MANUAL

MAINTENANCE PAINTING

DEP 70.48.10.10-Gen.

December 1995

DESIGN AND ENGINEERING PRACTICE

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1. INTRODUCTION

1.1 SCOPE

This is a new DEP which specifies requirements and gives recommendations for maintenance painting of existing equipment and structures. It describes the essential criteria for deciding whether maintenance painting is needed and it assists in the selection of a suitable paint system.

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 "Painting and Coating" are now rendered out of date and are withdrawn.

It is stressed that this DEP gives general requirements for maintenance painting only. For specific equipment where conflicting requirements are defined in other DEPs or other applicable publications, the requirements of those documents shall prevail.

This DEP may be used in conjunction with DEP 30.48.00.31-Gen. ("Painting and coating of new equipment") since the generic systems described therein are compatible with the systems used in this DEP.

NOTE: To avoid confusion between this DEP and DEP 30.48.00.31-Gen., the paint system numbers in this DEP are preceded by the letter "M" for maintenance.

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 or managed by the Royal Dutch/Shell Group. It may be distributed to 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, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this document 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 document 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 or maintenance 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

Chalking	The appearance of a loosely adherent fine powder on the surface of a paint coating, arising from the degradation of one or more of its constituents.
Cracking	The splitting of a dry paint film, usually as the result of ageing.
DFT	Dry film thickness; the thickness of a dried or cured paint or coating film.
Flaking	The detachment of pieces of the paint film itself either from its substrate or from paint previously applied. Flaking is usually preceded by cracking or blistering.
Operating Temperature	See DEP 01.00.01.30-Gen.
TDFT	Total dry film thickness; the thickness of the total number of coatings specified.
WFT	Wet film thickness, the thickness of an 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 in this DEP are listed in (10).

2. MAINTENANCE PAINTING PHILOSOPHY

Maintenance painting consists of two types of activity:

1. Large-scale maintenance, necessary because the existing coating has completely deteriorated or failed and the technical integrity or safety of the equipment is impaired. In this case local repairs are not economically justified and the only option is to apply a new paint system in accordance with DEP 30.48.00.31-Gen.
2. Repair work to rectify damage to a coating caused by corrosion, ageing etc.

Maintenance painting purely for the sake of appearance is not considered an economically justified criterion within the context of this DEP.

To determine how and to what extent any damage to a coating should be repaired, it is necessary to:

- establish the amount of corrosion present,
- establish the type and extent of paint defects present,
- select an appropriate repair procedure, which includes:
  - surface preparation,
  - choice and specification of coating system,
  - application,
  - testing and inspection.

3. ASSESSMENT OF SURFACE CONDITION

In order to establish the correct and successful maintenance painting procedure required, it is critical to assess the condition of the equipment in terms of corrosion and coating condition.

One or more of the following warning signs can indicate if maintenance painting is required:

- general rust formation;
- local rust attack resulting from mechanical damage, typically on edges, in corners, at corrosion traps and on weld seams;
- local rust attack on films that are too thin or caused by porous areas in the coating;
- rust creep from damaged areas;
- flaking of the substrate or between coats;
- blistering;
- cracking of the paint film.

The following sections give guidance with respect to the classification of surface condition.

3.1 CORROSION CRITERIA

To establish the amount of corrosion occurring on carbon and low alloy steels, reference shall be made to the degrees of rusting defined in ISO 4628-3.

NOTE: The approach for stainless steels is given in (3.4).

The estimated amounts of rust break-through on a coating and of the total apparent rust (rust break-through plus under-film rust) shown in this standard are given in Table 1. Comparative American and European standard rust grades are included in the table for reference since these were widely applied in the past, but the ISO standard is now accepted as the norm.

Table 1 Degree of rusting and area rusted

DEGREE OF RUSTING			AREA RUSTED (%)
ISO rust scale	**European rust scale**	**ASTM D 610**	
Ri 0	Re 0	10	0
Ri 1	Re 1	9	0.05
Ri 2	Re 2	7	0.5
Ri 3	Re 3	6	1
Ri 4	Re 5	4	8
Ri 5	Re 7	1 to 2	40 to 50

3.2 BLISTERING

The degree of blistering shall be evaluated in accordance with ISO 4628-2. This standard characterises blistering in terms of size and frequency.

When the blistering frequency observed on a coating becomes "medium", the nature of the blisters shall be studied in order to establish the need for maintenance.

If the area underneath the blisters is dry and the blister itself is raised by gas (e.g. from trapped solvent) there is no urgency for repair. This also applies if the blisters are filled with liquid and if there is little or no corrosion underneath.

Blisters with both liquid and corrosion product underneath indicate that corrosion has been initiated on the substrate and, therefore, repair is necessary. In this case the repair requires

complete removal of the blisters since experience has shown that on equipment repaired once (locally) and replaced in service, the blistering is rapidly renewed. Consequently, the only satisfactory procedure is to blast-clean the surface thoroughly, which means a repair comparable with the procedure for a rust scale of Ri 4 as given in Appendix 1.

3.3 CRACKING, FLAKING AND CHALKING

The degree of cracking, flaking and chalking in a coating shall be evaluated in accordance with ISO 4628-4, ISO 4628-5 and ISO 4628-6, respectively.

These phenomena alone shall not be used as a criterion for urgent maintenance painting provided that they are not accompanied by significant corrosion, i.e. provided that Ri $\leq$ 3 as indicated in (3.1)

3.4. STAINLESS STEEL SUBSTRATES

The necessity to carry out maintenance painting on stainless steel surfaces shall be governed by a visual judgement of the existing coating (including the condition of any insulation) since "degree of rusting" is not a relevant criterion for these substrates.

4. TYPES OF MAINTENANCE

Depending on the condition of the coating, one or more of the following four types of maintenance should be applied:

4.1 PREVENTIVE CLEANING

Periodic removal of all contaminants, e.g. salts, dirt, grease, oil, etc., by hosing with fresh water is sufficient if the coating is contaminated but no breakdown or corrosion is observed (i.e. Ri 0). If needed, a concentrated detergent may be used. If conducted regularly this will reduce the impact from the environment and result in longer maintenance intervals.

4.2 SPOT REPAIR

If the paint film, apart from local rust areas, is sound and adequate (Ri 3), the areas that are corroded shall be spot cleaned and touched up to full film thickness. All corrosion products shall be removed and the interface between the sound coat and cleaned areas shall be properly prepared.

4.3 RENOVATION

For renovation (Ri = 4), spot repairs shall be carried out to the existing coating in accordance with (4.2), and a full topcoat shall be applied. The existing coating system shall be sound and adequate and the new topcoat shall enhance the corrosion inhibition. In some cases a complete renovation may be needed for reasons of a change of colour or to prevent increased dirt retention.

4.4 REFURBISHMENT

This requires total removal of the existing coating system (Ri ≥ 5). Surface preparation and application of a new coating system shall be carried out in accordance with DEP 30.48.00.31-Gen.

Table 2 contains recommendations for the selection of the appropriate type of maintenance for coated surfaces based on their current condition.

Maintenance painting should not be necessary for coated surfaces where less than 1% of the surface area is corroded (Ri ≤ 3).

Table 2 Typical maintenance practices

PAINT SURFACE CONDITION	**RUST SCALE** (ISO 4628-3)	**MAINTENANCE**	**MINIMUM RECOMMENDED SURFACE PRETREATMENT** (ISO 8501)
Contaminated No corrosion	Ri 0	preventive cleaning (4.1)	-
1% of surface area corroded	Ri 3	spot repair (4.2)	St 2
< 10% of surface area corroded	Ri 4	renovation (4.3)	St 3 / Sa 2
> 10% of surface area corroded	Ri 5	refurbishment (4.4)	Sa 2½

5. PAINTING SYSTEM SELECTION

Based on the maintenance practices given in Table 2, painting schedules are given in (Appendix 1) for carbon steel and low-alloy steels where rust scales Ri 3 or Ri 4 have been detected.

The procedures for spot repair or renovation can then be derived from (Appendix 2), where the appropriate paint systems are listed.

The following factors should be taken into account in selecting the most appropriate, economic painting system:

- compatibility with existing coating systems;
- operating temperature;
- adhesion to the existing substrate;
- required lifetime before next maintenance;
- remaining life of the equipment or structure.

5.1 OPERATING TEMPERATURE

The Operating Temperature of the equipment shall be used in selecting a paint system in (Appendix 1).

5.2 COMPATIBILITY WITH EXISTING COATING SYSTEMS

For spot repair and renovation the selected paint systems shall be the same as or compatible with existing coating systems.

Epoxies and polyurethanes may only be applied on top of alkyd paints in exceptional cases and only after a thorough investigation has been conducted into the softening and adhesion of the proposed coating system. In such cases the paint Manufacturer shall be consulted.

Silicate-based paints shall not be applied on top of organic coatings or organic shop-primers as there is insufficient intercoat adhesion.

6. SURFACE PREPARATION

For the optimum performance of paint systems the surface preparation shall, wherever possible, be carried out by dry blast-cleaning. If dry blast-cleaning is not strictly necessary (e.g. rust scale Ri 3) or not feasible (e.g. due to limited access, risk of damage to equipment, light gauge steel, the proximity of electrical components or instrumentation) then power tool cleaning shall be applied.

6.1 SURFACE PREPARATION BY BLAST CLEANING

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.

If the surface being prepared lies adjacent to a coated surface which is not to be refurbished, the blast cleaning shall overlap the coated surface by at least 25 mm. The remainder of the existing coated surface shall be properly protected with shields or screens to prevent any possible damage to the coating.

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

6.2 BLAST-CLEANING TECHNIQUES

6.2.1 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.).

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

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

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.

6.2.2 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.

6.2.3 Performance and application conditions

Blast-cleaning shall only be performed in conditions suitable for painting, see (7.3).

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 be either 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.

6.3 SURFACE PREPARATION BY HAND AND POWER TOOL CLEANING

The most technically effective surface preparation method is blast-cleaning. Manual preparation shall only be used when blast-cleaning is either not feasible or not strictly required, e.g. for rust scale Ri 3.

Manual cleaning shall be performed using hand wire brushes or mechanically operated tools (grinders, chippers or wire brushes) in accordance with ISO 8504-3. The surface shall be left roughly abraded and a burnished surface shall be avoided.

If the surface being prepared lies adjacent to a coated surface which is not to be refurbished, the power tool cleaning shall overlap the coated surface by at least 25 mm.

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

St 2 : Thorough hand and power tool cleaning

St 3 : Very thorough hand and power tool cleaning

NOTE: Preparation grade St 1 is considered an unsuitable surface for painting.

7. PAINTING

7.1 GENERAL

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 in various conditions, indicating the maintenance 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.

7.2 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 work being performed by other contractors.
- Maintenance of the paint work until completion of the contract. This shall include the repair of any damage caused by third parties.
- The characteristics of the paints and paint materials obtained from the paint Manufacturer. The characteristics shall be obtained through 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 needed for 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.

7.3 PAINT APPLICATION

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.

Details on spray, brush and roller applications are given in DEP 30.48.00.31-Gen.

7.4 GENERIC PAINT DESCRIPTIONS

For ease of reference the generic description of the paints mentioned in this DEP, together with a specific characterisation of their properties are listed below.

High-solids amine-cured epoxies	Polyamine-cured epoxies offer generally good resistance to chemicals and solvents.
High-build polyamide-cured epoxies	Polyamide-cured epoxies exhibit longer potlife, superior flexibility and durability, compared with the polyamine-cured epoxies. They possess adequate chemical resistance .
High-build aliphatic polyurethanes	Two-component, isocyanate-free urethanes produce extremely hard, resistant and durable coating. 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.
Inorganic (mono) zinc silicates	One-component amine-stabilised acrylate modified zinc silicate is suitable for application to slightly contaminated surfaces up to 500 °C (dry service)
(Alkyl) zinc silicates	Two-component, moisture curing zinc (alkyl) silicate coating, containing a minimum of 87 % metallic zinc, is a hard, abrasion resistant coating, can withstand temperatures up to 600 °C.
Aluminium pigmented silicates	One-component (alkyl) silicate coating, zinc free. Suitable for substrate 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 during 2 hours is required to obtain sufficient cure.
Silicone acrylics	One-component aluminium (or colour) pigmented acrylic modified silicone resin, heat resistant up to 350°C. Full cure can be obtained 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 can be applied as a heavy duty coating up to 700 microns.

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.

8. TESTING AND INSPECTION

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:

8.1 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.

8.2 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.

8.3 DRY FILM THICKNESS, DFT

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

8.4 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.

8.5 ADHESION

If local repairs are to be carried out, partly leaving the original coating intact, the coating shall be examined for adhesion of the first coat to the substrate and for adhesion between coats. An adhesion test shall be carried out according to ISO 2409 or ISO 4624 at any location where there is evidence of any sort of failure in the coating.

The acceptance criteria for this test are:

ISO 2409: minimum pull-off force 300 N/cm^2

ISO 4624: minimum classification 0 or 1.

8.6 INSPECTION RECORDS AND REPORTS

The Principal shall have the right to inspect the paint work at all stages of preparation and to reject any and/or all 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.

9. 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

10. 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

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.
Painting and coating of new equipment	DEP 30.48.00.31-Gen.
Mounded horizontal cylindrical bulk storage vessels for pressurised gases at ambient temperature	DEP 34.51.11.30-Gen.
Shell Standard Colours booklet, issue 1987	

AMERICAN STANDARDS

Test methods for evaluating degree of rusting on painted steel surfaces	ASTM D 610

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

BRITISH STANDARDS

Colours for standard & protective coatings for the marine & building industries	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.

European Scale of Degree of Rusting

Issued by:
Comité Européen des Associations de Fabricants
de Peintures, d'Encres d'Imprimeie et de Couleurs d'Art
Square Marie Louise 49
B-1040 Brussels
Belgium.

INTERNATIONAL STANDARDS

Paint and varnishes - Cross-cut test	ISO 2409
Paints and varnishes - Determination of film thickness	ISO 2808
Paints and varnishes - Pull-off test for adhesion	ISO 4624
Paints and varnishes - Evaluation of degradation of paint coatings - Designation of intensity, quantity and size of common types of defect - Part 2: Designation of degree of blistering	ISO 4628-2
Paints and varnishes - Evaluation of degradation of paint coatings - Designation of intensity, quantity and size of common types of defect - Part 3: Designation of degree of rusting	ISO 4628-3
Paints and varnishes - Evaluation of degradation of paint coatings - Designation of intensity, quantity and size of common types of defect - Part 4: Designation of degree of cracking	ISO 4628-4
Paints and varnishes - Evaluation of degradation of paint coatings - Designation of intensity, quantity and size of common types of defect - Part 5: Designation of degree of flaking	ISO 4628-5
Paints and varnishes - Evaluation of degradation of paint coatings - Designation of intensity, quantity and size of common types of defect - Part 6: Rating of degree of chalking by tape method	ISO 4628-6
Preparation of steel substrates before application of paints and 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	ISO 8501-1
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 paints and related products - Tests 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	ISO 8502-4

condensation prior to paint application

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 paints 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 Varembé
CH-1211 Geneva 20
Switzerland.

Copies can also be obtained from national standards organisations.

APPENDIX 1 MAINTENANCE PAINTING SCHEDULE

Table 1-1 VESSELS, PIPING AND STRUCTURES

ITEM	OPERATING TEMPERATURE (°C)	SUBSTRATE	SURFACE CONDITION	PAINT SYSTEM (See Appendix 2)
PIPING, VESSELS, COLUMNS, EXCHANGERS, REACTORS, etc.	<120	carbon steel, low alloy steel	Ri 3	M1
			Ri 4	M2
	<120	9% Ni steel	Ri 3/4	M2
	120 - 200	carbon steel, low alloy steel	Ri 3	M3
			Ri 4	M4
	200 - 450	carbon steel, low alloy steel	Ri 3	M5
			Ri 4	M6 *
	ambient - 200	stainless steel	-	M7
	200 - 450	stainless steel	-	M8
STRUCTURAL STEEL, LADDERS, GRATINGS etc.	-	carbon steel, low alloy steel	Ri 3	M1
			Ri 4	M2
	-	carbon steel, hot dip galvanised	Ri 3 / 4	M9

* The M6 paint system is suitable for an operating temperature up to 550 °C.

APPENDIX 1 MAINTENANCE PAINTING SCHEDULE

Table 1-2 TANKS AND LPG STORAGE VESSELS

ITEM	OPERATING TEMPERATURE (°C)	SUBSTRATE	SURFACE CONDITION	PAINT SYSTEM (See Appendix 2)
CRUDE OIL TANKS BOTTOM and LOWEST SHELL COURSE - internal - non-corrosive	<80	carbon/ low alloy steel	Ri 3/4	Not applicable
- internal - corrosive	<80	carbon/ low alloy steel	Ri 3/4	M10
CRUDE OIL TANKS ROOF AND SHELL - internal -	<80	carbon/ low alloy steel	Ri 3/4	Not applicable
- external -	<80	carbon/ low alloy steel	Ri 3/4	M1
STORAGE TANKS - external -	<120	carbon/ low alloy steel	Ri 3	M1
			Ri 4	M2
	50 - 200	stainless steel	-	M7
- internal -	<120	carbon/ low alloy steel	Ri 3/4	Not applicable
STORAGE TANKS - internal - chemical resistant	<60	carbon/ low alloy steel	Ri 3	M11 *
			Ri 4	M12
STORAGE TANKS - internal - Industrial water	<80	carbon/ low alloy steel	Ri 3/4	M13
SPHERES AND BULLETS FOR LPG - internal -	<120	carbon/ low alloy steel	Ri 3/4	Not applicable
- external -	<120	carbon/ low alloy steel	Ri 3	M1
			Ri 4	M2
MOUNDED LPG STORAGE ** - external -	-	carbon steel	Ri 3/4	M14

* In case maximum chemical resistance is required, use system M12.

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

APPENDIX 1 MAINTENANCE PAINTING SCHEDULE

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

ITEM	OPERATING TEMPERATURE (°C)	SUBSTRATE	SURFACE CONDITION	PAINT SYSTEM (See Appendix 2)
FURNACES, STACKS, FLARE STACKS and FLUE DUCTS	<120	carbon steel, low alloy steel	Ri 3	M1
			Ri 4	M2
	120 - 500	carbon steel, low alloy steel	Ri 3	M5
			Ri 4	M6
	50 - 200	stainless steel	-	M7
	200 - 450	stainless steel	-	M8
OFFSHORE STRUCTURES AND SPLASH ZONE	<120	carbon steel, low alloy steel	Ri 3/4	M15
TOP SIDE FACILITIES, EQUIPMENT AND PIPING	<120	carbon steel, low alloy steel	Ri 3/4	M16
	120 - 200	carbon steel, low alloy steel	Ri 3/4	M17

APPENDIX 2 MAINTENANCE PAINTING SYSTEMS

SYSTEM NUMBER	SURFACE PREPARATION	PAINT SYSTEM		
		Primer	Inter coat	Top coat
M1	St 2	Surface tolerant, Al pigmented high-solids amine-cured epoxy DFT 75 microns	-	High-build, MIO pigmented, polyamide-cured epoxy DFT 100 microns
M2	Sa 2	Surface tolerant, Al pigmented high-solids amine-cured epoxy DFT 75 microns	High-build, MIO pigmented, polyamide-cured epoxy DFT 75 microns	High-build, aliphatic polyurethane DFT 75 microns
M3	St 3 / Sa2	Inorganic (mono) zinc silicate DFT 75 microns	-	2 coats silicone-acrylic TDFT 50 microns
M4	Sa 2½	(Alkyl) zinc silicate DFT 25 microns	-	2 coats silicone-acrylic TDFT 50 microns
M5	St 3 / Sa 2	Inorganic (mono) zinc silicate DFT 75 microns	Heat resistant Al-silicone DFT 25 microns	Heat resistant Al-silicone DFT 25 microns
M6	Sa 2½	(Alkyl) zinc silicate DFT 75 microns	Aluminium pigmented silicate DFT 30 microns	Aluminium pigmented silicate DFT 30 microns
M7	Sweep blast (or steam clean)	Silicone-acrylic DFT 25 microns	-	Silicone-acrylic DFT 25 microns
M8	Sweep blast (or steam clean)	Heat resistant Al-silicone DFT 25 microns	-	Heat resistant Al-silicone DFT 25 microns
M9	Sa 2	Zinc-rich epoxy primer DFT 40 microns	-	High-build, aliphatic polyurethane DFT 100 microns
M10	Sa 2	Polyamide-cured epoxy primer DFT 75 microns	-	Solvent free amine cured epoxy DFT 300 microns
M11	St 3	Surface tolerant high-solids amine-cured epoxy DFT 75 microns	Amine adduct-cured phenolic epoxy coating DFT 100 microns	HB amine adduct-cured phenolic epoxy coating DFT 100 microns
M12	Sa 2	Amine-cured phenolic epoxy primer DFT 100 microns	Amine adduct-cured phenolic epoxy coating DFT 100 microns	HB amine adduct-cured phenolic epoxy coating DFT 100 microns
M13	St 3	Zinc-rich epoxy primer DFT 75 microns	-	Solvent free high-solids, amine-cured epoxy DFT 500 microns
M14	Sa 2½	-	-	Solvent-free, high solids epoxy (hot or cold applied) DFT 800 microns
M15	Sa 2	Polyamide cured, epoxy primer DFT 75 microns	-	Solvent-free, high solids, amine-cured epoxy DFT 500 microns
M16	Sa 2/ St 3	Surface tolerant, Al pigmented, high-solids, amine cured epoxy DFT 75 microns	High-build, polyamide-cured epoxy DFT 75 microns	High-solids, polyamide-cured epoxy DFT 150 microns
M17	Sa 2 / St 3	Zinc-rich epoxy primer DFT 75 microns	-	2 coats silicone acrylic TDFT 50 microns