National Cooperative Highway Research Program

RESEARCH RESULTS DIGEST

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Protective Coatings for Highway Structural Steel

A staff (NCHRP) digest of the essential findings from the final report on NCHRP Project 4-6, "Protective Coatings for Highway Structural Steel," prepared by John D. Keane, Director of Research, Steel Structures Painting Council

THE PROBLEM AND ITS SOLUTION

The painting of steel is the principal means of protecting this important highway construction material against its primary enemy--corrosion. It is estimated that about $2 billion per year is spent on corrosion protection of structural steel, a large part of which consists of highway bridges. Much of the information available on this specialized subject is presented from the point of view of one type of product or method of application. In some locations infrequent painting provides adequate protection, whereas in a few situations the total cost of protecting a structure throughout its lifetime may exceed the original cost of the structure. A need exists for a definitive ranking of paint systems and methods of application for the specific exposure conditions to which highway bridges are subjected in this country.

With this objective in mind, the Steel Structures Painting Council undertook a program involving (1) an extensive literature survey, (2) review of current practice in this and other countries, (3) inspection of more than 4,000 paint exposure tests, and (4) conduct of paint film thickness measurement studies. This research was successful in arriving at specific recommendations for preferred paint systems (including surface preparation, pretreatment, application method, thickness, primer, intermediate coat, and finish coat) for five environmental zones representing a range of severity to which highway steel structures are exposed. Several special conditions are also covered.

FINDINGS

The essential findings of this study are the recommendations summarized in Table 3, Summary of Steel Coating Recommendations.

APPLICATIONS

At present, the painting of steel is more of an art than a science. There is no one "best" paint for all conditions or types of exposure. During this study, it was found that variations in environmental exposure, surface preparation, and coating thickness overshadowed the difference in performance between types of coatings. Other factors that may influence a final selection include appearance, costs, availability, and air pollution requirements.

Due to the comprehensive nature of this investigation, the recommendations summarized in Table 3 should materially aid highway agencies in the selection of suitable coating systems for protection of steel structures subjected to a variety of exposure conditions. The results of the study are particularly noteworthy in their contribution to the art of structural steel painting because the recommendations are sufficiently explicit to permit direct application without having to be combined with results from other research. Further, they are expressed in straightforward terms and, for the user's convenience, references are made to existing specifications of the Steel Structures Painting Council, the American Association of State Highway Officials, and the Federal Government whenever possible.

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TABLE 3
SUMMARY OF STEEL COATING RECOMMENDATIONS

ZONE [a]	ENVIRONMENT	PREFERRED SYSTEM	ALTERNATES
1A	Interior, normally dry (or temporary protection) Unusual in hwy. work, very mild (oil base paints would last 10 yr or more)	One coat of fast-drying shop paint (example: SSPC-Paint 13) over nominally hand-cleaned steel. Finish coat optional. (See SSPC-PS 7.01)	(1) Other one-coat primers (example: TT-P-636) (2) Rust proofing (SSPC-PS 8.01), or (3) More durable systems as per Zone 1B, or (4) Approved proprietary paint.
1B	Exteriors, normally dry (Includes most highway areas where oil base paints now last 6 yr or more)	Apply 2 coats oil base primer (example: SSPC-Paint 14) over wire-brushed steel. 1-2 finsh coats of long oil alkyd (SSPC-Paint 101 aluminum or SSPC-Paint 104 white, gray or green) 4.0 mils or more thickness. (See SSPC-PS 1.01 or 1.03)	(1) Blast clean (SSPC-SP 6) and use same paints or shorter oil alkyds. (2) Alternate primer (SSPC-Paint 2; TT-P-57, Type I; AASHO M72-57, Type I or II; or TT-P-615, Type V) or (3) Alternate intermediate TT-P-86, Type II or non-leafing aluminum), or (4) Equivalent state system, or (5) Same systems as Zone 2A or 2B, or (6) Proven proprietary system.
2A	Frequently wet by fresh water Involves condensation, splash, spray, or frequent immersion. (Oil base paints now last 5 yr or less)	Near-white blast clean surface; 4 coats (4.5 mils) of vinyl system (example: SSPC-Paints 8 or 9) (See SSPC-PS 4.04 or 4.02)	(1) Pickle (SSPC-SP 8) instead of blast cleaning. (2) Alternate vinyls are VR 3 or approved proprietaries. (3) Epoxy system guide (SSPC-PS 13.00), coal tar epoxy (SSPC-PS 11.01), chlorinated rubber system, or approved proprietary system.
2B	Frequently wet by salt water Involves condensation, splash, spray or frequent immersion. (Oil base paints now last 3 yr or less)	Near-white blast clean surface; apply zinc-rich primer (example: SSPC-PS 12.00 or MIL-P-23236 or California Highway Spec. 66-G-55) followed by approved wash primer and finish coat. (Example: SSPC-PT 3 plus SSPC-Vinyl Paint 8 or 9, 3+ mils) Assure satisfactory adhesion of finish coats.	(1) Use finish coat with same vehicle as zinc-rich primer (inorganic, epoxy, chlorinated rubber, vinyl, etc.) (2) Use vinyl paint system with wash coat and inhibitive primer (example: SSPC-PS 4.01 or 4.03) (3) Use as alternate finish coats or by themselves, coal tar epoxy (SSPC-PS 11.01), epoxy (guide SSPC-PS 13.00), or approved chlorinated rubber system, or other proven proprietary system.
3	Chemical exposures (Acidic, alkaline, oxidizing, solvents, etc.)	Same as for Zone 2B, but with chemically resistant finish coat system specially chosen to protect primer and base metal against specific chemical agent. (Zinc-rich unsatisfactory for very acid or very alkaline conditions.) Assure satisfactory adhesion of finish coats.	Same choices as for Zone 2B, but with special finish coats. (1) Coal tar epoxy (SSPC-PS 11.01) (at least 16 mils). (2) Straight vinyls for acid and alkali (SSPC-PS 4.01 or 4.03). (3) Epoxies for alkalies, salts, aliphatics, acid splash; not for strong solvents. (4) Neoprenes and other proven proprietary systems to resist specific conditions.
4	*Special Conditions*		
	Painting galvanized steel	Solvent clean to remove oil and grease. Wire brush to remove any rust. Apply zinc dust-zinc oxide paint TT-P-641 (Type II for new steel, Type I for old, as per SSPC-PS 2.05 and 1.04). Somewhat better adhesion if surface is weathered before painting.	(1) Chemical pretreatment of new work by commercial hot phosphate or wash primer. (2) Zinc-rich primer (example: Guide SSPC-PS 12.00). (3) Primer with SSPC-Paint 5. (4) Primer with proven proprietary cement-base, polyvinyl, acetate emulsion, or acrylic latex.
	Mildew	After surface preparation, wash mildewed surface with trisodium phosphate and dry. Add mildewcide to each coat of paint (example: 8-quinolinoleate). Vinyl, chlorinated rubber resins, and barium metaborate and zinc-rich pigmentations tend to resist mildew.	Alternate mildewcides and fungicides include copper naphthenate, chlorinated phenols, phenyl mercuric dodecylsueinate, proprietary agents. Add in amount recommended by the manufacturer.
	Temporary protection and rustproofing	See system for Zone 1A. Also see SSPC-PS 8.01, "Rust Preventive Compounds" (thick non-hardening films over minimum surface preparation)	Soft, heavy, or hard film compounds as per 52-MA-602. Type B, C, or D; or use proprietary rustproofing compounds.
	Painting welds	Before welding, do not paint within 2 in. of edges. Blast clean after welding. See SSPC-PA 1, Sections 3.5.2.4 and 3.5.2.5.	Chip and wire brush weld thoroughly. Wash with 5% phosphoric acid and rinse. See SSPC-SP 1, Section 3.1.6.

[a] These are intended as specific exposure zones of the portion of the structure under consideration rather than geographic zones. Severity of exposure can change sharply over very short distances due to such factors as wind, spray, and use of de-icing chemicals.