



TÉCNICO
LISBOA

Extended Abstract

“Technologies of application of paintings and pathologies in masonry walls and concrete elements”

Francisco Pedro Ferreira Maria Marques

**Dissertação para obtenção do Grau de Mestre em
Engenharia Civil**

Maió 2013

1. Introduction

The buildings paintings are one of the several types of coating that can be used in buildings construction to obtain finishes with pleasing visual appearance, but also for protection of surfaces. The painting materials as well as the raw materials used in their construction must comply with technical criteria defined by the European Commission and are defined in the International Standard ISO 4618 [1].

The paints are materials widely used in construction for coating surfaces. For this, contributes strongly the competitive costs they exhibit, when compared with other coating materials, combined with a continuous technological evolution of components employed in its manufacture, and methods of manufacture and application used.

This dissertation aims to carry out a guide of Quality Control Procedures in Buildings Paintings, particularly in facades and interiors constructed of concrete or masonry. This work is intended to help identify the causes of defects and/or diseases and propose solutions to prevent and/or minimize their appearance throughout the life of the buildings, and that usually have origin in wrong procedures, poor choices in terms of materials or faulty coating execution.

2. Coatings / Paints

The International Standard ISO 4618 defines **coating material** as a “product, in liquid, paste or powder form, that, when applied to a substrate, forms a film possessing protective, decorative and/or other specific properties” [1].

The coating materials may or may not be pigmented. A pigmented coating material which, when applied to a substrate, forms an opaque film is called a **paint**. Otherwise, if the coating materials have no pigments, it is called a varnish and when applied to a substrate forms a solid transparent film [2].

The obtained paint coating results from the application of a **coating system** that, according to ISO 4618, is “a combination of all coats of coating materials which are to be applied or which have been applied to a substrate”. The number of layers involved give rise to monolayer or multilayer coatings, being the last layer referred to as finishing [1][2].

Paints have two main phases: a dry extract and a volatile carrier (as shown in the Figure 1). Each phase includes several components that interact physically and chemically with each other, giving to the paint the necessary properties for a good performance. [7]

Mainly, paints are composed by four components:

- Resins - also called binders, vehicles or polymers, are predominantly amorphous macromolecular material that ranges from the solid to the liquid state and has a relatively low molecular mass [1] that form the paint film. Without resin there's no coating. This function may also be due to the use of drying oils.

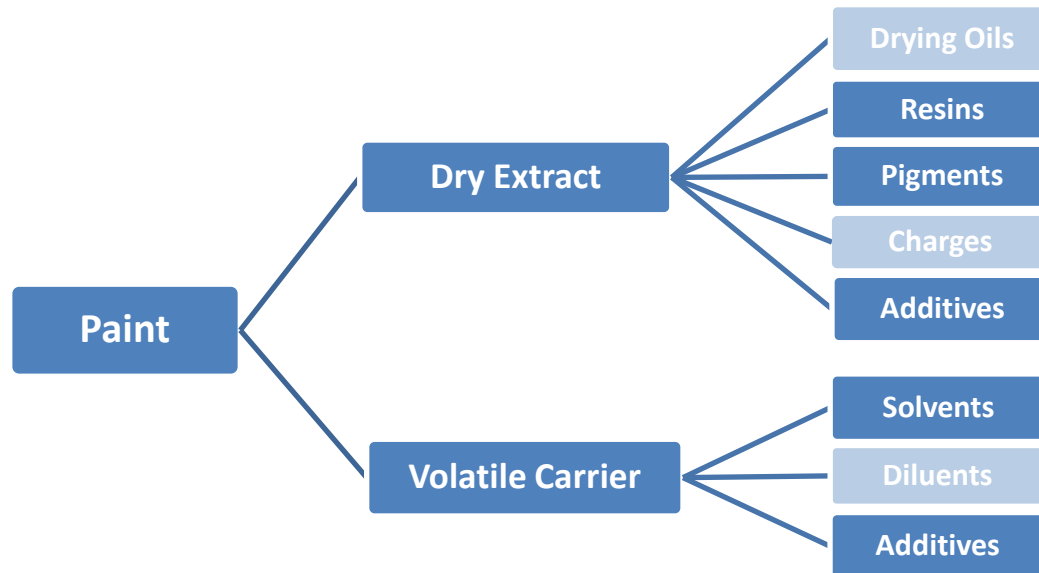


Figure 1 – Main components of paints

- Pigments – are coloring materials, generally in the form of fine particles, which is practically insoluble in the medium and which is used because of its optical, protective and/or decorative properties [1]. They provide opacity and color to the film applied, in addition to influencing many of its properties such as durability, corrosion resistance and fire resistance.
- Solvents - single liquid or blend of liquids, volatile under specified drying conditions and in which the binder is soluble [1] that are used in most liquid paints; they are not used in powder paints or in some liquid paints that cure by the UV light's action.
- Additives - are substances that can be added to paints or paints film, usually in small amounts, to impart certain characteristics.

Among all of these components, solvents and resins are present in higher quantity, representing the other components, a small percentage, as can be seen at figure 2.

Paint is manufactured mixing one or various resins and a solvent or a mixture of solvents with pigments and additives according a specific formulation. After proper application, the dry film will have certain performance characteristics and provide specific physical properties such as hardness, color, tensile strength and brightness.

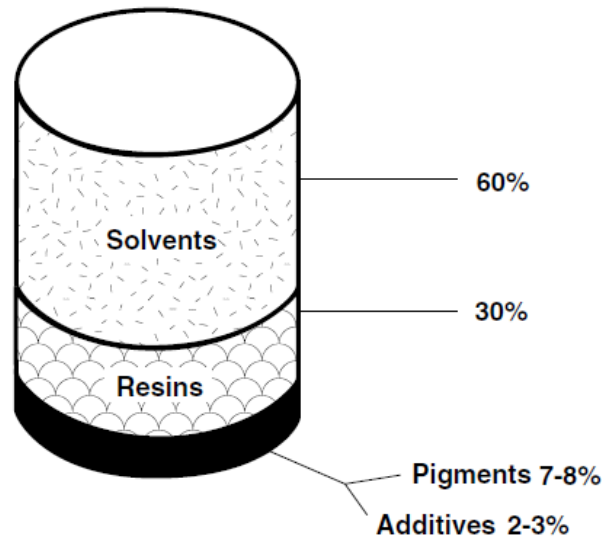


Figure 2 – General paint composition [4]

2.1. Paints characteristics

Paints have the ability to transport and apply on the surface a liquid having a combination of binder, pigment and solvent. Once applied on the surface, the solvent evaporates and remains a dry film composed by a pigment binder system [5]. All paints, once applied, may form a hard, impenetrable film, a soft and porous film, or combinations intermediate between those two [5].

Existing knowledge of the painting industry and its constituents allows the development of formulations with certain characteristics.

2.2. Film formation mechanisms

The main mechanisms by which binders are film forming, consist in reactions with the oxygen from the atmosphere (oxidation), solvent evaporation or chemical cross linking of the vehicle (polymerization). The dry films formed by these mechanisms may be thermoplastic (deform and soften upon exposure to heat) or thermosetting (do not deform and remain hard even in heat environment). The film formation mechanism is determined by the binder characteristics and its method of drying and/or curing [5].

2.3. Main types of paints

The traditional paints used an organic solvent-based petroleum resins to disperse the molecular resins. With evolution, currently are used other kind of paints [6].

- Paints with high solids content – these paints are an evolution of the traditional liquid formulations that are very similar but with a modification of the resin systems to produce paints

with low VOC (Volatile Organic Compounds). The technologies used for this paints can use conventional equipment, which may be attractive to manufacturers.

- Water-based paints - the water-based paints use water to disperse the resin, although they may also contain some solvent. This technology can use resins incompatible with water since they undergo a previous chemical modification.

Based on the physical properties and performance of the specific resin, the water-based paints are classified into solutions, emulsions and dispersions.

- Powder paints - the powder components are similar to wet paint but don't have a solvent carrier. Since the decade 1950 this technology is available and formulations has undergone major developments, mainly for metals.

2.3.1. *Paints classification*

The wide variety of coating materials available on the market, with varied characteristics and different applications, allows adapt products to each situation. When one intends to specify a coating product uses usually a type of classification based on the nature of the solvent, the nature of the binder or the purpose for which they are intended [2].

In the constructions practice, the paints are widely designated by terms related to the appearance of the finish obtained with or the purpose for which they are used, for example:

- Enamel Paint – offers a more or less glossy and smooth finishing.
- Plastic or emulsion paint - a water based paint with synthetic binders, which give a smooth and matte finish.
- Textured paint – the obtained film have a finishing rough surface.
- Powder paint - is a complete coating presented in powder form that may be applied by both electrostatic and fluid bed methods and cure by fusion [7].
- Acrylic paints - specific for aqueous atmospheric exposures, such as primary or finishing and have excellent color retention and gloss. Acrylics cure by coalescence / bonding [7].

3. Technologies of paints application

When carrying out a painting work, it must take into account different aspects in order to ensure the success of the process, since the painting's end result is conditioned by several environmental and technical factors.

3.1. Selection of the coating system

The selection of a coating system should be adapted to the requirements of the surface and exposure environment where the coating is to be applied, whereas, as already mentioned, the effectiveness of a coating depends on multiple factors, ranging from appropriate selection of the products to apply past the level of surface preparation and the quality of materials used, to the quality of the application [7].

Once defined the painting system, various methods can be selected according to the reference standards in force and test procedures for preparing the surfaces, applying, testing and maintenance of paints [7] [5].

To select the most suitable coating system to apply in a facility construction is necessary and essential to identify and understand their environmental exposure. Then will start the selection of the painting systems based on their historical successful use in environments identified [5].

The traditional paints used an organic solvent-based petroleum resins to disperse the molecular resins. With evolution, currently are used other kind of paints [6].

The identification of the surrounding environment it's probably the most important step, which consists in evaluating the conditions under which the paint system has to perform. This evaluation cannot be superficial once it should consider all conditions that may exist including small factors that could seem irrelevant. Sometimes a combination of two or more surrounding environments, acting together, can create a hostile environment [5].

Some factors should be considered within the surrounding environment, among others, the following:

- Temperature variations;
- High humidity;
- Immersion;
- Oxidation-reduction;
- Extreme pH;
- Exposure to solvents;
- Exposure to UV light;
- Impact / abrasion.

At this stage, there should be identified other aspects as the most difficult areas of painting, the regulatory and legal requirements and other alternatives such as the identification of surface preparation (for new construction and maintenance), the alternatives of paint application and system cathodic protection [5].

3.2. Surface preparation

The behavior of a coating by painting depends on the good quality of the support base, which has always to be conveniently prepared, to obtain a homogeneous surface and porosity known, suitable to receive the coating system chosen.

The proper surface preparation is essential to create a good adhesion to the substrate and increase durability and overall effectiveness of protective paint. The adhesion determinates whether it is sufficient to apply only one thin film layer on the surface or whether it will become part of the substrate [5].

An important aspect for improving adhesion, is to make the surfaces rough and rugged enough (within acceptable limits for the type of finish and texture desired), with small peaks and valleys engraved on the surface to be painted so as to provide an increased area contact to a mechanical joining of the paint to the substrate [5].

The procedure for surface preparation takes generally much longer than the paint itself, because if all the imperfections are not eliminated from the surface to be painted, it could compromise the quality, appearance and durability of the coating.

3.2.1. Usual methods of surface preparation

Surfaces to receive paint schemes should be dry, clean and free of contaminants, as well as remnants of old paint or other debris.

The equipment and techniques that can be used for cleaning and surface roughness desired to vary significantly [5], taking into account that surfaces of different materials require different preparations, since they may introduce conditions that require special treatment.

There are a variety of methods of surface preparation, and today, traditional methods are accompanied by new methods, innovative, which evolved mainly due to security issues [5]. In this dissertation was discussed the masonry walls and towed concrete elements surfaces preparation, at both the exterior and interior level.

Some of these methods are much more indicated to be used in the masonry walls and others for the concrete elements, so that's another care that must be taken to account. Next will be referred some methods of surface preparation and their purposes, which can go from cleaning tools and utensils to more sophisticated methods.

- Cleaning with solvents;
- Scraping;
- Sanding;
- Brushing;
- Heat gun;

- Pickling;
- Washing with a jet of high pressure water;
- Abrasive blasting;
- Etching.

3.3. Paint products application

The coatings application is affected by several variables, including the type of paint to be used, the type and size of the surface coating, the method chosen to carry out the painting and environmental regulations. [5]

It should be given special attention to the weather conditions existing at the time of the execution of the painting, since there are conditions that can cause defects in the final result and can easily be eliminated, provided that care is taken of:

- Not perform paintings at too low ambient temperatures, a 5 ° C lower limit for most water-based paints or non-aqueous solvent. Very low temperatures, besides preventing the application process, makes the paint take too long to dry, thereby allowing impurities from infiltrating air at the coating.
- Not perform paintings at too high ambient temperatures, 35°C upper limit, since this fact will make the paint dry too quickly, thus compromising the durability of the coating as well as its quality.
- Do not make paintings when ambient humidity is too low.
- Avoid performing paintings when the surfaces are directly exposed to sunlight, especially due to the high surface temperature.
- Avoid performing paintings on rainy days, since the need to stop the process in the middle may cause defects in the final result.

3.3.1. *Painting scheme*

Generally, the application of a coating system consists on a sequence of products coats applied in a particular order. The different nature of the paint products must be compatible with each other and have different but complementary functions (protection, texture, color.) [3].

The usual sequence when applying a coating system includes the primary coatings, intermediate coatings or undercoats and finish coatings. The simplest coating system generally consists of a primer coat followed by two to three coats of finishing paint.

3.3.2. Application

The paint application should always start from the top of the façade, and it should never stop painting a complete panel. All existing elements on façades such as doors, windows or possible ornaments must be protected with tape before carrying out painting.

There are different ways to transfer the paint from the can to the substrate, which may range from the simple application by brushes and rollers until the pistol applications. All application methods have inherent advantages and limitations [5] [7].

Security is a very important point when performing works in construction, and in this particular case, during the whole process which aims to the execution of a paint coating. Because of that, workers must use personal protective equipment during all the process.

A personal protective equipment (PPE) is, according to the decree-law n ° 348/93, "All the equipment, and any addition or accessory designed for use by workers to protect themselves from risks to their safety and their health." Therefore, the use of PPE is designed to protect the worker from external aggressions that are generated in the performance of a particular work activity, which means, PPE is intended to protect workers from environmental hazards, accidents and adverse health effects that may occur in the short or long term.

The completion of painting work requires the use by workers of eye and face, respiratory and skin protection.

4. Paint coatings pathologies

Pathologies are defects that occur in paintings or in other phases of construction, new or old, by the action of atmospheric agents, application errors and/or inadequate construction materials applied [17].

In paint coatings pathologies case, they are defects and anomalies which appear on the surfaces on which were applied coating systems.

The pathologies can occur at various stages of the process, which can range from storage of the paint, its application or during the coatings life. According to the phase at which they occur, these problems can be classified into [2]:

- Short term or immediate defects: are the defects that appear during the paint application, or a short time after the application is finalized.
- Medium term defects: are the defects that appear within the period of receipt of the work and the end of the "warranty period" of it (5 years).
- Long term defects: are natural defects due to aging of the surfaces over the years, mostly by the action of atmospheric effects. In general, these defects occur after the period of 5 years.
- Defects unexpected: are the defects due to unforeseen circumstances.

It should be noted that the short-term defects in paint coatings may put at risk the acceptance of a work based on the important decoration role they play and consequently could contribute to undermine confidence in the quality of work in general, all of which should be avoided [2].

The main causes for the coating pathologies appearance are:

- Materials selection;
- Paint formulation;
- Paint adhesion;
- Type of substrate;
- Application;
- Structure Design;
- External forces.

5. Conclusion

The pathologies in paint coatings, particularly those raised in the present work, existing in interior and exterior walls of concrete or plastered masonry, may have their origin in construction work prior to painting, and that manifest themselves only after painting or even some time later. Others may have direct bearing on the implementation phase of the coating system, particularly with the preparation of the surface to be painted. Yet, although in most cases, can be avoided or their impact minimized if correctly completed all stages of execution of a coating system, certain pathologies eventually appear naturally over time due to exposure to the environment and the expected lifetime for a painting.

It was concluded that both the process of identifying the surrounding environment and preparation of the surface that will receive the coating, are critical to the success of the coating system applied, taking into account that the majority of the defects and anomalies which appear are caused by physical or chemical incompatibilities between the support base and the products applied.

It was also concluded that some defects, visible only at the end of the execution, may be originate by incorrect procedures when the paint products are in storage. Thus, despite the obvious importance of care during the implementation phase of the paint schemes, it is essential that the storage products conditions must be fulfilled, since the failures that might occur at this stage, may compromise the final results of the coating.

Bibliography

- [1] International Standard ISO 4618, “Paints and varnishes — Terms and definitions”, first edition, 2006-10-15
- [2] Eusébio, M. Isabel e Rodrigues, M. Paula, “Anomalias em pinturas de paramentos exteriores e interiores de paredes de alvenaria e respectivas soluções de reparação”, Cadernos Edifícios 05 – Conservação e reabilitação de edifícios recentes, LNEC, 2005.
- [3] Nogueira, J. L., “Noções Básicas de Tintas e Vernizes”, Vol I, Vol II, Vol III, Associação Rede de Competências em Polímeros, Porto, 2009.
- [4] Roobol, Norman R., “Industrial Painting & Powdercoating: Principles and Practices”, 3rd edition, 2003.
- [5] ENGINEER MANUAL - “Painting: New Construction and Maintenance”. EM 1110-2-3400, Washington DC: Department of the Army, US Army Corps of Engineers, 30 April 1995.
- [6] WATERS, Jean S. et al. - “Environmentally Conscious Painting”. USA: Kansas Small Business Environmental Assistance Program (SBEAP) (a consortium of the Center for Environmental Education and Training at The University of Kansas, the Pollution Prevention Institute at Kansas State University, and the Center for Technology Application at Wichita State University), under contract from the Kansas Department of Health and Environment. June 1996.
- [7] Bortak, Tom N., “Guide to Protective Coatings: Inspection and Maintenance”, United States Department of Interior, Bureau of Reclamation, Technical Service Center, Sep 2002