Maintenance guidelines
Onboard Maintenance

0. INTRODUCTION

The advantages of correctly chosen and applied newbuilding coating as well as systematic maintenance painting of a vessel can be summarised as follows:

- better appearance
- cleaner and consequently more attractive place of work
- lower paint consumption
- less maintenance requirements
- longer intervals between maintenance jobs
- increased lifetime

and thereby an altogether
- better operating economy

Since 1915 HEMPEL have concentrated on protective coatings used in aggressive environments. During all those years, and especially during the last couple of decades, tremendous developments have taken place within coating materials as well as application technology.

Selecting the best coating for a maintenance job can be difficult, as one single coating may not be able to fulfil all the many different requirements.

The painting systems included in this manual have been selected after a close evaluation of the requirements of your vessel and on the basis of the maintenance policy of your company.

1. MAINTENANCE PLANNING

The protective coatings must be systematically maintained like engines and mechanical equipment.

Weather exposure, mechanical damage and spillage of chemicals will influence the condition of the protective paint film and cause the film to slowly disintegrate.

Preventive maintenance will reduce the extent of corrosion and postpone replacement of steel. Corrosion should not be allowed to develop into severe pittings and rust scale. This is not only on account of the strength and integrity of the structure, but also because it will at best involve a large expenditure to re-establish the performance of the protective coating to near original quality.

Preventive maintenance will involve periodic inspection of all painted surfaces and an estimation of the need for paint treatment.
1.1 Inspection

Divide the surface into smaller areas. Examine each small area according to the checklist below.

- Is the area corroded?
- Is corrosion local or scattered?
- Is the paint peeling off?
- Are peelings local or scattered?
- Is the paint blistering?
- Is the paint system worn?
- Is it local wear or is the system worn down completely?

What may be the causes for the defects?
- Wear and tear?
- Sharp edges, rough welding seams?
- Condensation?
- Insufficient pretreatment due to bad design?

When the examination is finished, type and extent of maintenance can be decided upon:

1.2 Improvement of the construction

If corrosion is caused by sharp edges, uneven welding seams or weld spatter, it may be a good idea before painting to improve the condition of the steel by rounding sharp edges, smoothing welding seams, removing weld spatter and, if possible, establish drainage. Such improvements will extend the lifetime of the paint system.

1.3 Maintenance painting

1.3.1 Touch-up painting

If the paint system in general is in good condition with only local corrosion such as mechanical damage or spot corrosion on edges or welding seams, then touch-up painting is sufficient. An intact paint film will protect the surface even if the film is bleached by the sun.

1.3.2 Touch-up followed by full coats

If the surface is locally corroded and the paint film has disintegrated on large areas, it may be appropriate after touch-up to apply one or more coats over the entire surface. Before painting, all areas are to be thoroughly cleaned.

1.3.3 Total recoating

Regardless of regular maintenance, the condition of the paint system may become so poor that repairs are impossible to carry out with sufficiently good results. In such cases, a full refurbishment must be carried out with professional equipment (grit blasting, airless
application), either during voyage, or if that is not practically possible, in harbour or during drydocking.

2. SURFACE PREPARATION

To obtain a sufficiently good quality of the painting work, the surface must be thoroughly cleaned, and all grease, oil and loose rust scales must be removed before painting.

In the following we shall describe the cleaning methods normally used by the ship’s crew. However, cleaning methods such as wet or dry abrasive blasting and water jetting may be impractical to carry out onboard even though the quality of these cleaning methods is second to none.

Finally, the new paint must be applied in the number of coats and to the full film thickness specified in order to ensure the re-establishment of its protection against corrosion and mechanical damage.

2.1 Surface contamination

2.1.1 Types of surface contamination

Before pretreatment and painting it is important to determine the extent and type of any surface contamination in order to decide upon the correct cleaning procedure.

Four types are commonly found:
- Rust, loose paint
- Oil and grease
- Water-soluble salts, e.g. chlorides from seawater
- Dust

A. Rust
Rust is recognised by its well-known red colour, but can also appear black in e.g. tanks. Rust can also occur under the paint (underrust). In such cases the paint will lift due to the high volume of rust compared to steel - up to 7 times higher. Rust has high porosity, poor strength, often contains soluble salts, and is therefore not suitable for overcoating.

B. Loose paint
Loose paint will cause poor adhesion and will consequently not be suitable for overcoating. Applying new paint on old paint will not improve the adhesion.

C. Oil and grease
Oil and grease can be caused by oil spillage, leakage and soot drops, and in engine rooms by long exposure to oil aerosols. This thin film will impair the adhesion between new and old paint.
D. Water-soluble salts
When located under a paint film, water-soluble salts will have an osmotic effect and will absorb water through the film, resulting in blistering of the paint. Salts, normally chlorides (from seawater) and sulphates (from exhaust gas), in conjunction with water will catalyse corrosion and produce underrust. Water-soluble salts are often transparent crystals and therefore difficult to spot. Exterior areas on ships will always be covered with sea-salt (sodium chloride).

E. Dust
Dust consists of fine particles coming from many sources: loading/unloading, fallout from rain, grinding and other pretreatment, and even spray dust from the painting itself. During application of paint, presence of dust can be a serious problem by preventing contact between new and old paint, and due to its ability to absorb acidic components, resulting in accelerated corrosion.

2.1.2 Removal of surface contamination

A. Degreasing
Oil and grease are most effectively removed by the use of an emulsifying agent. The cleaning agent is applied mixed with water in a suitable concentration depending on the contamination. The mixture is applied on the surface and worked into the greasy areas by means of a stiff nylon cleaning brush. The brush, which must be immersed frequently in the mixture, should be circulated over the area. After 10-15 minutes the cleaning agent has to be carefully removed by fresh water hosing, either by high pressure equipment or by hand.

This method will remove oil, grease, salts and dust in one operation.

Degreasing with cloths soaked in solvent or thinner tends to redistribute rather than remove oil and grease. Only clean cloths may be used and the cloths must be changed frequently.

After degreasing, water must not form beads on the surface, otherwise the degreasing process must be repeated.

B. Removal of salts
Surfaces to be painted must always be washed with clean, fresh water before painting. If the surface is heavily corroded, washing both before and after removal of the rust is recommended. High pressure hosing with fresh water is the most suitable method.

C. Removal of dust
If cleaning with water-soluble agents and/or washing with fresh water is carried out, only dust remaining from grinding or brushing has to be removed. This can be done by vacuum cleaning, by sweeping or air blowing. When the surface does not colour a clean cloth, the surface is clean and ready for painting.
2.1.3 Manual surface preparation

The common standard for control of the cleaning quality is ISO 8501-1:1988. The cleaning degree depends on the requirements for the specific paint to be applied.

A. Needle gun
The needle gun is excellent for removal of rust flakes and heavily rusted paint layers, especially on edges. The surface, however, will be uneven so subsequent grinding will be necessary.

B. Scraping
Scraping is a good method for removal of porous rust layers followed by wire brushing or disc grinding.

C. Machine grinding
Grinding is one of the best methods for removal of rust when abrasive blasting is impossible. This is an effective alternative to the scraping and wire brushing cleaning methods. However, machine grinding does not have the desired cleaning effect when the surface is heavily corroded and pitted. Grooves and pits can only be cleaned efficiently by abrasive blasting.

The recommended grinding materials are detailed in the table below. Whether to use coarse or medium grain size grinding materials depends on the thickness and type of layers to be removed. The last step in the process will in any case have to be medium grain size grinding. The grinding should be performed by moving the grinding machine in parallel, overlapping movements.

Finally, the edges of the intact paint system are “feathered” into the repaired areas to form a smooth appearance.

The table below lists grinding material particle sizes for different tasks:

<table>
<thead>
<tr>
<th>Task</th>
<th>Quality of grinding</th>
<th>Grade</th>
<th>Grindng material</th>
<th>Base material</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rust and mill scale</td>
<td>Very rough</td>
<td>24</td>
<td>Aluminium oxide</td>
<td>Fibre</td>
<td>Sanding disc only</td>
</tr>
<tr>
<td></td>
<td>Rough</td>
<td>40</td>
<td></td>
<td>Heavy duty quality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>60</td>
<td></td>
<td>Open linen</td>
<td></td>
</tr>
<tr>
<td>Paint and edges</td>
<td>Medium</td>
<td>80</td>
<td>Silicon-carbide</td>
<td>Paper, heavy duty quality, open</td>
<td>Sanding disc, Sanding belt</td>
</tr>
<tr>
<td>Paint in good condition</td>
<td>Fine polish and grinding matt</td>
<td>150</td>
<td>Silicon-carbide</td>
<td>Paper, heavy duty quality, open</td>
<td>Sanding disc, Sanding belt</td>
</tr>
</tbody>
</table>

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D. Wire brushing
This method will give a better cleaning of pits than grinding provided that the brushes are sharp. Worn brushes both in manual and power tools are ineffective and will polish instead of removing the rust. Twisted brushes are the best for power tools.
After cleaning the steel must be free from rust to the extent specified and the appearance must be uniform. The overlapping areas to be painted must have a flat appearance ready to receive paint.

2.1.4 Abrasive blasting
Abrasive blasting is the most efficient method for surface preparation. For optimum results, the cleaned surface must be of a plain grey colour - see ISO 8501-1:1988 - or just flash rusted in the case of wet blasting.

Dry open blasting is executed by air pressure propelling an abrasive through a nozzle on to the steel surface. The cleaning effect is obtained by impact from the abrasives.

Wet open blasting in principle works like dry open blasting but a small amount of water is added to the flow of abrasive right outside the nozzle.

Water blasting uses a high pressure water jet as propellant of the abrasive added in the water jet. This method results in a very good removal of rust and salt (by using fresh water), but leaves the surface “flash” rusted. For the normal range of maintenance paints this can be accepted provided the rust is flash rust only.

For smaller areas, vacuum blasting can replace dry open blasting. This is a hand-operated sandblasting machine equipped with a rubber mouthpiece to prevent dust contamination of surrounding areas. Used abrasive will be sucked back into the machine and reused.

The term “abrasive sweeping” is used to describe light abrasive blast cleaning using a fine abrasive. The purpose of abrasive sweeping is to roughen a surface, to remove contamination and salts formed on weathered shopprimers or light rust on previously blast cleaned steel surfaces that have been exposed to showers, etc.

Dust removal is performed by vacuum cleaning or by air blowing, and it must be performed immediately before application of the primer coat.

The surfaces should be so well cleaned that when touching them with a dry, clean cloth, little or no traces of dirt remain.

NOTE - look out for oil contamination in the air used for abrasive blasting and dust removal.

Water jetting yields a high velocity stream of water by forcing pressurised water through a specially designed, small orifice nozzle. No abrasives are used and the surface is left clean and free from contaminants. This method requires plenty of fresh water and specially trained operators.
3. **CLIMATIC CONDITIONS**

Outdoors, the pretreatment must be considered an integral part of the painting procedure, which means that the weather conditions should be sufficiently attractive for the paint to be applied immediately after pretreatment. Therefore, it is inexpedient to carry out the pretreatment during adverse weather conditions when there is a risk of the surface becoming wet or flooded by seawater.

If paint is applied on a wet surface, the result will be poor and the paint will peel off. If paint application is postponed due to poor weather conditions, the pretreatment has to be repeated before application.

### 3.1 Condensation

Special attention must be paid to condensation, which may occur during good weather conditions if the steel temperature is lower than the air temperature. This may be the case if a liquid on the reverse side of the steel (tanks, pipes, etc) cools the surface, or if the temperature of the steel increases more slowly than the air (condensation in the morning).

Normally the steel temperature must be at least 3°C (5°F) higher than the dew point of the air. Use a psychrometer and a dew point calculator to calculate the relative humidity and the dew point. The dew point can also be checked very simply by wiping the (dry) surface with a wrung, wet cloth. If the humidity has evaporated within max. 15 minutes, the surface is acceptable for paint application.

### 3.2 Temperature

The temperature is very important for a good result. Painting on heated surfaces may result in too rapid evaporation of the solvent. Under such conditions the film may end up with many pores.

Preferably, application has to be carried out at temperatures of min. 5-10°C (41-50°F) and max. 30-40°C (86-104°F). If the temperature is low, the drying time will be increased. Physically drying paints and low temperature curing paints can be applied when the temperature is below 0°C (32°F), but care must be taken to avoid ice on the surface, which will impair adhesion.

Cold weather will affect the paint in such a way that it will get thicker and, consequently, may be more difficult to apply; warm weather has the opposite affect on the paint. When applying the paint in cold weather, it may be necessary to store paint in heated containers in order to keep the viscosity at an acceptable level for application. In some cases thinning may be necessary, but must be kept to a minimum.

If applying two component paints at high temperatures, it must be noted that potlife will decrease considerably when the temperature rises (by 50% with a temperature increase of 10°C/18°F).
3.3 Wind

Painting should not take place during windy weather conditions if the wind contains sand or dust. Apart from spoiling the appearance of the painted areas, sand and dust particles will form drains through the paint film, thereby reducing the protective properties of the paint. In the case of spray application a too strong wind will also cause unnecessary paint dust and waste, resulting in a high consumption of paint.

4. APPLICATION

The application of paint must provide a uniform coating of the surface in the specified film thickness. It is a requirement that the dry film is without pores, blisters and similar defects.

To obtain the best possible protection, the instructions in the specifications and product data sheets must be followed.

4.1 Stripe coating

Stripe coating by brush of rough (hand) welds, free edges, narrow openings, the backs of stiffeners and other places difficult to reach/cover by spray, should be carried out before application of the full coat.

4.2 Application methods

Application methods of interest are:
- Brush application
- Paint roller application
- Spray application

4.2.1 Brush application

Brushes are especially suited for application of priming paint to small, touch-up areas on bare steel, as the anticorrosive is then worked very well into the substrate. Never use roller application for this purpose.

Typical brush types for application of steel are flat brushes, round (or oval) brushes and long-handled brushes. Flat brushes are especially suitable for large surfaces, while round and oval brushes are suitable for spot repair of small items such as pipes, bolts, etc. and for application of primer on bare steel.

Long-handled brushes are suitable for inaccessible surfaces and can be used as a supplement to airless spraying.
Round or oval brushes must be rotated during use in order to wear the brush evenly. Otherwise the brush will be spoilt by one-sided use, resulting in dog-ears and difficult application.

Flat brushes must have long bristles. They are suitable for large and smooth surfaces if the application technique is right. A wrong technique may result in a risk of small spots without paint around bolts, on welding seams etc. On such areas an additional coat must be applied with a 3/4” or 2” long-handled angle-brush.

During application the brush must be placed at right angles to the surface in order to provide a smooth and even film. The paint should be applied on the surface by moving the brush lengthwise and crosswise. Rough surfaces, welding seams, edges and angles should be given special attention.

After use the brushes must be cleaned in an appropriate thinner or tool cleaner.

The **ADVANTAGES** of brush application are the following:

- Brushes can be used for almost all surfaces, are easy to move and will not need electric power or compressed air
- The method is clean and demands no or only limited protective cover
- By thorough application dust and humidity (partly) are removed from the surface. On rough and uneven surfaces the wetting and penetrating quality is comparable with airless application. *Therefore, the brush is especially suitable for application of the first primer coat.*

The **LIMITATIONS** are the following:

- The method is not suitable for all types of paint. High-build coatings can be applied in “normal” film thickness only (approx. 40 micron/2 mils). Difficulties may arise on brush application of second or subsequent coats of some physically drying paints
- Brush application is slow compared to other application methods.

### 4.2.2 Paint roller application

The roller is first and foremost a tool that ensures a quick working procedure. Using a roller may, however, involve the risk that visual coverage is obtained without having applied the appropriate film thickness of the paint.

Since the corrosion protective value of the paint depends to a great extent on the film thickness applied and that the paint film is free from pores, application by roller is not recommended where optimum performance is required. Rollers should **never** be used for applying primers to bare metal.
Typical materials for paint rollers are:

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamb’s wool</td>
<td>Long-piled and therefore preferred for rough and uneven surfaces.</td>
</tr>
<tr>
<td>Mohair</td>
<td>Short-piled and therefore good for smooth surfaces. Special lacquer rollers are available for finishing work.</td>
</tr>
<tr>
<td>Nylon and Dynel</td>
<td>Hard-wearing synthetic alternatives to lamb’s wool and mohair.</td>
</tr>
<tr>
<td>Plast foam</td>
<td>A cheap but unstable material, unsuitable for application on steel and other metals.</td>
</tr>
</tbody>
</table>

The lamb’s wool rollers apply the paint in thicker layers than the mohair or nylon rollers, and therefore the former is used for uneven and rough surfaces and the latter for even and smooth surfaces.

The paint should be applied on the surface with slow and even movements up and down and across. Avoid draining the roller for paint, in which case the roller will raise paint dust. Do not spread the paint excessively, otherwise there will be a risk of film thickness being below specification.

The **ADVANTAGES** of roller application are the following:

- Easy to move from place to place and independent of electric power and compressed air
- More cleanly than spraying.

The **LIMITATIONS** are the following:

- Not suitable for application on irregular constructions and surfaces (pipes, welding seams, angle irons and bolts)
- Paint rollers give a risk of application of thin, uneven layers with many spots without paint and with pores (pinholes)
- Paint rollers give a poor wetting of the surface and are therefore not suitable for application of primers on bare steel
- High-build coatings can only be applied in normal film thicknesses (40 micron/2 mils).

### 4.2.3 Air spray application

During spray painting compressed air is used for atomisation of the paint and transportation of the atomised paint to the surface.

A needle valve operated by the trigger controls the paint quantity passing through the nozzle. The fan angle is controlled by the quantity of air passed through the “horn” of the gun.

In order to make a proper application by low-pressure equipment the air pressure must be 1½-4 bar (kg/cm²). As a rule of thumb for standard paint, the air pressure in the paint vessel must be 1½-2 bar and the atomisation pressure 2½-3 bar.
The distance from the spray gun to the substrate should be about 30 cm (12 inches) and the overlap 10-20 cm (4-8 inches).

Special attention must be paid to corners and edges, and places where overspray is possible, such as the borderline between horizontal and vertical areas, pipes, profiles, etc.

Among the **ADVANTAGES** of low pressure spraying are:

- Uniform coats in normal thickness are easy to obtain
- Adjustment of paint consumption and fan angle is simple and quick
- The method is essentially quicker than brush and roller application when the unit is rigged.

The **LIMITATIONS** are the following:

- Much spray-dust and therefore waste of paint
- Inexpedient for outdoor application, because wind as well as compressed air will raise dust
- Poor penetration and therefore inexpedient for application of first primer coat, especially on rough surfaces
- Insufficient covering of corners due to return of compressed air
- Only expedient for application of paint with low viscosity
- Risk of dry-spray
- Low flexibility compared with brush and roller
- Dependence on power supply (compressed air)

**4.2.4 Airless spray application**

Spray application should preferably be with airless spray equipment. The paint is transferred by hydraulics to the spray gun where it is atomised by passing through a very small nozzle at high pressure (100-350 bar). Airless spraying gives little paint dust and permits a good film formation and a high production rate.

The nozzles for airless spraying are available in a wide selection of orifice diameters and fan angle combinations. Further recommendations on the size of orifice are found in the product data sheets.
The high pressure equipment is operated by compressed air with a pressure of 5-7 bar/70-100 psi. Long, thin air and paint hoses must be avoided due to the risk of block-up. If long hoses are necessary, the diameter must be at least 3/8” with the exception of the last 5 metres (16 feet) where the diameter should be 1/4”.

Spray equipment with a pump ratio of minimum 1:30 and with a capacity of 6-12 litres/minute (1.6-3.2 US gallons/minute) will normally apply the paint without thinning.

The pump ratio is the ratio between the paint piston and the air piston. This means that if the pump ratio is 1:30 and the air pressure is 6 bar, the pressure in the nozzle will be 180 bar. The spraying distance must be 30 cm (12 inches) and the overlap between each passage at least 1/6 of the fan width. The gun should be held at right angles to the surface.

Before application, be sure that the spraying is perfect, i.e. without streaks (the pressure too low), paint-dust (the pressure too high) or other defects. In order to minimise paint-dust or local high thicknesses it must be recommended to shut down the paint supply at every turn of the gun. The trigger must then be reactivated when movement in a new direction starts.

During low temperature the paint may become so viscous that thinning is necessary.

The nozzles will be selected according to the type of job, but the following nozzle sizes are all-round for outdoor jobs:

<table>
<thead>
<tr>
<th>Type of work</th>
<th>Nozzle size</th>
<th>Fan angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large even areas</td>
<td>0.021”-0.025” (0.027”)</td>
<td>65°-(80°)</td>
</tr>
<tr>
<td>Complicated structures</td>
<td>0.017”-0.019”</td>
<td>40°-65°</td>
</tr>
</tbody>
</table>

Great caution must be observed in handling the gun, which works with very high pressure. To prevent accidents the nozzle must be equipped with an approved safety tip guard. Be sure that the equipment is explosion-proof.

For each type of airless equipment the supplier’s instructions for ready-making, cleaning and dismounting must be followed.

Extremely good results can be obtained with airless application. If faults occur, they are normally caused by:

- Insufficient pressure (too long or too thin hoses, insufficient pump capacity)
- Dirty or worn-out paint filter
- Worn-out or wrong nozzle

There are many **ADVANTAGES** of airless application, and the most conspicuous are:

- Fast working, when the equipment is mounted
- Excellent atomisation without atomised air and therefore little formation of paint dust
- Easy to obtain a thick paint film
- The only method for application of high-build paint
• Long range by use of extender pole

• Good penetration and therefore good adhesion of the paint to the surface. Very suitable for application of primers.

The **LIMITATIONS** are the following:

• Dependence on power supply (compressed air or similar)

• Limited flexibility compared with brush or roller

• Long time for mounting and dismounting and therefore inexpedient for painting of small areas

• Adjustment only by change of nozzle

• Demand for high security due to high pressure.

### 4.3 Checklist prior to application

- All power tools and pressure equipment (needle guns, disc grinders, high pressure washing units, wet abrasive blasting equipment, etc.) should be checked before and after use, and all worn or damaged parts renewed.

- When compressed air is used for surface preparation and spraying, it should be clean, dry and free from oil. It is always advisable to incorporate water and oil traps on the air delivery side of all air equipment.

- Paint brushes should be clean and free from excess cleaning solvent prior to use.

- Spray painting equipment should be checked prior to use to ensure that it is clean and free from previous coatings.

  - For conventional spray equipment, this means that paint hoses, the spray gun nozzle tip and needle should be checked, and any damaged or worn parts and packing replaced.

  - Airless spray equipment should be checked to ensure that the pump cylinder is clean and that ball valves are free to function. Paint hoses should be clean and of the correct type. The spray gun should be checked and the correct spray tip inserted. Worn tips should be replaced as should worn or damaged packings.

- External surfaces should not be painted during adverse or inclement weather conditions.

- No surface to be painted unless surface temperature is 3°C/5°F above the dew point.

- All paints to be thoroughly stirred before use.
Only the correct thinners to be used as stated on the product data sheet.

Two-component paints must be mixed in the correct mixing ratio. Do not thin down until after mixing.

If surfaces have been exposed to seawater, dust, etc. they must be washed down and air dried before painting commences.

When overcoating, the film thickness of the previous coat must be checked and if low, made good with the relevant materials.

4.4 Overcoating intervals

Each coat of paint should usually be completely dry before the application of a subsequent coat. It is equally important not to let too much time elapse before applying the next coat in order to avoid contamination.

The overcoating intervals mentioned in the data sheets refer to a temperature of 20°C (68°F). A decrease in temperature will increase the intervals and a rise in temperature will, on the other hand, result in a recoating interval which is shorter than indicated on the data sheets.

Alkyd systems and two component paint systems (epoxies and polyurethanes) are all paint types which dry or cure very hard - which is a condition of their excellent durability. When they have cured completely, the adhesion of the subsequent coat may be insufficient. Therefore, the minimum and maximum overcoating intervals mentioned in the data sheets must be carefully observed.

Should the maximum overcoating interval be exceeded, full adhesion can be obtained by roughening the surface, either by grinding or abrasive sweep blasting.

5. PAINT TYPES

Paint consists of binder and pigments. The binder determines the film formation and the general performance of the paint coating. In its liquid form the binder is usually diluted by a solvent to render the paint fit for application.

Paints are divided into two main groups according to their solidification or film formation, which may be either a physical or a chemical process.

5.1 Physical film formation

This mechanism can be described as evaporation drying. The solidification solely relies on evaporation of the solvent, which is a physical process. The binder in the dry film is chemically the same as it was in the can.
The principal binders are of widely different nature ranging from “traditional” bitumen and tar to “advanced” chlorinated rubber, vinyl and acrylic.

A special physical drying mechanism is used in emulsion paints. Although the main diluent is water, the dry film cannot be redissolved in water.

Physically drying paints have the following general characteristics:
- Good ventilation required during the film formation to allow the solvent to evaporate
- Sensitive to solvents, including their own solvent (except emulsion paints)
- Thermoplastic, becoming soft at high temperatures
- Easy to recoat.

5.1.1 Acrylic

General advantages and limitations of acrylic coatings are:
- Relatively quick drying
- Excellent intercoat adhesion, even after prolonged ageing.
- Good colour retention
- Usually only fair wetting properties
- Low solvent resistance
- Low to fair resistance to animal and vegetable oils and fats
- Dissolve in aromatic solvents.

5.1.2 Chlorinated rubber

General advantages and limitations of chlorinated rubber coatings are:
- Good water resistance
- Good chemical resistance
- Excellent intercoat adhesion
- Relatively good weathering, but they yellow and chalk
- Poor resistance to animal and vegetable oils and fats and solvents
- Low heat resistance
- Dissolve in aromatics (strong solvents)
- Contain chlorine (formation of hydrochloric acid at elevated temperatures such as when welding, burning, cutting, etc).

5.2 Chemical film formation

As the chemical processes differ, a further division into subgroups is made:

5.2.1 Oxidatively curing

The film formation mechanism is due to the fact that the binder contains drying oil. When exposed to air the binder takes up oxygen and is thus converted into a chemically new material. The most widely used type of oxidatively drying binder is alkyd.
General advantages and limitations of alkyds are:

- Reasonable to good weathering
- Reasonable to good gloss retention
- Reasonable to good colour retention
- Solvent is white spirit, a comparatively mild solvent
- Poor alkali resistance
- Limited water resistance
- Recoating limitations to be observed.

5.2.2 **Chemically curing**

In chemically curing paints the film is formed by chemical reactions in the binder. By definition the reactions do not include oxygen uptake. Normally the paint is delivered in two parts to be mixed prior to use. The best known types are **epoxy** and **polyurethane** (isocyanate).

A. **Epoxy**

General advantages and limitations of epoxy coatings are:

- Good chemical resistance (best for amine cured epoxies)
- Good adhesion to a wide range of materials
- Good water resistance
- Good physical properties, such as toughness, flexibility and abrasion resistance
- Good weathering (apart from chalking)
- Good temperature resistance
- Critical recoating
- Tendency to yellow and chalk
- Two-pack (attention to mixing and pot life)
- Curing is temperature dependent
- Low temperature curing versions available
- Can be formulated as zinc-rich primers.

B. **Polyurethane**

General advantages and limitations of polyurethane coatings are:

- Excellent gloss retention (aliphatic types)
- Excellent colour retention (aliphatic types)
- Excellent weathering
- Good hardness
- Good chemical resistance
- Low temperature curing
- Curing is temperature dependent
- High abrasion resistance
- Difficult application (trained painter and low relative humidity required)
- Critical recoating (for some types)
- Two-component (attention to mixing and pot life)
- Comparatively expensive.
5.3 Modified paints

In order to improve some characteristics the paint manufacturers have succeeded in developing composite paint containing binders from the two main groups described above. Modified alkyds like urethane alkyd, styrenated alkyd, and silicone alkyd belong to this group.

Styrenated alkyd has shorter drying time and better wearing qualities than normal alkyd. This better performance increases both the cost of the paint and requires a higher quality of pretreatment.

NOTE: Urethane alkyd and epoxy ester are essentially alkyds and have characteristics different from polyurethane and epoxy.

Another composite paint is coal tar epoxy produced from selected tar products and epoxy binder. Coal tar epoxy has better water resistance than pure epoxy due to the tar content, but poorer solvent resistance resulting in bleeding through new paint film during recoating.

Finally, epoxy mastic products are epoxy products modified to provide good surface tolerance. This means that contrary to normal, pure epoxy products, these products can be applied over power-tool cleaned surfaces with good performance results, which again means that epoxy mastic products are very suitable for onboard maintenance.

5.4 Compatibility between paint types

<table>
<thead>
<tr>
<th>EXISTING SYSTEMS</th>
<th>NEW TOP COATS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Emulsion</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Emulsion</td>
<td>OK</td>
</tr>
<tr>
<td>Alkyd</td>
<td>OK¹</td>
</tr>
<tr>
<td>Epoxy ester</td>
<td>OK¹</td>
</tr>
<tr>
<td>Chlorinated rubber</td>
<td>OK</td>
</tr>
<tr>
<td>Acrylic</td>
<td>OK</td>
</tr>
<tr>
<td>Epoxy</td>
<td>OK¹</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>OK¹</td>
</tr>
</tbody>
</table>

OK = Acceptable  NR = Not Recommended

NOTES

It should be ensured that the existing coating system is sound with good adhesion and that the existing coating surface is properly cleaned with the appropriate cleaning agents.

The solvent power of paint being applied should, normally, be no stronger than that of the existing coating. Also the final hardness of the paint being applied should not be higher than
the hardness of the recoated paint. Application of a small test area is recommended to test both adhesion and solvent action.

Note 1: Overcoating of these coatings should, as a principle, be done within the maximum recoating interval specified for each paint. If this interval is exceeded it will require abrading in order to provide a key for the subsequent coat.

Note 2: One problem in overcoating alkyds is solvent attacks from subsequent coatings. Furthermore, when overcoating cured alkyd coatings appropriate roughening of the alkyd film is necessary to ensure adhesion of the new coat due to the very hard dry alkyd paint film.