THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

EVALUATION OF PAINT AND PLASTIC COATINGS FOR SPRINGS

Report No 400

by

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AUGUST 1986

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SUMMARY

The variety of paint and plastic coatings available for protection of springs has increased considerably over the past few years. This report considers many of the coatings in regular use today and compares their relative effectiveness as corrosion protectives. A wide range of performance was noted, and the relative costs involved with each protective can be compared with their performance. The effect of shot peening prior to application of the paint systems should be carefully noted.

AUGUST 1986

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1. INTRODUCTION

Previous SRAMA reports have examined the effectiveness of several coatings for protection of springs against corrosion.[1, 2]

The present work extends the previous investigations, by examining the efficacy of corrosion protection being offered by a range of paint and plastic coating finishes, which were applied commercially to both springs and test panels.

2. SPRINGS AND TEST PANELS

As in previous work, compression springs were made from 4 mm diameter BS 2803 HD wire.[2] Half of the batch of springs was shot peened using S330 shot, in order to evaluate the corrosion protection afforded by the various paints and plastic coatings on both unpeened and peened surfaces.

The test panels were made from 150 mm long x 100 mm wide x 0.9 mm thick mild steel sheet. Half of the batch of test panels were shot peened using S110 shot, and care was taken to avoid distortion of the panels and to ensure that they were peened equally on both sides.

All the springs and test panels were lanolin coated for protection against accidental rust damage prior to the coating processes.

3. COATINGS EXAMINED

Eleven coating systems were examined during the present work, as shown in Table I. Of these, the first seven were non-sacrificial, whilst the remaining four conferred sacrificial protection.

Three of the sacrificial coatings were applied by a sherardizing process, which essentially involved heating the components at 320°C for one and a half hours in zinc powder to produce a zinc enriched steel surface. All sherardizing was carried out to the requirements of BS 4921: 1973: Class II (0.0006 in min).[3]

The full list of coatings is as follows:-

i) Black enamel paint. Applied by dipping.

ii) Black enamel paint with phosphate pretreatment. Applied by dipping.

iii) Black electro-cathodic water soluble paint, with phosphate pre-treatment. Cured 200°C/20 minutes.

iv) Polyester powder coat with phosphate pre-treatment. Applied by electrostatic spray. Cured 200°C/40 minutes.

v) Epoxy powder coat with phosphate pretreatment. Applied by electrostatic spray. Cured 200°C/40 minutes.

vi) Nylon. Samples were heated to 180°C and dipped into nylon powder.[4]

vii) Polytetrafluorethylene (PTFE). Applied by hand spray. Cured 250°C/20 minutes.[4]

viii) Sermetel 725. A sacrificial base of ceramic coated aluminium particles with an inorganic chromate/phosphate topcoat. Cured 350°C/60 minutes.[5]

ix) Sherardized only.

x) Sherardized with phosphate passivation.

xi) Sherardized with phosphate and chromate passivation.

4. SALT SPRAY AND ENVIRONMENTAL TESTING

4.1 Salt Spray Tests

Neutral salt spray testing to the requirement of ASTM B117-73 and BS 5466: Part 1: 1977, was carried out using the Liebisch STR 400 salt spray test cabinet at the SRAMA laboratories.

For each coating type, batches of three unpeened and three shot peened springs were exposed to salt spray for upto 800 hours.

Two failure criteria were adopted for the appearance of red rust on at least two springs from each batch, namely:-

i) Rusting beneath the end tip: Incomplete penetration at the region beneath the end tip has been shown to reduce the efficacy of protection offered to springs by both paint and plastic coatings. 6, 7

ii) Coating breakdown: More general breakdown of the coating film was represented by rusting of the active coils of the springs.

4.2 Environmental Exposure Tests

Both unpeened and shot peened panels were simultaneously tested under outside atmospheric conditions on the laboratory roof using special corrosion racks constructed in accordance with the conditions laid out in BS 3900: Part F6 (Notes for Guidance on the Conduct of Natural Weathering Tests for Paints). The racks were inclined at 45° to the horizontal and positioned, facing towards the equator, away from any protection or overshadowing by neighbouring objects. The panels were held in place by electrically non-conducting fibre washers to prevent contact with the steel rack and so eliminate any possible electrochemical corrosion.

5. RESULTS AND DISCUSSION

The results of salt spray tests on compression springs are shown in Tables II and III for end tip failure and general coating breakdown respectively.

Table IV shows the results obtained, up to the time shown, for flat panels exposed to the environment. In all three tables, the coatings are arranged in order of increasing protection against corrosion.

Tables II and III demonstrate that, for several of the coatings, rusting generally began underneath the end tip, at salt spray exposure times which were significantly shorter than those required for general breakdown of the coating on the active coils.

Omitting the two enamel coatings, both of which failed within 24 hours, the magnitude of this end tip effect was as follows for the present work.

Coating	Time to Failure (hours)		
	End Tip(T)	General Breakdown (B)	$\frac{T}{B}$%
Polyester Powder	24	412	6
PTFE	48	556	9
Electro-Cathodic	122	292	42
Nylon	220	No rusting	-
Epoxy Powder	292	412	71

This clearly confirms previous work at SRAMA, which showed that, for compression springs, end tip corrosion was likely to occur before general breakdown of the paint or plastic coating.[6, 7]

The polyester powder paint was most affected by failure beneath the end tip, whilst epoxy powder coating was much less affected. However, epoxy coatings can show some deterioration of the coating integrity during direct exposure to sunlight, and this factor must be taken into account when epoxy paints are considered for corrosion protection.

Of the coatings examined, all but Sermetel 725 showed evidence of rusting in some form during salt spray testing up to a total time in excess of 800 hours.

In addition to these findings, the results shown in Tables II and III clearly suggest that shot peening did not generally improve the performance of either the paint or the plastic coatings in respect of corrosion protection. In particular, shot peening significantly reduced the corrosion protection offered by three of the paints (electro-cathodic, polyester, epoxy) and one plastic (PFTE). The two results obtained for failure of black enamel and phosphate and black enamel during environmental testing confirm this finding in that the shot peened panels showed only 3-24% of the life associated with the unpeened panels.

Of the other finishes, on unpeened and shot peened panels, none showed any evidence of failure during environmental testing up to times of 3744 hours.

The three sherardized finishes did not distinguish themselves during salt spray testing, tending to rust over all the surface within 24-220 hours, although without preferential attack at the end tip zone. All three finishes performed much more satisfactorily during environmental testing, however, with no evidence of rusting after 3744 hours exposure. The environmental tests are continuing at SRAMA, and further results will be reported in the future.

For any particular application, the appropriate choice of coating will obviously be influenced by both cost and coating performance. The limitations of paint and plastic coatings must be recognised, however, in view of the tendency towards premature failure beneath the end tip. This limitation will be especially important for dynamic applications, where premature failure can be indicated by pitting corrosion and/or corrosion fatigue.

Although all three sherardized coatings, and the Sermetel 725 coat, peformed well during environmental exposure, the processing temperature of 320-350°C for up to one and a half hours may limit these finishes for some applications, such as shot peened springs or tension springs with high initial tension.

Finally, the findings suggest that shot peening, prior to coating application, can significantly reduce the efficacy of corrosion protection offered by several commonly used coatings. This should be investigated further, and methods should be sought to either avoid or overcome this effect of shot peening.

6. CONCLUSIONS

1. Of the five paint finishes tested, polyester and epoxy coatings gave the best salt spray corrosion performance. The best overall resistance to salt spray was provided by the nylon and the Sermetel 725 coatings.

2. Salt spray tests showed that all the paint and plastic coatings were susceptible to early failure beneath the end tip of compression

springs.

3. Although the sherardized coatings gave poor pefomances during salt spray tests, they showed no evidence of failure during atmospheric exposure tests of up to 3744 hours.

4. The black enamel treatments gave the worst corrosion perfomance.

5. At best, shot peening did not improve the protection offered by the coating. At worst, the shot peened springs and panels survived for times which were significantly less than those observed for unpeened samples. The effect appeared to be particularly severe during atmospheric exposure tests, which are more representative of service conditions under which springs will operate.

7. <u>REFERENCES</u>

1. O'Malley, M, "Temporary Corrosion Protectives", SRAMA Report No 373, March 1984.

2. Reynolds, L F, "Evaluation of New Surface Coatings for Corrosion Protection of Unpeened Springs", SRAMA Report No 381, May 1985.

3. Zinc Alloy Report - Proofing Co Ltd, Wolverhampton. Private communication.

4. Fluorocarbon Company Limited, Industrial Treatments Division, Sheffield, Yorks. Private communication.

5. Sermatech Technical Services, STS UK, Ripley, Derbyshire. Private communication.

6. Timmins, P F, "The Corrosion Fatigue Resistance of Plastic Coated Helical Compression Springs". SRAMA Report No 258, March 1976.

7. Hale, G, "The Effectiveness of Paints as Corrosion Protectives for Carbon Steel Springs". SRAMA Report No 299, September 1978.

TABLE I PROTECTIVE COATINGS INVESTIGATED AND COSTS RELATIVE TO BLACK ENAMEL COAT

Coating Type	Cost*
Black Enamel Only	1
Phosphate + Black Enamel	1.2
Phosphate + Electro-Cathodic	1.5
Phosphate + Polyester Powder	3
Phosphate + Epoxy Powder	2.5
Nylon	6.7
PTFE	10
Sermetel 725	100
Sheradized Only	1.4
Sheradized + Zinc Phosphate Passivation	1.7
Sheradized + Zinc Phosphate and Chromate Passivation	1.9

* Costs are necessarily approximate, but are based on a batch size of 10,000 springs, weighing 0.5 tonne.

TABLE II RESULTS OF SALT SPRAY TESTS FOR FAILURE OF COMPRESSION SPRINGS AT END TIP POSITION IN ASCENDING ORDER OF PROTECTION

Coating Identification	Time to Red Rust at End Tip (Hours)		Shot Peened as % Unpeened Life
	Unpeened	Shot Peened	
Black Enamel Only	<24	<24	-
Phosphate + Black Enamel	<24	<24	-
Phosphate + Polyester Powder	24	24	100
Sherardized Only	24	NT+	-
PTFE	48	48	100
Sherardized + Zinc Phosphate Passivation	48	NT+	
Phosphate + Electro-Cathodic	122	24	20
Nylon	220	484	220
Sherardized + Zinc Phosphate + Chromate Passivation	220	NT+	-
Phosphate + Epoxy Powder	292	48	16
Sermetel 725	No Visible Rusting‡	No Visible Rusting‡	-

\+ Not tested

‡ No rusting after 815 hours on test

TABLE III RESULTS OF SALT SPRAY TESTS FOR BREAKDOWN OF COATING ON ACTIVE COILS OF COMPRESSION SPRINGS, IN ASCENDING ORDER OF PROTECTION

Coating Identification	Time to Red Rust on Active Coils (Hours)		Shot Peened as % Unpeened Life
	Unpeened	Shot Peened	
Black Enamel Only	24	24	100
Phosphate + Black Enamel	24	24	100
Sherardized Only	24	NT+	-
Sherardized + Zinc Phosphate Passivation	48	NT+	-
Sherardized + Zinc Phosphate + Chromate Passivation	220	NT+	-
Phosphate + Electro-Cathodic	292	122	42
Phosphate + Polyester Powder	412	220	53
Phosphate + Epoxy Powder	412	292	71
PTFE	556	220	40
Nylon	No Visible Rusting‡	No Visible Rusting‡	-
Sermetel 725	No Visible Rusting‡	No Visible Rusting‡	-

\+ Not tested

‡ No rusting after 815 hours on test

TABLE IV RESULTS OF ENVIRONMENTAL TESTS ON TEST PANELS

Coating Ident	Time to Appearance of Red Rust (Hours)				Shot Peened as % Unpeened Life	
	Edge of Panels		Flat Surface of Panels		Edge Failure	Flat Surface Failure
	Unpeened	Shot Peened	Unpeened	Shot Peened		
Black Enamel Only	288	48	3744+	120	17	3
Phosphate + Black Enamel	888	120	3744	888	14	24

Remainder of coatings still on test with no signs of failure at 18/4/86(3744 hours)

\+ Paint film peeling around damaged area.