Guidance Note 8.05

High performance paint coatings

Scope

This Guidance Note describes the fundamental requirements relating to the application of paint coatings for the corrosion protection of steel bridges. Metal coatings applied by hot dip galvanizing and thermal spray are covered in separate Guidance Notes (GN 8.03 and GN 8.04 respectively).

The paint systems described are for new works.

General

Most new steel bridges other than those constructed from weathering (atmospheric corrosion resistant) steel are protected against corrosion by a metal coating + paint (duplex) or a paint system.

Specifications for new works systems for road bridges are contained in the Specification for Highway Works 1900 Series [1]. The current Specification includes paint-only systems designed to provide lives to first maintenance of up to and in excess of 20 years. Note that the aluminium spray Type II system was removed in August 2014 for general application to bridges, although a very similar Zinc-aluminium system (N1) is still listed in the Network Rail specification [2].

The paint coatings used have changed over the years, primarily as a result of new environmental legislation, development of high performance coatings for offshore structures and in response to the demand for extended lives to first maintenance by bridge owners. The legislation has effectively limited the range of paint coatings that can be applied. Generally, the use of high solids coatings has been adopted to comply with the legislation and to improve coating durability.

Additionally, it should be appreciated that modern high performance coatings have become increasingly more specialised and need to be correctly applied to optimise their properties and performance.

Paint coatings are complex chemically engineered products formulated to have specific properties to satisfy durability and appearance requirements.

The number of overall coats of paint in modern specifications is less than in previous specifications with the old 5 and 6 coat systems being replaced by 2 and 3 coat systems that effectively reduce time in the paint shop and enable quick completion of the work.

Specifications for the protection of new highway bridges now typically include epoxy ‘build’ undercoats with polyurethane, epoxy/acrylic, polysiloxane or more recently fluoropolymer resin-based finishes.

Single high build coatings, where correctly applied, have also indicated good long-term performance on bridge structures, suggesting a very long life to first maintenance.

The paints and systems to be used for highway bridges and railway bridges are subject to registration under the Design Manual for Roads and Bridges and Network Rail schemes respectively [3], [4].

However, it is important to appreciate that the overall performance of any coating system is dependent upon good workmanship at all stages of the surface treatment process, including substrate preparation, coating application and final inspection. For components painted in the shop, transport of parts also needs to be considered. Each stage must be carried out according to the requirements of the specification and in compliance with the information provided in the paint manufacturer’s datasheets.

Surface preparation

It is vital to prepare the surface of the steel properly before the application of any coating. The performance

of a coating is significantly influenced by a number of issues, including surface cleanliness, profile and the preparation of welds and cut edges. See GN 8.01 for further guidance.

The protective paint system

Modern coating systems usually consist of a sequential coating application of paints applied directly to prepared steel substrates or, in a duplex system, over metal coatings.

Conventionally, protective paint systems consist of primer, undercoat(s) and finish coats. Modern specifications typically comprise three coat systems. Each coating 'layer' in any protective system has a specific function.

It is usual for the primer and undercoats to be applied in the shop and untreated areas (such as bolted splices, site welds) brought up to the shop coating state before finish coats are applied on site.

The individual coats of paint are now described.

Primer

The primer is applied directly onto either the cleaned steel surface or, in the case of duplex systems, the sealed metal coating. Its purpose is to wet the surface and to provide good adhesion for subsequent coats. In the case of paint-only systems, primers are sometimes also required to provide corrosion inhibition.

There are two basic types of primer:

(i) Primers pigmented with metallic elements anodic to steel

These primers are formulated so that, when a break in the coating (due to damage or local corrosion) exposes the steel substrate, the anodic metal corrodes sacrificially in preference to the steel. This effectively stifles steel corrosion and under-rusting of the primer until the anodic metal is exhausted. Zinc rich primers are the most commonly used of this type.

(ii) Primers relying on the high adhesion and chemical-resistance properties of the binding media.

With these primers, good adhesion is obtained (provided that the surface is very thoroughly cleaned) and it is sufficient to prevent under-rusting at any break in the coating (due to damage). Two-pack epoxy primers are typical of this type. These primers may contain inhibitive pigments to interfere with the corrosion process. Zinc phosphate, for example, is a mildly inhibitive pigment and is widely used in modern primer formulations.

Undercoat(s) (intermediate coat(s))

Intermediate or undercoats are applied to build the total film thickness of the system. Undercoats are specially designed to enhance the overall protection and, when highly pigmented, to decrease permeability to oxygen and water. Generally, the thicker the coating the longer the life, as the path length for moisture and oxygen through the film is longer.

The incorporation of inert laminar pigments, such as micaceous iron oxide (MIO) or glass-flake, reduces or delays moisture penetration in humid atmospheres by increasing the path length and improves tensile strength.

Ideally undercoats must remain over coatable even when there are unavoidable delays in applying further undercoats and the finish coats, though in some cases such as epoxy-based undercoats, exposed for extended periods, some pretreatment might be necessary before overcoating.

Finish coat(s)

The finish coat provides the required appearance and surface resistance of the system. Depending on the conditions of exposure, it must also provide the first line of defence against the environment including, weather, ultra-violet light (UV), ozone, pollution, traffic spray, deicing salts, bird guano and micro-climates causing condensation (as on the undersides of bridges). Oil and weedkiller chemical resistance is also specified for railway bridges, and low surface energy coatings such as fluoropolymer and polysiloxane can make the removal of graffiti easier.

For good performance, including the aesthetic appearance of the structure, the resins used in finish coats need strong chemical bonds to resist breakdown from the environment. Hence epoxy-acrylic, polyurethane, polysiloxane and fluoropolymer resins are used. Some finish coats are also designed to allow indefinite overcoating with minimal surface preparation.

Paints tend to be gloss or semi-gloss to reduce dirt retention, which can hold moisture against the surface.

'Pure' epoxy paints can also be used as finish coats but are prone to chalking on exposure to ultra-violet.

In the more benign environments such as found in the interiors of structures such as box girder bridges thinner systems can be used with the undercoat also acting as the finish coat. Water based paints are also permitted in such environments and should be considered to reduce exposure to harmful solvent fumes.

Stripe coats

Stripe coats are additional coats of paint that are applied locally to welds, fasteners and external corners. Their function is to build a satisfactory coating thickness at edges and corners where the liquid paint film has a tendency to pull away from edges due to surface tension, causing contraction and thinning upon drying/curing. Specifications should indicate the type and number of stripe coats required and state when they are to be applied. Stripe coats, and indeed most intermediate coats, are specified in contrasting colours to aid application and inspection.

Small areas such as infill bars are provided with an additional coat overall as it is not practicable to apply coats only to the edges.

The paint system

The various superimposed coats within a painting system have to be compatible with one another. They can be all of the same generic type but nowadays it is more common for the chemistry of each coat to be different to suit their different functions, e.g. a recoatable polyurethane, fluoropolymer or polysiloxane finish coat, may be applied onto epoxy primer and intermediate coats. However, as a first precaution and often required as mandatory by the Specification, all paints within one system should be obtained from the same manufacturer; they must also be used in accordance with that manufacturer's recommendations.

Coating thickness

The coating thickness of the dried film (both overall and of individual layers) is an important factor in the performance of the coating system. Specifications usually quote minimum dry film thickness, although they usually also require that the application avoids excessive film thickness. The over application of paints can result in the formation of high stresses and may cause premature failure of the system. Guidance on the measurement of coating thickness is given in GN 8.06.

The application of paints

The method of application and the conditions under which paints are applied have a significant effect on the quality and durability of the coating. Standard methods used to apply paints to steel bridges include airless and air assisted spraying, plural component spraying and brushing.

For airless spraying, the paint is hydraulically compressed and, when released through a small orifice in an airless spray gun, it is atomised and projected onto the surface. By changing the orifice size and shape and by varying the hydraulic pressure, atomisation can be accomplished for a wide range of paint consistencies from thin to thick, to give a wide range of rates of deposition. The equipment required is much more expensive than for air assisted spraying, because it must withstand the much higher pressures involved. Hydraulic pressures up to 280 bar may be required.

A variant of airless spraying involves heating to reduce the viscosity of the paint rather than adding diluents. In this way, greater film thickness per application is achieved. This method can be used for the application of solvent-free materials such as two pack products that can be mixed at the spray gun nozzle at the moment of application. The use of expensive equipment and highly skilled labour is necessary for the achievement of optimum results but is justified for the protection of large and important structures.

Conditions at application

The principal conditions that affect the application of paint coatings are temperature and humidity. These can be more easily controlled under shop conditions than on site.

Temperature

Air temperature and steel temperature affect solvent evaporation, brushing and spraying properties,

drying and curing times and the pot life of two-pack materials, etc. Where heating is required, this should only be by indirect methods.

Humidity

Paints should not generally be applied when there is a risk of condensation onto the steel surface. This is checked by ensuring the steel substrate is above the dewpoint temperature by a specified margin, and that the relative humidity of the atmosphere is low enough that it will not affect the application or drying of the coating.

A limited range of moisture cured paints are available commercially, noting that all of the registered formulations under the approval schemes for highway and railway structures have been discontinued as they posed risks to health from the isocyanate curing agents. These moisture cure paints will require a Departure. Some alternative high build two pack polyurethane paints are also registered under Network Rail M34 systems [2] and are specifically formulated for application in cold, damp and humid conditions; reference should be made to the manufacturer's data sheets for details of limiting conditions of application.

Inspection and testing of paint coatings

It is essential that all of the stages of surface preparation, application of metal and paint coatings are inspected by appropriately qualified persons. The importance of inspection cannot be overstated. It is very important to the achievement of long-term performance to ensure that the coated structure has been correctly prepared, paints stored and mixed properly and the surfaces treated according to the specification and coating manufacturers' data sheets.

See GN 8.06 for further information about inspection of coatings.

Reference documents

[1] Manual of Contract Documents for Highway Works Specification for Highway Works, Series 1900: Protection of Steelwork against Corrosion, 2014, TSO.

[2] NR/L3/CIV/040: Network Rail Standards, Level 3 Work Instruction, for the use of protective coating systems, June 2023.

[3] Design Manual for Roads and Bridges, CG 303, - Quality assurance scheme for paints and similar protective coatings

[4] NR/L2/CIV/039: Network Rail Standards, Level 2 Specification. Assessment and certification of protective coatings (Issue 1), Network Rail, June 2023 (promoted to a Level 2 Specification, with a new document number)

Other relevant Standards and further reading

- BS EN ISO 8501-1:2007, Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness. Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.
- BS EN ISO 8503-1:2012, Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast cleaned steel substrates. Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast cleaned surfaces.

Information available on steelconstruction.info:

https://www.steelconstruction.info/Paint_coatings, BCSA, Steel for Life, SCI.

https://www.steelconstruction.info/Corrosion_protection , BCSA, Steel for Life, SCI.