Ship Coating Failures from Fitz Atlas 2

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Coatings are complex combinations of raw materials that have to be carefully formulated to satisfy the design and performance criteria. The coatings, either single pack, two pack or three pack have to be mixed, applied to a prepared substrate and dried and cured correctly to perform to their maximum ability. They have to be able to be applied under a wide range of environmental conditions and be expected to protect the substrate from the damaging effects of rain, sunlight, wind, heat, cold, humidity and oxygen in various combinations and cycles and still retain their integrity and often their aesthetic qualities. Coatings applied to ships also have to be resistant to abrasion in the case of cargo hold coatings, fouling in the case of outside shell coatings and cyclic changes of chemicals and tank cleaning in the case of tank linings.

With all the potential variables involved it is not surprising that coatings can suffer from premature failure. It is not generally straightforward to establish the reason for failure due to the many potential factors that may be involved. These could include formulation, surface preparation, application, drying and curing times and conditions of environmental exposure, with more than one contributing factor often being involved.

To determine the cause and mechanism of coating failure all potential contributory factors need to be evaluated together with a detailed history from the time of application to the time the failure was first noted. Many coating failures need further evaluation and analysis to be carried out by a qualified chemist or coating specialist often using specialized laboratory equipment.

The following examples of failures/defects, photomicrographs and types of marine fouling together with descriptions, probable causes and suggested preventative measures are reproduced by kind permission from Fitz's Atlas 2 of coating defects although some photographs have been included from other sources.

Fitz's Atlas 2 of coating defects *contains sections on welding faults, surface conditions, marine fouling and microscopy in addition to the main section of 237 photographs of coating defects and failures in 93 separate categories. An "App" of the Atlas is now available for iPad and Android devices. It is available in English, French, Spanish and Chinese and includes time lapse video footage of a number of coating defects as they develop.*

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ABRASION



Description:	The mechanical action of rubbing, scraping, scratching, gouging or erosion.
Probable Causes:	Removal of a portion of the surface of the coating or in severe cases removal to expose the substrate by contact with another object such as the use of metal chains for lifting, cargo, fenders, or the grounding of a ship.
Prevention:	Use of abrasion resistant coatings formulated with particular regard to resins and extender pigments. With severe cases of abrasion the effects will only be reduced or limited by an abrasion resistant coating.

ADHESION FAILURE ON GALVANISING



Description:	Paint fails to adhere to substrate or underlying coats of paint.
Probable Causes:	Surface contamination or condensation, incompatibility between coating systems and exceeding the overcoating time.
Prevention:	Ensure that the surface is clean, dry and free from any contamination and that the surface has been suitably prepared. Use the correct coating specification and follow the advised overcoating times.

BLISTERING



Description: Dome shaped projections or blisters in the dry paint film through local loss of adhesion and lifting of the film from the underlying surface. Blisters may contain liquid, vapour, gas or crystals.

Probable Causes: Many mechanisms can be involved including osmotic gradients associated with soluble salts, soluble pigments, corrosion products, retained solvents and solvents from cargoes. Non-osmotic blistering associated with cathodic disbonding, thermal gradients related to cold wall effects and compressive stress.

Prevention: Ensure correct surface preparation and application. Apply a suitable coating system after testing for soluble salts. Consider the possibility of the different blister mechanisms in the particular environment.

CATHODIC DISBONDING



Description: Blistering and delamination of a coating system around bare steel areas and coating defects associated with cathodic protection on buried pipelines, immersed structures and the hulls of ships.

Probable Causes: High overvoltage principally from impressed current systems but also to a lesser extent with sacrificial anodes when the number of anodes is excessive. Factors are incorrect installation, poor monitoring, and incompatible coating systems.

Prevention: Use a well designed cathodic protection system, regularly monitored with well placed reference electrodes and application of an alkali resistant coating system.

CRAZING



Description: Similar to checking but the cracks are generally wider and penetrate deeper into the film.

Probable Causes: Application temperature too low, incompatibility with previous coating, ageing and high film thickness.

Prevention: Apply a thinner coat of paint, add slower drying solvent, check application and drying conditions are correct for the paint system used and check compatibility.

DELAMINATION



Description: Loss of adhesion between coats of paint.

Probable Causes: Provided compatible paint materials have been used, delamination defects are generally related to poor surface preparation and application defects, such as contamination between coats; exceeding overcoat times; application to a glossy surface.

Prevention: Ensure no contamination between paint coats. Follow the recommended overcoating intervals. Lightly abrade and clean glossy surfaces between coats.

HEAT DAMAGE



Description: Discolouration, detachment and/or blistering and general degradation of a paint film.

Probable Causes: Effect of high temperature often applied to the reverse side of a steel plate from burning, welding or fire.

Prevention: Ensure that all welding/burning is completed prior to painting.

IMPACT DAMAGE



Description: Cracks which radiate from a point of impact.

Probable Causes: Impact damage to a relatively brittle coating. Often seen on glass fibre reinforced plastics. Also occurs when steel is deformed by impact.

Prevention: Prevent impact damage.

PEELING



Description: Similar to flaking, although peeling tends to be associated with soft and pliable fresh coatings which can be pulled away from or spontaneously flake away from the substrate or from between coats, due to loss of adhesion.

Probable Causes: Peeling is the reduction in bond strength of the paint film due to contamination or incompatibility of coats.

Prevention: Use correct coating system and specification applied to clean and uncontaminated surfaces.

RUST RASHING

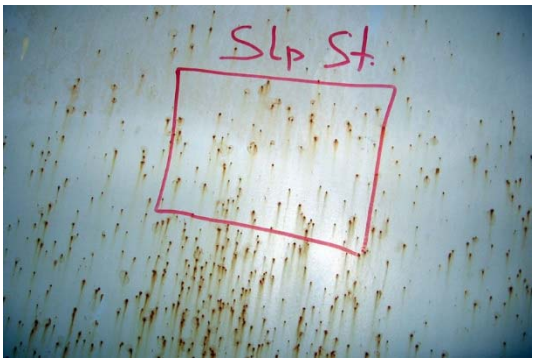


Description: Fine spots of rust which appear on a paint film, often a thin primer coat. The initial spots rapidly spread over the surface resulting in a film of rust through which the individual spots are difficult to discern. Also from holidays.

Probable Causes: Low film thickness often in combination with a high surface profile.

Prevention: Ensure that an adequate thickness of a primer coat is applied to cover the surface profile and check that the surface profile is not too large.

RUST SPOTTING



Description: Individual spots of rust which appear on a paint film and frequently start as localised spotting but rapidly increase in density.

Probable Causes: Low film thickness (more likely creating rust rashing), voids and holidays (more likely creating rust rashing), but also defects in the steel such as laminations and inclusions. Too high a surface profile may cause penetration of peaks through a paint film and cause rust spotting. May also occur from metallic contamination of a coated surface by grinding dust etc.

Prevention: Ensure that an adequate thickness of a primer coat is applied to cover the surface profile. Use a thicker coating system or a lower blast profile. Protect coating from contamination with grinding dust etc.

STRESS CRACKING



Description: Paint coatings with visible cracks which may penetrate down to the substrate.

Probable Causes: Stress cracking can be attributed to surface movement, ageing, absorption and desorption of moisture, thermal cycling and general lack of flexibility of the coating. The thicker the paint film the greater the possibility that cracking might occur. Often occurs around welds and changes in section.

Prevention: Use correct coating systems, application techniques and dry film thicknesses or use a more flexible coating system.

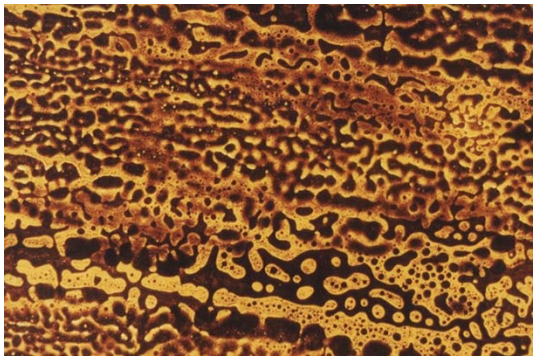
PHOTOMICROGRAPHS

EXUDATION



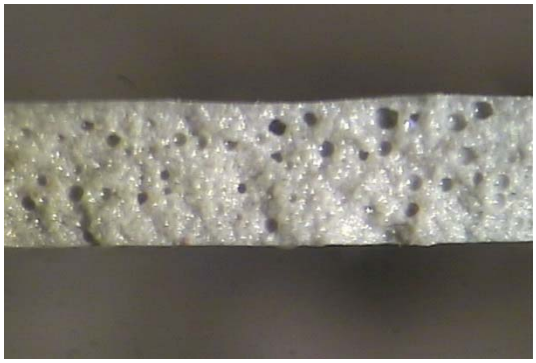
Description: The appearance of an oil-like film on the surface of the coating after drying. Migration of a component of a coating to the surface; examples being plasticizer, tar, etc.

INCOMPATIBILITY



Description: Incompatibility between two or more raw materials resulting in separation and a non-homogeneous film. In the above example tar and epoxy resin.

VOIDS/VACUOLES



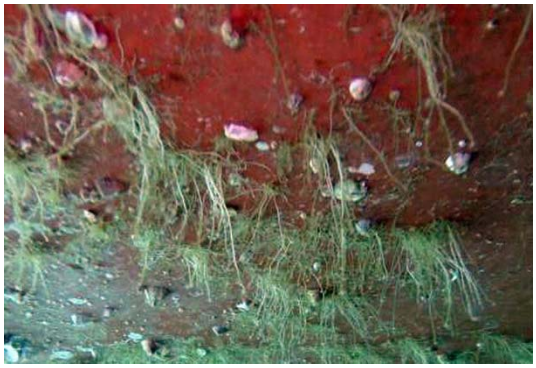
Description: Bubbles within the coating often related to air entrainment during mixing, solvent balance, over thickness, application in hot conditions or over a porous substrate. They can vary considerably in size and extent and if excessive can make the coating more permeable.

ACORN BARNACLES



Description: The most commonly encountered fouling animals. They live within hard calcareous shells and use a net of tentacles to trap planktonic food. They create a rough surface when attached to the outside shell of a vessel and adversely affect speed and fuel consumption.

HYDROIDS



Description: Although plant like in appearance they are animal fouling forms. They are often found on the flat bottom of vessels and often misinterpreted as types of algae/grass.

ENTEROMORPHA



Description: Commonly known as marine grass because of the similarity in appearance. It tends to predominate near the water line where the light intensity is higher.