TECHNICAL SPECIFICATION

PAINTING AND COATING OF NEW EQUIPMENT

DEP 30.48.00.31-Gen.

December 1995

DESIGN AND ENGINEERING PRACTICE

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of:

Shell International Oil Products B.V. (SIOP)
and
Shell International Exploration and Production B.V. (SIEP)
and
Shell International Chemicals B.V. (SIC)

The Hague, The Netherlands,

and other Service Companies.

They are based on the experience acquired during their involvement with the design, construction, operation and maintenance of processing units and facilities, and they are supplemented with the experience of Group Operating companies. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

The right to use DEPs is granted by SIOP, SIEP or SIC, in most cases under Service Agreements primarily with companies of the Royal Dutch/Shell Group and other companies receiving technical advice and services from SIOP, SIEP or SIC. Consequently, three categories of users of DEPs can be distinguished:

1) Operating companies having a Service Agreement with SIOP, SIEP, SIC or other Service Company. The use of DEPs by these Operating companies is subject in all respects to the terms and conditions of the relevant Service Agreement.

2) Other parties who are authorized to use DEPs subject to appropriate contractual arrangements.

3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, SIOP, SIEP and SIC disclaim any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any DEP, combination of DEPs or any part thereof. The benefit of this disclaimer shall inure in all respects to SIOP, SIEP, SIC and/or any company affiliated to these companies that may issue DEPs or require the use of DEPs.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, DEPs shall not, without the prior written consent of SIOP and SIEP, be disclosed by users to any company or person whomsoever and the DEPs shall be used exclusively for the purpose for which they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of SIOP and SIEP. The copyright of DEPs vests in SIOP and SIEP. Users shall arrange for DEPs to be held in safe custody and SIOP or SIEP may at any time require information satisfactory to them in order to ascertain how users implement this requirement.

All administrative queries should be directed to the DEP Administrator in SIOP.

NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

TABLE OF CONTENTS

APPENDICES

1. INTRODUCTION

1.1 SCOPE

This DEP gives requirements and recommendations for the surface preparation and the external painting and coating of new metallic equipment which will be exposed to atmospheric conditions (irrespective of whether it will be insulated). This DEP also covers the internal painting of above-ground steel tanks, and LPG storage vessels. This DEP is a revision of an earlier publication with the same number dated August 1983.

DEP 40.48.00.30-Gen. "Paint and Paint Materials" and DEP 30.48.00.10-Gen. "Painting and Coating" are now rendered out of date and are withdrawn.

For specific equipment where conflicting requirements are defined in other DEPs or other applicable publications, the requirements of those documents shall prevail.

The application of stoving lacquers or preservation with temporary preservatives such as Shell Ensis products are excluded from the scope of this DEP.

If approved by the Principal, alternative methods of protection may be used where local conditions and experience indicate that they would be acceptable.

Specifications for maintenance painting are covered in DEP 70.48.10.10-Gen. in which to avoid confusion, the paint systems specified have been assigned the letter "M" in front of the paint system number.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants, exploration and production facilities and supply/marketing installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General Definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific Definitions

DFT	Dry Film Thickness; the thickness of the dried or cured paint or coating film.
Equipment	The equipment to be painted is listed in Appendix 1 and includes piping, vessels, columns, exchangers, reactors, structural steel, fire-fighting systems, tanks, LPG storage vessels, furnaces, stacks, flare stacks, flue ducts, offshore structures and topside facilities
Grit	Particles that are predominantly angular, have fractured faces and sharp edges and are less than half round in shape.
Operating Temperature	See DEP 01.00.01.30-Gen.
Shot	Particles that are predominantly round, that have a length of less than twice the maximum particle width and that do not have edges, broken faces or other sharp surface defects.
TDFT	Total Dry Film Thickness; the thickness of the total number of coatings specified.
WFT	Wet Film Thickness; the thickness of the uncured or wet paint or coating film.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (8).

2. GENERAL

2.1 MATERIALS

All paints and paint materials used shall be obtained from Manufacturers approved by the Principal.

All material shall be supplied in the Manufacturer's original containers, durably and legibly marked with the description of the contents. This shall include the specification number, the colour reference number, the method of application for which it is intended, the batch number, date of manufacture, the shelf-life expiry date and the Manufacturer's name or recognised trade mark.

Different brands or types of paints shall not be inter-mixed.

The storage and preparation of paints and other coating materials shall be in accordance with the Manufacturer's instructions.

Samples for testing the paint being used may be taken by the Principal at any time. Should a sample fail to meet the required specification, the Contractor shall remove this paint from areas already covered and recoat them with paint that meets the specification.

Appendix 1 specifies painting schedules for various types of equipment, indicating the paint system to be used.

The painting schedules specified in Appendix 1 shall apply irrespective of whether the equipment will be insulated.

Appendix 2 specifies the details for the paint systems specified in Appendix 1.

2.2 PAINT APPROVAL

The paint (or range of paints) to be used shall be approved by the Principal.

2.3 PAINTING CONTRACTOR

The painting Contractor shall be responsible for:

- The quality of workmanship, which shall be performed in accordance with this DEP and all other relevant documents such as site regulations, safety rules, referred standards and codes, etc.
- Obtaining the Principal's assurance that the equipment is certified safe and available and that all appropriate tests are completed before starting any painting work.
- The protection of all equipment, structures and any other areas from mechanical damage, environmental damage, damage caused by abrasives during blast cleaning, paint droppings, or overspray.
- The earthing of electrical equipment.
- Taking all necessary precautions to avoid interference with the execution of work of other contractors.
- Maintenance of the paint work until completion of the contract. This shall include the repair of any damages caused by third parties.
- The characteristics of the paints and paint materials obtained from the paint Manufacturer. The characteristics shall be obtained via the provision of separate technical, and health and safety data sheets.
- Provision of all painting, thinning and cleaning materials, tools, site accommodation, transport services, and competent supervision, necessary for the satisfactory completion of the works.
- Control of waste resulting from the Contractor's painting and coating activities, in accordance with site regulations and specific contract requirements.
- Maintaining workshop facilities, tools and equipment in a good, clean condition. Spray

guns, brushes, rollers, paint pots and the like shall be regularly cleaned and shall be suitable for their purpose.

- Unless otherwise specified by the Principal, the supply of all necessary equipment, weather protection and scaffolding for the painting of storage tanks to ensure that the work is carried out in accordance with this DEP and to the agreed programme.
- Preparation of appropriate work planning, which shall be in agreement with that of the Principal.

3. SURFACE PREPARATION

3.1 GENERAL

For optimum paint performance surfaces to be painted or coated shall be completely dry and free from burrs, weld spatter, flux, rust, loose scale, dirt, dust, grease, oil and other foreign matter before any paint is applied.

If the surface has been exposed to a polluted, e.g. salt-laden, atmosphere, it shall be washed down with clean, fresh water prior to blasting or power tool cleaning.

After preparation of the substrate surface, any grit, dust etc. shall be removed and a layer of primer applied before any corrosion or recontamination occurs, normally within 4 hours after blasting.

Tests to check the efficiency of these cleaning procedures are given in (6.1).

Surface preparation shall be carried out by dry blast-cleaning wherever possible. The surface preparation grades shall be as specified in Appendix 2 for the various paint systems.

3.2 SURFACE PREPARATION BY BLAST CLEANING

3.2.1 General

Before blast cleaning any oil, grease and dirt shall be removed either by means of a suitable solvent, by steam cleaning, with an alkaline cleaning agent if necessary, or by water jetting. Excessive layers of rust shall be removed by chipping. Weld spatter and sharp edges shall be removed.

3.2.2 Blast cleaning equipment

The compressed air supply used for blast cleaning shall be free from water and oil. Adequate separators and traps shall be provided, installed in the coolest part of the system. They shall be emptied regularly to prevent carry over of water and oil. Accumulations of oil and moisture shall be removed from the air receiver by regular purging.

Air compressors shall not be allowed to deliver air at a temperature above 110 °C.

Abrasive blast cleaning equipment shall be an intrinsically safe construction and equipped with a remote shut-off valve triggered by the release of a dead man's handle at the blasting nozzle.

Where air-operated equipment is used, the operator's hood or head gear shall be ventilated by clean, cool air served through a regulator filter, to prevent blast cleaning residues from being inhaled.

3.2.3 Abrasives

Abrasives for use in blast cleaning carbon steels and low alloy steels are specified in ISO 8504-2.

Suitable abrasives are:

- Chilled iron grit or shot.
- Steel and malleable iron grit or shot.
- Non-metallic abrasive (aluminium oxide, copper slag, garnet, etc.).

NOTE: See (3.4) for abrasives for stainless steels and non-ferrous metals.

Sand or other materials producing silica dust shall not be used.

The abrasives shall be free from oil, grease, moisture etc. Re-used abrasive shall be clean, sharp and free from contaminants.

The blast profile shall be that recommended by the paint Manufacturer. Roughness measurement shall be carried out by the paint Contractor using instruments approved by the Principal and in accordance with ISO 8503-2.

3.2.4 Grades of surface finish

The following four preparation grades (in accordance with ISO 8501-1) are recognised:

- Sa 1 - Light blast-cleaning
- Sa 2 - Thorough blast-cleaning
- Sa 2½ - Very thorough blast-cleaning
- Sa 3 - Blast cleaning to visually clean steel

3.2.5 Performance and application conditions

Blast cleaning shall only be performed in conditions suitable for painting, see (4.2).

Sometimes it may be advantageous to use the wet abrasive or moisture injection blast cleaning techniques, so as to avoid dust or in cases where fire and/or explosion risks are present. Fresh water may either be mixed with the abrasive in the pressure tank or introduced directly behind or ahead of the blast nozzle.

To prevent rusting the cleaned surface should be washed off immediately after blast cleaning using fresh water containing a suitable corrosion inhibitor such as 0.3% wt sodium nitrite with 1.2% wt ammonium phosphate. It should also be considered to include a suitable corrosion inhibitor in the water used for blast-cleaning.

The cleaned surface shall be thoroughly dry before any paint is applied. In general it is not necessary to remove residues of the inhibitor before painting. However, the paint Manufacturer should be consulted on the inhibitor/primer compatibility.

3.3 SURFACE PREPARATION BY HAND AND POWER TOOL CLEANING

Manual cleaning using mechanical cleaning tools to remove mill scale and rust, according to ISO 8504-3, should not be used for new construction painting and may be used only if approved by the Principal.

3.4 SURFACE PREPARATION OF STAINLESS STEEL, HOT-DIP GALVANISED STEEL AND NON-FERROUS METALS

If stainless steel, galvanised or non-ferrous metal surfaces are to be painted, a suitable pre-treatment in the form of a light blast cleaning with an appropriate abrasive shall be given to ensure proper adhesion of the subsequently applied paint system.

Aluminium oxide or other abrasives (free from any chloride or iron/steel contamination) shall be used for blasting stainless steel.

If blast cleaning is impossible then solvent or steam cleaning with an alkaline detergent agent may be used for surface preparation.

If galvanised surfaces are contaminated with zinc salts and/or oil grease, etc., they shall first be cleaned by a fresh water wash and/or a suitable solvent.

4. PAINT APPLICATION

4.1 GENERAL

Paints and other coating materials shall be applied in accordance with the paint Manufacturer's instructions. The surface preparation shall be as described in (3).

All surfaces shall receive an appropriate paint system as specified in (5), (Appendix 1) and (Appendix 2), with the following exceptions:

- Any equipment (e.g off-the-shelf items) for which the Manufacturer's standard paint system has been approved for use by the Principal.
- Hot-dip galvanised steel, weathering steel and non-ferrous metals, unless specified by the Principal.
- Nameplates, code stampings and push buttons.
- Concrete brickwork, tile, glass and plastics unless specified by the Principal.
- Insulation weatherproofing material or sheeting.
- Any surface specified by the Principal not to be painted.

The painting requirements are often dependent on the temperature of the substrate to be painted. In selecting a paint system (Appendix 1) the Operating Temperature of the equipment shall be referred to.

4.2 PAINT APPLICATION REQUIREMENTS

The paint shall be applied in accordance with the paint Manufacturer's product data sheet, which shall include the mix ratio, the method of application, the use of thinners and overcoating times.

The dry film thicknesses shall be as specified in (Appendix 2). Areas with inadequate coating thickness shall be thoroughly cleaned and, if necessary, abraded, and additional compatible coats shall be applied until they meet the required film thickness.

Painting shall not be performed when the temperature of the surface is less than 3 °C above the dew point of the surrounding air or when the relative humidity of the air is greater than 85% unless local conditions dictate otherwise and the Principal is in agreement. Guidance on the estimation of the probability of condensation can be found in ISO 8502-4. The measurement of these conditions is the responsibility of the painting contractor.

In addition, paints shall not be applied under the following conditions:

- when the surface temperature is greater than 40 °C (unless a higher temperature is agreed by the paint Manufacturer),
- when the air temperature is less than approximately 4 °C, (depending on local conditions),
- when there is the likelihood of an unfavourable change in weather conditions within two hours after painting,
- when there is a deposition of moisture in the form of rain, condensation, frost, etc., on the surface,
- when the available light is less than 500 lux.

If condensation, rain, dust or other foreign materials contaminate the surface of a paint coating which is not dry to the touch, the paint shall be removed, the surface re-cleaned and fresh paint applied in accordance with this DEP.

Paints shall not be applied within 50 mm of edges which will later have to be welded. Such weld areas shall be taped for a distance of 50 mm either side of the weld line.

Extra coats of paint shall be applied on the areas where the shape and/or plane of application result in thinly applied coatings, e.g. at edges, welds, corners etc. To compensate for these effects, stripe coats of paints shall be applied (normally applied first

so that they will be covered by the full coat).

When zinc rich primers are used, care shall be taken to avoid any possibility of overspraying onto duplex or austenitic stainless steels, nickel alloys or 9% nickel steel components.

NOTE: Zinc rich primers shall not be applied on equipment located above equipment made from the above mentioned materials unless such equipment is located in a shielded position which will minimise the risk of molten zinc falling onto the equipment in the event of a fire.

Transport and construction of painted structures shall be carried out only after the drying time specified by the paint Manufacturer has elapsed. Damage to the paint system shall be avoided by taking appropriate measures, such as the use of non-metallic slings, etc. for handling and by minimising as far as possible handling after painting.

All steel equipment shall be provided with a priming or coating system to protect the steel surfaces during transport, storage, installation and construction.

4.2.1 Spray application

Airless or pneumatic spray applications are the preferred methods of application.

Spray painting may cause interference with other works and so approval from the Principal shall be obtained. If spray painting is to be carried out, the following shall be taken into account:

The correct spray tips, air pressures etc, as recommended by the equipment supplier, shall be used.

Each coat shall be applied uniformly and completely over the entire surface. All runs and sags shall be brushed out immediately or the paint shall be removed and the surface re-sprayed.

Very complex structures should be painted by brush instead of spray gun to avoid overspray, dry spray and unacceptable paint losses.

4.2.2 Brush application

Brush application may be used under the following circumstances:

- When areas cannot be properly coated by spraying for any reason, such as material or environmental considerations.
- For the initial coat of paint to corners, edges, crevices, holes, welds or irregular surfaces prior to spray application.
- For "touch up" or repairs to localized damaged paint or areas of incorrectly applied paint.
- Where the paint Manufacturer considers the coating material suitable for brush application.

Brushes shall be of a style and quality that will permit the proper application of paint.

Brush applications should be done in two passes that are perpendicular to each other so that a smooth coat, as near uniform in thickness as possible, is obtained. There should be no deep or detrimental brush marks. Paint shall be worked into all crevices and corners. Runs and sags shall be brushed out.

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

4.2.3 Roller application

Roller application shall only be used on relatively large surface areas and only if spraying is not an option. Roller application shall only be used if the first or priming coat of paint has been applied by brush. Roller application shall be in accordance with the paint Manufacturer's instructions.

5. PAINTING SCHEDULES AND PAINT SYSTEMS

5.1 GENERAL

Suitable paint systems for application on various types of equipment are indicated in the painting schedules given in (Appendix 1).

Details of the recommended paint systems, including quality of surface preparation and the recommended dry film thickness of the coatings are presented in (Appendix 2).

Complete shop application of paints is preferred. Where complete paint system application before transport to the site is not possible, primer and intercoat application in the shop followed by touch up and top coat painting on site is preferred over complete site application.

5.2 GENERIC PAINT CHARACTERISTICS

For ease of reference a generic description of the paints indicated in this DEP, together with a specific characterisation of some of their properties, is given below.

High solids, amine-cured epoxies:	Polyamine-cured epoxies generally have a good resistance to chemicals and solvents.
High build, polyamide-cured epoxies:	Polyamide-cured epoxies exhibit a longer potlife, superior flexibility and durability compared with amine-cured epoxies. They possess adequate chemical resistance.
High build, aliphatic polyurethanes:	Two component isocyanate-free urethanes produce extremely hard, resistant and durable coatings. Aliphatic urethanes are preferred over aromatic urethanes because of their excellent durability and gloss retention.
Phenolic epoxies:	Two component, high build, amine-cured phenolic epoxy coatings have excellent resistance to a wide range of solvents and (organic) acids.
(Alkyl) zinc silicates:	Two component, moisture curing, zinc (alkyl) silicate coating, containing a minimum of 87% metallic zinc, is a hard, abrasion resistant coating that can withstand temperatures up to 600 °C.
Aluminium pigmented silicates:	One component, (alkyl) silicate, zinc-free coating is suitable for temperatures up to 600 °C.
Aluminium silicones:	Aluminium pigmented, silicone resin-based paint. Heat resistant up to 450 °C. A minimum temperature of 200 °C is required for 2 hours to obtain a sufficient cure.
Silicone acrylics:	One component, aluminium (or colour) pigmented acrylic-modified silicone resin. Heat resistant up to 350 °C. Full cure can be achieved at ambient temperature.
Zinc-rich epoxy primer:	Two component, epoxy-based primer. Developed to provide sacrificial protection to steel surfaces.
Solvent free epoxies:	Two component, amine-cured, modified epoxies without solvent. They can be applied as a heavy duty coating up to 700 µm thick.
Polysiloxane:	Two component, inorganic polysiloxane. Used

	for heat resistance (continuous and cyclic) up to 1110 °C. Current experience with this coating is good but still very limited.
Thermally sprayed metal coatings:	Thermally sprayed metallic coatings may be used in applications where organic coatings are ineffective or cause product contamination. See DEP 30.48.40.31-Gen.

Lead containing paints, coal-tar epoxy paints and coal-tar urethane paints should not be used because of the associated health and environmental restrictions that apply.

Paints specifically intended for use on austenitic stainless steels or high nickel-chromium alloys shall not contain free chlorides or other halides after curing, although trace amounts in the raw materials may be acceptable. Chlorides or other halides tied up within the cured resin's chemical molecule are acceptable, unless they are subject to release through ageing within the temperature range specified. Such paint formulations shall also not contain metallic zinc, because of the possibility of inducing liquid metal embrittlement.

NOTE: It has been shown that zinc oxide or zinc phosphate, which are the more recent non-lead, non-chromate, corrosion inhibitive pigment developments, do not cause embrittlement even at 850 °C.

If an epoxy based micaceous iron oxide (MIO) sealer is specified, this shall be applied within 48 hours of the primer coat drying.

The selection of specialist paint systems, such as "temperature indicating paints" shall be approved by the Principal.

6. INSPECTION AND TESTING

Before painting activities commence the contractor shall submit an inspection procedure report indicating inspections and tests to be conducted during preparation and application of the paint system for approval by the Principal.

The following coating inspections and tests shall be applied:

6.1 SURFACE CONTAMINATION

Tests indicating the extent of substrate contamination as a result of iron, chlorides and dust are specified in ISO 8502-1, ISO 8502-2 and ISO 8502-3, respectively.

6.2 WET FILM THICKNESS, WFT

Spot checks shall be carried out during the course of the painting operation to ensure that film thickness is being maintained. These shall be performed according to the procedure described in ISO 2808, Method No. 7B.

6.3 DRY FILM THICKNESS, DFT

ISO 2808, Method No.6, describes the test techniques suitable for measurement of the dry film coating thickness.

6.4 HOLIDAY TESTING

Holiday testing shall be conducted in accordance with ASTM D 5162 on equipment where the continuity of the coating is important, for example internal tank linings which are subjected to corrosive conditions. The Principal shall specify the maximum number of holidays permissible.

6.5 ADHESION

The adhesion of the primer to the steel substrate and the intercoat adhesion of the subsequent coat(s) after curing shall be determined by the application of either a cross-cut test in accordance with ISO 2409 or a pull-off test described in ISO 4624.

6.6 INSPECTION RECORDS AND REPORTS

The Principal shall have the right to inspect the paint work at all stages of preparation and to reject any tools, instruments, materials, equipment or work which do not conform to this DEP.

Prior to final acceptance of the paint work an inspection shall be made. The Contractor and the Principal shall both be represented and they shall sign an agreed inspection report.

These reports shall include:

General
- Names of the Contractor and the responsible personnel.
- Dates when work was carried out.

Materials preparation
- Equipment and techniques used.
- Materials receipt condition.
- Type and calibration of instruments used.

Environmental conditions
- Weather and ambient conditions.
- Painting periods

Surface preparation
- Condition of surface before preparation.
- Tools and methods used to prepare surface.
- Condition after preparation.

Paints and painting
- Information on systems being applied.
- Mixing and testing prior to application.
- Paint application techniques.

Testing
- Type of quality control checks carried out, and results.
- Compliance or otherwise with specification.

7. COLOUR

The colour schemes shall be as specified by the Principal and may be governed by local regulations and customs.

If an intermediate coat has to be applied it should be applied a shade lighter than the top coat in order to increase the inspectability.

The Shell Standard Colours shall be used. If, for local reasons, this is not possible the following BS 4800 or RAL alternatives may be chosen:

Shell Standard		Alternative equivalent colour	
Number	**Colour**	**BS 4800**	**RAL**
1	Light grey	10 A 07	7037
2	Dark grey	10 A 11	7005
3	Aluminium	00 A 05	9006
4	Yellow	08 E 51	1021
6	Buff	08 C 35	8001
8	Blue green	-	6017
9	Dark green	-	6002
10	Blue	-	5009
11	Shell red	04 D 45	3002
12	Light red oxide	04 C 39	3009
13	Light red	04 E 53	2002
14	Chocolate brown	08 B 29	8014
15	Dark brown	-	8019
16	Olive green	-	6002
18	Middle grey	-	7033
22	Ivory	-	1014
25	Dark blue	-	5003
26	Silver grey	18 B 21	7032
27	Bright blue	18 E 53	5015
28	Shell Yellow	10 E 53	1018
32	Violet	24 C 39	4001
33	Alert orange	06 E 51	2003
40	Forest green	14 C 39	6028
54	Green	-	6021
55	Light grey green	12 B 17	6011
56	Pale grey	10 A 03	9002
-	White	-	9010
-	Black	-	9005

Where appropriate for safety reasons, the following colour scheme shall be applied:

Dangerous obstructions:	Black/Yellow (in alternate bands)
Dangerous or exposed parts of machinery:	Alert Orange
Fire equipment and services:	Shell Red
First aid equipment:	Dark Green

8. REFERENCES

In this DEP, reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Definition and determination of temperature and pressure levels	DEP 01.00.01.30-Gen.
Thermal spraying of coatings of zinc, aluminium and their alloys (endorsement of ISO 2063)	DEP 30.48.40.31-Gen.
Mounded horizontal cylindrical bulk storage vessels for pressurised gases at ambient temperature	DEP 34.51.11.30-Gen.
Maintenance painting	DEP 70.48.10.10-Gen.
Shell Standard Colours booklet, issue 1987	

AMERICAN STANDARDS

Standard practice for discontinuity (holiday) testing of non-conductive protective coating on metallic substrates	ASTM D 5162

Issued by:
American Society for Testing and Materials
1916 Race Street
Philadelphia, Pa 19103
USA.

BRITISH STANDARDS

Paint colours for building purposes	BS 4800

Issued by:
British Standards Institution
389 Chiswick High Road
London W4 4AL
England, United Kingdom.

GERMAN STANDARDS

RAL - colour cards

Issued by:
RAL
Bornheimerstraße 180
D-5300 Bonn 1
Germany.

INTERNATIONAL STANDARDS

Paints and Varnishes - Cross-cut test for adhesion	ISO 2409
Paints and varnishes - Determination of film thickness	ISO 2808
Paints and Varnishes - Pull-off test for adhesion	ISO 4624
Preparation of steel substrates before application of paints and	ISO 8501-1

related products - Visual assessment of surface cleanliness - Part 1: Rust grades and preparation grades of uncoated steel substrates and steel substrates after overall removal of previous coatings	
Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness - Part 1: Field test for soluble iron corrosion products	ISO 8502-1
Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness - Part 2: Laboratory determination of chloride on cleaned surfaces	ISO 8502-2
Preparation of steel substrates before application of paint and related products - Test for the assessment of surface cleanliness - Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)	ISO 8502-3
Preparation of steel substrates before application of paint and related products - Test for the assessment of surface cleanliness - Part 4: Guidance on the estimation of the probability of condensation prior to paint application	ISO 8502-4
Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blast cleaned steel substrates - Part 2: Method for the grading of surface profile of abrasive blast-cleaned steel - Comparator procedure	ISO 8503-2
Preparation of steel substrates before application of paints and related products - Surface preparation methods - Part 2: Abrasive blast-cleaning	ISO 8504-2
Preparation of steel substrates before application of paint and related products - Surface preparation methods - Part 3: Hand and power tool cleaning	ISO 8504-3

Issued by:
International Organisation for Standardisation
1 Rue de Varembe
CH-1211 Geneva 20
Switzerland.
Copies can also be obtained from national standards organisations.

APPENDIX 1 PAINTING SCHEDULES

Table 1-1 PIPING, VESSELS, COLUMNS, EXCHANGERS, REACTORS, STRUCTURAL STEEL AND FIRE-FIGHTING SYSTEMS

ITEM	OPERATING TEMPERATURE (°C)	SUBSTRATE	PAINT SYSTEM NUMBER (see Appendix 2)
PIPING, VESSELS, COLUMNS, EXCHANGERS, REACTORS, etc.	< 120	carbon steel, low alloy steel	1
	< 120	9% Ni steel	2
	120 - 200	carbon steel, low alloy steel	3
	200 - 450	carbon steel, low alloy steel	4
	ambient - 200	stainless steel	5
	200 - 450	stainless steel	6
	ambient -1100	carbon steel, stainless steel	7 *
STRUCTURAL STEEL, LADDERS, GRATINGS ETC.	-	carbon steel, low alloy steel	1
	-	hot dip galvanised carbon steel	8 **
FIRE FIGHTING SYSTEMS (above ground)	< 120	carbon steel	9

* Current experience with this polysiloxane coating is good but still very limited.

** This duplex system shall only be applied to hot dip galvanised steel in cases where access for future maintenance is difficult.

Table 1-2 TANKS AND LPG STORAGE

ITEM		OPERATING TEMPERATURE (°C)	SUBSTRATE	PAINT SYSTEM NUMBER (see Appendix 2)
CRUDE OIL TANKS BOTTOM and LOWEST SHELL COURSE	INTERNAL non-corrosive	<80	carbon steel, low alloy steel	10 *
	INTERNAL corrosive	<80	carbon steel, low alloy steel	11
CRUDE OIL TANKS ROOF and SHELL	INTERNAL	<80	carbon steel, low alloy steel	10 *
	EXTERNAL	<80	carbon steel, low alloy steel	1
STORAGE TANKS	INTERNAL	<120	carbon steel, low alloy steel	10 *
	EXTERNAL	<120	carbon steel, low alloy steel	1
		50 - 200	stainless steel	5
	INTERNAL, chemical resistant	<60	carbon steel, low alloy steel	12
	INTERNAL, industrial water **	<80	carbon steel, low alloy steel	11
LPG SPHERES and BULLETS	INTERNAL	<120	carbon steel, low alloy steel	10
	EXTERNAL	<120	carbon steel, low alloy steel	1
MOUNDED LPG STORAGE ***	EXTERNAL	ambient	carbon steel	13

* This treatment is a shop-applied temporary protection only. No further painting is required after construction.

** Primer is optional for use in industrial water tanks.

*** Full details about this system are given in DEP 34.51.11.30-Gen.

Table 1-3 FURNACES, STACKS, FLARE STACKS, FLUE DUCTS, OFFSHORE STRUCTURES, TOPSIDE FACILITIES

ITEM	OPERATING TEMPERATURE (°C)	SUBSTRATE	PAINT SYSTEM NUMBER (see Appendix 2)
FURNACES, STACKS, FLARE STACKS and FLUE DUCTS	<120	carbon steel, low alloy steel	1
	120 - 200	carbon steel, low alloy steel	3
	200 - 550	carbon steel, low alloy steel	14
	<400	carbon steel, hot-dip galvanised *	15
	<200	stainless	5
	200-450	stainless	6
	ambient -1100	carbon steel, stainless steel	7**
OFFSHORE STRUCTURES, TIDAL ZONES ***	<120	carbon steel, low alloy steel	11
TOPSIDE FACILITIES, EQUIPMENT and PIPING	<120	carbon steel, low alloy steel	9
	120 - 200	carbon steel, low alloy steel	3

* For long lifetime service (>20 years) a hot dip galvanised duplex system is preferred.

** Current experience with this polysiloxane coating is good but still very limited.

*** If economically attractive, thermally sprayed metal coating should be considered. See DEP 30.48.40.31-Gen.

APPENDIX 2 PAINT SYSTEMS

SYSTEM NUMBER	SURFACE PREPARATION	PAINT SYSTEM		
		Primer	Inter-coat	Top coat
1	Sa 2½	Alkyl zinc silicate DFT 75 microns	High build, epoxy sealer DFT 75 microns	High build, aliphatic polyurethane DFT 75 microns
2	Sa 2½	High build, polyamide-cured, (zinc-free) epoxy DFT 100 microns	-	High build, high solids, polyamide-cured epoxy DFT 100 microns
3	Sa 2½	Alkyl zinc silicate DFT 75 microns	-	2 coats silicone acrylic TDFT 60 microns
4	Sa 2½	Alkyl zinc silicate DFT 75 microns	-	2 coats heat-resistant, aluminium silicone TDFT 50 microns
5	Light sweep blast (steam clean if not possible)	Silicone acrylic DFT 25 microns	-	Silicone acrylic DFT 25 microns
6	Light sweep blast (steam clean if not possible)	Heat-resistant, aluminium silicone DFT 25 microns	-	Heat-resistant, aluminium silicone DFT 25 microns
7	Carbon steel - Sa 2½ Stainless steel - sweep blast to surface profile of 40 microns		Polysiloxane DFT 125 microns	Polysiloxane DFT 125 microns
8	Hot dip galvanised after light sweep blast	Zinc-rich epoxy primer DFT 40 microns	-	High build, aliphatic polyurethane DFT 100 microns
9	Sa 2½	Alkyl zinc silicate DFT 75 microns	Polyamide-cured, MIO pigmented, epoxy tie coat DFT 40 microns	2 coats high solids, Al-pigmented epoxy TDFT 200 microns
10	Sa 2½	Zinc-rich epoxy DFT 25 microns	-	-
11	Sa 2½	Polyamide-cured epoxy primer DFT 75 microns	-	Solvent-free high solids, amine-cured epoxy DFT 500 microns
12	Sa 2½	Amine-cured, phenolic epoxy primer DFT 100 microns	Amine adduct-cured, phenolic epoxy DFT 100 microns	High build, amine adduct-cured epoxy DFT 100 microns
13	Sa 2½	-	-	Solvent-free, high solids epoxy (hot applied) DFT 800 microns
14	Sa 2½	Zinc silicate DFT 75 microns	-	Alkyl silicate, Al-pigmented DFT 40 microns
15	Hot dip galvanised (slightly sweep blast if aged)	Zinc-rich epoxy primer DFT 75 microns	Polyamide-cured, MIO pigmented, epoxy tie coat DFT 40 microns	High solids, Al-pigmented epoxy DFT 100 microns