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Executive Summary

This report was prepared as an outcome of discussions within the Coatings Working Group of the Institute of Corrosion’s Corrosion Engineering Division (CED), where it was agreed to produce a number of technical guidance documents and make them available through the CED technical area of the Institute of Corrosion website. This document is intended to give an insight into Coating Application Methods, highlighting the methods available and the equipment used. Following a brief introduction and a note regarding the importance of ambient conditions during application, the document provides a brief description of the various methods of application, namely brush application, roller application, spray application, dip coating and flow coating. An extensive list of relevant standards is provided.
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1 Introduction

Paint, being an unfinished product until applied, will only perform as intended if the application method is correct. Multiple application methods may be considered and the method chosen may depend on the type of coating being used and the object being coated.

The main methods of application are:

- Brush
- Roller
- Spray
- Dip
- Flow

The details, contexts, advantages and disadvantages of these methods are outlined in the following sections.

1.1 Application Conditions

The quality and long-term performance of a paint coating are strongly influenced by the ambient temperature and humidity during application. These conditions are more readily controlled during in-shop application than in on-site application. Properties such as brushability and sprayability, amount of solvent evaporation, drying and curing times are influenced by the temperature of the air and that of the steel surface. Hence, coating specifications call for the use of specialised instrumentation and test procedures for monitoring the ambient conditions before work commences, and periodically during the work. Note that drying/curing should be assisted only by indirect heating if necessary. Coatings should not be applied when the relative humidity is likely to affect the application or drying process or if there is condensation on the substrate surface. The steel temperature should be measured using a contact thermometer and should always be at least 3 °C above the dew point.

2 Description of Methods

2.1 Brush Application

2.1.1 General points

- Brush application can be time-consuming and labour intensive (hence costly) and it is generally used for smaller jobs where roller or spray application may not be feasible and for repair or touch-up of damaged areas.
- If crevices or pits are present a brush can achieve good penetration.
- Brush application is crucial for the stripe coating of edges, welds, rivets, corners and bolts. This will not only achieve the desired film thicknesses, which a spray applied coating may not, but will also protect vulnerable edges that may be susceptible to damage or wear.
- Good wetting of the substrate can be achieved by forcing the paint into the surface. However, successful application depends on brushing techniques.
- The paint should be applied liberally and spread uniformly, followed by a criss-crossing action with the brush. This will ensure that the coating layer is of uniform thickness throughout and can be followed by ‘laying off’ in one direction for an aesthetic finish.
- Brush application is ideal for use on areas with poor accessibility and various sizes and shapes/angles are available on the market today.
The main limitation of brush application is that of achieving the specified film thickness - several coats will be required.

Achieving an even film is also a challenge; hence brush application is only an advantage for the priming of the steel, where it gives better wetting/penetration, or for small areas/restricted places.

Advantages of paint application by this method include low waste and little hazard of contamination of the surroundings.

The quality of the brush is an important consideration; avoid leaving discarded brush hairs/fibres within the wet coating layer as they may provide a passage for moisture back to the substrate, resulting in premature coating failure.

Some products have brush grades available. These will be formulated with slower solvents to give a longer 'open' time, thus allowing good amalgamation of adjacent painted areas and time for the brush marks to flow/level out.

2.1.2 Brush types

- Brush types include Flat, Dog's leg (Podger) and Finch.
- Bristles can be natural or synthetic. Natural bristles are made from animal hair (e.g. hog or badger). Synthetic bristles can be nylon, polyester or a combination of both. Natural bristle is best for solvent-based paints and synthetic bristle is best for water-based paints.
- Brushes come in a variety of widths, generally 1 to 5 inches. Brush size should be matched to the surface being painted.
- Most brushes are square cut, which is adequate for applying paint onto virtually any surface. For more control when painting into corners or along narrow edges a sash brush, which has bristles cut at a slight angle, can be used.

2.2 Roller Application

2.2.1 General points

- Rollers are a quicker method than using a brush and are also useful for areas with poor accessibility.
- Roller coating is used extensively for finishing flat sheets and coiled metals. The coatings are applied to the surfaces by resilient rollers. The length of the hair on a roller is called the nap or pile of the roller.
- When the substrate and rollers travel in the same direction and at the same speed, the technique is called direct roller coating. When the roller motion is opposed to that of the sheet or strip, the technique is called reverse roller coating.
- When coating is applied on a continuous strip, the technique is called coil coating.
- Roller application is not ideal for the first coat as it provides poor wetting of the substrate and low film thickness. Fibres may become embedded into the coating layer and may come into contact with the substrate, facilitating subsequent penetration of moisture into the coating layer and encouraging premature corrosion of the underlying layer.
- Roller applied coatings may also leave air pockets within the coating layer and potentially cause pinholes as the coating cures.
- The roller should be coated uniformly with paint, rolled over the surface with even pressure and moved in various directions to distribute the paint evenly.
- Roller application is best on large flat areas where distribution of the paint can be achieved by cross rolling.
A roller is a suitable method where there are environmental restrictions as no over-spray is created.

Note: check contract specifications for applicability.

2.2.2 Roller types

- Long haired mohair for textured coatings.
- Shorter haired mohair for most surfaces and most paint types.
- Smooth foam for painting emulsion onto smooth plastered walls. This is not recommended with emulsion paint as it tends to foam (bubble) a lot.
- Synthetic fibre for solvent-based paints,
- Lamb's wool for emulsion-based paints.

2.3 Spray Application

2.3.1 General comments

- Spray application is a faster method of paint application and the best method for rapid coating of large surface areas to achieve a uniform film.
- In spray application, the paint is atomised to produce fine droplets and projected onto the substrate surface where the droplets coalesce to form a continuous film.
- Spray is most commonly used for industrial application.
- Due to the limited access of spray application, stripe coating (see third bullet point in Section 2.1.1) is always recommended on sharp edges, weld seams, corners, and difficult areas to access prior to spraying. Stripe coating should be applied in a contrasting colour and before each full coat; this will allow visual traceability to ensure the stripe coating has been carried out successfully. One of the main reasons for stripe coating edges is that most paint coatings tend to flow away from edges.
- Spray painting requires skill and experience on the part of the operator and often the nature of the coating will determine the use of spray application; some products are easier to spray apply than others, usually depending upon their level of viscosity (consistency).
- The most important advantages are that a much more even film thickness is obtained, heavier film builds can be achieved with most coatings and the production rate is much faster than brush or roller application.
- Most high-solid coatings can, and in some cases must, be applied using specialised multi-component spray equipment. This is essentially similar to other spray equipment, but with several supply and metering pumps linked to a single applicator, thus enabling one-step metering, mixing and spraying of multi-component coatings. Hydraulic or air atomisation are possible, as are internal or external mixing.

2.3.2 Air Spraying

- In this technique, a standard spray gun is used to atomise the paint by mixing it with a stream of compressed air. A simple suction cup gun can be used to draw the paint into the air stream or a pressure pot can be employed to feed the paint into the spray gun under pressure.
- By changing the orifice size and angle and by varying the hydraulic pressure, atomisation can be accomplished for a wide range of paint consistencies, giving a wide range of deposition rates and application speeds.
- Careful consideration should be taken and the manufacturer's technical data sheet must always be consulted for spraying pressures and tip sizes.
2.3.3 Airless Spraying

- In this technique, the paint is hydraulically compressed and atomised upon release through the small orifice in the airless spray gun.
- Like air spraying, the technique can be applied to a broad range of paint consistencies and provide various deposition rates by varying the size and shape of the orifice and the hydraulic pressure.
- Due to the significantly greater pressures involved (up to 27,500 kPa or 4,000 psi), the equipment is more expensive than air-assisted spray equipment, which need only withstand pressures up to 690 kPa (100 psi).
- As an alternative to the addition of diluents, heating may be used to improve the paint consistency by reducing the paint thickness.
- The technique can be used for the application of solvent-free materials such as two-pack products which are mixed at the spray gun nozzle during application.
- In air-assisted airless spraying, compressed air is added to the airless spray to afford enhanced atomisation and spray control, thus enabling the use of lower fluid pressures and paint temperatures during the application of viscous, high-solid paints.

2.3.4 High-volume low-pressure (HPLV) spraying

- In this technique, the air is heated to reduce the cooling effects associated with atomisation, thus limiting condensation of atmospheric moisture and controlling solvent evaporation from the paint droplets.
- Air-atomising guns can be superseded by state-of-the-art HVLP spray guns which use compressed air from conventional sources.
- Blowback is reduced by the low atomising air pressures which result in low droplet velocities. Lower pressure also reduces overspray and completely avoids the vapour cloud generated by conventional spraying.

2.3.5 Electrostatic Spraying

- In electrostatic spraying equipment the coating droplets become charged as they flow past or come into contact with an electrode. The charged paint particles are thus electrostatically attracted to the substrate surfaces, which are generally at ground potential.
- The charged droplets can deposit onto the front and sides of the product and, in some cases, completely cover the back surface. This makes electrostatic applicators particularly useful for coating complex shapes.
- The disadvantage is that the electrostatic attraction is greater on outside corners, edges and around cut-outs than on inside corners and recesses, leading to variable film thicknesses.
- Airless electrostatic spraying makes use of a high-pressure hydraulic spray gun with a power pack to charge the atomized droplets. Blowback and overspray are reduced by the resulting low droplet velocity.
- Air-atomized electrostatic spray equipment imparts a higher velocity to the coating droplets, giving lower transfer efficiency than that of other electrostatic units.

2.3.6 Auto-deposition

- In this technique, a waterborne paint is deposited by means of chemical reactions. An external electrical current is not applied and no surface pre-treatment is required except for thorough cleaning.
Following passage through the auto-deposition tank, the chemical reaction is stopped and residual coating removed from the substrate surface by a standard rinse and post-rinse with deionised water. This is followed by low-temperature curing.

- The technique is applicable to any substrate that can be wetted by the coating material, but it is mainly used for steel.
- The thickness of the coating is self-limiting and hence uniform.
- Auto-deposition equipment is less bulky and more economical than electrostatic coating equipment.
- Since the technique employs waterborne coatings with no organic solvents, air pollution controls are not needed.

### 2.3.7 Rotating Electrostatic Discs and Bells

- High-speed rotating discs and bells can be used to atomise and apply high-viscosity, high-solid paints.
- Electrostatic rotating discs are mostly employed on automatic lines with a conveyor belt looped around the disc in a horseshoe shape.
- Rotating electrostatic bells can be used either manually or attached to robot arms and can apply coatings in either fixed or reciprocating modes.
- The liquid paint is pumped into the centre orifice of the rotating disc or bell and centrifugal force propels the coating to the disc or bell edge and into the atmosphere.
- The coating droplets are charged by high voltage at the outer rim of the disc or bell and are attracted to the oppositely charged substrate surface.

### 2.4 Dip Coating

In this technique, the product is immersed in a tank of the coating material. The excess coating is drained off in a solvent-saturated atmosphere then the coated substrate is dried or cured.

- This is a fast and efficient method capable of coating recessed areas and is generally satisfactory when appearance is not of primary importance.
- Coating thickness is controlled by viscosity and rate of withdrawal from the tank; hence the technique is readily automated.
- Disadvantages include: the tendency for light-weight parts to float and fall out; variation in film thickness from top to bottom; fire hazard associated with organic thinners due to the large volume of coating in the tank and the solvent-heavy atmosphere; and some coating removed by refluxing solvent vapours above the tank.

### 2.5 Flow Coating

- Flow coating overcomes some of the limitations of dip coating.
- Paint is pumped from a reservoir through hoses and nozzles onto the upper surface of the substrate to flow over and down the sides. Excess paint is allowed to drain into a shallow reservoir for re-cycling.
- Flow coating can be automated or applied manually in ventilated booths.
- This technique facilitates coating application to extremely large, complex shapes.
- As with dip coating, the ‘wedge effect’ and solvent reflux are problematic. Evaporation must be rigorously controlled to provide uniform coatings. Control of bubbling and foaming is essential when using waterborne paints.
Continuous coating is similar to flow coating, but employs airless spray nozzles mounted on rotating arms in a recycling cabinet to afford enhanced control and provide a more even coating.

In centrifugal or dip-spin coating, small parts are loaded into an inner basket and the tank is filled with sufficient coating material to cover them. The tank is then emptied while spinning rapidly to remove excess coating by centrifugal force. The surplus coating drains down the inside of the tank into a sump for recycling. The coating thickness is controlled by paint viscosity/percent solids and rotational speed.

In curtain coaters the coating material is pumped to a slotted pipe or a weir, from which it flows or falls under gravity as an unbroken ‘waterfall’ or ‘curtain’ which coats the substrate as it passes beneath. Surplus coating material collects in a gutter and returns to the reservoir for recycling. Coating thickness is controlled by flow rate and conveyor speed in this automated technique.

3 Standards

A number of standards relevant to coating application methods have been published by ASTM (formerly the American Society for Testing and Materials, now ASTM International), SSPC (Society for Protective Coatings) and ISO (The International Organization for Standardization). These are listed below.

ASTM D3276 Standard Guide for Painting Inspectors (Metal Substrates) - this describes the central elements of surface preparation, coatings application, and final approval for both field and shop work.

ASTM D6237 Standard Guide for Painting Inspectors (Concrete and Masonry Substrates) – this describes the central elements of surface preparation, coatings application, and final approval for both field and shop work.

ASTM D5068 Standard Practice for Preparation of Paint Brushes for Evaluation – this describes proper preparation of the brush before use in order to optimise paint application procedure.

ASTM D7801 Standard Terminology for Paint Brush Application Tools – this establishes the definitions for terminology used in testing and manufacturing of paint brushes.

ASTM D7802 Standard Terminology for Paint Roller Application Tools – this establishes the definitions or terminology used in the manufacturing and testing of paint rollers.

SSPC-PA COM, Commentary on Paint Application – this summarises and presents a general description of the SSPC standards, guides, and specifications for Paint Application (PA).

SSPC Monitoring and Controlling Ambient Conditions – this describes common coating defects related to adverse ambient conditions; which conditions to monitor and track; control of ambient conditions; use of information regarding ambient conditions.

SSPC-PA 1, Shop, Field, and Maintenance Painting of Steel – this covers the procedures for the painting of steel surfaces with specific and general requirements for paint application.

SSPC-PA 7 Applying Thin Film Coatings to Concrete – this covers methods and procedures for applying thin film organic coatings to concrete surfaces by brush, roller, or spray.

SSPC-PA Guide 4, Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems – this covers the steps necessary for repainting steel structures previously painted with oil base, alkyd, or other conventional paint systems.

SSPC-PA Guide 5, Guide to Maintenance Coating of Steel Structures in Atmospheric Service – this covers procedures for developing a maintenance coating program for steel structures.


ISO 12944-7:1988 Paints and varnishes -- Corrosion protection of steel structures by protective paint systems - Part 7: Execution and supervision of paint work.


4 References

Some of the details regarding coating application methods in the main text of this document were obtained from the following websites:

Coating for the Protection of Structural Steelwork, Guides to Good Practice in Corrosion Control, National Physical Laboratory (NPL)

The Basics of Plural Component Spray by Robin Hasak, Tnemec Company Inc.; http://www.paintsquare.com

The website of Products Finishing magazine - http://www.pfonline.com/articles/todays-paint-application-methods

5 Acknowledgements

The original version of this document was prepared by David Horrocks and Amy Brightmore. The present version contains further contributions from Douglas Mills and Ruth Bingham.