CHAPTER 23

CORROSION PROTECTION OF PUMPING STATION SUMPS

CONTENTS

CHAPTER 23

CORROSION PROTECTION OF PUMPING STATION SUMPS

23.000 INTRODUCTION

This specification covers the requirements for corrosion protection of the intrados surfaces (cast iron and concrete) of the sumps at the underground drainage pumping station located at Shakespeare Cliff (Pumping Station `D', off adit A1) and at the two low points of the UK undersea tunnels at Km 25 (Pumping Station `G' (W1)) and Km35 (Pumping Station `K' (W2)).

The sumps receive groundwater seepage from the tunnel and any fluid spillage which may occur in the system.

The sumps at pumping station `D' are contained in a concrete lined shaft with dividing concrete walls.

The sumps at pumping station `G' (W1) and `K' (W2) are formed by horizontal tunnels connected to vertical shafts which contain the suction wells. The sumps in these locations are lined with Spheroidal Graphite Iron (SGI) bolted segments, but contain concrete dividing walls, floors and end bulkheads.

23.010 Scope

1. This Specification covers the surface preparation and coating of all internal cast iron and in-situ concrete surfaces (i.e. walls, floors and bulkheads) of wet sumps.

23.020 Definitions

The Coatings Contractor

The individuals and or firms responsible for the physical application of coatings in accordance with this specification.

The Purchaser

The organisation which appoints one or more Coatings Contractors or sub-contractors.

Cementitious Substrates

Any substrate material containing cement such as concrete and the materials normally used to repair its defects.

Metal Substrate

Any metallic substrate including SGI segments, bolts and metal washers.

Coating System

Any combination of single coating layers that forms all or part of the total coating thickness.

The Manufacturer

The organisation who manufactures the coating materials.

23.030 Areas to be Coated

The areas to be coated under the provisions of this specification are shown on the Construction Drawings.

23.040 Safety

1. Shop and site work shall conform to the appropriate statutory regulations and by-laws at all times. Prior approval of all works procedures shall be obtained from the Tunnel Construction Manager or his delegated representative.

2. No coating work shall be carried out in the tunnels without the prior approval of the site safety department.

23.050 General

1. This document contains a general section followed by sections relating to specific substrates. Where the substrate type has not been identified in the main heading, sub-heading or paragraph, the word "substrate" shall refer to all surfaces to be coated.

2. Throughout this specification, wherever a product is to be shown to comply with a specific performance criteria, the Manufacturer's test data, performance and test certificates, independent test results and reference to previous experience of using the same product under similar service conditions without deterioration may constitute compliance in whole or part with such a requirement.

3. All the tools, equipment and materials necessary for compliance with this specification, testing, quality control and all surface treatment shall be supplied by the Coatings Contractor.

4. Whenever conflict arises between the requirements of this Specification and Manufacturer's instructions, the matter shall

be resolved by the Engineering Manager or his delegated personnel.

5. All surface preparation and coating work shall be subject to inspection and acceptance by the Engineering Manager or his delegated personnel.

6. The Engineering Manager or his delegated personnel shall be given at least three days notice prior to initiation of any work.

7. Access shall be provided to the job site and areas of work at all times during normal working hours for the Engineering Manager or his delegated personnel.

23.100 GENERAL REQUIREMENTS FOR ALL COATINGS

1. All coatings materials and systems to be used shall be shown to comply with the requirements of this specification. Evidence to support the same shall be supplied by the Coatings Contractor.

2. The generic type of each coating layer for each substrate shall be determined from the tables of appendix II. No other generic types shall be used and in particular the following generic types shall not be used:

Urethanes, chlorinated rubbers, coal tar modifications and other paints that produce voluminous toxic smoke and fumes.

3. The Coatings Contractor shall obtain approval from the Purchaser for all materials prior to their use. In order to facilitate such approval, the Coatings Contractor shall provide the Purchaser with the following information:

(a)Details of the material properties.

(b)The proposed method of use including any surface preparation.

(c)Evidence of compliance with this specification.

4. The substrates plus the Coating System specified for their protection shall comply with the following:

(a)BS 476 Part 7. Method for Classification of the Surface Spread Flame of Product - Compliance Criteria shall be Class 1. All specimens shall be coated in accordance with the Manufacturer's instructions to the maximum thickness before testing.

(b)BS 476 Part 6. The Method of Test for Fire Propagation for Products - Compliance Criteria shall be Fire Propagation Index 12/6.

(c)BS 6853 Fire Precautions in the design and Construction of Railway Passenger Rolling Stock. (Test for evaluation of smoke production) compliance criteria, category 1

Smoke Index Ao (ON) < 2.0
A0 (OFF) < 3.0

5. The Coatings Contractor shall not apply any material without obtaining a written fire safety approval from the Purchaser. To facilitate such approval, the Coatings Contractor shall supply the Purchaser with details of the material's likely combustion products for toxicity appraisal. This data shall be obtained from the Manufacturer.

6. The surface coatings shall be shown to satisfy this specification and performance criteria with regard to protecting the internal surfaces of the sumps from degradation due to long-term continuous or intermittent exposure to seawater containing small amounts of hydrocarbons under submerged or waterline conditions,

and to the by-products of bacterial activity in such an environment (acid plus hydrogen sulphide).

7. The coatings shall be suitable for immersion in seawater, hydrocarbons, 30% dilute acids or any combination thereof.

8. The coating shall not be attacked by any form of biological growth.

9. Once approval has been given for the use of products of one or more Manufacturer, only those Manufacturers' coatings shall be used. Different substrates may be coated by products from different Manufacturers. Under no circumstances shall any product made by different Manufacturers be mixed in the same Coating System without written approval from the Engineering Manager or his delegated personnel who shall seek advice from the Manufacturers involved.

10. All coatings and thinners shall be delivered to the job site in the Manufacturer's original sealed labelled containers. The containers shall be of sufficient strength to prevent undue damage during handling, transport and storage. Date of manufacture, colour, description, manufacture batch number and name of the Manufacturer shall be shown on container labels. Coatings shall have no more than two components. All materials shall be stored in the manner recommended by the Manufacturer.

11. Coating Systems as required by this Specification shall have a design life of 25 years.

23.200 STANDARD OF WORKMANSHIP

23.210 General

Coatings approved by the Purchaser shall be applied by the Coatings Contractor in accordance with the best standard practice and shall be supervised and carried out by competent tradesmen. Plant and equipment for surface preparation shall be of the appropriate type and quality and shall be maintained in good order. Mixing and application of paints shall be in accordance with the Manufacturer's data and application sheets.

Painting shall be carried out in an environment which ensures satisfactory and uninterrupted application and curing.

23.220 Codes and Standards

Surface preparation methods and application of all coatings and any other activity associated with the preparation and coating of surfaces shall be in accordance with the coating Manufacturer's recommendations and the latest applicable Codes and Standards (Appendix IV).

23.300 SURFACE PREPARATION

23.310 Preparation of Substrates

1. Details of surface preparation methods for the following substrates are given in other sections of this document:

a)SGI segments prior to installation - by Blast Cleaning (section 23.700).

b)Damage repair to SGI segments subsequent to installation - by mechanical power tool cleaning (section 23.800).

c)Bolts, washers and nuts - as required by the Manufacturer (section 23.830).

d)Concrete substrates - by high pressure water jetting (section 23.920).

e)Repair of damage to coatings on concrete exposing substrate - by mechanical power tool cleaning (section 23.930).

23.320 Solvent Cleaning

1. After abrasive blasting, mechanical cleaning or water jetting and prior to painting, all substrates shall be examined for traces of oil or grease. All traces of oil or grease shall be removed by solvent washing then rinsed thoroughly with potable water and where the surface preparation has degenerated the area shall be re-treated.

2. Surface contaminants (e.g. soluble salts) on the cleaned substrates, first coat or intermediate coats shall be removed by potable water washing or other methods approved by the Engineering Manager or his delegated personnel.

23.330 Priming

Immediately after completion of surface preparation, one coat of primer

shall be applied to abrasive blasted or power tool prepared surfaces to prevent any deterioration of the surface.

23.400 APPLICATION OF COATINGS

23.410 General

1. After surface preparation, each substrate type shall be coated in layers to a thickness in accordance with Appendix II.

2. All paints shall be stored, mixed, applied and cured strictly in accordance with Manufacturer's recommendations. Thinners, or clean up materials shall comply with paint Manufacturer's recommendation. Paint shall not be thinned except as directed in the Manufacturer's data sheets or by the Manufacturer in writing.

3. The surfaces to be coated shall be illuminated with lights of sufficient intensity to ensure visibility approximating that of normal daylight.

4. Surfaces to be painted shall be between the temperature of 5°C and 32°C. The relative humidity shall not exceed 85 per cent immediately prior to coating. Humidity, surface and ambient temperatures shall be measured and recorded at the start of and every 4 hours during the coating operation using a hygrometer, surface thermometer and air thermometer respectively. Painting shall not proceed when the surface temperature is less than 3°C above the dew point.

5. The last applied coat shall be the Finish coat nominated under the appropriate Coating System.

6. All edges of flanges or other features, where grinding is not possible for the removal of sharp protrusions and edges, shall

be coated with an additional brush applied coat of the specified primer.

7. Coatings shall be within the specified DFT and free of porosity, bubbles, over-spray, sags, runs, mudcracking or other defects. All coatings on areas containing such imperfections shall be removed or made good to the satisfaction of the Engineering Manager or his delegated personnel.

8. The coated substrates shall not be subjected to normal service conditions before the coating has fully cured and quality control tests are satisfactorily completed.

9. Coating materials which have livered, gelled or otherwise deteriorated shall not be used and shall be removed from the work area.

10. Each coating shall be allowed to dry or cured thoroughly as per Manufacturer's instructions, prior to the application of a succeeding coat. If the Manufacturer's maximum overcoating times are exceeded the surface of the preceding coating shall be prepared as required by the Manufacturer and to the satisfaction of the Engineering Manager or his delegated personnel before any other coating is applied.

23.420 Spray Application

1. Spray guns, lines and pressure pots shall be kept clean and in good working order.

2. Conventional spray pressure pots shall be equipped with dual regulators and an air driven agitator. All spray equipment shall be equipped with fluid tips, needles and air caps consistent with the coating Manufacturer's recommendations. The air supply line shall be fitted with an efficient oil and moisture separator which shall be regularly emptied.

3. All coating material shall be thoroughly mixed with a power mixer before application. Two pack materials and zinc pigmented primers shall be agitated during application in accordance with the Manufacturer's instructions.

4. The pot life of coating materials shall not be exceeded. When the pot life limit is reached, the spray pot shall be emptied, remaining material discarded, the equipment cleaned and new coating material prepared.

23.430 Brush Application

1. No paint brush shall exceed 100mm in width and extended handles shall not be permitted.

2. Brushing shall be carried out such that a smooth, uniformly thick coating is obtained. There shall be no deep or detrimental brush marks. Paint shall be worked into all crevices and corners.

3. During application of each coat, all areas such as corners, edges, small brackets, bolts, nuts and interstices shall receive additional coating to ensure that these areas have at least the minimum specified film thickness and to ensure continuity of the coating.

23.440 The Coatings Contractor Markings

Signwriting, stencilling or marking shall not be applied to the surfaces unless specifically approved in writing by the Engineering Manager of his delegated personnel. When approved it shall be compatible with the paint system employed.

23.500 DAMAGE REPAIR AND TRANSPORT

23.510 Acceptable Damage for Repair

1. All coatings visibly damaged or on which damage has been detected where the total damaged area is less than or equal to 5% of the total component area, shall be repaired by local preparation to sound substrate and restoration of the full specified Coating System.

If the damaged area of the component is greater than 5%, then remedial action shall be as directed by the Engineering Manager or his delegated personnel.

For the purposes of applying this clause to concrete, a component area shall be that area with radius 1.5m centred on any defect. Defects within that component area shall not themselves become centres of new component areas.

23.520 Transport of Coated SGI Segments

Suitable packing and protection shall be used to prevent damage to coated units during handling, loading, transportation and unloading at the tunnel face and elsewhere. Such protection shall not retard or prevent the curing process of the Coating System.

23.600 THE CONTROL OF QUALITY

23.610 General

1. In order to assess and maintain a high standard of quality, the following test procedures shall be carried out by the Coatings Contractor.

2. Damage due to destructive tests shall be repaired in accordance with procedures described later in this specification.

3. Pre-works trials shall be carried out by the Coatings Contractor in order to establish the following parameters acceptable to the Engineering Manager or his delegated personnel:

a)Blast Cleaning surface profile for SGI segments. During such trials the appropriate surface roughness for subsequent quality control tests shall be selected using an ISO Surface Profile Comparator conforming to ISO 8503 part 1 1988 by the Engineering Manager or his delegated personnel. The appropriate degree of visual surface cleanliness shall also be selected by the Engineering Manager or his delegated personnel from the Swedish standard SIS 05 5900-1967 during the same trials.

b)The grade and grit number of sandpaper complying with BS 871:1981 that shall be used for comparison with water-jetted Cementitious Substrates during quality control procedures.

c)The method of surface preparation to nuts, bolts and washers as advised by the Manufacturer.

d)The correct Wet Film Thickness (WFT) giving the specified Dry Film Thickness (DFT) for each coating layer after full cure.

e)The method of assessing degree of cure using a solvent test as directed by the Manufacturer.

4. The test frequency shall be increased as directed by the Engineering Manager or his delegated personnel on failure to meet the acceptance criteria.

23.620 Quality Tests and Test Methods

The following tests and test methods that shall be used for the control of quality are detailed in appendix III :

A) Substrate Surface Profile Measurement
a)Surface Profile Measurement for SGI Segments
b)Surface Comparison for Cementitious Substrates
B) Wet Film Thickness (WFT) Measurement
C) Dry Film Thickness (DFT) Measurement
a)Non-destructive test for SGI segments
b)Destructive test for Cementitious Substrates.
D) Degree of Cure Measurement
E) Measurement of Adhesion
F) Measurement of Coating Continuity
a) low voltage method for DFT < 300 micrometres
b) high voltage method for DFT > 300 micrometres

23.630 Application of Quality Tests and Testing Frequency

23.631 SGI Segments

A) Surface Preparation

This test shall be applied to surfaces after preparation and before the application of any coating. Five points selected by the Engineering Manager or his delegated personnel shall be tested per segment surface to be coated.

B) Wet Film Thickness (WFT)

This test shall be applied during the application of each coating layer. Five random points shall be tested per coated segment within 2 minutes of coating application.

C) Dry Film Thickness (DFT)

This test shall only be applied to the fully cured Coating System. Four spot measurements selected by the Engineering Manager or his delegated personnel shall be taken on every segment.

D) Degree of Cure

This test shall be applied to the full Coating System. Three points selected by the Engineering Manager or his delegated personnel shall be tested per segment.

E) Adhesion

This test shall be applied to the full Coating System. One point shall be tested on each of 10 segments to be selected at random by the Engineering Manager or his delegated personnel.

F) Continuity

This test shall be applied to the full Coating System. The full coated area of each segment shall be tested.

23.632 Cementitious Substrates

A) Surface Comparison

This test shall be applied to surfaces after preparation and before the application of any coating. One point every 1 m^2 of the surface to be coated shall be selected by the Engineering Manager or his delegated personnel and compared with the standard established during pre-works trials.

B) Wet Film Thickness (WFT)

This test shall be applied during the application of each coating layer. One random point per square metre of coated substrate shall be tested within 2 minutes of coating application.

C) Dry Film Thickness (DFT)

This test shall only be applied to the fully cured Coating System. One spot measurement shall be taken every 20 m^2 at a point selected by the Engineering Manager or his delegated personnel. Adhesion tests shall be carried out on the same site.

D) Degree of Cure

This test shall be applied to the full Coating System. One point shall be selected for testing by the Engineering Manager or his delegated personnel every 10 m^2.

E) Adhesion

This test shall be applied to the full Coating System and on the same sites as the DFT point test.

F) Continuity

This test shall be applied to the full Coating System. 1 m^2 in every 10 m^2 of coated substrate shall be selected by the Engineering Manager or his delegated personnel for testing.

23.633 Repaired Damage on SGI and Cementitious Substrates

A) Surface Preparation

a)SGI SEGMENTS - This test shall be applied to surfaces after preparation and before the application of any coating. One point per 0.5 m^2 of metal substrate area to be repaired shall be selected by the Engineering Manager or his delegated personnel for testing.

b)CEMENTITIOUS SUBSTRATES - This test shall be applied to surfaces after preparation and before the application of any coating. Two random points per 0.5 m^2 shall be selected by the Engineering Manager or his delegated personnel and compared with the standard established during pre-works trials.

B) Wet Film Thickness (WFT)

This test shall be applied during the application of each coating layer. One random point per 0.5m^2 within 2 minutes of coating application shall be tested.

C) Dry Film Thickness (DFT)

This test shall only be applied to the fully cured Coating System.

a)On SGI segments - three spot measurements shall be taken every 0.5m^2.

b)On Cementitious Substrates - one spot measurement shall be taken every 1m^2.

D) Degree of Cure

This test shall be applied to the fully cured Coating System. One random point shall be tested every 0.5 m^2.

E) Adhesion

This test shall be applied to the full Coating System

a)On SGI segments - one point to be selected by the Engineering Manager or his delegated personnel shall be tested every 1m^2 of accumulative area repaired for each pumping station sump.

b)On Cementitious Substrates - at the same site as the DFT point test.

F) Continuity

This test shall be applied to the full Coating System over the full repair area.

23.640 <u>Acceptance Criteria</u>

A) Surface Appearance

a)Metal Substrates - When the prepared surface is visually compared using the Swedish standard SIS 05-5900-1967, it shall be the same as grade Sa 22 of that standard for abrasive blasted surfaces and grade St-3 for surfaces cleaned by power tools. For abrasive blasted surfaces the degree of roughness measured using the surface profile comparator conforming to ISO 8503 part 1 1988 shall be Medium or Coarse as required by the Manufacturer.

b)Cementitious Substrates - When the prepared surface profile is compared with sandpaper grade, as determined during pre-works trials, the prepared surface shall have a similitude acceptable to the Engineering Manager or his delegated personnel.

B) Wet Film Thickness (WFT)

The WFT measured shall be the same as that required to give a DFT within

the specified range in Appendix II.

C) Dry Film Thickness (DFT)

The average of the spot measurements taken shall not be less than the specified minimum DFT (see Appendix II and III) and no single spot measurement shall be less than 90% of the specified minimum DFT. Single gauge readings (see Appendix III) constituting any spot measurement shall not be less than 75% of the specified minimum DFT and no single spot measurement shall be more than 25% above the maximum specified DFT.

D) Degree of Cure

There shall be no change to the appearance of the coating.

E) Adhesion

Acceptance criteria shall be a rating of 4 or 5.

F) Continuity

There shall be not discontinuities in the full Coating System.

23.650 Treatment of Results

All test results with full explanation of them shall be transmitted to the Purchaser on a weekly basis.

23.660 Rejected Coatings

All coatings not meeting the acceptance criteria (above) shall be treated as follows:

A) Failure of Surface Preparation

Repeat the surface preparation until the specified surface profile is obtained.

B) Failure of WFT

Additional thickness of the same material shall be applied immediately on failure, until the specified WFT is obtained.

C) Failure of DFT

The test area shall be extended as directed by the Engineering Manager or his delegated personnel in all directions and the extended area tested for DFT using the same acceptance criteria over the extended area. The failed coating shall be completely removed, the surface prepared again and the coating re-applied until the specified DFT is obtained.

D) Failure of Degree of Cure

If the Coatings Contractor fails to demonstrate a curing trend over the following 72 hours in accordance with the Manufacturer's information, then the coating shall be rejected, removed and the surface prepared again and a coating re-applied until the specified degree of cure and other requirements of this specification are satisfied.

E) Failure of Adhesion

the coating shall be removed over the specified test area, the surface prepared again and the coating re-applied until the specified adhesion is obtained.

F) Failure of Continuity

Defects shall be repaired in accordance with the repair procedure for each substrate as specified (sections 23.800 and 23.930).

23.700 ADDITIONAL REQUIREMENTS FOR COATING OF CAST IRON SEGMENTS PRIOR TO INSTALLATION

23.710 Surface Preparation

23.711 General

1. Deposits of oil or grease shall be removed by solvent cleaning using halogenated-hydrocarbons by vapour-degreasing (solvent naphtha) or white spirit for swabbing or by solvent immersion prior to abrasive blasting.

23.712 Blast Cleaning

1. Contamination of blasted surfaces by handling shall be removed by solvent cleaning followed by reblasting.

2. Blasted surfaces shall be vacuum cleaned, blown or brushed free of shot-dust or grit before inspection and coating application.

3. Dry blasting in the workshop shall be stopped when the metal surface temperature is less than 3°C above the dew point or when the relative humidity exceeds 90%.

4. Existing coatings not intended to be blast cleaned shall be protected from blast cleaning operations.

5. When wet abrasive blasting is used, the water used shall be suitably inhibited to prevent discolouration by flash corrosion. Blasted surfaces shall be thoroughly cleaned with inhibited fresh water to remove all adhering spent abrasive etc. All inhibitors used shall be shown to be compatible with the Coating System and the Manufacturer shall approve specific inhibitors.

23.713Abrasives

1. Blasting abrasives used for the dry process shall be dry and all abrasives shall be clean and free from metallic contamination. In particular blasting abrasive shall contain less than 50 ppm of water soluble chloride and less than 0.3% copper.

2. Abrasives which have a tendency to shatter and adhere or embed in the metal surface are not acceptable.

23.714 Surface Defects

1. Surface defects such as slivers, cracks, laminations and excessive pitting exposed by abrasive blasting shall be reported to the Engineering Manager or his delegated personnel for evaluation. Coating shall not proceed without approval.

2. Defects deemed to render the surface unsuitable for coating without special remedial measures outside the scope of this specification shall be referred to the Engineering Manager or his delegated personnel.

3. Structurally non-detrimental defects such as holes, crevices and voids shall be filled with a coatable sealant previously approved by the Manufacturer after blasting and priming are completed, but before topcoating.

23.715 Conditioning

All segments to be coated and materials to be used shall be conditioned with specific reference to the temperature, humidity and environment of the work area.

23.800 ADDITIONAL REQUIREMENTS FOR NUTS, BOLTS AND WASHERS AND THE REPAIR OF DAMAGED COATINGS SUBSEQUENT TO ASSEMBLY OF CAST IRON SEGMENTS

The repaired areas shall have the same performance characteristics as the original coating.

23.810 Damage Exposing Bare Metal

1. The surface preparation for damaged coatings exposing bare metal shall be by power tool cleaning to remove rust, loose paint or other matter.

2. All burrs, sharp edges cuts etc. made by the various surface preparation tools shall be smoothed with emery paper or abrasives. The entire area shall be wire brushed to abrade the surface free of all loose particles left after the scraping, chipping etc. Sufficient pressure shall be applied to clean the surface without any detrimental degree of burnishing or polishing of the substrate.

3. The areas patched with primer shall be overcoated with intermediate and finish coats as specified in Appendix II for each particular area involved, to the full specified thickness and appropriate colour.

4. The edges of any existing surrounding sound coatings shall be gradually feathered over a minimum distance of 50mm from that edge. A distinct step at the edge of a repair is unacceptable.

23.820 Coating Damage not Exposing Bare Metal

1. Damaged areas requiring repair of intermediate and finish coats shall be solvent cleaned, washed down with a 2% Teepol/ fresh water solution to remove any contamination and copiously rinsed with potable water and wiped dry.

2. Coated edges around the damaged area shall be chamfered/ feathered over a minimum distance of 50mm from that edge to a smooth finish. The parent coating shall not contain any steps.

3. Where primer is exposed and the thickness is found to be insufficient, the primer coat thickness shall be increased by application of additional primer after such surface preparation as is recommended by the Manufacturer.

4. Intermediate and finish coats shall then be applied in accordance with Appendix II.

5. Every coat applied shall overlap each adjacent coat by at least 50mm.

23.830 Coatings To Nuts, Bolts and Washers

23.831 General

1. The Coating System used, with special reference to the primer, shall be shown to be compatible with sherardized surfaces and the surrounding Coating System.

2. The performance of the Coating System to be used on sherardized surfaces, including adhesion, shall be established by the

Coatings Contractor and approved by the Purchaser during pre-works trials.

23.832 Surface Preparation

1. The surface of nuts, bolts and washers shall be cleaned to remove all traces of dirt, grease and dust.

2. Power tool abrasion shall not be used. Chemical etching or other methods of surface preparation shall be approved in writing by the Manufacturer and Purchaser.

23.833 Control of Quality

Tests for the control of quality shall not be applied to nuts, bolts and washers except for visual inspection and any non-destructive tests as specified by the Engineering Manager or his delegated personnel.

23.900 ADDITIONAL REQUIREMENTS FOR COATING TO CEMENTITIOUS SUBSTRATES

23.910 Special Requirements

1. The coating to be used for Cementitious Substrates shall be applicable to surfaces saturated with water and in damp conditions, but without free surface water.

2. Any specified test applicable to concrete shall be carried out using concrete having the same properties as that to be coated on site.

23.911 Time of Application

Coatings shall not be applied to substrates with an age of less than 30 days.

23.912 Abrasion Resistance

When tested in accordance with ASTM D4060 using a CS17 wheel, 1000g loading and 1000 cycles the wear index shall be less than 100.

23.913 Alkali Resistance

1. The Coating System selected for Cementitious Substrates including any primer system shall be shown to be completely compatible with and unaffected by the typically high alkali environment within concrete structures.

2. The coating shall undergo both of the following tests, and at the end of each shall not show any reduction in hardness or adhesion as measured in accordance with the Quality Tests (above), abrasion as measured in accordance with BS 3900:Part E2:1970-

Scratch Test, permeability (see above) or visual signs of peeling, blistering or swelling.

a)Soak in highly alkaline environment (pH 14) for 28 days.
b)Subject to 12 wetting and drying cycles where one cycle shall constitute immersion for 1 day in highly alkaline environment (pH 14) maintained at 50(+/-1)°C for 1 day.

23.914 Acid Resistance

Five samples of substrate (100x100mm each) coated to the specified thickness (see Appendix II) shall be immersed in a solution of 30% sulphuric acid (H_2SO_4) for 28 days at 23°C. After this period, the coating of any sample shall not show any sign of peeling, blistering or swelling on any part of its area. The edges and back of test pieces shall be adequately protected by an acid-resistant material before immersion.

23.920 Surface Preparation

1. The surface to be coated shall be free from grease, oil, dirt, dust, surface efflorescence and loose particles. Such contaminants shall be removed using techniques appropriate to the Coating System to be applied.

2. Cementitious surfaces shall be prepared by water jetting to achieve the surface preparation agreed with the Engineering Manager or his delegated personnel during pre-works trials (above).

3. The edges of any surrounding coating which has been applied previously and is to be repaired or extended shall be gradually feathered over a minimum distance of 50mm from that edge. A distinct step at the edge of coating layers shall be

unacceptable.

4. All dirt, dust, abrasive and surface particles shall be removed and the surfaces thoroughly vacuum cleaned by a suction power of greater than 30g/cm^2.

5. Any surface holes, cracks or defects shall be repaired using a repair material that shall be shown to be compatible with both the substrate and the Coating System to be applied. The Coating System itself may be deemed to be a repair material for certain size of defects. The size and defects for which the Coating System itself may be deemed to be a repair material shall be decided by the Engineering Manager or his delegated personnel.

23.930 Repair of Damaged Coatings

1. The repaired areas shall have the same performance characteristics as the original coating.

2. For all areas left bare or where the Coating System is damaged to bare substrate, the surface shall be prepared in the same manner as an uncoated substrate.

3. The damaged areas shall be coated with coating layers as specified in Appendix II to the full specified thickness and appropriate colour.

4. Damaged areas requiring repair of only the intermediate and finish coats shall be solvent cleaned, washed down with a 2% Teepol/ fresh water solution to remove any contamination and copiously rinsed with fresh potable water and wiped dry.

5. The edges of any surrounding coating which has been applied previously and is to be repaired or extended shall be gradually feathered over a minimum distance of 50mm from that edge. A distinct step at the edge of coating layers shall be unacceptable.

6. Every coating applied shall overlap any adjacent layer by at least 50mm.

APPENDIX 1

GENERAL COATING TYPES AND TYPICAL MANUFACTURERS' PRODUCTS

FOR CORROSION CONTROL PURPOSES ONLY .

OTHER PAINT MANUFACTURERS MAY BE USED

GENERIC TERM: Zinc-Phosphate 2-pack Epoxy Primer
APPLICATION : Cast Iron (SGI) segments off-site
MANUFACTURER: W. J. Leigh & Co.
PRODUCT : Epigrip L425 (HS)
MANUFACTURER: Crown
PRODUCT : HB2TV

GENERIC TERM:Re-coatable Epoxy, 2-pack
APPLICATION : Cast Iron (SGI) segments off-site
MANUFACTURER: W. J. Leigh & Co.
PRODUCT : Epigrip L524
MANUFACTURER: Crown
PRODUCT : 5NZ

GENERIC TERM: Solvent-Free Epoxy, 2-pack
APPLICATION : All dry metal areas on-site
MANUFACTURER: International Paints
PRODUCT : Interline 925

GENERIC TERM: Solvent-Free Epoxy, 2-pack
APPLICATION : All areas on-site
MANUFACTURER: Sigma Coatings Limited
PRODUCT : Colturiet CSF
MANUFACTURER: Fosroc International Ltd.
PRODUCT : Nitocote EP405

APPENDIX II

1.0 Coatings Specification

The following appendix provides specification guidelines for the minimum and maximum dry film thickness and the minimum and maximum recoating time for the primer, undercoat and top coats of general coating types. The minimum re-coat times given can be reduced by an increase in temperature in accordance with the manufacturer's instructions. Some general notes are also included. Appendix I gives some indication of the types of paint that could be used from a corrosion prevention viewpoint only, not fire and toxic fume hazard. The Lloyds Register of Shipping Approved Prefabrication Primers and Corrosion Control Coatings also lists suitable coatings from paint manufacturers from many countries and is regarded as a good basis for paint selection.

TITLE Coating Specification 1 - Coating Materials for SGI Segments to be coated off-site

USE SGI Segments

SURFACE PREPARATION Local preparation to clean metal to SIS-05-5900-1967, grade Sa 22 (visual appearance to be determined during trials) and surface roughness to ISO 8503 part 1.

Paint Systems	Dry Film Thickness - Micrometres		Min Recoat Time (Hrs)	Max Recoat Time(days)
	Min	Max		
1st Coat Two Pack Epoxy Zinc Phosphate Primer	50	75	12	7
2nd Coat Two Pack Recoatable Epoxy	200	250	12	7
3rd Coat Two Pack Recoatable Epoxy	200	250	12	7
Total Dry Film Thickness	450	575	-	-

Notes:

1) Each coat of the paint system shall be distinguishable from previous coats by a variation in its colour or shade such that the extent of the coated area may be determined.

TITLE Coating Specification 2 - Materials for Coating SGI Segments on site

USE Repair Coatings for SGI Segments

SURFACE PREPARATION Local preparation to clean metal to SIS-05-5900-1967 Grade St3. Edges of existing paint feathered.

Paint Systems	Dry Film Thickness - Micrometres		Min Recoat Time (Hrs)	Max Recoat Time(days)
	Min	Max		
1st Coat (Spot Primer) Two Pack Epoxy Zinc Phosphate Primer	50	75	12	7
2nd Coat Two Pack Solvent Free Epoxy	200	250	12	7
3rd Coat Two Pack Solvent Free Epoxy	200	250	12	7
Total Dry Film Thickness	To match existing coating thickness			

Notes:

1) Two pack epoxy zinc phosphate primer shall be compatible with the existing coatings.

2) Two pack solvent free epoxy shall be compatible with existing coating.

TITLE Coating Specification 3 - Site Applied Coatings to metal components.

USE Nuts, bolts, washers and other minor surfaces

SURFACE PREPARATION Local preparation to remove dirt, grease and other foreign matter, as recommended by the Manufacturer and determined during pre-works trials.

Paint Systems	Dry Film Thickness - Micrometres		Min Recoat Time (Hrs)	Max Recoat Time(days)
	Min	Max		
1st Coat (Spot Primer) Two-Pack Epoxy Zinc Phosphate Primer	50	75	12	7
2nd Coat Two Pack Solvent Free Epoxy	200	250	12	7
3rd Coat Two Pack Solvent Free Epoxy	200	250	12	7
Total Dry Film Thickness	To match existing coating thickness			

Notes:

1) Two pack epoxy zinc phosphate primer shall be compatible with the existing coatings.

2) Two pack solvent free epoxy shall be compatible with existing coating.

TITLE Coating Specification 4 - Site Applied coatings to Cementitious Substrates

USE Concrete and cement based surfaces

SURFACE PREPARATION Water Jetting to provide surface texture equivalent to smooth sandpaper (grade to be determined during trials).

Paint Systems	Dry Film Thickness - Micrometres		Min Recoat Time (Hrs)	Max Recoat Time(days)
	Min	Max		
1st Coat Two Pack Solvent Free Epoxy	200	250	12	7
2nd Coat Two Pack Solvent Free Epoxy	200	250	12	7
Total Dry Film Thickness	400	500	-	

Notes:

1) Repair coating shall match existing coating thickness.

2) Two pack solvent free epoxy shall be compatible with existing coating.

APPENDIX III - TEST METHODS

A. Surface Roughness Measurement

a) Surface Profile Comparator Method for SGI Segments:

The comparator unit which shall comply with ISO 8503 part 1 and be used in accordance with ISO 8503 part 2, consists of a reference disc made of high purity nickel, which is an electro-formed duplicate of a master disc and a 5X illuminated magnifier with magnetic disc holder. The disc has surface profiles ranging from 10 to 100 micrometre. The blast cleaned surface shall be compared with the reference disc thorough the illuminated magnifier.

b) Visual Surface Comparison for Cementitious Substrates:

The prepared surface of the substrate shall be compared visually with the specified grade and texture of sand paper.

B. Wet Film Thickness (WFT) Measurements

The comb-type gauge shall be used for the measurement of WFT. The surfaces selected for measurement shall be smooth and flat.

C. Dry Film Thickness (DFT) Measurements

The following method shall be used for the measurement of DFT:

a) Metal Substrates - A magnetic or electro-magnetic gauge shall be used and calibrated/checked daily. The average measurement of the DFT at 3 points of close proximity to each other shall constitute a spot measurement.

b) Cementitious Substrates - A paint inspection Gauge conforming to BS 5411:Part 5 shall be used in accordance with the manufacturer's instructions. One point measurement shall constitute one spot measurement.

D. Degree of Cure

The method for the assessment of the degree of cure shall be determined during pre-works trials.

E. Measurement of Adhesion

The following cross-cut test method shall be used to measure adhesion of the coating to the substrate:

This method is to be used to check Coating Systems having a DFT greater than 125 but less than 750 micrometres.

In this test an X cut is inscribed by two 20mm lines intersecting at approximately 10mm from their ends at 30° to 45°. The knife blade is inserted at the point of the X cut, at 45° to the surface then with an upward flicking action attempt to dislodge the coating within the X. If little or no coating is removed repeat this action in the X cut point at least 4 times to confirm the integrity of the coating. Examine the appearance of the disbonded surface and compare with the progressive scale of descriptive standards given below, the number of the matching descriptive standard being the rating applying.

Adhesion Rating Number

Rating 1.Coating is removed with no chipping of the coating and minimal resistance. No coating remains adhering to the metal/substrate within the X-cut (100% adhesive failure).

Rating 2.coating is removed in chips which are substantially larger than the area of the knife point. Little coating (70% adhesive failure 30% cohesion failure) remains adhering in the X cut to the substrate.

Rating 3.Coating is removed in chips which are slightly larger in area than the knife point inserted under the coating. Some of the coating remains adhering to the surface of the substrate within the X cut. (70% cohesive failure 30% adhesive failure).

Rating 4.Coating is removed in small chips with some difficulty. Substantial coating remains adhering to the surface profile. (90% cohesive failure 10% adhesive failure).

Rating 5.Coating is not removed clearly at any point in the X cut. The entire profile contains adherent coating. (0-5% adhesive failure).

Coatings with rating 1 or 2 are poor. Coatings with rating 4 or 5 are good.

F. <u>Coating Continuity Test Method</u>

Where specified the following methods shall be applied:

a) Wet Sponge Low-Voltage Inspection for DFT < 300 micrometres

This method of detecting discontinuities such as pinholes and holidays in coatings shall be used to check Coating Systems having a DFT less than 300 micrometres. The surface shall be well wetted with potable water containing 3 drops of detergent approved by the instrument manufacturer per litre to ensure penetration of faults or pinholes. The saturated sponge of the tester shall be systematically passed over the entire coated surface and as a coating discontinuity is approached the detector will give a visual and/or audible alarm signal. All such indications shall be suitably marked immediately, to ensure their repair.

The wet sponge continuity tests shall not be used without having determined that the coating will not be detrimentally affected by water at that stage of the application/degree of cure.

b) High Voltage Electrical Inspection for DFT > 300 micrometres

This type of inspection is to be used only for the detection of discontinuities in the coating film such as pinholes, cracks etc., and to detect hidden or non-visible defects such as bubble or blister type voids, thin spots and foreign inclusions or contaminants that are of such size, number or conductivity as to significantly lower the electrical resistance or dielectric strength of the coating.

All Coating Systems having a DFT of 300 micrometres or greater shall be checked for discontinuities or other defects as described above by this method where specified.

For continuous d.c. detectors, the speed of travel shall be limited to ensure that contact is maintained between the coating and the test electrode. For pulse d.c. detectors the speed of travel shall not exceed 300 mm/sec.

The search electrode shall be either carbon impregnated neoprene or a wire brush. Adequate precautions shall be taken to earth the item under test prior to testing.

The position of flaws/holidays detected shall be clearly marked for subsequent repair. After repair, the repair area shall be retested with the holiday detector set at the appropriate voltage as described above and if necessary further repairs shall be carried out.

APPENDIX IV

List of Codes and Standards Relevant to this Specification.

THIS LIST IS FOR GUIDANCE ONLY.

BS 410 -British Standard Specification for Test Sieves

BS 476 -Fire tests on Building Materials and Structures Parts 6 & 7

BS 729 -Specification for Hot Dip Galvanised Coatings on Iron and Steel Articles, 1971.

BS 871 -Specification for Abrasive Papers and Cloths, 1981.

BS 1881 -Part 5 Methods for Testing of Hardened Concrete for other than strength, 1970.

BS 2015 - Glossary of Paint Terms, 1965.

BS 3900 -Methods of Test for Paints

BS 4921 - Specification for Sherardized Coatings on Iron or Steel, 1988.

BS 5411 -Part 5 Measurement of Local Thickness of Metal and Oxide Coating by Microscopical Examination of Cross-Section, 1984.

BS 5493 -Code of Practice for Protective Coating of Iron and Steel Structures Against Corrosion, 1977.

BS 7079 -Part 1 - Specification for Rust Grades and Preparation Grades of Uncoated Steel Substrates and of Steel Standards After Overall Removal of Previous Coatings, 1989.

BS 6853 -Fire Precautions in the Design and Construction of Railway Passenger Rolling Stock, 1987.

COSHH - Control Of Substances Hazardous to Health, 1988.

Svensk Standard SIS 05 5900-1967 - Pictorial Surface Preparation Standards for Painting Steel Surfaces.

Lloyds Register of Shipping - Approved Prefabrication Primers and Corrosion Control Coatings - 71 Fenchurch Street, London, EC3M 4BS, UK.

SSPC-SP1 -Steel Structures Painting Council - Surface Preparation Specification No.1 - Solvent Cleaning.

ISO 8503 -Part 1 - Surface Profile Comparator for the Assessment of Abrasive Blasted Cleaned Surfaces, 1988.

Part 2 - Method of Use of Comparator, 1988.

ISO 8501 -Part 1 - Rust Grades and Preparation Grades of Uncoated or Overall Cleaned Substrate, 1988.