Du Pont de Nemours, E. I. & Co.
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Tests for evaluating the outdoor durability of coatings, by M. P. Morse. 1976.

TESTS FOR EVALUATING THE OUTDOOR DURABILITY OF COATINGS

Outdoor weathering tests are conducted to provide the information needed to predict the durability performance of coatings in service. In order to obtain results that correlate well with in-service performance, coatings must be applied, exposed, and rated by specific procedures. Following is a discussion of procedures found to be useful for evaluating the durability of different types of products and some comments regarding their reliability. Tables are included that outline the test procedures.

Durability Evaluation of Automotive Coatings (Table I)

For evaluation of coatings designed for the exterior bodies of cars, phosphate coated cold rolled steel panels are coated with a primer and a topcoat. The coated panels are exposed in Florida on 5°S open racks or on 5°S black box racks. Black box racks produce panel surface temperatures comparable to the temperatures observed for coatings on the hoods, roofs, and decks of cars parked in direct sunlight. Significantly lower panel temperatures are produced by the open racks.

The exposed coated panels are rated for gloss loss, distortion, scumming, color change, and checking (after gentle washing). Gloss loss is measured with a 20° glossmeter, the other types of failure are rated visually. Generally, ratings are made at intervals of six months of exposure, but occasionally ratings are performed at more frequent intervals to obtain an early indication of performance, particularly for gloss loss.

Florida 5°S black box exposures produce gloss loss, distortion, scumming, and checking at an average rate of 1.5 times the rate produced by Florida 5°S open rack exposures. These two conditions do not always produce the same performance rankings for a series of coatings, since the degradation of some products is greatly accel erated by the higher panel temperatures produced by the black box.

Useful predictions of coating performance on cars can be obtained from both the Florida 5°S black box and 5°S open rack exposures. Black box exposures are considered to be superior for predicting the performance of coatings on the hoods, roofs, and decks of cars. Reliable predictions of relative product performance can be obtained from 12 months exposure under these conditions with the use of controls of known performance for comparison and with sufficient replication of exposures. Fairly reliable predictions can be obtained from only six months exposure if the exposure period consists of the spring and summer months.

Florida exposures are an accelerated test for predicting coating performance on cars in more temperate climates. For example, Florida 5°S open rack exposures produce gloss loss and distortion at an average rate of about 1.5 times the rate produced by Delaware 5°S open rack exposures.

Occasionally, coated panels are exposed on the black box in Colorado to determine their susceptibility to stress cracking. This is a type of failure that occurs on cars in cold climates and is not produced by coated panel exposures in Florida or Delaware.

For evaluations of coatings on flexible parts of cars (e.g. filler panels), topcoats are applied to elastomeric substrates with or without a primer, depending on the in-service requirements. The coated panels are exposed in Florida usually on the 5°S open racks. The panel temperatures produced by open rack exposures are considered to be more comparable to the surface temperatures on flexible parts of cars than are the higher temperatures produced by the black box. In addition to the types of failure mentioned above, the coated panels are rated for loss of flexibility at room temperature and at low temperatures.

With the use of controls of known performance for comparison and sufficient replication of exposures, reliable predictions of relative coating performance on flexible

parts of cars can be made from 12 months exposure on the Florida 5°S open racks. As mentioned above, fairly reliable predictions of relative performance can be obtained with only six months exposure if the exposure period consists of the spring and summer months.

In some cases, exposures on EMMAQUA, the outdoor accelerated weathering device operated in Arizona by Desert Sunshine Exposure Tests, Inc., can provide useful qualitative evaluations of durability. For example, it has been judged to be satisfactory for the screening of pigments for their color durability in specific automotive coating vehicles. It has provided average rates of gloss loss, chalking and color change at roughly ten times the rates produced by Florida exposures. EMMAQUA exposures have not proven reliable for screening different types of vehicles for their durability in automotive coatings.

Durability Evaluation of Coil Coatings for Exterior Structures (Table II)

For evaluation of coil coatings designed for aluminum substrates, chromate treated aluminum panels are used to which topcoats are applied with or without a primer, depending on the in-service requirements. For coatings designed for steel substrates, topcoats are applied to galvanized steel panels coated with a primer.

All coated panels are exposed in Florida at 45°S and are rated for gloss loss, color change, chalking, dirt collection, mildew, erosion, and adhesion. Gloss loss is measured with a 60° glossmeter, and color change is measured with a colorimeter. The other types of failure are rated visually. A section of each coated panel is gently washed for the ratings of all types of coating failure except dirt collection, which is rated on an unwashed section.

With the exception of dirt collection and mildew, reliable predictions of product performance on exterior structures can be obtained from coated panels exposed for 24 months

on 45°S open racks. Fairly reliable predictions can be obtained frequently from only 12 months exposure with the use of controls of known performance and sufficient replication of exposures. These Florida exposures are an accelerated test for determining the performance level of coatings exposed to more temperate climates.

Reliable predictions of dirt collection performance and fairly reliable predictions of mildew performance are obtained from exposures on Florida NV racks for 24 months. Reliable predictions of mildew performance are obtained from NV exposure of 24 months in the rain forest of Puerto Rico.

The Florida and Puerto Rico exposures are accelerated tests for determining the performance of coatings in more temperate climates.

EMMAQUA exposures in Arizona can be useful in screening different types of vehicles as well as different types of pigments in a specific vehicle for durability in coil coatings. EMMAQUA has provided gloss loss and color change at average rates of roughly five times Florida 45°S exposures.

Durability Evaluation of Exterior House Paints and Trim Paints (Table III)

The most reliable predictions of the durability of exterior house paints and trim paints are obtained from exposures on houses, when a control of known performance is applied adjacent to the product to be evaluated and sufficient replication of houses is used. However, nearly as reliable predictions can be obtained from the exposure of coated panels on outdoor racks if the proper type of substrate and exposure conditions are used.

For evaluations of dirt collection, mildew, chalking, and color change; products are applied to primed red cedar panels. One half the panel is coated with the product to be evaluated, while the other half is coated with a control of known performance.

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Fairly reliable predictions of mildew performance on houses are obtained from coated panels exposed on Delaware NV racks for 6-12 months (depending on season of exposure), while fairly reliable predictions of dirt collection are obtained from coated panels exposed on Delaware NV racks for 12 months. Reliable predictions of chalking and color change are obtained from coated panels exposed on Florida 45°S racks for 12 months. Florida exposures are accelerated tests for the predictions of chalking and color change on houses in more temperate climates.

For fairly reliable predictions of cracking, flaking, and peeling, topcoats (with controls) are applied over un-primed yellow pine panels and exposed on Delaware 45°S racks for 24 months. More reliable predictions can be obtained by applying topcoats (with controls) over yellow pine panels coated with chalked and cracked weathered oil based paint and exposing them on Delaware 45°S racks for 24 months.

Durability Evaluation of Exterior Maintenance Paints (Table IV)

For screening maintenance paint candidates for relative durability performance over steel substrates, unweathered cold rolled steel panels can be used as a substrate. These panels are coated with a primer and then a topcoat is applied to two thirds of the panel. An "X cut" is made in the topcoated and untopcoated section of the panel.

Exposures are made in Florida on horizontal and 45°S racks, using panels coated with controls of known performance for comparison. These conditions represent the most severe weather conditions to which most maintenance paints are subjected.

After exposure, the coated panels are rated visually for chalking, blistering, color change, cracking, peeling, erosion, and rusting. Rust creep is rated at the "X cut". Useful information for directing product development can be obtained after 12-24 months of exposure.

For fairly reliable predictions of product performance, hot rolled steel panels that have been rusted outdoors (e.g. Delaware or Florida) are used as a substrate. Loose rust

is removed by wire brushing and a primer and a topcoat are applied as described above. Coated panel exposures are made in Florida on horizontal and 45°S racks, using panels coated with controls of known performance for comparison. The coated panels are rated after 12-24 months exposure for the types of failure mentioned previously.

The most reliable predictions are obtained from the use of hot rolled steel substrates that have been rusted at the site where the coatings are to be used in service. Loose rust is removed by wire brushing and the primer and topcoat are applied as above. The coated panels are exposed at the in-service site on horizontal and 45°S racks, using panels coated with controls of known performance for comparison. The coated panels are rated after 2-5 years exposure for the type of failure mentioned previously.

Durability Evaluation of Marine Paints (Table V)

For the evaluation of the performance of marine paints above the water line, unweathered cold rolled steel panels are coated with a primer, an intermediate coat, and a topcoat. These panels are exposed 45°S in a Florida or New Jersey marine atmosphere using panels coated with controls of known performance for comparison. After 24 months exposure the coated panels are rated visually for chalking, erosion, blistering, cracking, peeling and rusting. The reliability of predictions for in-service performance from these exposure results is considered to be good.

For evaluation of the performance of marine paints below the water line, grit blasted hot rolled steel panels are coated with a primer, an intermediate coat, and a topcoat. For evaluation of cathodic protection, a small section (1" square or less")of the panels is uncoated. These panels are exposed in Florida to sea water in the tidal zone (half way between low and high tide) and to complete immersion at constant depth. Panels coated with controls of known performance are included for comparisons.

After 12-24 months of exposure, the coated panels are rated visually for marine growth as well as for corrosion, blistering, peeling, and erosion. Cathodic protection is

rated by examination of the uncoated section. The reliability of predicted product performance from these immersion tests is only fair because of the large variability encountered in the exposure results.

Use of Controls and Replication

The degrees of reliability given for the predictions of in-service performance from the types of coating exposures described above require that (1) controls of known performance be included in each exposure series and (2) a sufficient number of replicate series be exposed to provide statistically valid judgements of durability. The number of replicate exposures needed will vary depending on whether the series is designed to roughly screen candidates or whether it is designed to establish precisely the durability level of products.

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TABLE I

OUTDOOR EXPOSURE TESTS OF COATINGS FOR AUTOMOBILES

Substrate	Coating	Properties Rated	Exposure Conditions	Period	Reliability for Predictions of Performance on Cars
Phosphate treated steel panels	Topcoat over primer	Gloss loss Color change Distortion Scumming Checking	Florida 5°S Black Box OR Florida 5°S Open Rack	12 months 18-24 months	Good Good
"	"	"	Arizona EMMAQUA	2 months	Fair-Good for screening candidates
"	"	Stress cracking	Colorado 5°S Black Box	18-24 months	Good
Flexible elastomeric panels	Topcoat over Primer or No primer	Gloss loss Color Change Scumming Checking Flexibility	Florida 5°S Open Rack	12-18 months	Good

TABLE II

OUTDOOR EXPOSURE TESTS OF COIL COATINGS FOR EXTERIOR STRUCTURES

Substrate	Coating	Properties Rated	Exposure Conditions	Period	Reliability for Prediction of Performance on Structures
Chromate Treated Aluminum Panels or Galvanized Steel Panels	Topcoat over Primer or No Primer	Dirt Collection	Florida 45°S	12-24 months	Fair
		Color Change	"	"	Good
		Chalking	"	"	"
		Gloss Loss	"	"	"
		Erosion	"	"	"
		Adhesion	"	"	"
"	"	Dirt Collection	Florida SV	24 months	Good
"	"	Mildew	Florida NV	24 months	Fair-Good
		"	Puerto Rico NV		Good
"	"	Gloss Loss Color Change	Arizona EMMAQUA	4 months	Fair-Good for screening of candidates

TABLE III

OUTDOOR EXPOSURE TESTS OF EXTERIOR HOUSE PAINTS AND TRIM PAINTS

Substrate	Coating	Rated	Conditions	Period	Reliability for Predictions of Performance on Houses
Red Cedar Clapboards	1/2 panel w/control topcoat, 1/2 panel w/ exp. topcoat-both over primer	Mildew Dirt Collection	Delaware NV "	12 months	Fair-Good "
"	"	Chalking Color Change*	Florida 45°S	12 months	Good "
Yellow Pine Clapboards	Topcoat No Primer	Cracking Flaking Peeling	Delaware 45°S	24 months	Fair
Cracked and chalked oil paint on yellow pine clapboards	Topcoat No Primer	Cracking Flaking Peeling	Delaware 45°S	24 months	Good

*Expose metal panels for colorimeter measurements

TABLE IV

OUTDOOR EXPOSURE TESTS OF EXTERIOR MAINTENANCE PAINTS

Substrate	Coating	Properties Rated	Exposure Conditions	Exposure Period	Reliability for Predictions of Performance on Substrates
Unweathered Cold Rolled Steel Panels	2/3 panel w/topcoat + primer, 1/3 panel w/topcoat no primer	Chalking Cracking Blistering Rusting Rust Creep Erosion Peeling	Florida 45°S and Florida Horizontal	12-24 months	Poor Good for screening candidates only
Exposure Station Rusted Hot Rolled Steel Panels	Same as Above	Same as Above	Same as Above	Same as Above	Fair
On Site Rusted Hot Rolled Steel Panels	Same as Above	Same as Above	On Site 45°S and On Site horizontal	2-5 Years	Good

TABLE V

OUTDOOR EXPOSURE TESTS OF MARINE PAINTS

Substrate	Coating	Properties Rated	Exposure Conditions	Exposure Period	Reliability for Predictions of Performance on Structures and Ships
Unweathered Cold Rolled Steel Panels	Topcoat with intermediate Coat and Primer	Rusting Chalking Erosion Blistering Cracking Peeling	Florida 45°S in Marine atmosphere	18-24 months	Good
			N.J. 45°S in Marine atmosphere	24 months	Good
Grit Blasted Hot Rolled Steel Panels	"	"	Florida Tidal Zone	12-24 months	Fair
"	"	"	Florida Salt Water Immersion	12-24 months	Fair

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