts a refined metal into a more chemically-stable form such as oxide, hydroxide, or sulfide. It is the gradual destruction of materials by chemical and/or electrochemical reaction with their environment.

Corrosion in boot top area

- The boot top is defined as the black area between the minimum load waterline and 12 inches above the maximum load waterline.
- This area can be immersed in seawater and exposed to the topside weather environment.

Reason for corrosion in Boot top area

- Boot top area is being exposed to the atmosphere and immersed in seawater alternatively during ballast and cargo condition of the ship respectively.
- due to this immersion in seawater and exposure to UV rays of the sun, it is most susceptible for corrosion and marine growth on this particular area of the ship's hull.
- Therefore special coating of paint is being used in these areas.



Paint layers specified on FREEBOARD:
Top – Gray amine-cured polysiloxane, 5-8 mils DFT
Gray AC polyamide/polyamidoamine-cured epoxy, 4-8 mils DFT
Bottom – Red AC polyamide/polyamidoamine-cured epoxy, 4-8 mils DFT

Paint layers specified on BOOT TOP:
Top – Black AF polyamide cuprous oxide coating, 4-6 mils DFT
Black AF polyamide cuprous oxide coating, 4-6 mils DFT
Red AF polyamide cuprous oxide coating, 4-6 mils DFT
Gray AC polyamide/polyamidoamine-cured epoxy, 4-8 mil mils DFT
Bottom – Red AC polyamide/polyamidoamine-cured epoxy, 4-8 mils DFT

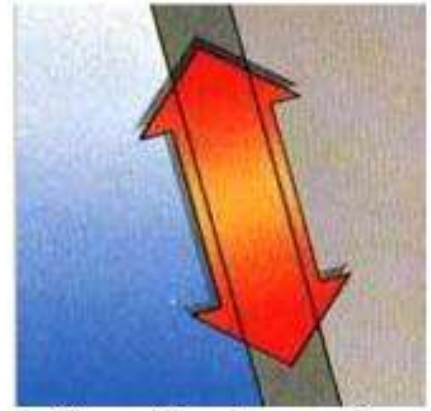
Paint layers specified on UNDERWATER HULL:
Top – Red AF polyamide cuprous oxide coating, 4-6 mils DFT
Black AF polyamide cuprous oxide coating, 4-6 mils DFT
Red AF polyamide cuprous oxide coating, 4-6 mils DFT
Gray AC polyamide/polyamidoamine-cured epoxy, 4-8 mils DFT
Bottom – Red AC polyamide/polyamidoamine-cured epoxy, 4-8 mils DFT

Paint to protect corrosion

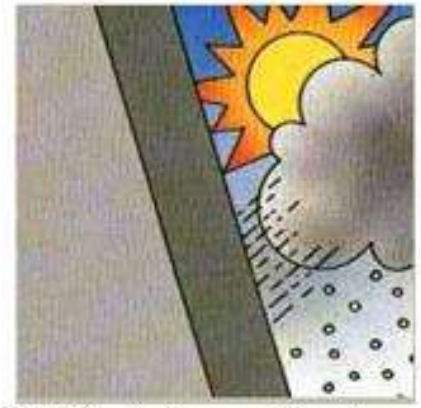
- Protection by Means of Paints : It is often assumed that all paint coatings prevent attack on the metal covered simply by excluding the corrosive agency, whether air or water. This is often the main and sometimes the only form of protection; however there are many paints which afford protection even though they present a porous surface or contain various discontinuities.
- For example certain pigments in paints confer protection on steel even where it is exposed at a discontinuity. If the reactions at the anode and cathode of the corrosion cell which form positive and negative ions respectively, are inhibited, protection is afforded. Good examples of pigments of this type are red lead and zinc chromate, red lead being an anodic inhibitor, and zinc chromate a cathodic inhibitor. A second mode of protection occurs at gaps where the paint is richly pigmented with a metal anodic to the basis metal. Zinc dust is a commercially available pigment which fulfils this requirement for coating steel in a salt water environment. The zinc dust is the sacrificial anode with respect to the steel.
- Anti-fouling paints offer protection against vegetable and animal growth which can lead to increased resistance requiring additional power, hence fuel, to maintain the same speed. The greater the time spent at sea the less the fouling; but areas of operation and seasons also decide the amount of fouling, and with modern anti-fouling compounds the problem today is less important.

Adhesion

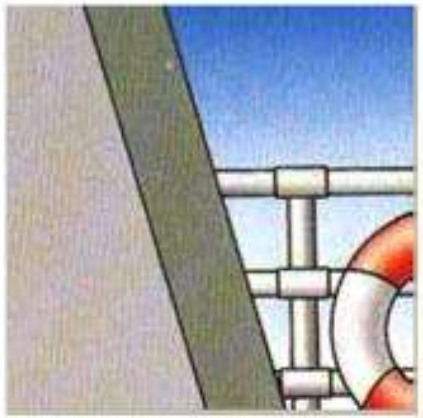
Pliability and elasticity



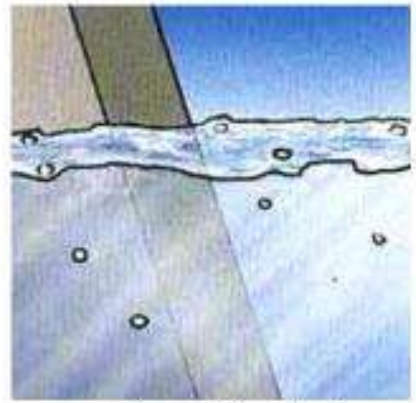
Tensile strength



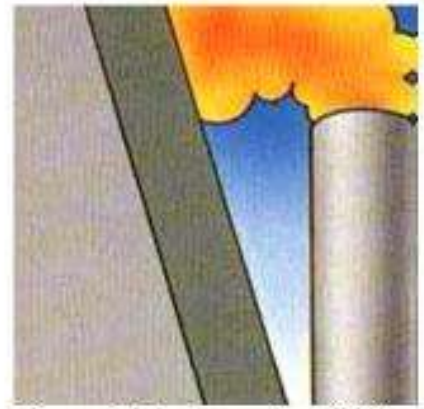
Artificial weathering



Resistance to salt fog



Immersion Resistance and water permeability



Resistance to SO_2

Figure 1. Coating, protecting from corrosion

Paints used in Boot top area of ships

- Chlorinated rubber
- Epoxide
- Oleoresinous

Top - Black AF Polyamide cuprous oxide coating 4-6 mils DFT

Red AF Polyamide cuprous oxide coating 4-6 mils DFT

Grey AC Polyamide/Polyamidoamine-curred epoxy 4-8 mils DFT

Bottom - Red AC Polyamide/Polyamidoamine-curred epoxy 4-8 mils DFT

ALKYD

- *An alkyd is a polyester modified by the addition of fatty acids and other components. They are derived from polyols and a dicarboxylic acid or carboxylic acid anhydride and for protection of steel exposed to relatively mild environments.*
- Alkyd paints are made from alcohol and acid with the addition of fatty acid or oil. The addition of fatty acid and/or oil can be varied to give alkyds with different properties.
- Instead of pigment suspended in oil, alkyd paints are typically formed by an alkyd resin dissolved in a thinner.
- Most commercially available “oil-based paints” are made with pigment suspended in a solution of an alkyd resin and a petroleum-based solvent such as naptha.

ALKYD COMPOSITION

- Alkyd coating composition comprising an alkyd resin, a modified vegetable oil, a drying agent and an organic solvent, characterized in that it further comprises a peroxide compound in the amount of 0.25 to 2.0 wt.h.
- When the total content of all components, wt. hours : alkyd resin, modified vegetable oil, based on 100% resin 100,0, desiccant 2,0-6,0, peroxide organic compound 0,25-2,0, organic solvent 70,0-100,0.
- The technical result - the provision of the necessary hardness of the coating, reduce the time of curing and receiving light paint compositions

BITUMEN

- Bitumen Paint is a mixture of bitumen with white sprit including stabilizer additives and viscosities stuff.
- Bitumen paint is used for painting of concrete, cement, wood and steel structure.
- The bitumen paint is used as prime coat and sealant.
- Bitumen paint on steel is fast drying bitumen, solvent based, and full-bodied bituminous paint providing an effective waterproof, weatherproof and corrosion resistant protective coating.

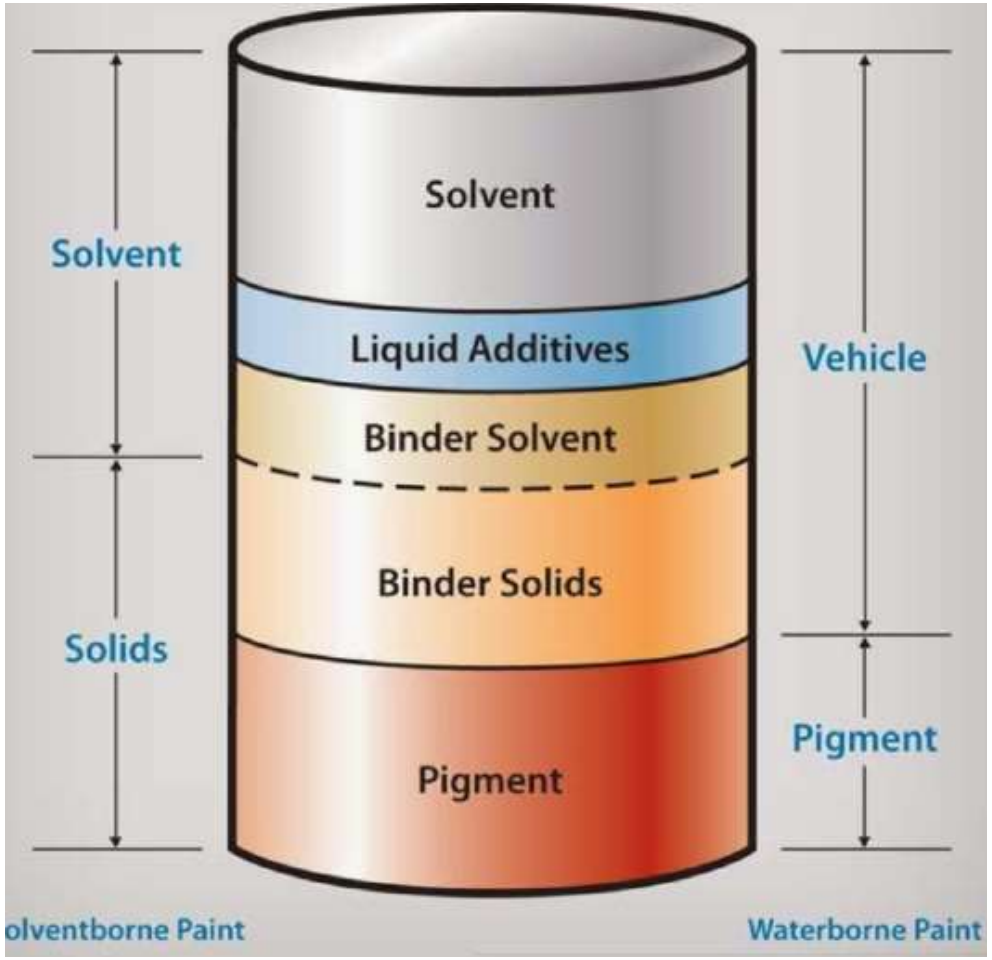
COMPOSITION OF BITUMEN

- Molecular weight wise, bitumen is a mixture of about 300 - 2000 chemical components, with an average of around 500 - 700.
- Elementally, it is around 95% carbon and hydrogen (± 87% carbon and ± 8% hydrogen), and up to 5% sulfur, 1% nitrogen, 1% oxygen and 2000ppm metals. Bitumens are composed mainly of highly condensed polycyclic aromatic hydrocarbons.
- They also contain several elements, a number of which are toxic.

UNIT 3

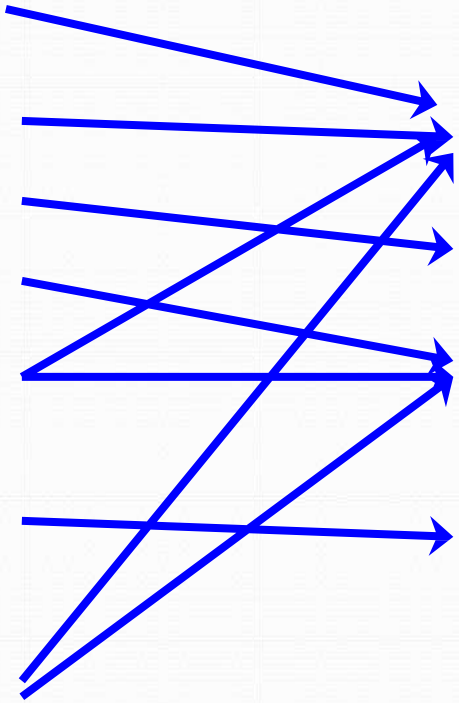
PAINTS

- Paints are the chief material used on board ships for corrosion prevention.
- There are different types of paints available as per requirements and place of application on ship.
- Paints when applied on a structure create barrier between the structural surface and corrosion causing phenomenon.



The role of coatings is to protect against corrosion each part of ships, which are continuously exposed to severe conditions, i.e. sea water immersion, splashes of sea water, UV rays maintain the value of the assets ensure vessel safety protect cargoes, e.g. grain or liquids

- Water ballast tanks
- Under water hulls and sides
- Cargo tank linings
- Cargo holds
- Boot-topping and splash zones
- Topsides and external superstructures
- Offshore oil drilling platforms



Key Performances requirements

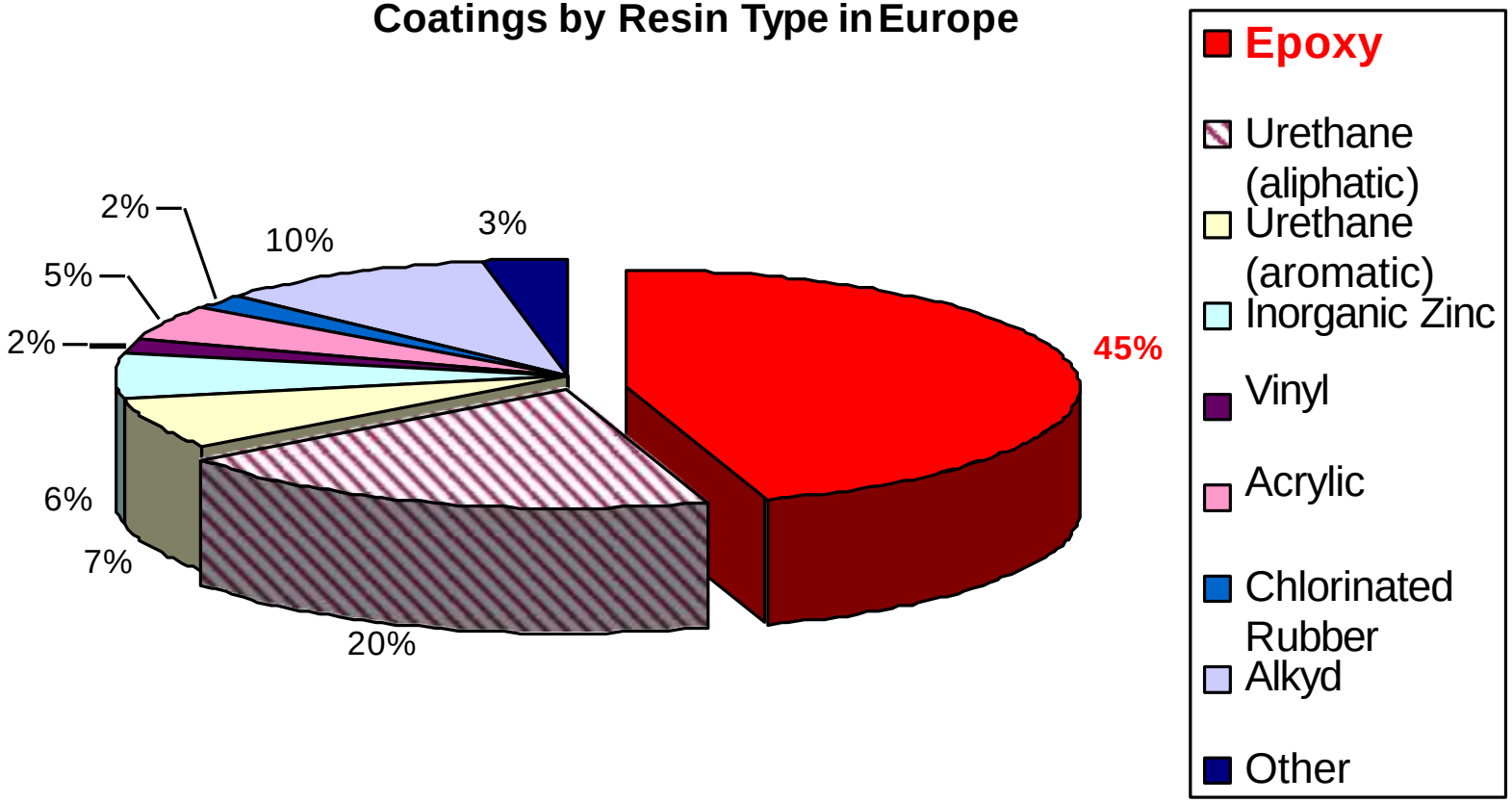
Resistance to corrosion

Chemical resistance

Mechanical resistance, e.g. abrasion

Weatherability

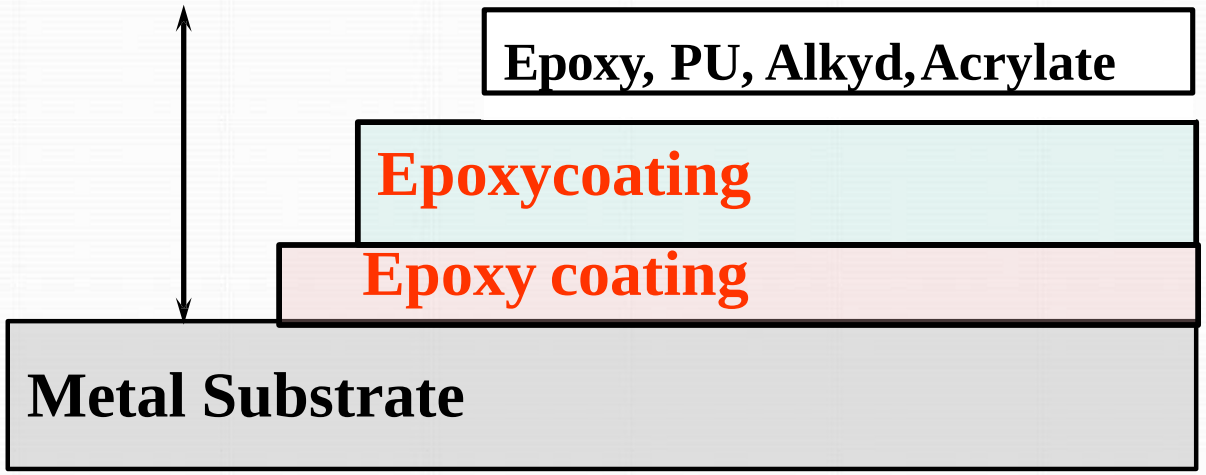
Consumption of High-Performance Anticorrosion Coatings by Resin Type in Europe



Source: SRI report 2001

- Epoxy Resins are essential raw materials for Marine & Protective Coatings.
- Epoxy systems offer an outstanding balance between performances [durable corrosion protection] and costs.

- **Top Coat:** Appearance & Protection against UV-light
- **Mid Coat:** Barrier Protection effect. Intercoat adhesion
- **Primer:** Corrosion protection & Adhesion



Aliphatic Diisocyanates

Importance of Marine Coatings

A wide variety of ships around the world rely on coatings technologies that use ADI chemistry as a key component.

Polyurethane coatings are used on commercial and leisure craft, as well as heavy offshore structures such as oil rigs, tanker platforms, pipeline and storage facilities.

Coatings made with ADI provide important benefits including:

- Maximum colour and gloss retention
- Excellent weather resistance i.e., resistance to yellowing, chalking or degradation by sunlight
- Outstanding water, solvent, oil and chemical resistance (helps prevent corrosion)
- Excellent abrasion and impact resistance (the ship's hull flexes with stress; it is normal for the vessel to have contact with docks, or other structures and equipment used to access the vessel)
- Superior application properties i.e., fast-drying, so a ship in dry-dock can be serviced more quickly

- These coatings are generally spray-applied and workers are required to wear appropriate personal protective equipment during application to protect themselves from inhalation and other potential hazards.
- There are a variety of paint and coatings technologies used by the marine industry to meet customer requirements and government regulations.

CONSTITUENTS OF PAINTS

- Binder (Sometime the binders are termed as vehicle, medium, resin, FILM former or polymer)
- Pigment and Extender
- Solvent

- Binder and the pigment in the paint form the dry paint FILM.
- Solvents in the paint help in the application of the paint.

SOLVENTS

- Solvent is a medium where the binder, pigment and additives are dispersed in molecular form (true solution) or as colloidal dispersion (sols or emulsions).
- A solvent is usually a liquid but can also be a solid, a gas or a superficial fluid (a substance above its critical point).
- A solvent may be water or organic liquid. Solvent like thinner is used for viscosity modification of the paint mixture which helps for application with tools such as rollers, brush, spray tins, etc.

There are two (2) important characteristics of solvent which includes:

1. Ability of dissolution of the combined ingredients.

2. The rate of evaporation of the solvent.

Some major examples of solvent used in the coating industry includes:

Water – (H2O), it is regarded as a universal solvent.

Ketones - is an organic solvents, which is denoted by the presence carbonyl group (C=O) as the functional group.

Xylene - is an aromatic solvent with two methyl group appended to a benzene ring structure in its molecule (C6H10(CH3)CH3)

White Spirit (Turpentine) - is a mixture of saturated aliphatic and alicyclic hydrocarbons.

Alcohols (n-butanol, isopropanol): are organic compounds having hydroxyl groups (-OH) bound to the carbon atoms of an alkyl group.

There are other solvents too but the ones mentioned have consistently been used in the coating industry space.

BINDERS

- Binders (Resin)
- Binders are polymers (resins) forming a continuous film responsible for firm adhesion on the substrate surface. They are the major ingredient of coatings. The binder holds the pigment particles distributed throughout the coating. The binder is dispersed in a carrier (water or organic solvent either in molecular form (true solutions) or as colloidal dispersions(emulsions or sols).
- Some major examples of Binders (Resins) used in the coating industry includes:

- Binders determine the physical and chemical characteristics of the paint coating. Binder can be of liquid type, solid type or solid type with curing agents.
- Paints are generally named after their Binder component. For Example: Epoxy Paints, Chlorinated Rubber Paints, Alkyd Paints etc.

Binders are generally classified into two classes

- **Convertible Binders**
- **Non-Convertible Binders**

Convertible Binders

Convertible binders are associated with chemical reaction and work in two stages

Stage 1

- Solvent is lost from the film by evaporation and the film becomes dry to the touch.

Stage 2

- The film progressively becomes more chemically complex by:
- Reaction with atmospheric oxygen
- Reaction with an added chemical curing agent
- Reaction with moisture in the atmosphere.
- Artificial heating
- Solar Heating.

Non convertible binders

- Non-Convertible binders do not involve any chemical reaction, but loss of solvent by evaporation.
- Simple solutions of various resins or polymers are dissolved in suitable solvent(s). Drying of paint is by solvent evaporation and there is no chemical change.

Binders which are in this category are:

✓Chlorinated Rubber

✓Vinyl

✓Bituminous

✓Cellulose