THE SPRING RESEARCH ASSOCIATION

Temporary Corrosion Protection

Report No. 176

by

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SUMMARY

A range of temporary corrosion protectives, which can be applied by dipping, has been evaluated for their suitability for protecting hardened and tempered spring steel. The work consisted primarily of an evaluation of each coating to determine degree of protection afforded, cost, ease of application, ease of removal, drying aspects, adhesion of protective film, and where applicable a dewatering test. General recommendations have been made but no order of merit has been drawn up since only the user can decide what rating to give to a particular property as this will be influenced by the application. However, by the use of the detailed information in the tables, it should be possible to choose the best protective for a particular application.

Future work could cover a further range of protectives which are available on the market.

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1. INTRODUCTION

If the surface of a spring steel is not protected in some way then it is likely to corrode in transportation and in storage prior to use. Temporary corrosion protectives consist basically of a protective medium in a base of some solvent such as white spirit. The two most important factors to consider in selection are the degree of protection given and the cost, although other factors have to be taken into account such as ease of removal, adhesion and whether dewatering characteristics are evident.

The programme of work covered the evaluation of 20 different coatings from six manufacturers and, although no overall best protective has been specified, the properties have been listed so that the most suitable protective for a given application can be chosen.

Wherever possible, testing has been in accordance with B. S. 1133, Section 6, 1966 which covers the temporary corrosion protection of metal surfaces during transportation and storage. SI units have been used throughout this report.

2. EXPERIMENTAL WORK

2.1 Materials Used

Six manufacturers of temporary corrosion protectives were approached for samples of their products. The coatings examined in this investigation are listed in Table I. They were mainly of the soft (non-drying) type which could be applied by dipping.

It should be noted that Croda Pentagel 1/40 (sample No. 1) and Croda Pentagel 3/20 (sample No. 3), 'gelled' in storage before testing, and were replaced by samples 11 and 12. Croda Aquamove B (sample 8) and Snowdrift WGB (sample 24) were supplied from the stocks of member companies and served to compare with samples 7 and 23 which were supplied direct from the manufacturers. Croda Croblak H2587 (sample 10) and Shell Ensis Fluid 260 (sample 16) were 'hard drying' coatings, expected to give good corrosion resistance, and were included to give a comparison with the soft drying coatings.

Testing of the coatings was undertaken on standard size corrosion panels (150 mm x 100 mm x 1.23 mm) made from En42 material, which were hardened and tempered to 500 HV. 30 to give a blued surface comparable with that encountered on hardened and tempered springs.

2.2 Area Protected and Relative Cost

Two factors influence the cost of a temporary corrosion protective. Firstly the price per litre and secondly the area covered by a litre of protective.

Twelve panels were used for the evaluation of each protective. They were coated by dipping into a weighed amount of protective, allowed to drip-back into the dish containing the coating for one minute, and then removed to drying racks. The dish and remaining protective were reweighed in order to calculate the weight of protective used to cover a panel of known area. By measuring the density of the protectives, it was possible to calculate the area in square metres that could be covered by one litre. Finally, knowing the price per litre, it was possible to calculate the cost per square metre protected.

2.3 Corrosion Protection

This part of the experimental work consisted primarily of measuring the resistance to corrosion in a humidity cabinet, although to give some indication as to the order of the severity of the test, in comparison with a more usual environment, additional atmospheric tests were made on the the roof of the laboratories in Sheffield.

After coating the panels by dipping, they were allowed to dry for 24 hours before the corrosion tests were commenced. Six panels per coating were tested, three in the humidity cabinet, one on the roof of the building and two in the laboratory, these last two panels were also used to provide data on the ease of removal of the coating after ageing at room temperature.

The humidity cabinet contained distilled water and the environment was kept at 100% relative humidity by means of a circulating fan, heaters and thermostats. Temperature cycling between 42°C and 48°C gave alternate conditions of evaporation and condensation on the panels which were inclined at about 60° to the horizontal. Each complete heating and cooling cycle lasted about 45 minutes.

The panels were inspected for the onset of corrosion once every weekday and when two of the three panels (of a particular coating) had broken down as indicated by the onset of rusting, the coating was considered to have failed and all three panels were removed from the cabinet. When an unusually short life was found the test was repeated; the repeatability of the results in the humidity cabinet was found to be within 15% for lives of less than 10 days. Panels under test in the humidity cabinet are illustrated in Figure 1.

The majority of the coated panels were also tested at the same time under outside atmospheric conditions in the corrosion racks on the roof. However, certain protectives were not subjected to exactly the same outdoor conditions. Only one panel per coating was put onto the roof rack which was inclined at 45° to the horizontal; the panels were held in place by electrically non-conducting fibre washers, in order to eliminate electrochemical corrosion between the panels and the corrosion rack. As with the tests in the humidity cabinet, the panels were inspected every weekday and the first trace of corrosion was again taken as an indication of the length of the useful life of the coating. Figure 2 illustrates the corrosion rack and the panels under scrutiny.

2.4 Ease of Application and Removal

It was assumed that most companies would wish to apply the protectives by dipping, consequently the evaluation was limited to this method of application.

Removal of the coating may be important, especially after the protective has dried and aged. Most of the protectives examined were based on white spirit and this can be used for removing the coatings. However, trichloroethylene is in common industrial use and therefore the ease of removal using either of these solvents was noted.

In order to simulate the ageing of the coating, one set of coated panels was, after being allowed to dry for 24 hours at room temperature, baked in an oven at 60°C for 10 days with a plentiful supply of air, whilst another set was stored at room temperature for the duration of the experimental work (approximately 35 days). The relative ease of removal was noted and clasified in three categories i. e. A: removed by dipping alone, B: removed by dipping and rubbing, C: removed by dipping and hard scrubbing.

2.5 Adhesion Test and Drying Time

Some measure of the time taken for the protective to dry was required and this was done by noting the time to dry according to Appendix E of B.S. 1133, Section 6, 1966. This test consisted of dropping a small quantity of sand, sifted to pass a No. 52 mesh B.S. sieve but not a No. 100 mesh B.S. sieve, from a height of 100 mm onto the panel. The panel was considered to be dry if all the sand could be brushed off with a camel hair brush, leaving the coating undisturbed.

In order to assess the adhesion of the coating to the test panels and whether the coatings would stick to packaging materials, an adhesion test, according to Appendix G of B.S. 1133, Section 6, 1966, was carried out. This consisted of coating the panels with the range of protectives and allowing them to dry for 24 hours at room temperature. Then a standard sized piece of brown packaging paper (of defined quality) was pressed onto the panel with a standard weight for a standard time. On removal it was noted whether any protective was removed, thus exposing the bare metal, and in addition whether the paper became greasy, or if the paper stuck to the panel.

2.6 Dewatering Test

If a layer of moisture is present between a surface being protected and the freshly applied protective coating, then corrosion of the metal will occur. One way of overcoming this is to use a protective containing a dewatering additive.

The protectives which were claimed to possess dewatering characteristics were tested in accordance with Appendix B, B.S. 1133, Section 6, 1966. The outline of this test was that two test panels per protective were firstly dipped in 3 percent aqueous sodium chloride solution for a total of 2 minutes, allowed to drain for 10 seconds, then immersed in the respective dewatering protective for 2 minutes, and finally suspended, together with a control panel, which was coated with salt solution in the atmosphere above a saturated solution of sodium carbonate for 72 hours. The panels were then examined for traces of corrosion.

3. RESULTS

It was noticed on receipt of Croda Pentagel 1/40 and 3/20 (samples 1 and 3) that these had 'gelled' and consequently replacement samples were requested together with an explanation of the cause of the 'gelling'. Replacement samples Nos. 11 and 12 were received together with an explanation that the 'gelling' could be as a result of exposure to low temperatures. A similar 'gelling' effect was observed on exposing the Pentagels to the atmosphere in an open dish for about one week, and it was then difficult to restore the fluid to its original viscosity by the addition of white spirit.

The area protected and relative cost of all the samples examined in terms of pence per square metre protected are given in Table II. A summary of cost and degree of protection to humidity is given in Table V.

The prices per litre given in Table II were for a minimum supply of 205 litres, except for the Canning 10% lanolin solution and Snowdrift WGB from a member firm which were for 4.5 litre quantities.

The time for the onset of corrosion of the panels in the humidity cabinet, and on the roof of the building, was recorded in Table III. In addition it should be noted that all the panels were free from corrosion after 35 days within the laboratory atmosphere except those coated with Sunbeam Ferromede 140 (sample 18) and I.C.I. Granodine 'S830-23' (sample 22) which had corroded within this time. Table IV gives details of the ease of removal, adhesion and handleability. All the protectives could be applied by dipping, and most were easy to remove after drying and ageing. It was found that trichloroethylene removed all the coatings about twice as quickly as white spirit, and provided that there is adequate ventilation this solvent is recommended. Although for convenience this evaluation involved dipping in liquid trichloroethylene, it is expected that removal using vapour will be more rapid and this technique is to be recommended since contamination of the solvent would be avoided. The coating of Snowdrift WGB (received from a member, sample 24) was difficult to remove due to its bulkiness, although it was soluble in white spirit.

None of the coatings when dried, with the exception of Kephos 'S841-253', met the requirements of Appendix E of B.S. 1133, Section 6, 1966. Comments on handleability are given in Table IV since this feature could be a factor in the choice of a protective.

Samples claimed by the manufacturers to be dewatering types which passed the dewatering test were Nos. 5, 6, 10, 15, 16, 22 and 24, whilst those failing were Nos. 7, 8 and 18.

4. DISCUSSION

Croda samples consisted of a series of Pentagels, which are a recently developed 'gelled' oil; Aquamove B, a well established dewatering type; G311, a straight 30% lanolin solution; and Croblak H2587, a hard film protective claimed to give a very good corrosion protection. The Pentagel range was cheap or medium in cost and all gave good protection. Pentagel 2/40 with dewatering addition (sample 5) and Pentagel 2/50 with dewatering addition (sample 6) are recommended for the protection of small springs in large quantities. These protectives do not dry to a hard film thus, with batch treatment, sticking together of individual springs on drying would not be a problem. Both Aquamove B samples failed the dewatering test, and in terms of cost and protection the sample received from the stocks of a member firm (sample 8) was inferior to the sample supplied by the manufacturer (sample 7). In all other respects this was a most satisfactory protective being cheap and giving very good protection. The G311 (sample 9) is recommended if a lanolin solution is required. Croblak H2587 (sample10) gave very good protection, was of medium cost, but it was difficult to remove. The only reservation in recommending the Pentagel range was the excessive 'gelling' that occurred. On excessive 'gelling' the protective did not spread satisfactorily and it therefore became more expensive to cover a given area (e.g. samples 1 and 3). Due probably to an increase in film thickness there was an increase in the degree of protection given by the excessively 'gelled' samples.

Shell Ensis Oils 152 and 158 (samples 13 and 14) were non-drying oils which continued to drain off the test panel for several hours, making them uneconomical to use, although they gave a good resistance to humidity. Shell Ensis 256 and 260 Fluids (samples 15 and 16) were solvent deposited dewatering protectives and both are recommended. The Ensis 256 did not dry as hard as Ensis 260 and therefore would be more suitable where the sticking together of a large number of components could be a problem. Ensis 260 gave very good corrosion resistance to outdoor environment and although the humidity cabinet life was shorter it was still satisfactory.

Canning 10% lanolin in white spirit solution (sample 17) was the least difficult to handle of all the protectives examined, gave medium term protection, and was cheap to use.

Sunbeam Ferromede 140 (sample 18) was a solvent deposited soft film type which cannot be recommended due to its very poor corrosion protection, although it was the cheapest coating examined. This product can be supplied in a range of simple colours for identification purposes.

The I. C. I. products gave medium protection at medium cost except Kephos 'S841-253' (sample 20) which gave poor corrosion resistance and was probably more suitable as a pre-treatment for a permanent coating. Kephos produces a lacquer sealed phosphate coating on dipping. The Granodine oils are solvent deposited coatings giving a greasy or oily film after drying. With the exception of Granodine 'S830-23' (sample 22) the I. C. I. products were difficult to handle.

Snowdrift WGB direct from the manufacturers (sample 23) was vastly different from the sample forwarded by a member firm (sample 24). The latter was thick red grease with a covering rate of about one fifth of the former which was a thin red fluid. However, both these products gave good protection but they were rather unpleasant to handle and apply.

Although some measure of the various properties of the protective coatings is given in this report, only the user can decide which temporary protective to use because the final choice will be governed by the particular application. It is suggested that the most important factor is corrosion protection closely followed by cost. The next factor could well be ease of application, or the type of coating produced when the solvent has evaporated. In some instances ease of removal may be an important factor.

If a dewatering type of protective is required to ensure that no traces of moisture are trapped between the metal and the coating, then the protective should pass the appropriate British Standard Test.

A guide to the selection of a suitable temporary corrosion protective is given in Table VI, which gives a rating to various film properties in terms of one star (worst) to five stars (best).

5. CONCLUSIONS

1. No overall 'best buy' can be recommended since this will depend on the weighting given by the user to the various attributes.

2. The following protectives can be recommended for the short term corrosion protection of spring steels.

(a) Where dewatering is required

Croda Pentagel 2/40 with dewatering addition
Croda Pentagel 2/50 with dewatering addition
Croda Croblak H2587
Shell Ensis Fluid 256
Shell Ensis Fluid 260

(b) Where dewatering is not required

Croda Aquamove B
Croda G311
Croda Pentagel 2/40
Croda Pentagel 2/50

3. If long term protection is required a hard drying film, as provided by Croda Croblak H2587 and Shell Ensis Fluid 260, will be satisfactory.

6. FUTURE WORK

A further evaluation could be made using samples provided by members of the Association to determine whether ageing during shelf life had any deleterious effect on performance compared with stocks as received direct from the manufacturers. Additionally, further coatings could be evaluated and in particular those types which produce a hard dry film could be worthy of investigation.

7. ACKNOWLEDGEMENTS

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I. C. I. Ltd.
Shell Mex & B. P. Ltd.
Snowdrift Lubricants Ltd.
Sunbeam Anti-Corrosives Ltd.

Acknowledgement is also made to the following member firms for supplying samples of protectives from their stocks:

The Tempered Spring Co. Ltd.
Timsons Ltd.

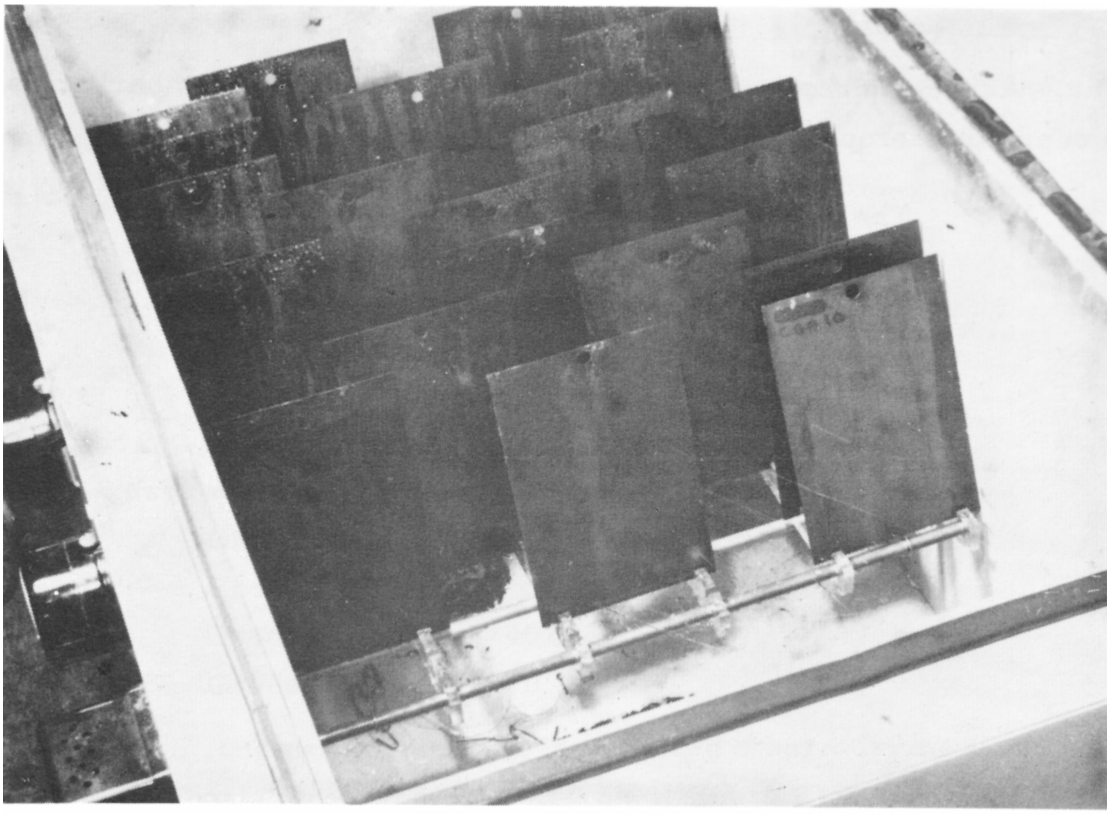

Fig. 1. TEST PANELS UNDER TEST IN HUMIDITY CABINET

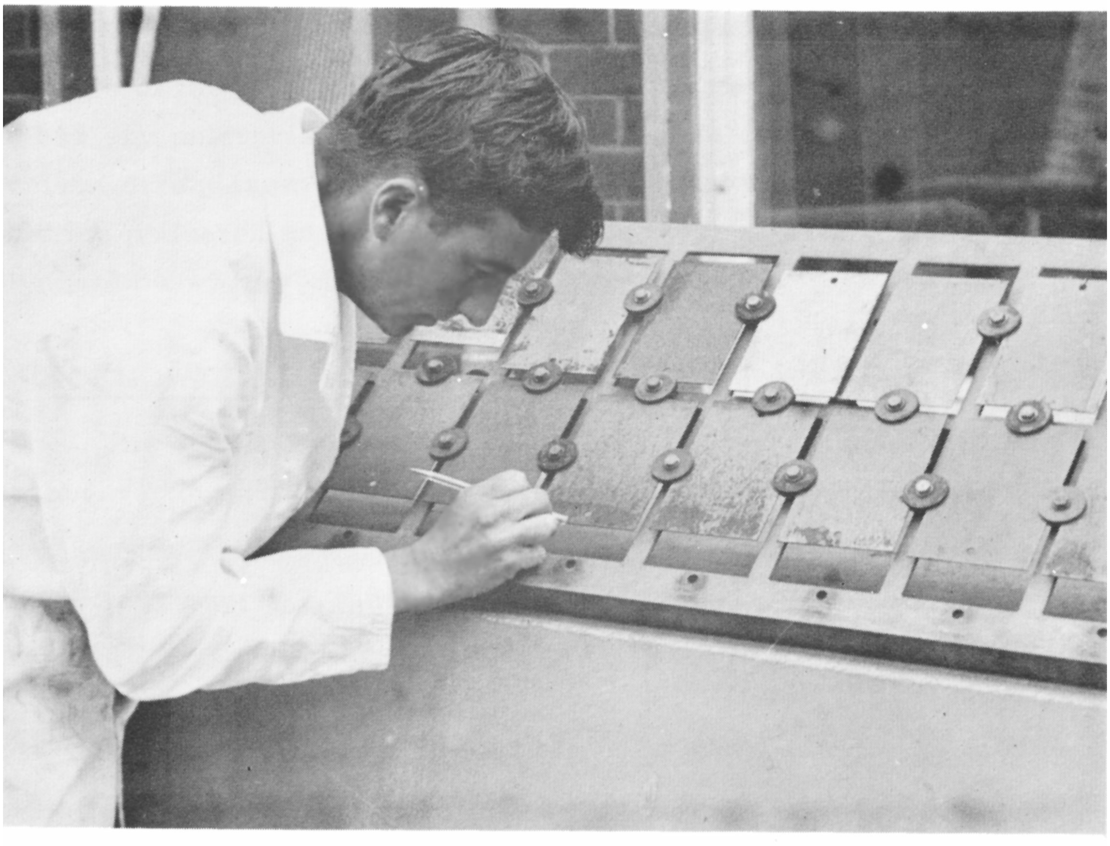

Fig. 2. TEST PANELS UNDER SCRUTINY ON ATMOSPHERIC CORROSION RACKS ON ROOF OF SRA LABORATORIES IN SHEFFIELD.

TABLE I

RANGE OF TEMPORARY CORROSION PROTECTIVES EXAMINED

Code	Type of Protective
1	CRODA Pentagel 1/40 - sample 'gelled' and replaced by sample 11.
2	CRODA Pentagel 2/40
3	CRODA Pentagel 3/20 - sample 'gelled' and replaced by sample 12.
4	CRODA Pentagel 2/50
5	CRODA Pentagel 2/40 - with dewatering addition.
6	CRODA Pentagel 2/50 - with dewatering addition.
7	CRODA Aquamove B
8	CRODA Aquamove B - supplied from the stocks of a member firm
9	CRODA G. 311
10	CRODA H2587
11	CRODA Pentagel 1/40 - replacement sample from manufacturer.
12	CRODA Pentagel 3/20 - replacement sample from manufacturer.
13	SHELL Ensis Oil 152
14	SHELL Ensis Oil 158
15	SHELL Ensis Fluid 256
16	SHELL Ensis Fluid 260
17	CANNING 10% lanolin in white spirit.
18	SUNBEAM Ferromede 140
19	I. C. I. Granodine 'S830-21'
20	I. C. I. Kephos'S841-253'
21	I. C. I. Granodine'S830-22'
22	I. C. I. Granodine'S830-23'
23	SNOWDRIFT WGB
24	SNOWDRIFT WGB supplied from the stocks of a member firm.

TABLE II

COST OF PROTECTIVE BASED ON PRICE PER LITRE AND COVERAGE IN SQUARE METRES PER LITRE

Code	Manufacturer and Product	Price d/l	Coverage m^2/l	Cost d/m^2
	CRODA			
1	Pentagel 1/40	24.7	6.3	3.9
2	Pentagel 2/40	22.3	25.3	0.9
3	Pentagel 3/20	39.6	2.4	16.5
4	Pentagel 2/50	24.5	22.2	1.1
5	Pentagel 2/40 with dewatering	23.8	26.9	0.9
6	Pentagel 2/50 " "	25.7	14.6	1.8
7	Aquamove B	21.4	18.0	1.2
8	Aquamove B from a member firm	20.9	9.3	2.2
9	G. 311	20.9	18.2	1.1
10	Croblak H2587	18.5	5.1	3.6
11	Replacement Pentagel 1/40	24.7	6.9	3.6
12	Replacement Pentagel 3/20	39.6	15.3	2.6
	SHELL			
13	Ensis Oil 152	19.0	8.3	2.3
14	Ensis Oil 158	20.6	5.6	3.7
15	Ensis Oluid 256	21.8	25.3	0.9
16	Ensis Fluid 260	21.8	17.8	1.2
	CANNING			
17	10% lanolin in white spirit	39.6	34.8	1.1
	SUNBEAM			
18	Ferromede 140	19.9	31.7	0.6
	I. C. I.			
19	Granodine'S820-21'	26.4	12.7	2.1
20	Kephos'S841-253'	68.6	22.5	3.0
21	Granodine'S830-22'	21.1	8.9	2.4
22	Granodine'S830-23'	38.2	32.1	1.2
	SNOWDRIFT			
23	WGB	27.4	7.9	3.5
24	WGB from a member firm	32.6	1.4	23.3

Note: d/l x 0.38 = shillings/gallon
m^2/l x 48.9 = ft^2 / gallon
d/m^2 x 0.093 = d/ft^2

TABLE III

LIFE OF COATING IN HUMIDITY CABINET, AND ON THE ROOF OF THE LABORATORIES.

Code	Number of days before onset of corrosion	
	In humidity cabinet	On roof
1	112 N/F	112 N/F
2	29	27
3	Not tested	69
4	28	27
5	29	27
6	29	27
7	74	81
8	29	74
9	22	25
10	60	60
11	55	65
12	81	63
13	22	12
14	21	12
15	22	67
16	22	68
17	17	15
18	4	9
19	18	11
20	2	8
21	14	4
22	24	17
23	28	72 N/F
24	72 N/F	72 N/F

N/F - Not Failed

TABLE IV

EASE OF REMOVAL, ADHESION TEST, AND COMMENTS ON HANDLEABILITY OF THE COATING SIX HOURS AFTER APPLICATION

Code	Ease of removal		Adhesion Test			
	10 days at 60°	60 days at Room Temp	Paper sticks to panel	Metal left unprotected	Paper becomes greasy	Handleability after 6 hours
1	A	B	No	No	Yes	Workable
2	A	A	No	No	Yes	Workable
3	A	B	No	No	Yes	Workable
4	A	A	No	No	Yes	Workable
5	A	A	No	No	Yes	Workable
6	A	A	No	No	Yes	Workable
7	A	A	No	N0	Yes	Workable
8	A	A	No	No	Yes	Workable
9	A	A	No	No	Yes	Workable
10	A	A	No	No	Yes	Workable but tacky
11	A	A	No	Yes	Yes	Workable
12	A	A	Yes	No	No	Workable
13	A	A	Yes	Yes	Yes	Greasy oil
14	A	A	Yes	Yes	Yes	Greasy oil
15	A	A	No	No	No	Workable but tacky
16	A	A	Yes	No	No	Workable but tacky
17	A	A	No	No	No	Workable
18	A	A	No	No	No	Oily
19	B	B	No	No	No	Greasy oil
20	Not removed	Not removed	No	No	No	Dry
21	B	B	Yes	Yes	Yes	Greasy oil
22	B	B	No	No	No	Greasy oil
23	A	A	Yes	No	Yes	Very greasy
24	C	C	Yes	Yes	Yes	Very greasy

A - Removed by dipping alone
B - Dipping and rubbing required
C - Scrubbing necessary

TABLE V SUMMARY OF COST AND PROTECTION AGAINST HUMIDITY

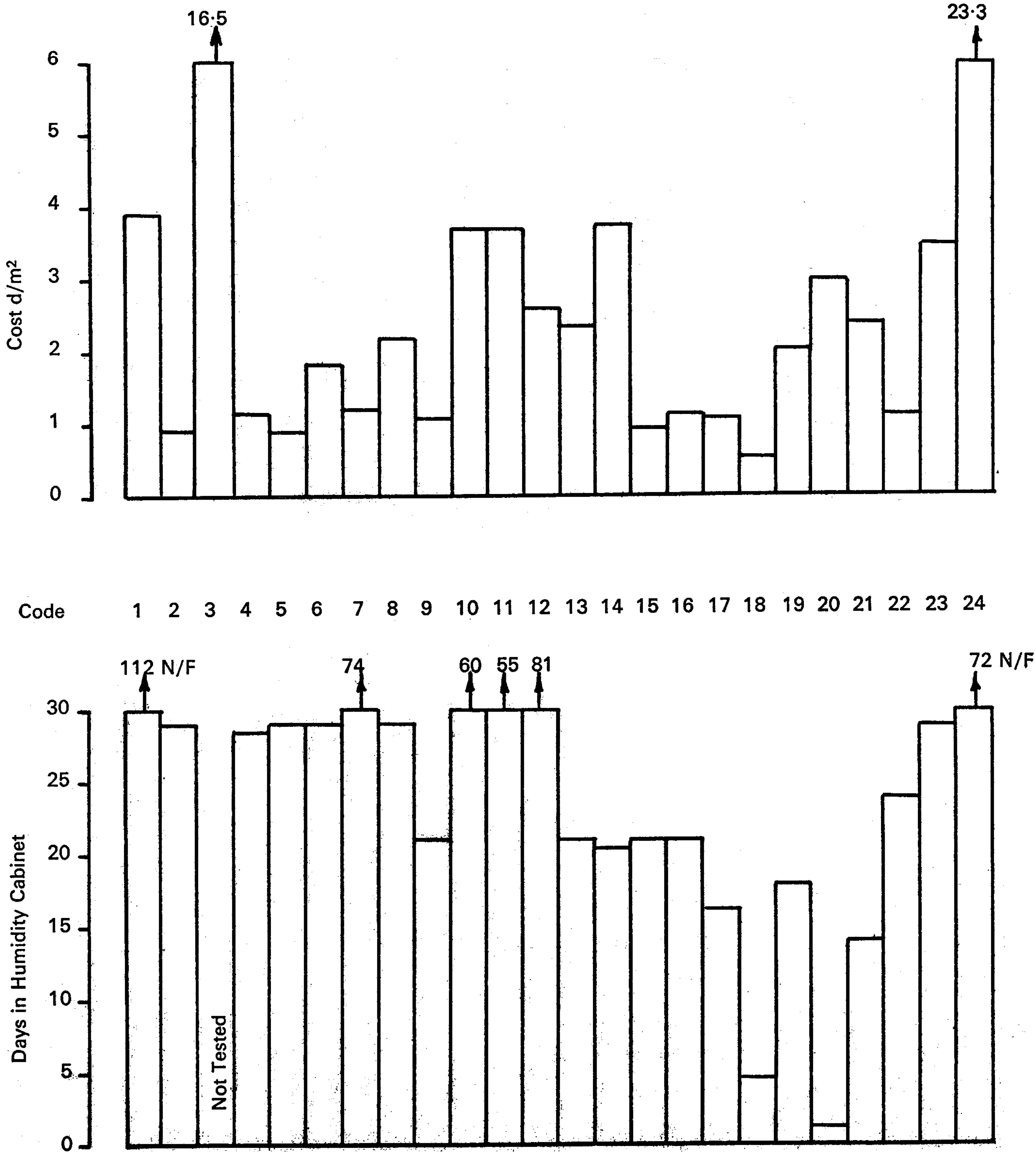

TABLE VI

A GUIDE TO THE SELECTION OF A TEMPORARY CORROSION PROTECTIVE

Manufacturer and type of protective	Cost based on area protected	Protection against humidity	Removal using Tricholoroethylene	Handleability	Dewatering Test
Croda Pentagel 1/40	xxx	xxxxx	xxxxx	xxxxx	Not applicable
Croda Pentagel 2/40	xxxxx	xxxx	xxxxx	xxxxx	Not applicable
Croda Pentagel 3/20	xxx	xxxxx	xxxxx	xxxxx	Not applicable
Croda Pentagel 2/50	xxxx	xxxx	xxxxx	xxxxx	Not applicable
Croda Pentagel 2/40	xxxxx	xxxx	xxxxx	xxxxx	Passed
Croda Pentagel 2/50	xxxx	xxxx	xxxxx	xxxxx	Passed
Croda Aquamove B	xxx	xxxxx	xxxxx	xxxxx	Failed
Croda G311	xxxx	xxxx	xxxxx	xxxxx	Not applicable
Croda Croblak H2587	xxx	xxxxx	xxxxx	x	Passed
Shell Ensis Oil 152	xxx	xxxx	xxxxx	xxx	Not applicable
Shell Ensis Oil 158	xxx	xxxx	xxxxx	xxx	Not applicable
Shell Ensis Fluid 256	xxxxx	xxxx	xxxxx	xxxx	Passed
Shell Ensis Fluid 260	xxxx	xxxx	xxxxx	xxxx	Passed
Canning 10% lanolin	xxxx	xxx	xxxxx	xxxxx	Not applicable
Sunbeam Ferromede 140	xxxxx	x	xxxxx	xxx	Failed
I. C. I. Granodine'S830-21'	xxx	xxx	xxx	xx	Not applicable
I. C. I. Kephos'S841-253'	xxx	x	Not removed	xxx	Not applicable
I. C. I. Granodine'S830-22'	xxx	xxx	xxx	xx	Not applicable
I. C. I. Granodine'S830-23'	xxxx	xxxx	xxx	xx	Passed
Snowdrift WGB	xxx	xxxx	xxxxx	xxx	Not applicable