CLASSIFICATION OF VARNISH-AND-PAINT MATERIALS

Various industries use a wide range of varnish-and-paint materials. This is due to complex and diverse operating conditions of metal structures and technical facilities, as well as a variety of corrosive environment and other factors.

Coating materials can be classified into several categories:

- By type;
- By preferential destination area;
- By type of film-forming substances.

By type of paints coating materials are divided into varnishes, paints, powder coatings, primers, putties and enamels.

Depending on the purpose of usage, coating materials can be divided into 9 groups:

1. Weather-resistant;
2. Limited weather-resistant;
3. Preservation material;
4. Water-resistant;
5. Special;
6. Oil-resistant;
7. Chemically resistant materials;
8. Heat-resistant;

By type of film-forming substance coating materials are divided into more than 40 groups, from which only the following materials are used in anticorrosive practice:

- EP - epoxy;
- PUR - polyurethane;
- AK - alkyd;
- AY - acrylic;
- PVC - polyvinyl chloride;
- CR - chlorinated rubber;
- ESI - ethyl silicate;
- BIT - bitumen;

Many manufacturers write their material identification in the following order:

- Type of varnish-and-paint material;
- Film-forming substance designation;
- Identification of the predominant group of destination;
- Sequence number, assigned to this coatings;
- Verbal or numerical color identification.
PRIME COATINGS

Coating materials of this type are applied to the protected surface on the basis of the necessary protection systems, which consist of several layers of primers and enamels. The first layer of such system is usually the primer, the main purpose of which is to ensure good adhesion to the substrate and subsequent coating layers, as well as increasing anticorrosive properties of paint.

Primers are divided into five main groups:
- Isolating;
- Passivating;
- Phosphating;
- Protector protection;
- Rust modifying agents.

The isolating (or non-reactive) primers are created on the basis of inert pigments (oxides of iron, zinc, titanium, etc.). They are designed to improve adhesion and create a mechanical barrier to the penetration of corrosive atmospheric constituents and removal of the corrosion products.

Passivating primers produce on the metal surface adsorptive or passive phasing layers, which are lead to slower corrosion process. The water permeating through the coating to the metal partially dissolves pigments (zinc chromate, barium, strontium and other metals, phosphates, chromium, zinc, etc.) which are contained in the primer layer. This forms a solution having passivating properties in a certain concentration.

Phosphating primers form a phosphate film on the metal, which improves the adhesion of the coating and promotes the passivation of metal. The primer formulations always contain phosphoric acid, which in case of inaccurately proportioning may contribute to corrosion of the metal and cause destruction of the first coating layers.

Protector protection contains metal particles having an electronegative potential and performing the function of sacrificial anodes, i.e. having dissolved, they electrochemically protect the metal under the coating film. Very fine zinc powder is usually used for this purpose.

Rust modifying agents are used in case when it is impossible or not economically feasible to clean completely the painted metal surface from corrosion products. This type of primer coating reacts with the hydrated metal oxides, which promote the formation of insoluble and inactive compounds against corrosion. However, in most cases, the coatings obtained with the usage of rust modifiers agents without removing the corrosion products from the surface are inferior in protective properties to a coatings applied to a well prepared surface.
FILLER PASTES

Putty is a thick paste, consisting of a film-forming bases, fillers and pigments. They are used to eliminate irregularities and correction such defects as dimples, blisters or scratches on the surface to be painted.

Fillers unlike primers and enamels contain a small amount of film-forming bases, the dosage of which requires close monitoring. With an excess of bases the putty polished badly, with a deficiency - it becomes brittle, less water-resistant. Chalk, talc, lithopone, iron oxide pigments are usually used as fillers for putties.

ENAMELS AND PAINTS

After priming and filling (if the latter is provided in the coating system) the subsequent layers of coating are applied. Top coating layers are selected depending on the operating conditions and the desired design of the product, taking into consideration the nature of the material of the lower layers. In accordance with the purpose of coatings various in type and chemical nature paints and enamels are used.

There is no clear distinction between enamels and paints. Enamels usually are called as a suspension of pigments or their mixtures in a solution of a synthetic film-forming substance, which after drying creates an opaque solid film with a different gloss and surface texture. If oil-varnish, oil or dispersions are used as film-forming substances, such material is referred to the paints.

A variety of external factors affecting the coverage, and their combinations lead to the need for usage the plurality of coating systems that meet specific conditions.

FILM-FORMING PROCESS

The formation of a solid paint coating from liquid ones usually occurs due to several factors:

- Physical process of evaporation of solvents (chlorinated rubber, vinyl, vinyl-chloride copolymer materials);
- Chemical curing reaction using the low molecular weight crosslinking agents (epoxide, polyurethane);
- Chemical oxidation reaction of conjugated with double bonds oxygen (alkyd materials).

Chemical reactions usually occur simultaneously with the physical process of solvents’ evaporation.

No matter what processes underlie the film formation, their external manifestation is gradual or abrupt increase in the viscosity of the material. If the starting material was liquid, at a certain stage of the process it becomes viscous and finally acquires the properties of a solid vitreous body.

Film formation in which there are no chemical transformations (film is formed only by physical processes), determines the preparation of reversible (thermoplastic and soluble) coating. In many respects the properties of the film material correspond to the initial film-forming properties. In these case polymers of amorphous or crystal structure: vinyl, acrylic, polyamides, cellulose esters and others are advantageously used.

Depending on the chemical nature of the film-forming agent, its solubility and thermoplasticity are obtained coatings from solutions, melts, water and organic dispersions aero dispersions (powder systems).
More than 90% of industrial paints and varnishes contain solvents. Therefore, film formation from solution, which is associated with the removal of the solvents from their composition, is spread in the art of coatings. The solvents are usually removed by evaporation.

**From the kinetic point of view the evaporation of solvents can be divided into two stages:**

1. The evaporation from the liquid film the speed of which is proportional to the difference in vapor partial pressure above the solution in the environment;
2. The evaporation of the formed film, the speed of which is controlled by diffusion of solvent within the film.

   The speed of the first stage increases with decreasing temperature and relative air humidity. In a second step the speed increases in case of increasing the air velocity near the painted surface and increasing temperature.

In forming coatings from solution, as in any liquid coating materials, there are two states of films: dust-free drying when the film loses tackiness and practical drying when the coating takes the hardness required for the subsequent use of the products. Time for dust-free drying is generally correlated with the duration of film evaporation by approximately in 60% solvents types, while dissolving the coating material on the surface is stopped even at evaporation of 25-30% of solvent. The completion of the coating formations is usually judged by their hardness, stickiness, and electrical parameters.

Naturally formed coating always contain a certain amount (0.1-2%) of residual solvents, which are often stored for a long time, adversely affecting the properties of the coatings and lead to deteriorate operating conditions of colored rooms. These defects occur in the case of usage very volatile solvents and can be avoided by using less volatile solvents.

Film formation which is effected by chemical transformation involves chemical reaction with the monomers or oligomers in a thin layer on the substrate. As a result of this fact the formation of branched linear or spatially-linked polymers is appeared. Such coatings are usually irreversible.

The duration of the coatings formation is determined by the rate of chemical reactions and their properties – by the degree of completion of the process.

Coatings are formed at positive temperature, the rate of curing increases with the temperature.

The physic and mechanical characteristics and chemical resistance of such coatings are usually high, especially in the case of obtaining a barrier material with a three-dimensional spatial structure.

Chemically curing coating materials are made from two or more components immediately before the usage. Also, such coatings typically contain a minimum quantity of solvents and they can be applied in a wide range of thicknesses. Epoxy and polyurethane coatings are commonly used from chemically curable coatings.

The initiator of polymerization is oxygen of the air in the alkyd paints and varnishes. This is due to the special structure of the chain of such monomers and oligomers, and accordingly a high activity of conjugated double bonds in the radical addition and substitution reactions. Crosslinking of molecules occurs via oxygen bridges, wherein the upper portion of the films is always richer in oxygen.
than the lower. By the time, when the coating forming is finished, the degree of double bonds never reaches 100%, so the film is capable to reaction, and the process of oxidative polymerization proceeds during the coating operation. This explains the gradual increase of the hardness of alkyd coatings in use. When exposed to sunlight the process accelerates by initiating the formation of free radicals by ultraviolet radiation.

To speed up the curing process in coating materials are used accelerators of free radicals generating - driers, as well as energetic, photochemical, radiation initiation methods. To ensure uniform cure on the whole thickness of surface one should avoid application of thick coating layers.

Alkyd materials contain large amounts of solvents, so during the film formation the oxidative polymerization process proceeds simultaneously with the process of physical evaporation of the solvent.

The choice of coating materials for different operating conditions

The main factors which have impact on the choice of coating materials for coloring concrete designs and products are the peculiarities and environmental parameters.

Coating materials are usually divided into weather-resistant, waterproof and resistant to aggressive conditions of usage. Under the special environments we imply the impact of oil and oil products, various chemicals, bio-active environments, and the environments with high temperature operating conditions.

However, it is not enough to rely only on the type of environment; you must consider a number of operational, technological and economic factors, which include the following ones:

- Material of the object;
- required durability of the coating;
- Maintenance ability;
- Compatibility with other protection techniques (e.g., cathodic protection);
- adaptability of material`s application;
- Decorative requirements;
- The required degree of surface preparation;
- Fire safety and explosion-proof requirements;
- Hygiene requirements;
- Economic feasibility.

In each case, experts consider, as a rule, several options for coatings, combined advantages and disadvantages and choose the best option.

The main types of paints: their properties, the preferred areas of application, advantages and disadvantages are represented below.

EPOXY MATERIALS

Epoxy paints are almost always two-component. The epoxy resins which are linear polyether usually are used as a base for epoxy materials. Molecular chains of these polyesters comprise reactive epoxy groups on both ends, and secondary hydroxyl groups along the chain.
The formation of spatial polymers (resin curing) occurs as a result of crosslinking linear molecules when they interact with organic nitrogen-containing compounds (hardeners). During the reaction, the curing of the resin is appeared, after that its conversion occurs to the insoluble, infusible three dimensional structure of the compound without isolating the reaction byproducts. That is why there is only a slight shrinkage of the coating.

One of the most promising materials is coating that does not contain solvents. They are prepared based on liquid epoxy resins. To reduce the viscosity the reactive diluents are used, which give the coating material paint properties without the use of volatile solvents. It is especially important to use solvent-free paints when you need to color tanks and other confined spaces. This can significantly reduce the toxicity of the material, as well as increase fire safety and explosion-proof qualities.

Coatings based on epoxy resins have good adhesion to metal, wood and other materials, high hardness and chemical resistance, excellent water resistance; they are resistant to oil and oil products.

The disadvantages of pure epoxy coating materials include the following factors:
- Lower temperature is limited when apply the coating (not below 10°C)
- The need for careful preparation of the surface,
- Two-component material,
- limiting the viability after mixing (for some materials at least 1 hour)
- Tendency to chalking under the influence of solar radiation,
- The need for matting in the case of applying subsequent layers after a certain period of time.

To reduce the cost sometimes epoxy materials are used in conjunction with various bitumen, yielding epoxy-coal materials.

To solve the temperature limit of application of epoxy materials they are modified by other substances, for example, a copolymer chloride-vinyl resins. In modified epoxy material the lower temperature limit is decreased to -5°C and below. If necessary, special additives can also be administered, which help to reduce the requirements for surface preparation to a 2-813 degree.

**POLYURETHANE MATERIALS**

Polyurethane materials such as epoxy ones, often are two-component. This is the reaction products of polyols and polyisocyanates. In recent years, it began to be widely used rather one-part polyurethane, which are curing with the help of atmospheric moisture. Their using is most justified in areas with high humidity.

By resistance to aggressive substances (gases, acids, alkalis, solvents, including aromatic) polyurethanes are superior to many coatings. Materials based on polyurethanes have excellent gloss, very high abrasion resistance and weather-proof, including UV radiation exposure. Polyurethane coatings can be applied at lower temperatures than epoxy ones.

The disadvantages of polyurethane coatings include the two-component structure, the complexity of application, causing toxicity, high cost.
ALKYD MATERIALS

Despite the systematic expansion of the range of coatings, alkyd materials retain a leading position because of their volume of production and use. Alkyd resins are called polyesters of branched structure, which are the reaction products of polybasic alcohols, polybasic acids and fatty oils. To impart solubility and increase water-resistance and elasticity to alkyd resins and coatings which are based on these materials they are modified with plant oils or fatty acids. Alkyd paints are most often one-component. Sometimes, to accelerate drying and curing it is recommended to enter a desiccant into their composition before usage. The cost of alkyd materials is significantly lower than epoxy and polyurethane ones; they do not require a careful surface preparation. Alkyd coatings have a sufficiently high weather resistance, flexibility, good adhesion to materials and wood, concrete and high interlayer adhesion. Disadvantages of alkyd materials include low resistance to water and chemically active environments, relatively large drying time (24 hours at 20°C), the need for drying at a temperature higher than 5°C.

ACRYLIC MATERIALS

In recent years acrylic coatings are widespread all over the world. This type of coating is created by polymerization of acrylic and methacrylic acids or their derivatives. They are used in the form of solutions, aqueous and organic dispersions. Coatings based on acrylic copolymers have high weather- and lightfastness. These materials are flexible, resistant to shocks, have good adhesion to the painted surface. Acrylates of stoving are usually used as high-quality decorative coatings. The disadvantages of acrylic paint materials include low solvent resistance, low dry residue (50%), and small thickness of a single-layer coating (20-30 micron). Materials based on vinyl chloride copolymers There coatings that are based on copolymers of vinyl chloride and vinyl acetate are widespread in the world. Copolymer which contains 85% vinyl chloride has about nine molecules on every one molecule of chloride-vinyl acetate. This improves the solubility of the resin, as the solubility of the copolymers increases with the increase of vinyl acetate content. Coatings derived from a copolymer of vinyl chloride with vinyl acetate, have water, chemical resistance and weather resistance, mechanical strength and high elasticity. These materials are of physical cure, so they can be applied at low temperatures. The positive qualities are rapid drying (1-3 hours), and a single-component structure. To increase chemical resistance of coating materials based on vinyl chloride copolymers, they are modified with epoxy resin. These coatings are resistant to the aqueous medium, alkalis and acids and can be used in industrial and marine atmosphere. The temperature of application is between minus 10°C to plus 35°C.
Disadvantages of vinyl chloride copolymer materials include low dry residue (30-45%), small thickness of a single coating (40-50 microns), low resistance to solvents. They also need careful surface preparation.

**MATERIALS BASED ON CHLORINATED RUBBER**

These materials are most often products of the chlorination of natural or synthetic rubbers in combination with chlorine gas. Because of chlorination the rubber loses its elasticity and can be dissolved in aromatic solvents. Lamination gives the opportunity to create a resistant, elastic coating. To create coatings people used the following proportion: 1-2 parts of plasticizer to 1 part chlorine rubber. Chloroparaffins are most often used as the plasticizer. Chlorinated rubber materials are physically curing.

Chlorinated rubber coatings are water, acid and alkali resisting. Due to the high chlorine content, they have a reduced flammability. These advantages also include a one-component structure, the possibility of applying at low temperatures (down to minus 15°C) and the relatively short drying time between coatings.

The disadvantage of chlorinated rubber materials are the deterioration of physical and mechanical properties under the sunlight, low resistance to solvents and petroleum products, low dry residue (50%), a small thickness of the single-layer coating (50-70 micron), the need for careful preparation of the surface.