

ADNOC GROUP PROJECTS AND ENGINEERING

PAINTING AND COATING SPECIFICATION

Specification

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 - ii. ADNOC Onshore, ADNOC Offshore, ADNOC Sour Gas, ADNOC Gas Processing, ADNOC LNG, ADNOC Refining, ADNOC Fertilisers, Borouge, Al Dhafra Petroleum, Al Yasat
- b. The following are stakeholders for the purpose of this specification:
 - i. ADNOC PT&CS Directorate
- c. This specification has been approved by the ADNOC PT&CS is to be implemented by each ADNOC Group COMPANY included above subject to and in accordance with their Delegation of Authority and other governance-related processes in order to ensure compliance.
- d. Each ADNOC Group COMPANY must establish / nominate a Technical Authority responsible for compliance with this specification.

DEFINITIONS

“ADNOC” means Abu Dhabi National Oil COMPANY.

“ADNOC Group” means ADNOC together with each COMPANY in which ADNOC, directly or indirectly, controls fifty percent (50%) or more of the share capital.

“Approving Authority” means the decision-making body or employee with the required authority to approve Policies & Procedures or any changes to it.

“Business Line Directorates” or **“BLD”** means a directorate of ADNOC which is responsible for one or more Group Companies reporting to, or operating within the same line of business as, such directorate.

“Business Support Directorates and Functions” or **“Non- BLD”** means all the ADNOC functions and the remaining directorates, which are not ADNOC Business Line Directorates.

“CEO” means chief executive officer.

“Group COMPANY” means any COMPANY within the ADNOC Group other than ADNOC.

“Specification” means this Painting and Coating Specification.

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TABLE OF CONTENTS

1	GENERAL	12
1.1	INTRODUCTION.....	12
1.2	PURPOSE.....	12
1.3	DEFINITIONS AND ABBREVIATIONS.....	12
SECTION A - GENERAL		19
2	REFERENCE DOCUMENTS	19
2.1	INTERNATIONAL CODES AND STANDARDS	19
2.2	ADNOC SPECIFICATIONS.....	23
2.3	STANDARD DRAWINGS.....	23
2.4	OTHER REFERENCES.....	24
3	DOCUMENT PRECEDENCE.....	24
4	SPECIFICATION DEVIATION / CONCESSION CONTROL.....	24
5	DESIGN CONSIDERATIONS / MINIMUM DESIGN REQUIREMENTS.....	24
5.1	DESIGN BASIS	24
5.2	DESIGN REQUIREMENTS FOR COATING APPLICATION	25
6	GUARANTEES AND WARRANTY.....	25
SECTION B PART 1 - TECHNICAL REQUIREMENTS (EXTERNAL COATING)		26
7	HANDLING OF PAINTED ITEMS.....	26
8	EXECUTION.....	26
8.1	SHOP VERSUS FIELD PAINTING POLICY	26
8.2	RESPONSIBILITIES OF THE SUPPLIER	27
8.3	RESPONSIBILITIES OF THE COATING MANUFACTURER.....	28
8.4	RESPONSIBILITIES OF THE SUB-CONTRACTOR	28
8.5	APPLICATION PROCEDURE.....	29
9	MATERIALS.....	30
9.1	ABRASIVE MATERIAL DRY STORAGE	31
9.2	ABRASIVES	31
9.3	SELECTION OF ABRASIVES.....	32
9.4	COMPRESSED AIR	33
9.5	PAINT MATERIAL STORAGE.....	33
9.6	PAINT MATERIALS	34
9.7	HAZARDOUS MATERIALS	35
10	GENERAL REQUIREMENTS.....	36

10.1	STEEL PREPARATION	36
10.2	SURFACES NOT TO BE PAINTED	36
10.3	PROTECTION OF STAINLESS-STEEL AND CRA SURFACES	36
10.4	SAFETY REQUIREMENTS	37
10.5	PRE-JOB MEETING	37
11	SURFACE PREPARATION	37
11.1	ITEMS TO BE PROTECTED	37
11.2	BASIC CLEANING	38
11.3	SHOP PRIMING	39
11.4	PRE-BLAST CLEANING	39
11.5	CLEANING OF CARBON STEEL / ALLOY STEEL SURFACES	40
11.6	CLEANING OF GALVANIZED AND INORGANIC ZINC SURFACES	41
11.7	CLEANING OF STAINLESS-STEEL AND CRA SURFACES	41
11.8	CLEANING OF GLASS REINFORCED EPOXY SURFACES	41
11.9	RESIDUAL SALT CONTAMINATION	41
11.10	SURFACE DUST	42
11.11	PRESENCE OF MILL SCALE	42
11.12	SURFACE PROFILE	42
12	PAINTING APPLICATION	42
12.1	SCHEDULING	42
12.2	PREPARATION FOR PAINTING	43
12.3	PAINTING APPLICATION	43
12.4	APPLICATION CHECKS	45
12.5	FINISHED COATING	47
13	REPAIR	48
13.1	GENERAL REQUIREMENTS	48
13.2	PAINTING DAMAGE NOT EXPOSING SUBSTRATE SURFACE	48
13.3	PAINTING DAMAGE EXPOSING SUBSTRATE SURFACE AND FIELD WELDS	49
13.4	REPAIR OF ZINC SILICATE PRIMER	49
13.5	REPAIR OF FULLY CURED EPOXY PAINTING	49
14	INSPECTION AND TESTING	49
14.1	GENERAL	49
14.2	BEFORE SURFACE PREPARATION	49
14.3	BEFORE AND DURING PAINT APPLICATION	49

14.4	AFTER PAINTING	50
14.5	INSPECTION AND TESTS SUMMARY	51
15	THERMAL SPRAY ALUMINIUM (TSA) - QUALIFICATION.....	52
15.1	GENERAL.....	52
15.2	TSA SUB-CONTRACTOR QUALIFICATION	53
15.3	THERMAL SPRAYER QUALIFICATION.....	53
15.4	TESTING OF TSA PRODUCTION COATING PROPERTIES.....	55
15.5	COATING REPAIR	57
16	INSPECTION RECORDS AND REPORTS	58
17	MAINTENANCE AND PAINTING OPTIONS.....	58
17.1	GENERAL.....	58
17.2	REFURBISHMENT	59
17.3	CRITERIA FOR MAINTENANCE COATING IN ATMOSPHERIC SERVICE.....	61
17.4	SPOT REPAIR PROCEDURE.....	61
17.5	SPOT REPAIR AND FULL TOPCOAT PROCEDURE.....	62
17.6	RENOVATION PROCEDURE	62
17.7	STAINLESS STEELS	62
	SECTION B PART 2 - TECHNICAL REQUIREMENTS (INTERNAL LINING)	63
18	GENERAL	63
19	HANDLING.....	63
20	EXECUTION.....	63
21	MATERIALS AND EQUIPMENT	64
21.1	DEGREASER	64
21.2	ABRASIVES	64
21.3	EQUIPMENT	64
21.4	COMPRESSED AIR	65
21.5	LINING MATERIALS	65
22	GENERAL REQUIREMENTS	65
22.1	SURFACE CONDITIONING	65
22.2	DEHUMIDIFICATION	66
22.3	VENTILATION	66
22.4	LIGHTING	66
22.5	SURFACE PREPARATION.....	67
22.6	CARE OF CLEANED AND COATED SURFACES	67

23	LINING MATERIAL APPLICATION	68
	23.1 GENERAL REQUIREMENTS.....	68
	23.2 LINING SYSTEMS.....	68
	23.3 SERVICE AND LINING SYSTEMS SCHEDULE	68
	23.4 MIXING OF MATERIALS	68
	23.5 NUMBER OF COATS AND THICKNESS OF LINING	69
	23.6 RECOATING.....	69
	23.7 CURING	69
	23.8 CONTINUITY TESTING OF THE LINING	69
24	LINING IDENTIFICATION.....	70
25	LINING REPAIR	70
26	INSPECTION.....	71
	26.1 GENERAL INSPECTION.....	71
	26.2 SURFACE PREPARATION.....	72
	26.3 APPLICATION OF LINING.....	72
	26.4 LINING INSPECTION	73
	26.5 INSPECTION INSTRUMENTS	73
	26.6 INSPECTION ACCEPTANCE CRITERIA	74
	SECTION B PART 3 - TECHNICAL REQUIREMENT (INTERNAL COATING OF LINE PIPE FOR NON-CORROSIVE SALES GAS TRANSMISSION)	76
27	INTRODUCTION	76
28	COATING AND SUB-CONTRACTOR QUALIFICATION	76
	28.1 GENERAL.....	76
	28.2 COATING MATERIAL QUALIFICATION.....	77
	28.3 REQUIREMENTS FOR QUALIFICATION OF THE COATING MATERIAL	77
	28.4 COATING REQUIREMENTS FOR THE QUALIFICATION OF THE APPLIED COATING SYSTEM.....	78
	28.5 PACKAGING, LABELLING AND STORAGE.....	80
	28.6 PRODUCT DATA SHEET	81
	28.7 QUALIFICATION CERTIFICATE	82
	28.8 BATCH TEST CERTIFICATE.....	83
	28.9 SUB-CONTRACTOR QUALIFICATION	84
29	APPLICATION OF THE COATING MATERIAL.....	86
	29.1 GENERAL.....	86
	29.2 PIPE SURFACE PREPARATION	86

29.3	PAINT PREPARATION	87
29.4	PAINT APPLICATION	88
29.5	HEALTH AND SAFETY AND PROTECTION OF THE ENVIRONMENT	88
30	PRODUCTION CONTROL.....	89
30.1	ASSESSMENT OF COATING ON THE PIPES	89
30.2	ASSESSMENT OF COATING ON STEEL PANELS	90
31	COATING REPAIRS	91
32	HANDLING STORAGE AND TRANSPORT	91
32.1	RECORDS AND REPAIRS	91
33	DOCUMENTATION.....	91
33.1	PRE-MANUFACTURING DOCUMENTATION	91
33.2	CERTIFICATION	92
	SECTION D - APPENDICES.....	93
	APPENDIX A1. PAINTING SCHEDULES FOR EXTERNAL SURFACES	93
	APPENDIX A2. PAINTING SYSTEMS FOR EXTERNAL SURFACES	95
	APPENDIX A3. PQT REQUIREMENTS FOR SYSTEMS A4 AND A5	101
	APPENDIX A4. EXTERNAL PROTECTION FOR FASTENERS	104
	APPENDIX A5. POWDER COATING	105
	APPENDIX A6. SAFETY COLOUR CODING AND IDENTIFICATION - GAS PROCESSING.....	106
	APPENDIX A7. SAFETY COLOUR CODING AND IDENTIFICATION - REFINING	115
	APPENDIX A8. SAFETY COLOUR CODING AND IDENTIFICATION - ONSHORE	123
	APPENDIX A9. SAFETY COLOUR CODING AND IDENTIFICATION - OFFSHORE	130
	APPENDIX A10. SAFETY COLOUR CODING AND IDENTIFICATION - LNG	145
	APPENDIX A11. LINING SCHEDULES FOR INTERNAL SURFACES.....	151
	APPENDIX A12. LINING SYSTEMS FOR INTERNAL SURFACES.....	152
	APPENDIX A13. OFFSHORE HELIDECK IDENTIFICATION	155
	APPENDIX A14. FIBERGLASS REINFORCED EPOXY LININGS FOR BOTTOM OF CRUDE OIL STORAGE TANKS.....	170

LIST OF TABLES

TABLE 1.1 LIST OF ABBREVIATIONS	13
TABLE 1.2 LIST OF DEFINITIONS	15
TABLE 9.1 ABRASIVE MATERIAL	32
TABLE 9.2 GARNET BLASTING MEDIA REQUIREMENTS	33
TABLE 9.3 PHYSICAL TEST PROPERTIES	35
TABLE 14.1 INSPECTION AND TESTS	51
TABLE 15.1 QUALIFICATION TEST REQUIREMENTS FOR TSA SUB-CONTRACTOR AND SPRAYER	55
TABLE 15.2 TEST REQUIREMENT FOR TSA COATING DURING TSA PRODUCTION COATING.....	57
TABLE 17.1 RECOMMENDED MAINTENANCE PAINTING SYSTEM OPTIONS	61
TABLE 26.1 INSPECTION ACCEPTANCE CRITERIA FOR LINING WORK	74
TABLE 28.1 MINIMUM INFORMATION TO BE INCLUDED IN PRODUCT DATA SHEET.....	81
TABLE 28.2 MINIMUM INFORMATION TO BE INCLUDED IN QUALIFICATION CERTIFICATE	82
TABLE 28.3 MINIMUM INFORMATION TO BE INCLUDED IN BATCH TEST CERTIFICATE.....	83
TABLE 28.4 REQUIREMENTS AND TEST SAMPLES REQUIRED FOR QUALIFICATION OF COATING SYSTEM AND THE SUB-CONTRACTOR	85
TABLE 29.1 MINIMUM ITEMS TO BE CHECKED AND RECORDED DURING THE COATING PROCESS ...	86
TABLE 30.1 REQUIRED FREQUENCY OF, AND ACCEPTANCE CRITERIA FOR, THE PRODUCTION- CONTROL TESTS	90
APPENDIX TABLE 1.1 PAINTING SCHEDULES FOR EXTERNAL SURFACES.....	93
APPENDIX TABLE 2.2 PAINTING SYSTEMS FOR EXTERNAL SURFACES.....	95
APPENDIX TABLE 3.3 PAINTING SYSTEM A4 EPOXY NOVOLAC COATING SYSTEM REQUIREMENTS	101
APPENDIX TABLE 3.4 PAINTING SYSTEM A5 PQT REQUIREMENTS.....	101
APPENDIX TABLE 6.5 REQUIRED SAFETY AND IDENTIFICATION COLOUR CODING - GAS PROCESSING.....	106
APPENDIX TABLE 6.6 GAS CYLINDERS - GAS PROCESSING	109
APPENDIX TABLE 6.7 PIPING COLOUR CODING - GAS PROCESSING	110
APPENDIX TABLE 7.8 REQUIRED SAFETY AND IDENTIFICATION COLOUR CODING - REFINING	115
APPENDIX TABLE 7.9 GAS CYLINDERS - REFINING	118
APPENDIX TABLE 7.10 PIPING COLOUR CODING - REFINING	119
APPENDIX TABLE 8.11 FINISH COLOURS - ONSHORE.....	123
APPENDIX TABLE 8.12 REFERENCE COLOURS FOR EQUIPMENT - ONSHORE	124
APPENDIX TABLE 8.13 BASIC IDENTIFICATION COLOURS - ONSHORE	125

APPENDIX TABLE 8.14 SAFETY COLOURS - ONSHORE	126
APPENDIX TABLE 8.15 REFERENCE COLOURS - ONSHORE	126
APPENDIX TABLE 8.16 COLOUR CODE GUIDE - ONSHORE	127
APPENDIX TABLE 9.17 COLOUR CODING FOR UMM SHAIF / LOWER ZAKUM / NASR / UMM LULU - OFFSHORE.....	130
APPENDIX TABLE 9.18 COLOUR CODING FOR UPPER ZAKUM / SATF / UADF - OFFSHORE	130
APPENDIX TABLE 9.19 COLOUR CODING OF DAS ISLAND - OFFSHORE.....	131
APPENDIX TABLE 9.20 COLOUR CODING OF ZIRKU, ARZANAH AND ARTIFICIAL ISLANDS - OFFSHORE.....	132
APPENDIX TABLE 9.21 COLOUR CODING OF GENERAL ITEMS - OFFSHORE	132
APPENDIX TABLE 9.22 BASIC IDENTIFICATION COLOURS FOR FLUIDS - OFFSHORE	133
APPENDIX TABLE 9.23 ADDITIONAL IDENTIFICATION COLOURS - OFFSHORE.....	134
APPENDIX TABLE 9.24 BANDS FOR PIPELINE - OFFSHORE	135
APPENDIX TABLE 9.25 COLOUR CODING OF STORAGE TANKS EXTERIOR - OFFSHORE	137
APPENDIX TABLE 9.26 PIPELINE IDENTIFICATION COLOURS - OFFSHORE	138
APPENDIX TABLE 10.27 PIPELINE IDENTIFICATION COLOURS - LNG	145
APPENDIX TABLE 10.28 BS 1710 (BS 4800) COLOUR REFERENCE - LNG	147
APPENDIX TABLE 10.29 PLANT AND EQUIPMENT COLOUR SCHEME - LNG	148
APPENDIX TABLE 10.30 SCHEDULE OF PROCESS CODE IDENTIFICATION - LNG	148
APPENDIX TABLE 11.31 LINING SCHEDULES FOR INTERNAL SURFACES.....	151
APPENDIX TABLE 12.32 LINING SYSTEMS FOR INTERNAL SURFACES	152
APPENDIX TABLE 14.33 MINIMUM LEVEL OF INTERNAL STEEL SURFACE OF TANK BOTTOM	170

LIST OF FIGURES

APPENDIX FIGURE 6.1 PIPING COLOUR CODING ARRANGEMENT - GAS PROCESSING	113
APPENDIX FIGURE 7.2 PIPING COLOUR CODING ARRANGEMENT - REFINING	120
APPENDIX FIGURE 8.3 EXAMPLE OF APPLICATION OF SAFETY COLOUR AND CODING - ONSHORE	125
APPENDIX FIGURE 9.4 APPLICATION OF COLOUR IDENTIFICATION SYSTEM - OFFSHORE	144
APPENDIX FIGURE 10.5 LINE NUMBERS - LNG	150
APPENDIX FIGURE 13.6 TOUCHDOWN / POSITIONING MARKING CIRCLE - OFFSHORE	155
APPENDIX FIGURE 13.7 LOCATION OF TOUCHDOWN MARKINGS - CENTRALISED TOUCHDOWN MARKINGS - OFFSHORE.....	156

APPENDIX FIGURE 13.8 LOCATION OF TOUCHDOWN MARKINGS - FULLY OFFSET TOUCHDOWN MARKINGS - OFFSHORE.....	156
APPENDIX FIGURE 13.9 DIMENSIONS OF THE HELIDECK IDENTIFICATION “H” MARKING (STANDARD SIZE) - OFFSHORE	157
APPENDIX FIGURE 13.10 HELIDECK IDENTIFICATION MARKING REFLECTING A SWUNG OBSTACLE FREE SECTOR) - OFFSHORE	159
APPENDIX FIGURE 13.11 FORM AND PROPORTIONS OF NUMBERS AND LETTERS - OFFSHORE	160
APPENDIX FIGURE 13.12 MAXIMUM ALLOWABLE MASS MARKING (TYPICAL) - OFFSHORE.....	161
APPENDIX FIGURE 13.13 FATO / TLOF PERIMETER MARKING (TYPICAL) - OFFSHORE.....	161
APPENDIX FIGURE 13.14 D-VALUE MARKINGS TYPICAL - OFFSHORE	162
APPENDIX FIGURE 13.15 CHEVRON EXAMPLES AT OFFSHORE FACILITIES - OFFSHORE.....	163
APPENDIX FIGURE 13.16 HELIDECK CHEVRON - OFFSHORE.....	164
APPENDIX FIGURE 13.17 HELIDECK NAME MARKING - OFFSHORE.....	165
APPENDIX FIGURE 13.18 EXAMPLES OF AN ALTERNATIVE PROHIBITED LANDING SECTOR (PLS) MARKING – OFFSHORE	166
APPENDIX FIGURE 13.19 EXAMPLE OF HELIDECK MARKING IN ACPT-2 CORNICHE TYPICAL - OFFSHORE.....	167
APPENDIX FIGURE 13.20 EXAMPLE OF HELIDECK MARKING IN SOUTH ARTIFICIAL ISLAND TYPICAL – OFFSHORE.....	167
APPENDIX FIGURE 13.21 EXAMPLE OF HELIDECK MARKING IN NORTH SATELLITE TYPICAL - OFFSHORE.....	168
APPENDIX FIGURE 13.22 EXAMPLE OF HELIDECK MARKING IN PC 063 - OFFSHORE	168
APPENDIX FIGURE 13.23 EXAMPLE OF HELIDECK MARKING IN PC 042 - OFFSHORE	169
APPENDIX FIGURE 13.24 EXAMPLE OF HELIDECK MARKING IN LZ / US FIELD - OFFSHORE	169
APPENDIX FIGURE 14.25 APPENDIX INTERFACE AREA BETWEEN THE GFRE SYSTEM AND BARGE STEEL - DAS ISLAND COS TANKS	173
APPENDIX FIGURE 14.26 INTERFACE AREA BETWEEN THE GFRE SYSTEM AND BARGE STEEL - ZIRKU ISLAND COS TANKS.....	174

1 GENERAL

1.1 Introduction

This specification defines the minimum requirements for surface preparation, selection of painting systems and their application, personnel qualification, inspection and quality control and health, safety and environment requirements related to surface preparation and paint application.

It applies to all coastal, onshore facilities and offshore facilities.

This specification covers all external surfaces of structures, equipment, machinery, piping, valves, instruments and accessories, including buried piping / equipment and well casings.

This specification also covers the general design, materials, surface preparation, application, and testing requirements for lining the internal surfaces of shop and field fabricated tanks, pressure vessels, piping and other equipment in a shop or jobsite environment.

This specification does not cover the following:

- a. External coating of pipelines.
- b. Coatings for buildings.

1.2 Purpose

The materials and procedures specified herein are provided to protect the following:

- a. External surfaces of plant equipment and piping from corrosion and to provide an aesthetically pleasing environment for operating personnel.
- b. Internal surfaces of plant equipment and piping from corrosion and to prevent the possibility of product contamination.

The ADNOC Business Unit specifications listed in Section 2.2 shall also be considered part of this specification, where indicated as applicable in the Purchase Order.

1.3 Definitions and Abbreviations

The following defined terms are used throughout this specification:

“[PSR]” indicates a mandatory Process Safety Requirement

“**COMPANY**” means ADNOC, ADNOC Group or an ADNOC Group COMPANY, and includes any agent or consultant authorized to act for, and on behalf of the COMPANY.

“**CONTRACTOR**” means the parties that carry out all or part of the design, engineering, procurement, construction, commissioning or management for ADNOC projects. CONTRACTOR includes its approved MANUFACTURER(s), SUPPLIER(s), SUB-SUPPLIER(s) and SUB-CONTRACTOR(s).

“**MANUFACTURER**” means the Original Equipment MANUFACTURER (OEM) or MANUFACTURER of one or more of the component(s) which make up a sub-assembly or item of equipment assembled by the main SUPPLIER or their nominated SUB-SUPPLIER.

“**may**” means a permitted option

“**shall**” indicates mandatory requirements

“**should**” means a recommendation

“SUB-CONTRACTOR” means any party engaged by the CONTRACTOR to undertake any assigned work on their behalf. COMPANY maintains the right to review all proposed SUB-CONTRACTORS; this right does not relieve the CONTRACTOR of their obligations under the Contract, nor does it create any contractual relationship between COMPANY and the SUB-CONTRACTOR.

“SUPPLIER” means the party entering into a Contract with COMPANY to provide the materials, equipment, supporting technical documents and / or drawings, guarantees, warranties and / or agreed services in accordance with the requirements of the purchase order and relevant specification(s). The term SUPPLIER includes any legally appointed successors and / or nominated representatives of the SUPPLIER.

“SUB-SUPPLIER” means the sub-contracted SUPPLIER of equipment sub-components software and / or support services relating to the equipment / package, or part thereof, to be provided by the SUPPLIER. COMPANY maintains the right to review all proposed SUB-SUPPLIERS, but this right does not relieve the SUPPLIER of their obligations under the Contract, nor does it create any contractual relationship between COMPANY and any individual SUB-SUPPLIER.

The abbreviations used throughout this specification are shown in Table 1.1

Table 1.1 List of Abbreviations

Abbreviations	
ACPT	Accommodation Platform
ADEWA	Abu Dhabi Water & Electricity Authority
AL	Aluminium
ASTM	ASTM International, (formerly known as American Society for Testing and Materials)
BGAS-CSWIP	British Gas Approved Scheme - Certification Scheme for Personnel
BS	British Standards
CIP	Coating Inspector Programme
CPT	Coating Procedure Test
CRA	Corrosion Resistant Alloys
CS	Carbon Steel
CUI	Corrosion Under Insulation
DFT	Dry Film Thickness
FATO	Final Approach and Take-off
FROSIO	FROSIO Faglig Råd for Opplæring og Sertifisering av Inspektører innen Overflatebehandling (Norwegian Professional Council for Education and Certification of Inspectors of Surface Treatment)
GFRE	Glass Fibre Reinforced Epoxy
GFRP	Glass Fibre Reinforced Plastic
GRE	Glass Reinforced Epoxy
GS	Galvanised Steel
HDG	Hot-Dip Galvanized
HLL	Helideck Landing Limitation

Abbreviations	
HSE	Health, Safety and Environment
ICAO	International Civil Aviation Organisation
IMO	International Maritime Organization
ISO	International Organization for Standardization
ITP	Inspection Test Plan
LOS	Limited Obstacle Sector
MDEA	Methyl Diethanolamine
MEK	Methyl Ethyl Ketone
MIO	Micaceous Iron Oxide
MSC	Maritime Safety Committee
MSDS	Material Safety Data Sheet
MSL	Mean Sea Level
MTDS	Material Technical Data Sheet
N/A	Not Applicable
NACE	National Association of Corrosion Engineers
NDFT	Nominal Dry Film Thickness
NPS	Nominal Pipe Size
OEM	Original Equipment MANUFACTURER
OFS	Obstacle Free Sector
P&ID	Piping and Instrumentation Diagram
PPE	Personal Protective Equipment
PQT	Procedure Qualification Test
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
RAL	Reichs-Ausschuß für Lieferbedingungen und Gütesicherung
RH	Relative Humidity
SS	Stainless Steel
SSPC	The Society for Protective Coatings (formerly known as Steel Structures Painting Council)
SWL	Safe Working Load
TDFT	Total Dry Film Thickness
TLOF	Touchdown and Lift-off
TPA	Third Party Agency
TSA	Thermally Sprayed Aluminium

Abbreviations	
VOC	Volatile Organic Compound
WFT	Wet Film Thickness
WIN	Work Identification Number

The definitions used throughout this specification are shown in Table 1.2.

Table 1.2 List of Definitions

Definitions	
Abrasive Blast Cleaning	The impingement of a high kinetic-energy stream of blast cleaning abrasive onto the surface being prepared.
Anchor Profile	Contour of a blast-cleaned surface on a plane perpendicular to the surface.
Application Data	Application instructions, recommendations, and guidelines described in the published literature of the Coating / Lining MANUFACTURER, referenced industry standards, and any specific requirements noted in this specification including drawings issued to the SUB-CONTRACTOR. In case of conflicting requirements between the documents, SUB-CONTRACTOR shall submit all conflicting information to the CONTRACTOR for resolution. If the published literature of the Coating / Lining MANUFACTURER does not contain required information, SUB-CONTRACTOR shall obtain additional information from the parent corporate office when the local Coating / Lining MANUFACTURER is a licensee or a subsidiary of a multinational organization. Any deviations from or changes to Coating / Lining MANUFACTURER's published literature shall be subject to CONTRACTOR's review, acceptance, or rejection without comment, explanation and / or justification. (Note: Where recommendations and instructions are given in permissive language such as "may," "should," and "recommend," compliance with those recommendations, instructions, and guidelines shall be considered mandatory unless otherwise instructed by the CONTRACTOR).
Carbon Steel	Carbon steels and low alloy steels with chromium content less than or equal to 9%.
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, typically caused by UV attack.
Chart Datum	The water level that depths displayed on a nautical chart are measured from. A chart datum is generally derived from some phase of the tide.
Checking	Breaks in the coating film or system that do not penetrate to the underlying surface.
Coat	One full layer of a material applied to its specified thickness. Multiple passes including initial mist pass are necessary to form a coat. A mist pass is not considered as a full coat. The cost of a coat shall include the cost of mist passes. (Note: Mist coats are used interchangeably with mist passes.)

Definitions	
Coating Material	The liquid, liquefiable, mastic or any other composition and material that after application to a substrate, is converted into a solid protective adherent film.
Corrosion Under Insulation	An acceleration of corrosion due to ingress of moisture into external insulation.
Cracking	Breaks in the coating film or system that penetrate through to the underlying substrate.
Dry Film Thickness	The thickness of the dried or cured paint or coating film.
Dry Film Thickness Measurement	The average value of three readings recorded using a properly calibrated dry film thickness gauge. The readings shall be within a 150 mm radius and evenly spread out from a given spot.
Dry Spray	Phenomenon that may occur during paint application by spray. Dry particles (dusting) of atomized paint fall over areas already coated or to be coated, but not yet dried, making surface rough and matt. If over coated it can cause possible adhesion problem.
Equipment	Process equipment and skid mounted equipment other than control, electrical, rotating and non-custom equipment. Equipment includes items such as custom fabricated equipment, skid units, boilers, heat exchangers, heaters, heat recovery steam generators (HRSGs), vessels, drums, shop fabricated tanks, stacks, made-to-order equipment, and related items including structural components which are an integral part of these items. This category also includes all other items not covered by the definitions of piping and steel structure.
Feathered	Gradual taper in thickness from a coated surface to an uncoated surface.
Feathering	Bevelling or tapering off the edge of a surface coating prior to repair of the coating at damaged areas.
Holiday	Discontinuity in a coating, which exhibits electrical conductivity, when exposed to a specific voltage.
Holiday / Pinhole	Pinhole or very small size defect in a coating system, penetrating the entire thickness of the coating.
Hot-Dip Galvanizing	Formation of a coating of zinc and / or zinc-iron alloys produced by dipping prepared steel in molten metallic zinc.
Insulated Surfaces	Surfaces for which insulation requirements are specified or noted on the drawings and related documentation and which will be insulated later.
Integrity	An asset has integrity if it operates as designed for its assigned life (or greater) with all its risks kept as low as reasonably practical, or as nominated.
Lining	A coating or layer of sheet material adhered to or in intimate contact with the interior surface of a container used to protect the container against corrosion by its contents and / or to protect the contents of the container from contamination by the container material.
Material Safety Data Sheet	Document published by the Coating / Lining MANUFACTURER describing all the aspects related to health and safety of a coating material or thinner.
Material Technical Data Sheet	Document published by Coating / Lining MANUFACTURER describing product characteristics, use, application and storage instructions.

Definitions	
Operating Temperature	The maximum temperature of the substrate surface under the insulation or exposed to weather (indoor and outdoor) during operating conditions. For example, operating temperature of refractory lined equipment for painting purposes shall be the temperature of the metal surface exposed to the environment during operating conditions. Steam out temperature of piping and equipment shall not be considered as a basis for paint system selection unless specifically instructed in writing by the COMPANY and acknowledged by the CONTRACTOR. The painting or coating system used shall be determined by the "maximum operating / exposure temperature of the substrate" and not the "design temperature".
Paint System	The total sum of the coats or similar products that are to be applied or which have been applied to a substrate to provide corrosion protection.
Peeling	An area where the coating has pulled away, indicating poor adhesion but implies cohesion of the coating film.
Pinholes	Formation of tiny circular holes in the coating film usually having a solid particle (contamination or oversized pigment) in the middle.
Piping	Piping includes fittings, pipe supports and accessory items.
Poor Adhesion	A layer of coating or paint that when measured by a correctly calibrated coating adhesion unit, shows an adhesion factor that is less than the Coating / Lining MANUFACTURER's lowest published adhesion factor or number.
Pore	Pinhole or very small size defect in a coating system, penetrating the entire thickness of the coating.
Pot Life	Maximum time, at any temperature during which a coating material supplied as separate components can successfully use after they have been mixed together.
Qualification	Evaluation process of a paint system allowing, through laboratory tests, the selection of the suitable paint system intended for the different environments in which the structure will operate.
Quality Assurance	All those planned and systematic actions (QA) necessary to ensure quality i.e. to provide adequate confidence that a product or service will be fit for its intended purpose.
Quality Management System	The structure organization, responsibilities, activities, resources and events that together provide organized procedures and methods of implementation to ensure the capability of the organization to meet quality requirements.
Quality Manual	A document setting out the general quality policies, procedures and practices of an organization.
Quality Plan	A document prepared by the CONTRACTOR / SUB-CONTRACTOR setting out the specific quality practices, resources and activities relevant to a project.
Quality System	The structure organization, responsibilities, activities, resources and events that together provide organized procedures and methods of implementation to ensure the capability of the organization to meet quality requirements.
Reference Panels	Panels with lining system applied by the Lining MANUFACTURER and approved by the CONTRACTOR for use as standard reference panels for testing and inspection of the lining system applied by the SUB-CONTRACTOR.

Definitions	
Refurbishment Painting	Where maintenance painting is required at an existing facility to restore the integrity of the coating.
Rust	Formation of visible iron oxide, a result of corrosion of iron or steel. May be described in order of severity; scattered pinpoints, blush or powdery; freckled or streaked; light scale; paper thin; flaked; medium scale; (layer up to 3mm thick); heavy scale (layer over 3mm thick).
Shelf Life	Time during which a coating material will remain in good condition when stored in its original sealed container under normal storage condition.
Shop or Prefabrication Primer	Primers applied to blast cleaned steel in a shop, fabrication or manufacturing facility to provide temporary protection to steel components during transport and / or fabrication.
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.
Site	The land and other places on, under, over, in or through which the contracted Works or any parts of the contracted which the contracted Works or any parts of the contracted Works are to be executed or carried out.
Splash Zone	Zone from 2m below MSL up to 5m above MSL.
Sprayer	SUB-CONTRACTOR of TSA (Thermally Sprayed Aluminium).
Stainless Steel	Stainless Steel types 300 and 400. Other austenitic alloys, when specifically marked on the drawings as requiring coating shall be considered to have been included in this category.
Stripe-coat	Additional coat of paint applied usually by brush on difficult-to-reach-areas and on weld seams, edges, bolts, nuts, etc., to assure that the specified film thickness is achieved.
Structural Steel	Carbon steel structural members such as columns, beams and all items which are not specified to be galvanized.
Submerged Zone	Zone below the splash zone (i.e. permanently submerged).
Substrate	Solid surface intended to be coated or lined with the specified coating system.
Thinner	Volatile liquid added to lower the viscosity of the paint to ease application.
Total Dry Film Thickness	The overall thickness of the total number of coats in a paint or coating system.
Undercutting	Corrosion that has initiated at the point of damage to the coating where Barge substrate is exposed. The corrosion then continues under the coating film and results in wider damage, corrosion and loss of coating integrity.
Uninsulated Surfaces	Surfaces for which insulation requirements are not specified or noted on the drawings and related documentation.
Wet Film Thickness	The thickness of the wet paint or coating film.

SECTION A - GENERAL

2 REFERENCE DOCUMENTS

2.1 International Codes and Standards

The following Codes and Standards shall form a part of this specification. When an edition date is not indicated for a Code or Standard, the latest edition in force at the time of the contract award shall apply.

ASTM

ASTM A380	Standard practice for cleaning, descaling, and passivation of stainless-steel parts, equipment, and systems
ASTM B117	Standard practice for operating salt spray (fog) apparatus
ASTM C109	Standard test method for compressive strength of hydraulic cement mortars (using 2-in. or [50 mm] cube specimens)
ASTM D149	Standard test method for dielectric breakdown voltage and dielectric strength of solid electrical insulating materials at commercial power frequencies
ASTM D2240	Standard test method for rubber property - durometer hardness
ASTM D2583	Standard practice for generation of environmental data related to waste management activities: quality assurance and quality control planning and implementation
ASTM D4060	Standard test method for abrasion resistance of organic coatings by the taber abraser
ASTM D4228	Standard practice for qualification of coating applicators for application of coatings to steel surfaces
ASTM D4285	Standard test method for indicating oil or water in compressed air
ASTM D4541	Standard test method for pull-off strength of coatings using portable adhesion testers
ASTM D4752	Standard practice for measuring MEK resistance of ethyl silicate (inorganic) zinc-rich primers by solvent rub
ASTM D4940	Standard test method for conductimetric analysis of water-soluble ionic contamination of blast cleaning abrasives
ASTM D5064	Standard practice for conducting a patch test to assess coating compatibility
ASTM D5162	Standard practice for discontinuity (holiday) testing of nonconductive protective coating on metallic substrates
ASTM D520	Standard specification for zinc dust pigment
ASTM D5894	Standard practice for cyclic salt fog / UV exposure of painted metal, (alternating exposures in a fog / dry cabinet and a UV / condensation cabinet)

ASTM D6677	Standard test method for evaluating adhesion by knife
ASTM E337	Standard test method for measuring humidity with a psychrometer (the measurement of wet- and dry-bulb temperatures)
ASTM G14	Standard test method for impact resistance of pipeline coatings (falling weight test)
ASTM G42	Standard test method for cathodic disbonding of pipeline coatings subjected to elevated temperatures
ASTM G8	Standard test methods for cathodic disbonding of pipeline coatings

BS

BS 1710	Specification for identification of pipelines and services
BS 4800	Schedule of paint colours for building purposes
BS EN 14594	Respiratory protective devices. Continuous flow compressed air line breathing devices. Requirements, testing and marking
BSI PAS 102	Specification for processed glass for selected secondary end markets

ISO

ISO 10005	Quality management - Guidelines for quality plans
ISO 11124 (Parts 1 to 4)	Preparation of steel substrates before application of paints and related products - Specifications for metallic blast-cleaning abrasives
ISO 11125 (All Parts)	Preparation of steel substrates before application of paints and related products - Test methods for metallic blast-cleaning abrasives
ISO 11126 (All Parts)	Preparation of steel substrates before application of paints and related products - Specifications for non-metallic blast-cleaning abrasives
ISO 11127 (All Parts)	Preparation of steel substrates before application of paints and related products - Test methods for non-metallic blast-cleaning abrasives
ISO 12944 (All Parts)	Paints and varnishes - Corrosion protection of steel structures by protective paint systems
ISO 14918	Thermal spraying - Qualification testing of thermal sprayers
ISO 1524	Paints, varnishes and printing inks - Determination of fineness of grind
ISO 15741	Paints and varnishes - Friction-reduction coatings for the interior of on- and offshore steel pipelines for non-corrosive gases
ISO 19840	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces
ISO 2409	Paints and varnishes - Cross-cut test
ISO 2431	Paints and varnishes - Determination of flow time by use of flow cups
ISO 2808	Paints and varnishes - Determination of film thickness

ISO 2811 (All Parts)	Paints and varnishes - Determination of density
ISO 2812-1	Paints and varnishes - Determination of resistance to liquids - Part 1: Immersion in liquids other than water
ISO 2812-2	Paints and varnishes - Determination of resistance to liquids - Part 2: Water immersion method
ISO 2815	Paints and varnishes - Buchholz indentation test
ISO 3233 (All Parts)	Paints and varnishes - Determination of the percentage volume of non-volatile matter
ISO 3251	Paints, varnishes and plastics - Determination of non-volatile-matter content
ISO 3679	Determination of flash no-flash and flash point - Rapid equilibrium closed cup method
ISO 4287	Geometrical Product Specifications (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters
ISO 4624	Paints and varnishes - Pull-off test for adhesion
ISO 4628 (Parts 1 to 6)	Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance
ISO 6743-4	Lubricants, industrial oils and related products (class L) - Classification - Part 4: Family H (Hydraulic systems)
ISO 6860	Paints and varnishes - Bend test (conical mandrel)
ISO 8501-1	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 of steel substrates after overall removal of previous coatings
ISO 8501-2	Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Part 2: Preparation grades of previously coated steel substrates after localized removal of previous coatings
ISO 8501-3	Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Part 3: Preparation grades of welds, edges and other areas with surface imperfections
ISO 8502 (Parts 1 to 6 & 9)	Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness
ISO 8503 (All Parts)	Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blast-cleaned steel substrates
ISO 8504 (All Parts)	Preparation of steel substrates before application of paints and related products - Surface preparation methods
ISO 9117-3	Paints and varnishes - Drying tests - Part 3: Surface-drying test using ballotini
ISO 9227	Corrosion tests in artificial atmospheres - Salt spray tests

NACE / SSPC

NACE RP0184	Repair of Lining Systems
NACE RP0274	High-Voltage Electrical Inspection of Pipeline
NACE SP0178	Design, fabrication, and surface finish practices for tanks and vessels to be lined for immersion service
NACE SP0188	Discontinuity (holiday) testing of new protective coatings on conductive substrates
NACE SP0287	Field measurement of surface profile of abrasive blast-cleaned steel surfaces using a replica tape
SSPC Paint 20	Zinc-Rich Coating Inorganic and Organic
SSPC-AB 1	Mineral and slag abrasives
SSPC-AB 3	Ferrous metallic abrasives
SSPC-AB 4	Recyclable encapsulated abrasive media (in a compressible cellular matrix)
SSPC-CS 23.00 / AWS C2.23M / NACE No. 12	Specification for the application of thermal spray coatings (metallizing) of aluminium, zinc, and their alloys and composites for the corrosion protection of steel
SSPC-Guide 12	Guide for illumination of industrial painting projects
SSPC-PA 2	Procedure for determining conformance to dry coating thickness requirements
SSPC-QP 1	Standard procedure for evaluating the qualifications of industrial / machine painting contractors (field application to complex industrial and machine steel structures)
SSPC-QP 3 / AISC 420	Certification standard for shop application of complex protective coating systems
SSPC-SP 1	Solvent cleaning
SSPC-SP 10 / NACE No. 2	Near-white metal blast cleaning
SSPC-SP 11	Power tool cleaning to Barge metal
SSPC-SP 16	Brush-off blast cleaning of coated and uncoated galvanized steel, stainless steels, and non-ferrous metals
SSPC-SP 5 / NACE No. 1	White metal blast cleaning
SSPC-SP 7 / NACE No. 4	Brush-off blast cleaning
SSPC-TR 3 / NACE 6A192	Dehumidification and temperature control during surface preparation, application, and curing for coatings / linings of steel tanks, vessels, and other enclosed spaces
SSPC-VIS 1	Guide and reference photographs for steel surfaces prepared by dry abrasive blast cleaning
SSPC-VIS 3	Guide and reference photographs for steel surfaces prepared by hand and power tool cleaning

OTHER

API RP 5L1	Recommended practice for railroad transportation of line pipe
API RP 5LW	Recommended practice for transportation of line pipe on Barges and marine vessels
CAAP 071	Standards, guidance and information regarding helidecks
NORSOK M-501	Surface preparation and protective coating
RAL 840-HR	Primary colour standards

2.2 ADNOC Specifications

The ADNOC Business Unit specifications listed shall also be considered part of this specification, where indicated as applicable in the Purchase Order.

Applicable ADNOC Business Group specifications shall form part of this specification where they are specifically indicated as applicable in the Purchase Order.

Document Number	Document Title
As Applicable	Cold Insulation for Piping and Equipment
As Applicable	Cold Insulation for Piping and Equipment
As Applicable	Hot Insulation for Piping and Equipment
As Applicable	Fire Proofing
As Applicable	Galvanizing
As Applicable	Corrosion and Materials Selection Philosophy
As Applicable	Criticality Rating System
As Applicable	Engineering Specification - Tag Plates for Field and Indoor Equipment
As Applicable	Field Coating of Buried Valves and Fittings
As Applicable	Coatings for Underground Steel Pipe
As Applicable	Specification for Concrete Construction
As Applicable	Specification for Ceramic Coating of Nuts / Bolts and Fasteners for High Temperature Exposure
As Applicable	Specification for Spun Hot Dip Galvanization and Polytetrafluoroethylene (PTFE) Coating of Nuts / Bolts and Fasteners

2.3 Standard Drawings

None at present.

2.4 Other References

None at present.

3 DOCUMENT PRECEDENCE

The specifications and codes referred to in this specification shall, unless stated otherwise, be the latest approved issue at the time of contract award.

It shall be the CONTRACTOR's responsibility to be, or to become, knowledgeable of the requirements of the referenced Codes and Standards.

The CONTRACTOR shall notify the COMPANY of any apparent conflict between this specification, the related data sheets, the Codes and Standards and any other specifications noted herein.

Resolution and / or interpretation precedence shall be obtained from the COMPANY in writing before proceeding with the design / manufacture.

In case of conflict, the order of document precedence shall be:

- a. UAE Statutory requirements
- b. ADNOC HSE Standards
- c. Equipment datasheets and drawings
- d. Project specifications and standard drawings
- e. COMPANY specifications
- f. National / International Standards

4 SPECIFICATION DEVIATION / CONCESSION CONTROL

Deviations from this specification are only acceptable where the Coating / Lining MANUFACTURER has listed in their quotation the requirements he cannot, or does not wish to comply with, and the COMPANY / CONTRACTOR has accepted in writing the deviations before the order is placed.

In the absence of a list of deviations, it will be assumed that the Coating / Lining MANUFACTURER complies fully with this specification.

Any technical deviations to the Purchase Order and its attachments including, but not limited to, the Data Sheets and Narrative specifications shall be sought by the Coating / Lining MANUFACTURER only through Concession Request Format. Concession requests require CONTRACTOR's and COMPANY's review / approval, prior to the proposed technical changes being implemented. Technical changes implemented prior to COMPANY approval are subject to rejection.

5 DESIGN CONSIDERATIONS / MINIMUM DESIGN REQUIREMENTS

5.1 Design Basis

All painting and coating systems shall meet the performance requirements and the coating systems as specified in this specification with a minimum environment of Category CX, ISO 12944-9.

All Offshore requirement shall comply to ISO 12944-9.

Coating system selection on immersed applications shall address maximum foreseen parameters and assure the compatibility for the intended design life.

5.2 Design Requirements for Coating Application

All structures and equipment shall be designed in accordance with ISO 12944-3. The design shall be suitable for:

- a. Corrosion prevention, utilising the “good” designation as much as practical (ISO 12944-3 Annex D).
- b. Surface preparation and coating application in accordance with the requirements defined in this specification (Accessibility - ISO 12944-3 Annex A to C), as far as practicable.

Weld profile requirements to be in accordance with NACE SP0178.

6 GUARANTEES AND WARRANTY

The CONTRACTOR shall guarantee performance of the paint and / or lining (shop and field) as follows:-

- a. External Blasting / Painting - 5 years
- b. Internal Blasting / Lining - 6 years
- c. Thermal Spray Aluminium - 10 years

The above guarantee shall be applicable from the date of provisional acceptance by the COMPANY when the entire materials selection, materials application, selection of the SUB-CONTRACTOR, supervision of the SUB-CONTRACTOR and all tasks related to coatings are under 100% control of the CONTRACTOR within the requirements of this specification.

This guarantee applies to painting of carbon steel, galvanized steel, stainless steel surfaces and items painted by Coating / Lining MANUFACTURER's and SUB-CONTRACTOR's standards.

The CONTRACTOR shall be liable for remedial actions such as spot repair, renovation, over-coating and refurbishment of the areas of paint failures / defects at site when:

- a. The estimated amounts of rust breakthrough on a coating and of total apparent rust (rust breakthrough plus under film) rust exceed ISO 4628-3 rust scale Ri 1(0.05% area rusted).
- b. There is an appearance of defects in the paint film and / or lining such as blistering, peeling, flaking, inter-coat delamination, mud-cracking, etc. affecting the overall integrity of the coating.

The repair procedure and the extent of repair shall be subject to approval by COMPANY. All defective spots shall be repaired. In case defects occur on more than 8% of the total surface of an individual item, the entire item shall be refurbished.

The degree of blistering shall be evaluated in accordance with ISO 4628-2. The degree of cracking and flaking in a coating shall be evaluated in accordance with ISO 4628-4, ISO 4628-5 and ISO 4628-6, respectively.

The CONTRACTOR shall undertake to recommence all or part of the paint work subject to agreement with COMPANY, at any time during the guarantee period. “Recommence” is understood to mean blast cleaning, supply and application of paint in conformity with the present specification, on site and at the expense of the CONTRACTOR.

Final acceptance shall in principle take place when the guarantee period expires. A detailed inspection of all painted surfaces before the guarantee period expires shall then be carried out.

Remedial actions, if any, shall be decided based on the results of the inspection.

SECTION B PART 1 - TECHNICAL REQUIREMENTS (EXTERNAL COATING)

7 HANDLING OF PAINTED ITEMS

Preparation for shipment and packing will be subject to inspection and acceptance by the COMPANY's / CONTRACTOR's inspectors. All costs related to any rejection by the COMPANY and CONTRACTOR shall be to the account of the SUB-CONTRACTOR.

Facilities and methods of yard storage and protection of the pipe during transportation shall be subject to approval by the CONTRACTOR.

Preparation of painted items for shipment shall be in accordance with the SUB-CONTRACTOR's standards and as noted herein. SUB-CONTRACTOR shall be solely responsible for the adequacy of the preparation for shipment provisions with respect to painted items, and to provide equipment at the destination in ex-works condition when handled by commercial carriers

Adequate protection shall be provided to prevent mechanical damage to the applied paint system and subsequent atmospheric corrosion in transit and at the jobsite.

Finished painted structure, equipment, pipe or pipe spools shall be handled and / or stored in a manner to protect the coating from damage. They shall not be dropped, rolled or impacted with or against solid objects with a force capable of causing coating damage.

Finished painted items shall be shipped using sufficient padding to adequately protect the pipe coating.

Finished painted items shall be lifted, lowered, or suspended by the use of rubber or canvas belt with removable pin and clevis on one end to permit removal of belt without damage to the painting. The belt shall be of sufficient width to prevent any damage being sustained by the painting. Use of ropes of any kind, hooks, bands, chains, or cables shall not be permitted.

Painted items shall be stored off the ground on sufficiently padded skids, properly levelled and spaced, to support the coated item. Each painted item shall be separated from each adjacent item.

Unapplied coatings and related materials shall be protected to withstand ocean transit and an extended period of storage at the jobsite, but not in excess of the Coating MANUFACTURER's stated shelf life, for each coating material. All materials shall be protected to safeguard against all adverse environments, such as: heat, humidity, moisture, rain, dust, dirt, sand, mud, salt air, salt spray, and sea water.

Gasket contact surfaces and machined surfaces shall be protected with grease film or other CONTRACTOR approved material to prevent rusting during transportation / storage and covered with plastic or similar caps.

8 EXECUTION

8.1 Shop Versus Field Painting Policy

Shop and field painting shall be based on the following policy. Shop application of the complete coating system is preferred.

Fabricated items of plant and equipment (e.g., vessels, columns, heat exchangers, pipe spools) coated at the SUB-CONTRACTOR's / SUPPLIER's works or in site-based temporary coating facilities shall be fully painted with all coats of the specified coating system.

Field painting shall be limited to touch-up and repair of damaged coating and complete painting of field weld areas.

CONTRACTOR shall submit a work plan / method statement delineating painting work execution between shop and field painting and obtain COMPANY's approval.

All documentation submitted shall be endorsed by the proposed Coating MANUFACTURER clearly defining subsequent surface preparation and approved extended over-coating period.

CONTRACTOR accepts full responsibility for any repairs required to damage areas due to transportation and handling.

8.2 Responsibilities of the SUPPLIER

The SUPPLIER at their facility shall perform surface preparation and full painting system (unless advised otherwise in a specific project and approved by COMPANY) to the following items:

- a. Boilers
- b. Exchangers
- c. Heaters
- d. Piping
- e. Stacks
- f. Structural steel
- g. Tanks
- h. Valves
- i. Vessels
- j. Other miscellaneous items

Non itemized (bulk) stainless steel valves shall receive at shop a prime coat which corresponds to the intended service of the items as mentioned above.

The SUPPLIER shall perform surface preparation, priming, and finish painting of the following items including all attachments thereto in accordance with the painting systems of this specification or their standard paint specification provided the total paint system has a minimum corrosion resistance of 2000 hours when tested in accordance with ASTM B117 and / or ISO 12944-5 Table A6, CX, high durability and passes the minimum laboratory requirements of ISO 12944-6. Offshore coating shall comply with 4200 hrs in accordance with ISO 12944-9.

- a. Compressors
- b. Control equipment
- c. Electrical equipment
- d. Fans
- e. Itemized valves
- f. Motors
- g. Pumps
- h. Shelf items
- i. Specialty equipment

j. Turbines

Equipment package components specifically listed in APPENDIX A1 (structural members, pipe, fittings, valves, filters, tanks, vessels, etc) shall be coated with the specified systems even when they are intimately associated with an item to be coated with a SUPPLIER's standard system (compressors, pumps, etc).

Any painting procedures submitted by the SUPPLIER and approved by the CONTRACTOR and COMPANY shall be considered additional to the requirements of this specification but shall not be considered in lieu of or substitution for the procedures and requirements stated in this specification.

In case of packaged equipment, electrical equipment and other MANUFACTURER's standard items, the paint system shall be suitable for environmental classification of CX as per ISO 12944-2 and ISO 12944-9 for Offshore, unless otherwise specified by COMPANY.

8.3 Responsibilities of The Coating MANUFACTURER

Coating MANUFACTURER's representative shall have technical inspection accreditation by NACE CIP Level 2 or FROSIO Level 2 (see Section 14.1) or BGAS-CSWIP Level 2 or equivalent and approved by COMPANY.

The Coating MANUFACTURER's technical representative shall submit a periodic report to CONTRACTOR confirming that painting (shop / field at site) is being carried out in accordance with their instructions and quality of workmanship is acceptable to them. This report shall also cover analysis of technical problems (if any).

8.4 Responsibilities of The SUB-CONTRACTOR

The SUB-CONTRACTOR shall be responsible for:

- a. Submission of Inspection and Test Plan (ITP) to COMPANY for review / approval prior to commence the painting activities.
- b. Supply and application of all paint materials, labour, supervision, coating equipment, inspection tools and each and every item of expense necessary for complete application of the paint system.
- c. Supply, erection and removal of scaffolding to perform the painting work.
- d. Removal of identification marks on Barge or unfinished equipment, piping and structural steel and re-application of the identification marks on the finished surfaces. The SUB-CONTRACTOR shall consult with the CONTRACTOR on the size of the markings.
- e. Full protection from abrasives and paints to items, which shall not be painted.
- f. Cleaning and application of painting systems on welded and damaged surfaces.
- g. Collection and disposal of all toxic waste materials from the work site as directed by the CONTRACTOR and COMPANY in accordance with hazardous waste management system.
- h. Appropriate arrangements for technical services of the Coating MANUFACTURER before and during planning and application of the paint systems. SUB-CONTRACTOR's purchase order for paint materials shall include a provision stating that the Coating MANUFACTURER's technical representative shall directly report to the CONTRACTOR regarding the acceptability and workmanship of the paint application. A copy of purchase order for the materials showing this provision shall be transmitted to the CONTRACTOR / COMPANY.
- i. Preparation of appropriate work planning and taking all precautions to avoid interference with the execution of work of other CONTRACTORS.

- j. Obtaining the CONTRACTOR's releases that the equipment is certified safe and available and that all appropriate tests are completed before starting any painting work. At offshore locations, blasting / painting equipment shall be Zone 2 certified.
- k. Earthing of abrasive blast cleaning / painting equipment.
- l. Obtaining latest Application Data and maintaining the same for use by all the parties.
- m. Application of the paint systems to the extent stated in the procurement documents in accordance with this specification and all other relevant documents such as site regulations, safety rules, referenced standards and codes, etc.
- n. Providing personnel qualified for the job intended to be carried out and shall have a demonstrated experience with a similar job within 6 months before the work begins. In-house qualification, compliance with the requirements described in SSPC-QP 1 and SSPC-QP 3 / AISC 420 or qualification in accordance with NORSOK, BGAS-CSWIP or other international schemes are acceptable with written approval from the COMPANY.
- o. Providing qualified painting inspectors to NACE CIP Level 2 or FROSIO Level 2 or BGAS-CSWIP Level 2 or equivalent and approved by COMPANY, and testing tools for carrying out specified inspection and quality control measures.
- p. Completing painting inspections, based on the ITP, and reporting during all phases of coating activities from surface preparation through to final topcoat application.
- q. CONTRACTOR is to cover COMPANY's logo as per specification.
- r. Develop coating and painting completion dossier.
- s. Before commencement of any painting activities, the project based "Working Procedure" shall be submitted for COMPANY's approval. If dispute arises in an approved working procedure / method statement or any other similar document, then this specification shall be consulted to make final decision.

8.5 Application Procedure

A detailed application procedure shall be established by the CONTRACTOR / SUB-CONTRACTOR for COMPANY approval based on the requirements of this specification. No painting work shall begin before the application procedure is approved by COMPANY.

The application procedure shall include at the minimum the following information:

- a. Equipment / structure / piping to be coated.
- b. Range of operating temperature of the equipment.
- c. Type of substrate to be coated: carbon steel, stainless steel, galvanized steel, non-ferrous alloy, etc.
- d. Exposure: atmospheric, immersed, buried, under insulation / fireproofing.
- e. Painting system to be used from APPENDIX A2.
- f. Coating products to be used.
- g. Ambient / environmental conditions required for safety and quality of work.
- h. Surface preparation method, including detail of the abrasive intended to be used.
- i. Methods of application and application requirements, including the colour of each coat.
- j. Test and inspections in accordance with Section 14.

- k. Certification of the personnel in accordance with Section 8.4.
- l. Product data sheets (abrasives and paint materials).
- m. Safety data sheets.
- n. Health and safety requirements.
- o. Handling and storage.
- p. Disposal of waste, debris, and unconsumed coating materials.
- q. Template of painting daily report.

The application procedure shall apply to:

- a. Main site painting works (structural steelwork, piping, storage tank internal and external surfaces).
- b. Packaged units.

A pre-production test shall be used to qualify all coating procedures using an appropriate test panel representative of the structure to be painted. ASTM D4228 can be used as a reference.

The products used shall be sampled from the same batches as those intended for the works.

Environmental conditions, surface preparation, coating application equipment, and procedures shall be similar to those anticipated for the actual coating work. All coating application, curing, inspection, and testing requirements for the qualification, including acceptance criteria, shall be as required in this specification.

During surface preparation and paint application, all tests described in Section 14 shall be followed.

When the painting systems are fully cured, visual inspection and adhesion testing shall be carried out to confirm that the performance of the painting systems meet those specified for each system.

The repair procedure shall also be demonstrated on a simulated defect. Section 13 shall apply. Checks shall include visual inspection, adhesion, thickness of repair area and thickness of overlap area. The repair procedure qualification can be used as a reference for the appearance of coating repairs.

9 MATERIALS

All paints used shall be obtained from Coating MANUFACTURERS approved by the COMPANY.

Equipment and materials specified or referenced by the Coating MANUFACTURER's name and / or brand name are intended to describe the type and quality level of the equipment and materials desired and are not intended to be restrictive or to exclude similar items by other Coating MANUFACTURERS. Alternate equipment and materials of similar quality or better may be submitted for CONTRACTOR and COMPANY approval.

All material shall be supplied in the Coating MANUFACTURER's original containers, durably and legibly marked with the description of the contents, colour reference number, batch number, date of manufacture, the shelf-life expiry date and the Coating MANUFACTURER's name or recognized trademark.

Paints containing heavy metals, such as cadmium, lead, coal tar epoxy or any toxic material to environment / personnel shall not be used.

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 Coating MANUFACTURER's instructions. Samples for testing the paint being used may be taken by the COMPANY 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.

Paint materials shall not be used beyond their shelf life and taking into consideration, storage conditions shall be commensurate with the Coating MANUFACTURER's recommendation. Revalidation or extending the paint shelf life shall not be permitted.

9.1 Abrasive Material Dry Storage

Abrasive for blasting shall be supplied in 25 kg reinforced fabric sacks and one tonne Jumbo bags shall be made from reinforced fabric.

All abrasive material shall be stored in shaded designated storage areas capable of supporting the load applied by the total weight of abrasive.

One tonne abrasive jumbo bags must be lifted using only certified 4-leg slings attached to the lifting points on the bags. Bags shall be visually inspected, free from defects and snags and marked with their SWL (Safe Working Load).

Each bag must be used for one trip only.

Access ways must be kept clear. Storage areas and the areas around blasting pots must be kept clean and tidy with sweepings of abrasive properly disposed of using empty sacks and bags.

Proper manual lifting techniques must be used to prevent personal injury when moving sacks of abrasive.

9.2 Abrasives

Abrasive for use on carbon steel and low alloy steels shall be in accordance with ISO 8504-2. Abrasives shall be grit manufactured from chilled iron, steel, and malleable iron; non-metallic abrasives such as aluminium oxide and garnet. Abrasive shall be angular in shape.

Abrasives for use on stainless steel, duplex, super austenitic materials and other CRA surfaces where painting is required shall be free from chlorides, zinc, and ferrous contamination. Abrasives shall be glass beads, aluminium oxide and garnet.

All abrasive material to be used shall be approved by COMPANY / CONTRACTOR. Silica sand or other media producing silica dust shall not be used.

Blasting abrasives shall be dry, clean and free from contaminants that will be detrimental to the performance of the coating. Abrasives selected shall be suitable for producing the required profile and surface roughness and have a minimal health impact.

The properties of abrasives used shall meet the requirements of the relevant parts of ISO 11124, ISO 11126-4, ISO 11126-7, ISO 11126-10, SSPC-AB 1, SSPC-AB 3 and SSPC-AB 4.

Test methods shall be in accordance with the tests specified in ISO 11127.

Each batch of abrasive should be tested from COMPANY approved laboratory to check that the abrasive meets the requirements as specified in the relevant ISO standard.

The conductivity of abrasive for carbon steel and stainless steels shall be a maximum of 150 $\mu\text{S}/\text{cm}$. Conductivity shall be checked at site for each batch and delivery of abrasives.

The COMPANY shall approve the use of alternate abrasive materials after testing and evaluation.

Expendable grit, such as iron silicate, aluminium silicate, garnet and chilled iron may be used. Expendable grit shall be of grain sizes between 0.5 mm and 2.5 mm. Under no circumstances shall expendable grit be re-cycled.

The type, particle size distribution and hardness of grit employed shall ensure that the surface roughness and profile of the substrate is in accordance with the requirements for the applicable coating system as specified in APPENDIX A2, herein is achieved prior to paint application.

Safe and environmental disposal of spent abrasives shall be the responsibility of the SUB-CONTRACTOR.

Table 9.1 Abrasive Material

Type	Generic Name	Characteristics	Standard
Metallic	Iron Grit	> 1.7% Carbon	ISO 11124-2
	Steel Grit	0.8% to 1.2% Carbon	ISO 11124-3
Natural Mineral	Garnet	Calcium Iron Silicate	ISO 11126-10
	Glass Cullet	High-Grade Soda Lime Glass	BSI PAS 102
	Staurolite	Iron / Aluminium Silicate	ISO 11126-9
Synthetic Material	Aluminium Oxide	Crystalline Corundum	ISO 11126-7
	Recyclable Encapsulated Abrasive Media	Aluminium Oxide	SSPC-AB 4

Almandite garnet is an iron aluminium silicate with the chemical formula $\text{Fe}_3\text{Al}_2(\text{SiO}_4)_3$. Other forms of garnet, such as andradite garnet, which is a calcium iron silicate with the chemical formula $\text{Ca}_3\text{Fe}_2(\text{SiO}_4)_3$, exist but these garnet abrasives are not covered in ISO 11126.

9.3 Selection of Abrasives

Steel or iron grit is commonly used as recyclable abrasives. In general, when steel shot is used, it shall be used together with steel grit and approved by the COMPANY. The shot content in such a mix shall not exceed 67%.

The abrasives shall be free from oil, grease, moisture, chloride contamination, etc., and supplied with certification documentation traceable to batches of material. Abrasive (mesh size ranges) sizes to be selected based on the blast clean profile required.

Effective recycling system of the metallic abrasives shall be provided by the SUB-CONTRACTOR. Conductivity of the recycled metallic abrasives shall be checked a minimum of two times per shift.

Only approved Garnet shall be used as an abrasive media on Offshore installation. Garnet shall be used for all site works and yard work where there is no recovery system in place. Garnet used on COMPANY facilities shall be from Company approved Abrasive MANUFACTURERS.

Garnet Blasting Media used for COMPANY work shall conform to the following requirements:

Table 9.2 Garnet Blasting Media Requirements

Description	Specific Measure
Hardness (Mohs)	7.2 - 8.0
Moisture Content wt. %	Non-hygroscopic < 0.1
pH	7 – 9
Total Soluble Chlorides	< 18 ppm or < 18 mg/Kg
Oil, Grease, Hydrocarbon residue	Nil
Free Iron	< 0.01%
Copper	< 0.01%
Sulphur	< 0.01%
Other Heavy Metals	< 0.01%
Free Silica	< 0.5%

9.4 Compressed Air

The compressed air supply used for abrasive blasting shall be free of water and oil. Adequate separators and traps shall be provided, and these shall be kept emptied of water and oil and regularly purged. The control of compressed air cleanliness shall be in accordance with ASTM D4285.

Compressed air temperature shall not exceed 90°C at the blasting nozzle. In addition, the pressure at the nozzle shall not be below 90 psig / 6.21 barg.

After cooler shall be used during summer to ensure the air is dry. It shall be tested for oil and moisture by blotting paper test regularly. Oil traps and moisture traps shall be cleaned when required.

Where personal breathing equipment is used, the operator's hood or headgear shall be ventilated by clean cool air, free from water, oil and any other organic contaminants served through a regulator filter to prevent blasting residues from being inhaled by the operator. Air supplies must comply as a minimum with BS EN 14594 and the quality of the breathing air shall be checked regularly.

9.5 Paint Material Storage

All coating materials and thinners shall be properly stored in the CONTRACTOR's facility, following Coating MANUFACTURER's recommendations. The following minimum requirements must be satisfied:

- The store shall be appropriately ventilated and comply with provisions law in force concerning safety and fire prevention.
- Coating materials (liquid, solid or packaged) shall be kept in their original sealed and labelled containers or package.
- Coating materials shall be protected from direct sun, frost and rain, stored in a thermally controlled store with constant temperature in the range of +15°C to +25°C.
- The coating materials store shall be located at a proper distance from any significant heat source and from any area where free flames, welding works, and tools causing sparks are used.

- e. Containers and packages shall not be placed nor stored on wet or damp surfaces, nor in areas where flood can occur.
- f. All paint products including containers or packaging that become damaged or show signs of being altered shall be removed from the paint store and disposed of accordingly. Damaged or altered paint products shall not be used.
- g. Coating materials shall be stored and used in a manner that assures that products are used within their storage limits (shelf-life), and those stored first are the first used.

9.6 Paint Materials

Paints for use over stainless steels or nickel alloys shall be free from low melting points (e.g. halides, zinc, etc.) which might cause embrittlement.

All paints and related materials shall be as identified in the respective Paint Systems.

Primers, mid-coats, and finishes shall be factory tinted, sealed, and labelled. Thinners and solvents shall be as identified in the Coating MANUFACTURER's data sheets.

All paint materials shall be used on a first-in, first-out basis.

Polyurethane finishes shall have excellent colour retention and high gloss.

Primer colours shall be Coating MANUFACTURER's standard colours. Finish colours, except for silicone aluminium, shall be as noted in the applicable Safety and Identification Colour Coding requirements. For services above 93°C, if heat stable colours matching specified colours are not commercially available from the Coating MANUFACTURER's standard stock, heat stable colours shall be selected regardless of colour match subject to COMPANY's choice of standard stock colour.

CONTRACTOR / SUB-CONTRACTOR shall bear responsibility in VOC (Volatile Organic Compounds) emissions and monitor the use of the solvents as directed by the Coating MANUFACTURER during all paint application.

Paint material supplied / applied shall be from the same Coating MANUFACTURER throughout the coating system. Different brands or types of paint shall not be inter-mixed

All proposed materials shall be supplied with an infra-red fingerprint and ash content of all components in accordance with recognised International Standards (see Section 2.1) with the approval documentation. The COMPANY shall require at least two random samples from each coating product to be taken during the coating activities and tested at an independent laboratory to confirm that the supplied goods match the proposed products.

The following properties of the components associated with each coating product shall be identified:

- a. An infrared spectrum of the mixed paint components (fingerprint).
- b. Specific gravity of the resin base and curing agent and the mixed paint components (ISO 2811).
- c. Volatile and non-volatile matters in the mixed paint (ISO 3251).
- d. Viscosity of the resin base, curing agent and the mixed paint components (ISO 2431).
- e. Fineness of grind of the mixed paint components, Hegman scale (ISO 1524).
- f. Percentage of zinc by weight (zinc rich primers only), percentage weight in the dry film shall be measured using test panels.
- g. Percentage of glass flake by weight (glass flake containing coatings only), percentage weight in the dry film shall be measured using test panels.

Thereafter each batch of coating material to be used shall have been tested and accompanied with certification of the properties addressed above.

The selected laboratory shall test the components of the coating material in order to verify the accuracy and consistency of the data for physical properties provided by the Coating MANUFACTURER. Analysis and tests listed in below table shall be performed.

Table 9.3 Physical Test Properties

Test Type	Standard Method	Acceptance Criteria
Specific Gravity	ISO 2811 [(23 ±2)°C and (50 ±5)% RH]	±2% of value stated by Coating MANUFACTURER
Solid Content	ISO 3233 [(23 ±2)°C and (50 ±5)% RH]	±3% of value stated by Coating MANUFACTURER
Pot Life (Mixed Product)	[(23 ±2)°C and (50 ±5)% RH]	±3% of value stated by Coating MANUFACTURER
Flash Point	ISO 3679	±5% of value stated by Coating MANUFACTURER
Dry Time	ISO 9117-3 [(23 ±2)°C and (50 ±5)% RH]	±5% of value stated by Coating MANUFACTURER

- For the zinc rich primer, organic or inorganic, the content of zinc dust by weight shall conform the Level 1 of the standard SSPC Paint 20. The zinc dust pigment shall comply with the requirements specified in standard ASTM D520.
- For zinc phosphate primer, based on polyamide cured two pack epoxies. Zinc phosphate content shall be not less than 20% by weight in the dry film.
- Micaceous Iron Oxide epoxy (MIO) pigments shall be minimum 80% weight of total pigmentation being mainly min. 85% natural laminar ferric oxide (Fe₂O₃). Volume solid content 80% ±5.
- Glass Flake product shall contain glass flake in the cured film not less than 20% of total pigmentation.

Paint System Qualification Tests for each specification shall also be included.

9.7 Hazardous Materials

This specification may call for the use of hazardous substances and procedures. Handling for application and the subsequent disposal of all surface preparation consumables and coating materials specified in this specification shall conform to all relevant local regulatory requirements and bylaws.

The CONTRACTOR shall ensure that all layers of a coating system and all abrasive blasting materials comply with any local and / or regional standards or regulations on banned materials such as lead, chromate, crystalline silica or coal tar. Any coating system shall fully comply with any local and / or regional air quality or VOC levels or emission standards or regulations.

MSDS's shall be available for review at sites and shops where coating is applied. All PPE requirements stated in the MSDS shall be met when working with coatings and solvents.

Handling and disposal of hazardous waste resulting from the CONTRACTOR's painting activities shall be in accordance with regulations, HSE Manual Volume 10/5 and specific contract requirements.

Excess or used solvents, paint, waste materials and cleaning materials shall be handled in strict accordance with MSDS requirements and applicable local Government and Purchaser disposal procedures and not dumped on the ground or emptied into sewers.

Hazardous waste management system to dispose of hazardous material.

10 GENERAL REQUIREMENTS

10.1 Steel Preparation

Fabrication should be complete before surface preparation begins. Any prefabrication 'shop' primers shall be removed after fabrication by blasting and the surface shall be blasted to the specified surface cleanliness unless otherwise agreed with the COMPANY. The method for repair of pitted steel prior to coating application shall be agreed with COMPANY.

Flame cut areas and weld spatter shall have been ground flush with the requirements of ISO 8501-3, preparation Grade P3. SUB-CONTRACTOR is responsible for inspecting steel preparation at steelwork reception and for highlighting any non-conformance to CONTRACTOR.

All mating surfaces of equipment subject to outdoor exposure shall be coated with the full coating system prior to assembly (saddles, skirts, base plates, bolted components, flanges, etc.).

10.2 Surfaces Not to be Painted

The following items should not be painted unless specified by COMPANY on a case by case basis:

- a. Aluminium fins of air coolers.
- b. Operating parts of machinery and equipment, e.g. valve stems and shafts.
- c. Polished and machined surfaces e.g. bevelled edges and edges of items to be site welded (unless with weldable primer).
- d. Other miscellaneous items as gauge glass, name plates, push buttons, code stampings, sacrificial anodes.

10.3 Protection of Stainless-Steel and CRA Surfaces

The SUB-CONTRACTOR shall segregate the carbon steel, stainless steel (including super duplex stainless-steel) and CRA items, before painting in the shop and select the coating system as per this specification. Stainless steel surfaces shall not be treated with carbon steel cleaning tools or any tools previously used on carbon steel. Carbon steel supports for storage shall be systematically painted and lifting equipment shall prevent iron contamination.

All stainless-steel surfaces shall be coated prior to coating of carbon steel or galvanized surfaces. All uncoated CRA shall be pickled and passivated in accordance to ASTM A380 after installation on site.

All stainless steel to be coated shall be thoroughly cleaned in accordance with Section 11.7 before application of any coating materials and shall be painted in accordance with APPENDIX A1.

Under no circumstances, paints containing zinc are allowed to come into contacts (applied, over-sprayed or dripped) with stainless steel, nickel-based alloys or copper-based alloys components.

10.4 Safety Requirements

All necessary precautions shall be taken to ensure the safety of personnel and property. The CONTRACTOR shall comply with applicable National, State or local codes and regulations and safety orders and practices of the COMPANY covering working conditions, scaffolding, clothing, fire and explosion hazards, safety equipment, solvents, lighting, venting and grounding of vessels.

The following precautions shall be taken for austenitic stainless steel, duplex stainless steel, nickel alloy or 9% nickel steel piping or equipment located below structural steelwork, platform flooring and hand railing:

- a. Prevent zinc contamination of the piping or equipment when working on the galvanized material or applying the zinc containing paint.
- b. Application of temporary shielding e.g., fire blankets.

Handling for application and the subsequent disposal of all surface preparation consumables and coating materials shall conform to all relevant local regulatory requirements and bylaws.

Rags and other waste material soiled with paints, thinners or solvents shall be kept in tightly closed metal containers while on the job or not in use.

Extreme precautions shall be used when working with paint materials, cleaning fluids, etc. especially in close proximity to oxygen piping or oxygen equipment. Heavy concentrations of volatile or toxic fumes shall be avoided. When working in confined areas, blowers or exhaust fans shall be used.

10.5 Pre-Job Meeting

The SUB-CONTRACTOR shall schedule a pre-job meeting to ensure that job requirements are fully understood.

The personnel present at the meeting shall include, but not be limited to, the COMPANY's and CONTRACTOR's representative, the SUB-CONTRACTOR's representatives, painting engineer, quality control and safety.

If required a technical representative of the Coating MANUFACTURER / SUPPLIER shall be present.

Roles and responsibilities shall be clarified at the pre-job meeting, such as when the COMPANY deals with the SUB-CONTRACTOR, who are the focal points and how administration procedures are executed.

Technical aspect such qualification of SUPPLIERS / Sprayers, approved application procedures, equipment, approved Inspection Test Plan (ITP) shall be discussed. It shall be confirmed that all parties have the latest version of the contract, application procedure, technical specification, approved drawings and ITP.

11 SURFACE PREPARATION

11.1 Items to be Protected

Before abrasive blast cleaning, all equipment which could be damaged by blast, dust or particulate matter shall be suitably protected by wrapping, taping, or other means to prevent damage. This equipment shall include, but is not limited to the following:

- a. Bearings
- b. Conduit
- c. Control panels
- d. Control valves

- e. Couplings
- f. Expansion joint bellows
- g. Exposed moving parts
- h. Fire system sprinkler heads
- i. Flange facings (pipe) until and unless specified by COMPANY
- j. Instrument dials
- k. Level gauge glasses
- l. Machined surfaces
- m. Nameplates / Code stampings
- n. Push buttons
- o. Screws
- p. Shafts
- q. Sight Glasses
- r. Spring hanger graduations
- s. Spring support casing level gauges
- t. Tags
- u. Valve and equipment grease nipples
- v. Valve stems and position indicators
- w. Lighting
- x. Instruments
- y. Cable trays

11.2 Basic Cleaning

The following cleaning procedure is mandatory for all surfaces before blast cleaning. This cleaning procedure is also mandatory before applying field coatings over shop coated items and any surface which requires coating.

Dust, dirt and debris shall be removed from the substrate surfaces by high pressure fresh water washing. Stubborn deposits shall be removed by scrubbing with stiff plastic brushes. The water wash shall continue until all water-soluble salts are removed from the surfaces.

Prior to paint application the blasted substrate shall be tested for Soluble Salts as per ISO 8502-6 & 9 by Bresle kit and maximum levels are indicated on each paint system in this specification.

Surface contaminants such as oil, grease, hydrocarbons etc. shall be removed by water based biodegradable cleaner in accordance with the application data. SUB-CONTRACTOR shall request and obtain Coating MANUFACTURER's recommendations for the cleaner concentration, appropriate for the type of surface to be cleaned.

The degreased surfaces shall be further washed with fresh water to remove all traces of the cleaner chemicals.

Potable water shall be used for washing of substrates with high pressure of 3500 psig / 241.32 barg as a minimum. The acceptance criteria of used potable water shall contain of 50 ppm chlorides as a maximum and pH value of 6.5 to 8.0.

The surfaces shall be allowed to thoroughly dry before proceeding with any further coating work. All bolt holes shall be solvent cleaned prior to blast cleaning.

11.3 Shop Priming

The CONTRACTOR, in case of particular yard conditions, procedures and / or other project requirements, may use shop-primed steel plates and profiles for the construction of the various items. The shop-priming shall be performed in accordance with the following requirements:

- a. The surfaces (steel plates, pipes, beams, profiles etc.) shall be cleaned by abrasive blast cleaning in accordance with standard SSPC-SP 10 / NACE No. 2.
- b. Application of one coat of Inorganic Zinc Ethyl-Silicate shop-primer (prefabrication primer) with DFT of 25 microns.

The shop-primer and the relevant DFT shall conform the standards, cutting and welding procedures and shall be approved by the competent authority.

The above procedure shall be performed only in shops with automatic equipment both for the steel grit blasting and for the shop-primer application.

CONTRACTOR shall perform all required checks two times per shift and any malfunction of the equipment and/or working defects shall be promptly corrected and repaired.

Metallic abrasives shall meet the requirements of ISO 11124 Parts 1 to 4, applicable to the type of abrasive intended to be used. Tests and controls shall be completed according to ISO 11125 Parts 1 to 7.

11.4 Pre-Blast Cleaning

Welded areas shall be cleaned, and ground as needed to remove sharp rough areas. Weld reinforcement removal is not required, if the reinforcement has rounded edges. Sharp edges, fillets, corners, and weld seams shall be radiused or smoothed to a minimum of 3 mm. All bolt holes shall be drilled and ground prior to blast cleaning.

The SUB-CONTRACTOR shall give special attention to all weld areas for removal of burrs, weld spatter, weld flux, slivers indentations, protrusions and other foreign matter to be removed by grinding prior to abrasive blast cleaning. If grinding is to be carried out after blast cleaning, the ground surface shall be re-abrasive blasted to restore the specified profile.

Supports for items to be blast cleaned shall have a configuration such that the contact points are as small as practical to limit surface area covered.

Random salt contamination tests shall be carried out to verify the need or otherwise for solvent detergent washing (or alternative method) prior to abrasive blast cleaning.

All steel stored in a coastal site or shipped as deck cargo shall be water washed and checked for salt contamination prior to coating operations. The frequency and nature of these checks shall be sufficient to ensure the surface cleanliness of the substrate.

Any oil, grease or other contaminants on the working surface shall be removed by solvent cleaning in accordance with SSPC-SP 1.

Fabricated items shall be released from welding in writing confirming all hot work is completed and accepted and required pre-cleaning is carried out in accordance with this specification requirements.

11.5 Cleaning of Carbon Steel / Alloy Steel Surfaces

Carbon Steel / Alloy Steel surfaces shall be prepared by blast cleaning as specified for the paint system. Blast cleaning shall only be performed when appropriate conditions exist (see Section 13.1).

Specific surface preparation method shall be as specified for each individual coating. Abrasives for blast cleaning shall be clean, dry, and free of any constituent part that could be detrimental to long term coating performance and shall be selected to provide the proper surface profile for the coating to be applied. Silica sand and Copper slag shall not be used. All blast media used shall be submitted to CONTRACTOR and COMPANY for approval prior to initiation of any surface preparation work.

Surface profile shall be angular in shape and within the recommended range as per relevant paint specification system.

Blast cleaned surfaces shall be primed as shortly as possible, but in no case may exceed intervals given below:

- a. Immediately if condensation is likely to take place due to weather change or if weather conditions are likely to worsen.
- b. 2 hours if shift is changing.
- c. 4 hours or before any blooming occurs, whichever sooner.

Blast cleaned surfaces shall meet the requirements of the surface preparation standard specified for the particular paint specification. After blast cleaning, any metal protrusions or other metal imperfections found shall be ground out and re-blast cleaned.

Surfaces shall be clean, free of dust and abrasive particles before priming. Care shall be taken to keep cleaned surfaces free of contamination from dirt, dust, grease, weld slag, and any other foreign material.

No acid washes, cleaning solutions, solvents or other chemical treatments shall be used on metal surfaces after they have been dry blast cleaned.

Surface preparation shall be subject to inspection before the prime coat is applied to ensure all traces of dust and foreign matter including soluble salts have been removed by brushing, blowing with clean compressed air, or vacuum cleaning.

The surface profile, of a blast cleaned surface, shall also be subject to inspection prior to application of the prime coat. The methods and equipment as noted in Section 0. Inspection and Testing shall be used to determine and maintain the appropriate surface profile.

Abrasive blast-cleaning equipment shall be of an intrinsically safe construction and equipped with a remote shutoff 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 headgear shall be ventilated by clean, cool air served through a regulator filter, to prevent blast cleaning residues from being inhaled.

Blasting abrasives used on open sites or in facilities not specifically controlled to preserve the cleanliness of spent abrasive shall not be re-cycled. Spent abrasive shall be completely removed from the prepared surface. Under no circumstances shall expendable grit be re-cycled.

Where a requirement is identified, sweep / light blasting shall be carried out at reduced pressure, typically 40-50 psig / 1.38-2.07 barg in order to attain SSPC-SP 7 / NACE No. 4 Sa 1 cleanliness.

11.6 Cleaning of Galvanized and Inorganic Zinc Surfaces

Hot-dip galvanized steel surfaces shall be prepared before application of any painting in accordance with the application data.

Galvanized or zinc primed surfaces shall be free of all zinc salts, oil and grease before application of any surface treatment or coating. Zinc salts, oil and grease shall be removed by high pressure fresh water washing with 5% ammonia solution containing detergent then subsequent rinsing with water. Surfaces shall then be lightly blast cleaned with appropriate abrasive to ensure proper adhesion of subsequently applied coating. Any other surface treatment shall require COMPANY's approval.

11.7 Cleaning of Stainless-Steel and CRA Surfaces

Surface preparation of stainless steel (including super duplex stainless-steel) or CRA surfaces shall be in accordance with ISO 8504-2, Sa 1 light blast cleaning to achieve a 25-40 µm profile. Abrasive media shall be strictly in accordance with requirements of Section 8.1. At the jobsite, when blast cleaning is not practical due to safety reasons or with thin stainless steel sheeting, high pressure steam cleaning with an appropriate thorough solvent cleaning (chloride free) or alkaline detergent if the surface has foul deposit, may be used provided such a method is acceptable to the COMPANY and upon prior approval from the CONTRACTOR and COMPANY. The use of steam or solvent cleaning only, at a shop SUB-CONTRACTOR's facility is not acceptable. Surface profile shall be checked by SUB-CONTRACTOR.

In situations where blast cleaning is impractical, power brush cleaning can be used subjected to COMPANY approval, only stainless-steel brushes should be considered acceptable for stainless-steel (including super duplex stainless-steel).

Alternately, for small items or thin sheets of Stainless Steel or sensitive instruments / gauges it could be hand or machine abraded with non-metallic abrasives or bonded fibre machine or hand abrasive pads to impart a scratch pattern to the surface and to remove all polish from the surface, followed by the application of Paint system in accordance to this specification

11.8 Cleaning of Glass Reinforced Epoxy Surfaces

The exterior of Glass Reinforced Epoxy pipes, installed on external areas, shall be cleaned by high-pressure fresh water washing to remove salt and any other contaminants.

The surfaces shall be abraded using power tool (light rotary disc, Scotch-Brite or equal and approved by COMPANY) in order to provide a rough surfaces for the proper adhesion of the specified coat.

11.9 Residual Salt Contamination

The maximum allowable total soluble salts level on the blast cleaned surfaces shall not exceed 20 mg/m² and shall be measured in accordance with ISO 8502-6 and 9 by Bresle kit only.

Where pitting corrosion is identified, the area shall be cleaned in accordance with ISO 8501-2, to the specified level of surface cleanliness.

Testing of the level of salts shall be carried out on each component.

The tests shall be carried out a minimum of three times per day during the progress of the work.

11.10 Surface Dust

The dust level on the blast cleaned surface at the time of painting shall not exceed quantity rating 2 and Class 1 in accordance with ISO 8502-3.

Checks on dust level shall be made at least once component of prepared Surfaces and a minimum of three checks per day during the progress of the work.

In addition, when galvanised components are painted, zinc corrosion products (white rust) and / or rust present shall be removed.

11.11 Presence of Mill Scale

Checks on the presence of mill scale shall be made on each component of prepared surface, and a minimum of three checks per day.

11.12 Surface Profile

At the beginning of each project, blast cleaned steel sample plates to assess blasting operators shall be prepared in compliance with the surface preparation requirements in the Procedure Qualification Test (PQT).

The anchor profile shall be measured in accordance with ISO 8503-2 or ISO 8503-5.

For field measurements of surface profile, the following methods may be used:

- a. Replica tape.
- b. Portable micrometre.

Checks on surface profile shall be made on each component of prepared surface and a minimum of 3 times per blasting operator per day.

12 PAINTING APPLICATION

12.1 Scheduling

Painting shall NOT be applied when:

- a. The ambient temperature is less than 4°C.
- b. The relative humidity is more than 85 percent, except for Inorganic Ethyl Zinc Silicate up to 95%.
- c. The surface temperature is less than 3°C above the dew point.
- d. The metal surface temperature is higher than 50°C except for special paint systems in accordance with Coating MANUFACTURER's recommendations / datasheet.
- e. Surface preparation has not been completed or oil, grease, and dust are present on the substrate to be painted.
- f. Poor weather conditions for painting exist or are expected within two hours of application such as blowing sand, fog or rain.
- g. Where there is a deposition of moisture in the form of rain, condensation, frost, etc. on the surface.
- h. Where the available light is less than 500 lux.

Dew point determination shall be completed in accordance with ISO 8502-4 and humidity measurement shall be made in accordance with ASTM E337. Coatings shall not be applied to surfaces exceeding a substrate temperature of 50°C or as advised in the Coating MANUFACTURER's data sheet. Higher substrate temperatures shall only be accepted if the Coating MANUFACTURER has confirmed in writing that this application shall not affect the performance of the coating work.

12.2 Preparation for Painting

Storing, thinning, mixing and handling, of paint materials shall be in accordance with the Application Data. All containers shall remain closed in factory sealed containers until required for use. Each container must have full identification information including Coating MANUFACTURER's name, product identification, and batch number, date of manufacture, shelf life, basic instructions and contact telephone number for technical service. All aspects of safety relating to the use of coatings and associated thinners shall be in complete accordance with the Coating MANUFACTURER's stated requirements.

The Coating MANUFACTURER's pot-life and induction time (necessary time for reaction of 2 pack paint materials, if required) requirements shall be followed. Mixing of different brands or different generic types of coating materials is not allowed. On-site mixing of approximate proportions is not permitted. All mixing shall be completed using factory proportioned containers only. Hand mixing shall not be permitted allowed in any can above 5 litres.

Hydrostatic or other testing of shop and field welds shall be completed prior to painting of weld area.

To ensure that only correctly blasted surfaces are coated, a minimum of 100 mm around the edges of prepared areas shall be left uncoated.

Ends of pipe and related components, tank plate, structural steel, and like areas of other items that will require subsequent welding at site, shall be masked off after blast cleaning and left uncoated for a distance of 50 mm from all areas requiring welding. The masking material shall be removed as soon as possible after priming or painting. It shall be the SUB-CONTRACTOR's responsibility to see that all masking material is thoroughly removed from the equipment and any damage to the primed / painted surface is repaired prior to shipment.

Before any painting work starts, the compatibility with existing coating systems or layers shall be checked with the Coating MANUFACTURER / SUPPLIER.

If there is any doubt about compatibility, a patch test, in accordance with ASTM D5064, shall be conducted to evaluate the inter-coat adhesion.

12.3 Painting Application

Surfaces shall be painted with paint systems specified in APPENDIX A1.

Paint shall be applied to dry, clean, prepared surfaces under favourable conditions and in accordance with the Application Data.

Pigmented and catalysed materials shall be thoroughly mixed using power mixers before being applied. Sticks shall not be used.

Continuous agitation type spray pots shall be used when applying metal pigmented coatings such as zinc or aluminium loaded coatings.

A mist coat shall be applied over inorganic zinc primer to avoid surface defects. The SUB-CONTRACTOR shall exercise necessary care to ensure a smooth and uniform coating is applied over inorganic zinc primer.

Extra coats of paint shall be applied on areas where shape and / or plane of application results in thinly applied coating; e.g., at edges, welds, corners, etc. To compensate for these effects, a stripe-coat of paint shall be brush applied before applying the full coat.

All painting shall be uniformly applied without runs, sags, solvent blisters, dry spray or other blemishes. All blemishes and other irregularities shall be repaired or completely removed and recoated. Special attention shall be paid to crevices, corners, edges, weld lines, bolt heads, nuts, and small brackets, to apply the specified minimum dry film thickness by brush application if spray will not completely cover all surfaces.

Surfaces that will be inaccessible after assembly, including the surfaces of nozzle necks, lap joint stub ends, lap rings, bolt holes and some welded joints, shall receive the complete painting system before being assembled. Contact surfaces of bolted connections are to be primed only.

On structural steel areas subject to be assembled by high strength friction grip bolts, contact surfaces shall be only primed with Inorganic Ethyl Zinc Silicate. Intermediate and final coat shall not be applied.

Inter coat contamination shall be minimized by maintaining proper cleanliness and by applying intermediate and finish coats within the inter-coat time period recommended by COMPANY. If contaminants are present, they shall be removed before applying succeeding coats.

Applied coatings shall not be left without over-coating for a period more than 21 days or the maximum over coating time recommended by the Coating MANUFACTURER whichever is shorter. If above mentioned over-coating time is exceeded, COMPANY shall be consulted for course of action prior to the application of the subsequent coats.

Flanges, nozzles, clips, access ways, saddles and other attachments which protrude through insulation shall be considered uninsulated and shall be painted in accordance with APPENDIX A1 and APPENDIX A2.

Adhesion qualification test plates shall be prepared at the same time and under the same conditions as the production coating work.

Where carbon steel pipes are welded to stainless steel pipes, both sides of the joint shall be coated with a coating system that meets the performance requirements for both substrates under the specified environmental conditions and overlaps a minimum of 50 mm (2 in) onto the carbon steel side.

At contact points such as where piping rests directly on a support, either a saddle type or support beam there is a potential for crevice corrosion and metal loss due to abrasion. Therefore, coated surfaces which are in contact with other surfaces shall be protected with non-metallic composite wrapping. Such protection system shall be applied over fully cured paint on resting beam and anchor on the underside of the resting beam and covering the pipe extending about 150 mm on either side in addition to pipe resting area to yield high impact and abrasion resistance.

12.3.1 Spray Application

Hose and containers shall be thoroughly cleaned before addition of new materials. The spray gun shall be held no closer than 200 mm or more than 600 mm from the surface to be coated. During application the spray gun shall always be held at a right angle to the substrate. Each pass shall overlap the previous one by 50 percent. In order to achieve a uniform application, when large surface areas are being coated, spray application shall be made in two directions so that the passes are at right angles to each other. Pressures and spray fan shall be adjusted so that the optimum spray pattern is utilized for the surface being coated.

The spray equipment and sizes of tips for the spray guns shall meet the recommendations set forth by the Coating MANUFACTURER for the required paint materials. Lines and pots shall be thoroughly cleaned before adding new materials, and only the Coating MANUFACTURER's recommended cleaning agents shall be used.

Atomizing air and paint-pot pressure shall be regulated to the minimum amount required to properly atomize coating material for application without dry spray, runs or sags. If a particular coating system requires a special pump(s) or equipment, then only that specific equipment will be acceptable for coating application.

An adequate moisture trap shall be placed between the air supply and pressure feed to gun. The trap shall continually bleed off any water or oil from air supply. Lines and pot must be cleaned before adding new materials. Suitable and working regulators and gauges shall be provided for both air supply to pressure-pot and air supply to pressure gun.

Separate regulators shall be used to adjust the paint-pot pressure and atomization pressure. Each regulator shall be provided with a pressure gauge operating properly at all times.

12.3.2 Brush Application

Application with brush is only acceptable under the following conditions:

- a. When areas cannot be properly coated by spray for justifiable reason.
- b. For touch-up or repair of localized damaged paint or to areas of incorrectly applied paint.
- c. For painting of stripe-coat.
- d. When the materials to be applied are suitable for brush application.
- e. When applying the initial coat of paint to corners, edges, crevices, holes, welds or other irregular surfaces prior to spray application.

The number of coats shall be adjusted to comply with the dry film thickness requirements.

Paint brushes used shall be of a style and quality that will permit appropriate application of the material being applied.

Material applied by brush shall be smooth, uniform in thickness, without any apparent surface defects such as brush marks, runs, sags, or curtains.

12.3.3 Roller Application

Paint application by roller brush is not acceptable because poor wetting of the substrate and incorporates air into the paint film. Use of roller will not be allowed for application of any zinc rich primer and any type of first coat of the paint system. The roller should be used, subject to COMPANY approval, only for topcoat application when thickness less than 50 microns is required.

Due to poor wetting of the substrate, roller brush is not acceptable for the Primer coat application.

12.4 Application Checks

12.4.1 Wet Film Thickness (WFT)

Spot checks of WFT shall be carried out during the course of the paint application to ensure that film thickness is being maintained. This shall be completed according to ISO 2808, Method No. 1A - comb gauge.

12.4.2 Dry Film Thickness (DFT)

Coating dry film thickness (DFT) shall be measured by means of a thickness meter based on eddy-current or electromagnetic techniques, in accordance with ISO 2808, methods 7B (magnetic-flux), 7C (magnetic-induction)

or 7D (Eddy-current). The procedure (including sampling plan and areas requiring special consideration), reading correction, acceptance criteria, test report shall comply with ISO 19840.

- a. The arithmetic mean of all the individual dry film thicknesses shall be $\geq$ NDFT.
- b. All individual dry film thicknesses shall be $\geq$ 90% of the NDFT.
- c. Individual dry film thicknesses between 90% of the NDFT and the NDFT are acceptable provided that the number of these measurements is less than 10% of the total number of individual measurements taken.

The requirement below for maximum DFT shall be added to acceptance criteria. For each individual layer the maximum allowed DFT shall be considered as 1.5 times the NDFT, except:

- a. For areas such as corners or repairs where overlaps are difficult to avoid for such areas a maximum of 2.5 times the NDFT shall be accepted.
- b. Coating MANUFACTURER recommendation is lower than 1.5 times the NDFT, in this case the Coating MANUFACTURER recommendation shall apply.

12.4.3 Over-coating Colours

Different colours shall be used for all successive coats of the paint system. The finishing coat of the required colour shall be sufficiently opaque to cover the shade of the undercoat.

For certain light topcoat colours, it may be necessary to apply a thicker or an additional topcoat to achieve complete cover of the undercoat.

12.4.4 Over-coating and Curing Time

Prior to applying a succeeding coat, all previous coatings shall be allowed to dry in accordance with timeframes specified by the Coating MANUFACTURER. The maximum over-coating interval shall be 21 days or the maximum over coating time recommended by the Coating MANUFACTURER whichever is shorter. In case over-coating interval is expired, the previously coated surface shall be sweep (light) abrasive blasted to create a mechanical key to subsequent coat except for primer in which full abrasive blasting to original specification is recommended.

Prior to overcoating, over-runs, drips and other imperfections shall be removed and repaired. If the DFT does not meet the requirements of this specification, repair work shall be applied until correct DFT readings are achieved.

12.4.5 Zinc Rich Primers

Zinc rich primers shall be applied over carbon and low alloy steel surfaces only. Paints containing metallic zinc shall not be applied, over sprayed or dripped onto stainless steel components.

During application, the product shall be stirred at all times.

If relative humidity is below 60%, the painted surface shall be sprayed with fresh water for at least two hours after application to enhance curing of inorganic zinc primer. A solvent rub test using MEK in accordance with ASTM D4752 shall be carried out to ensure inorganic zinc primers are fully cured before over-coating. The rating shall be minimum 4.

Zinc primers shall be overcoated as soon as possible. Zinc salts (white rust) shall be removed in accordance with the Coating MANUFACTURER's instructions prior to overcoating.

12.5 Finished Coating

12.5.1 General Coating Appearance

The completed coating shall be free from defects such as runs, sags, holidays, pinholes, bubbles, blisters, orange peel, grit inclusions, dust inclusions or other deleterious anomalies and be of good visual appearance. The topcoat shall completely cover the colour of the underlying layers.

If anti-skid systems are applied, the anti-skid material shall be uniformly dispersed on the surface of the coating.

12.5.2 Top-coat Colour

The final topcoat colour for external coatings shall comply with 0 through APPENDIX A10.

12.5.3 Total DFT

The same requirements as for individual layer DFT shall apply. See Section 12.4.2.

12.5.4 Adhesion

The quality of adhesion between the coating system and the steel substrate, and of the adhesion between the coating layers, shall be measured as follows:

- a. 5 MPa for zinc primed coating systems.
- b. 7 MPa for non-zinc primed coatings systems.

For coating systems with a maximum total NDFT of 150 μm , a crosscut test in accordance with ISO 2409, Class O.

Testing shall be completed on fully cured systems according to the Coating MANUFACTURERS recommendations given in the product datasheet. This shall not be less than 7 days after the application of the final layer for epoxy systems. Adhesion testing shall be carried out on test plates coated at the same time as the inspected components.

12.5.5 Holiday Detection

Holiday detection shall be carried out in accordance with ASTM D5162 on 100% of coated area for external coatings of buried tanks, vessels and piping.

The high voltage technique (ASTM D5162 test method B) shall be used for coating systems with a nominal total DFT $\geq 500 \mu\text{m}$.

For coating systems with a nominal total DFT $< 500 \mu\text{m}$, the wet sponge technique with low voltage holiday detector at 90V (ASTM D5162 test method A) shall be used.

Defects found shall be marked, repaired and retested in accordance with this specification.

The SUB-CONTRACTOR shall provide the necessary equipment for calibrating the holiday detector.

13 REPAIR

13.1 General Requirements

SUB-CONTRACTOR shall submit a repair procedure for each coating system.

Prior to the application of succeeding coats, all damaged and defective areas shall be repaired to specification requirements.

Adhesion qualification tests are mandatory and shall be performed to determine the compatibility for each repair method.

Surface preparation shall wherever possible be carried out by dry blast cleaning. If dry blast cleaning is not specified or not feasible (e.g. due to limited access, risks of damage to equipment, light gauge steel, the proximity of electrical components or instrumentation), then power tool to manual cleaning by mechanically operated tools shall be performed. In this instance, the use of power or mechanically operated tools is subject to COMPANY approval.

Unless otherwise specified Bristle Blasting, power tooling shall be carried out in accordance with the requirements of ISO 8504-3 and ISO 8501-1 Grade St 3.

Power tool cleaning (grinding) to Barge metal shall be completed in accordance with SSPC-SP 11, if approved by COMPANY.

Bristle Blaster power tooling is acceptable for use on small area preparation such as inaccessible areas. Areas and frequency of use are subject to COMPANY approval.

Compare the degree of cleaning offered by bristle blasting utilizing the pictorial standard issued by the Steel Structures Painting Council, SSPC-VIS 3.

When bristle blasting technique used for inaccessible area surface preparation, a surface tolerant coating system shall be applied. The surface tolerant coating system is subject to COMPANY approval.

If the surface being prepared lies adjacent to a coated surface not requiring to be repaired, the surface preparation shall overlap the coated surface by at least 50 mm. The remainder of existing coated surface shall be adequately protected with shields or screens to prevent any possible damage to the coating.

Inorganic zinc primer shall not overlap adjacent intermediate and finish coats. Any overlapping shall be removed with fine grade of emery paper.

Areas with inadequate painting thickness shall be thoroughly cleaned, prepared and additional compatible coats applied until they meet this specification. These additional coats shall blend in with the final coating on adjoining areas. Colour match shall be achieved.

13.2 Painting Damage Not Exposing Substrate Surface

Surfaces to be over coated which become contaminated or damaged shall be cleaned by solvent cleaning and / or lightly brush blasted ensuring that the surface is free of all contaminations prior to applying the following coats. After cleaning, any residual contaminants shall be removed by dry compressed air and wiped by hand with clean, dry rags. The painting around the damaged area shall be chamfered by approved methods to ensure continuity of the patch coating. The full painting system shall then be reapplied strictly in accordance with the specification.

13.3 Painting Damage Exposing Substrate Surface and Field Welds

Damaged areas and all Field welds shall be abrasive blasted and prepared to original specification and the coating system re-applied in accordance with relevant paint specification. All cleaning shall carry over onto the tightly adhering surrounding coating not less than 50 mm all around. Edges shall be chamfered by a method approved by the COMPANY.

13.4 Repair of Zinc Silicate Primer

Damaged surfaces of zinc primer shall be cleaned to remove all loose materials and blast cleaned with a portable vacuum blast cleaning unit. The blasted surface shall be painted with one coat of the primer.

If blast cleaning is not practical, power tool cleaning may be used subject to the COMPANY and CONTRACTOR approval. In such cases, subject to operating temperature limitations, polyamide epoxy zinc primer may be used in lieu of zinc silicate primer. Use of polyamide epoxy zinc primer is subject to COMPANY and CONTRACTOR approval.

13.5 Repair of Fully Cured Epoxy Painting

Repairs to fully cured epoxy painting shall only be carried out after the surface to be painted has been suitably abraded by light (sweep) abrasive blasting to provide an adequate profile for further coating to be applied.

14 INSPECTION AND TESTING

14.1 General

The COMPANY and CONTRACTOR shall have the right to inspect the paint work at all stages of preparation and to reject any tools, materials, equipment or work which do not conform to this specification. Before painting activities commences, the CONTRACTOR shall submit an Inspection and Test plan for COMPANY approval. CONTRACTOR shall employ a qualified Painting Inspector whose resume shall be approved by the COMPANY.

CONTRACTOR Qualified Inspector shall have either NACE CIP Level-2 (National Association of Corrosion Engineers), FROSIO Level-2 (The Norwegian Professional Council for Education and Certification of Inspectors for Surface Treatment) or BGAS-CSWIP Level 2 certification or equivalent and approved by COMPANY.

All items painted by the SUB-CONTRACTOR shall be inspected on arrival. All damaged areas shall be repaired by SUB-CONTRACTOR / CONTRACTOR. In cases where there is damage of more than 5% of the surface area not exposing to Barge metal or, the finish coat appearance is not acceptable, COMPANY reserves the right to instruct CONTRACTOR to rectify the defects in accordance to this specification at no cost to COMPANY.

Minimum inspection intervention points / items shall be included in ITP as minimum.

14.2 Before Surface Preparation

Prior to initiation of blast cleaning, the SUB-CONTRACTOR shall confirm that all environmental and safety requirements relating to blast cleaning have been met.

14.3 Before and During Paint Application

Prior to painting, all surfaces shall be visually inspected to assure that the proper surface conditions necessary for painting exist. SUB-CONTRACTOR shall:

- a. Verify and document that surface preparation cleanliness and surface profile are as specified.

- b. Surface profile testing shall be carried out by utilization of a CONTRACTOR approved instrument and in accordance with ISO 8503-2.
- c. Verify that blast cleaned surfaces have been kept free of contamination. Tests to indicate the presence of chlorides and dust shall be carried out in accordance with ISO 8502-1, ISO 8502-6 & 9 and ISO 8502-3, respectively. The maximum allowable level of contamination shall be 20 mg/m². Surfaces that do not meet this criterion shall be reprocessed.
- d. Just prior to painting, inspect surface cleanliness and profile again to assure that no surface imperfections, moisture, or other contaminants are present.
- e. Verify that elapsed time from blasting has not exceeded specified time between blasting and painting.
- f. Verify that surfaces not to be coated are masked off or otherwise protected.
- g. Document the air temperature, humidity, and substrate surface temperature.
- h. Verify that storage, mixing, thinning, and application of primer, intermediate, and finish coats are in accordance with the application data.
- i. Verify by spot checking the Wet Film Thickness (WFT) during the course of the paint application to ensure that the film thickness is being maintained. These checks shall be performed according to the procedure described in ISO 2808, Method No. 7B.
- j. Verify the level of dust contamination at the same frequency as surface profile measurements in accordance with ISO 8502-3. The Cleanliness rating shall be 2 or better.

14.4 After Painting

After application of painting, SUB-CONTRACTOR shall verify and document dry film thickness of the primer, intermediate and finish coats. In accordance with SSPC-PA 2.

Each coat of a system and the complete system shall be visually inspected for adhesion and surface imperfections. If upon visual inspection, loss of adhesion is suspected or found, an adhesion test shall be made. In all cases, complete system involving silicone-based paint shall be tested for adhesion by pull-off test method. The adhesion of the primer to the steel substrate and the inter-coat 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 to maximum grade C2 or a pull-off test described in ISO 4624, 5 MPa for zinc primer based system and 7 MPa for non-zinc primer system.

TSA coatings applied to blast cleaned steel surface, exhibiting an adhesion of less than 7 MPa shall be rejected.

Each painting system and repair method shall be tested on a test plate for an adhesion qualification test. The test plate shall be painted at the same time and under same conditions as the production work.

Repairs made in the field shall be documented and re-inspected as outlined above.

14.5 Inspection and Tests Summary

Table 14.1 Inspection and Tests

Test Type		Method	Extent / Frequency	Acceptance Criteria
Preliminary Tests				
Storage of coating materials		Visual	All	Specification Requirements
Container's integrity		Visual	All	Specification Requirements
Shelf life		Visual	All	Product Data Sheet Requirements
Steel and Welding Imperfections				
Steel and welding imperfections		ISO 8501-3	100%	According to requirements and conform to the specified grade
Surface Preparation				
Environmental conditions		ISO 8502-4	Before start of each shift and every two hours	Specification Requirements
Welding flux removal		Distilled water and litmus paper	100%	pH neutral (6.5 - 7.5)
Pre-cleaning of surfaces		SSPC-SP 1	100%	Free of oil, grease and other contaminants.
Protection of fittings and accessories		Visual	100%	Specification Requirements
Compressed air		ASTM D4285	Every 2 hours	Free of oil and moisture
Breathing air		XX	Twice per day	To meet BS EN 14594 requirements
Abrasive materials		ASTM D4940	Every Batch	≤ 150 μmS/cm at 20°C
Abrasive blast cleaning		SSPC-VIS 1	100%	Conform to the grade specified in the applicable painting system
Power tool cleaning		SSPC-VIS 3	100%	According to the general requirements
Roughness		NACE SP0287	Spot Checks ⁽¹⁾	Conform to grade specified in the applicable painting system
Dust test		ISO 8502-3	Spot Checks ⁽¹⁾	Maximum rating "1" and dust class "2"
Water soluble salts ⁽²⁾		ISO 8502-6 ISO 8502-9	Spot Checks ⁽¹⁾	≤ 2 μmg/cm ² (20 mg/m ²)
Coating Application				
WFT		Metallic "Comb Gauge"	Methodically during application	According to specified DFT
Cleaning of each coat	Dust test	ISO 8502-3	Spot Checks ⁽¹⁾	Maximum rating "1" and dust Class "2"

Test Type		Method	Extent / Frequency	Acceptance Criteria
	Water soluble salts	ISO 8502-6 ISO 8502-9	Spot Checks ⁽¹⁾	≤ 2 µmg/cm ² (20 mg/m ²)
DFT of each coat and of complete paint system		ISO 19840	100% of surfaces	Specification requirements
Curing of the inorganic zinc silicate		ASTM D4752	Spot Checks ⁽¹⁾	Conform to Level 5
Adhesion		ASTM D4541 TYPE III, IV or V adhesion tester	Spot Checks ⁽¹⁾	To be performed on test panels Minimum value 5 MPa for Zinc primer-based system and 7 MPa for non-Zinc based primer system
Visual examination		Visual and ISO 4628-1 to 6	100% of surfaces	No sagging, contaminations, orange peel, cracking, blistering, rust, damages and any other defects
Holiday Testing ⁽³⁾ , if applicable		NACE SP0188	100% of surface	Free of holidays and pinholes
Stripe Coating by brush		N/A	Prior to each coat	Mandatory requirement
Note: 1. Number and location shall be defined and agreed during pre-job meeting. 2. Soluble salt tests shall be conducted with Bresle procedure only. 3. Holiday testing shall be performed according to the following requirements: a. DFT ≤ 500 microns Low-Voltage Wet sponge testing b. DFT > 500 microns High-Voltage Spark testing according to the voltage values listed in NACE SP0188				

15 THERMAL SPRAY ALUMINIUM (TSA) - QUALIFICATION

15.1 General

The Painting CONTRACTOR's facility and painting equipment shall be qualified prior to starting any production painting operations.

The qualification program for production and the pre-approval qualification shall include application of TSA coating of pipe or components, as applicable for the work to be undertaken and shall include all the testing required. Both of these exercises shall be witnessed by an authorized representative of the COMPANY. Where applicable, it shall also be witnessed by the CONTRACTOR and any 3rd party inspectors. Where significant changes are been made in the TSA application process or materials, CONTRACTOR shall demonstrate that the coating will meet the requirement by providing additional test data on the TSA coating application. Data shall cover both the TSA application process and materials.

Where requested by the COMPANY or CONTRACTOR, an application trial shall be conducted at the painting application site. As part of the trial, the painting CONTRACTOR shall coat a sample to demonstrate that the applicable procedure and quality control will produce coatings that meets the requirements of this specification. All coatings shall meet the requirements proposed for the system and shall be applied using equipment and procedures to that used for production coating application.

Each TSA SUB-CONTRACTOR and each individual TSA Sprayer shall be pre-qualified before they are allowed to apply TSA.

This specification shall be used for general qualification purposes and for specific projects.

General pre-qualification is performed for the purpose of an overall qualification of the TSA SUB-CONTRACTOR but is not necessarily related to a specific project.

15.2 TSA SUB-CONTRACTOR Qualification

TSA SUB-CONTRACTOR qualification consists of the following points:

- a. Abrasives - name of product and Abrasive MANUFACTURER / SUPPLIER, mesh size, cleanliness report.
- b. Blasting and thermal spray equipment - type and name of the Coating MANUFACTURER / SUPPLIER.
- c. Spray material - name of Coating MANUFACTURER / SUPPLIER, wire size, chemical composition.
- d. Sealer - name of product and Coating MANUFACTURER / SUPPLIER.
- e. Review of quality plan including surface preparation and application procedures.
- f. Review coating repair method.
- g. Witness the coating application on the required test panels and coupons.
- h. Witness the coating testing, including sealer inspection.
- i. Witness coating repair application.
- j. Two B1 test pieces according to ISO 14918.
- k. At least 3 coupons (dimensions as per SSPC-CS 23.00 / AWS C2.23M / NACE No. 12) for bend testing.
- l. Test panel, thickness 6 mm (1/4 in), the minimum surface area of 1 m² (10.7 ft²) (also for sealer application).
- m. Two test panels (200 mm x 200 mm x 6 mm) (8 in x 8 in x 1/4 in).
- n. TSA Coating shall be applied within 4 hours of completion of blast cleaning or before any blooming occurs, whichever is sooner.
- o. The applied TSA thickness shall be 250 microns minimum and 500 microns maximum (10 mils to 20 mils).
- p. Testing shall be completed according to the test procedure.

15.3 Thermal Sprayer Qualification

The qualification tests as specified in ISO 14918 Annex B.1 and B.9 shall be witnessed and certified by an Independent third-party authority.

Individual sprayer shall be qualified in accordance with ISO 14918 requirement.

Additional qualification tests as specified below shall be executed and shall be witnessed by the COMPANY or Delegate of the COMPANY. This qualification can be completed during the TSA SUB-CONTRACTOR qualification. Any sprayer that has been inactive for 1 year shall be re-qualified. The TSA SUB-CONTRACTOR must produce documentation providing the sprayer has produced acceptable commercial TSA product coatings within the required time period to sustain the sprayer qualification.

For the test coupons, the same type of base steel shall be used as the actual component. Coating material, spray technique and coating thickness shall comply with the specification.

The coating repair methods proposed by the CONTRACTOR shall also be qualified. Repair methods shall comply with this specification.

15.3.1 TSA Qualification Test

15.3.1.1 Visual inspection of TSA coating:

The TSA coated surfaces on all test plates shall have a uniform appearance, no blisters, Barge patches, defects or non-adhering coating.

15.3.1.2 Bend test:

Each thermal sprayer shall prepare and spray a minimum of three comparison bend test coupons (dimensions as per SSPC-CS 23.00 / AWS C2.23M / NACE No. 12). The thermal spray bend test coupons shall not be sealed or top coated. The coating thickness shall be as specified in the specification.

The bend test entails bending at least three thermal spray coated steel coupons through 180° on a 13 mm (1/2 in) diameter steel mandrel.

Should any one of the bend tests fail the acceptance criteria specified in Table 15.1, the thermal sprayer may make one additional attempt to qualify by spraying and testing a further three coupons. Should any one of these fail, the sprayer shall be deemed to have failed the qualification test.

15.3.1.3 Adhesion test:

Each thermal sprayer shall apply TSA at the required thickness onto a test panel (thickness 6 mm (0.25 in), with a minimum surface area of approximately 1 m² (10.7 ft²). The painted surface shall not be sealed or top coated.

The adhesion strength between the thermal spray coating and the steel substrate shall be measured by means of a portable, self-aligning, hydraulic controlled adhesion tester in accordance with ISO 4624. The adhesive between the dolly and the thermal spray coating shall be an epoxy.

A minimum of three pull off adhesion tests shall be conducted. Should any one of the pull off adhesion tests fail the acceptance criteria in Table 15.1, the thermal sprayer may make one additional attempt to qualify by spraying and testing a further panel. Should any one of the subsequent pull off adhesion tests fail, the sprayer shall be deemed to have failed the qualification test.

15.3.1.4 Sealer:

TSA shall be top coated with a sealer coat to close the TSA porosity following completion of the pull off adhesion tests, the test panel used shall be sealed with the project sealer material.

The sealer coat shall be selected based on the operating temperature of the TSA coated surface. The sealed surface area of the thermal spray coated test panel shall be examined holiday testing. The sealed surface shall show 100% coverage, no holiday and no open pores shall be present at the surface.

Summary of qualification tests and acceptance criteria:

Table 15.1 Qualification Test Requirements for TSA SUB-CONTRACTOR and Sprayer

Property	Test Method	Measurements	Acceptance Criteria
ISO Qualification	ISO 14918 Annex B.1 and B.9	Thickness, visual, adhesion.	Full compliance with ISO 14918
Coating Appearance	Visual Inspection	100% surface	Uniform appearance, no blister, Barge patches, defects or non-adhering coating.
Coating Thickness	ISO 2808	All surfaces	250 to 500 microns
Coating Adhesion	ISO 4624	At least 3 at random	> 7 MPa (1000 psig / 68.95 barg) Single measurements.
Bend Test	SSPC-CS 23.00 / AWS C2.23M / NACE No. 12	At least 3	Minor cracks, with no coating lifting or spalling.
Sealer	Visual Inspection and Holiday Test	100% of surface	100% coverage, no open pores present at the surface / No holiday.

15.4 Testing of TSA Production Coating Properties

15.4.1 Coating Appearance

The thermal spray coating shall be free from defects such as blisters, spatters, cracks, loose particles, areas with Barge substrate steel, etc., when examined with 10 time's higher magnification.

Sealer visual inspection shall be performed for every 50 m² of manually sprayed and 100 m² of machined spray coating. The sealed surface shall show 100% coverage, and no open pores shall be present at the surface, when examined with 10 time's higher magnification.

15.4.2 Coating Thickness

Spot checks shall be carried out during application of the thermal spray coating to ensure that the specified coating thickness is being maintained.

The coating thickness shall be measured by means of a thickness meter based on eddy-current or electromagnetic techniques, in accordance with ISO 2808, methods 7B (magnetic flux), 7C (magnetic-induction) or 7D (Eddy-current).

The coating thickness gauge shall be calibrated on the blasted steel surface.

For flat surfaces, coating thickness measurements shall be taken along a straight line. The average value of five readings taken in a line at 25 mm (in) intervals.

For complex geometries, spot measurement shall be taken. TSA thickness shall be determined by the average value of five readings taken in line at 25 mm (in) intervals.

For the acceptance of an inspected area the following criteria shall apply:

- Individual local thickness of the thermally sprayed coating shall not be lower than 90% of the specified minimum thickness.

- b. Individual local thickness of the thermal sprayed coating, e.g. at corners shall be maximum 2 times the specified minimum thickness.

If the thermal spray coating local thickness is less than 90% of the specified minimum value, an additional layer shall be applied to meet the minimum thickness requirement.

If the local thickness is greater than 150% of the specified maximum value, the COMPANY shall be notified for resolution of this discrepancy. The pull of adhesion test may be performed on a coating with excessive thickness to check its integrity (max thickness is 1000 microns). Any unacceptable applied thermal spray coating shall be blasted off and a new coating applied, in compliance with this specification.

Records shall be kept of all areas with coating thickness outside the specified minimum or maximum value.

15.4.3 Adhesion Strength

The adhesion strength between the thermal spray coating and the steel substrate shall be measured by means of a portable, self-aligning, hydraulic controlled adhesion tester in accordance with ISO 4624.

The adhesive between dolly and the thermal spray coating shall be an epoxy.

The maximum pull-off adhesion strength for thermal spray coating shall be minimum 7 MPa for any single measurement. Three measurements shall be performed per test panel. If any of the three measurement falls below the minimum specified value of 7MPa the degraded TSA coating shall be removed and reapplied.

15.4.4 Bend Test

During the application of thermal spray coatings, steel companion coupons shall be used to monitor the quality of the thermal spray coating.

The bend test entails bending at least three steel coupons (dimensions as per SSPC-CS 23.00 / AWS C2.23M / NACE No. 12) through 180° on a 13 mm diameter steel mandrel.

For the test coupons, the same type of steel shall be used as for the actual component or structure to be coated. Surface preparation, painting material, spray technique, painting thickness, etc., shall comply with this specification.

Three companion coupons shall be abrasive blasted and sprayed to the specified minimum thickness Range and a minimum of three bend tests shall be performed once per 100 m² (1070 ft²) of thermal sprayed surface, with a minimum of three bend tests per day per shift, and / or after any change in parameter settings of the spray apparatus. When the test has shown a repeatable sufficient performance, the COMPANY may decide to reduce the test frequency. The thermal sprayed coupons for the bend test shall not be sealed or top coated.

15.4.5 Test Requirement for TSA Coating During TSA Production Coating

Table 15.2 Test Requirement for TSA Coating During TSA Production Coating

Property	Test Method	Measurements	Acceptance Criteria
Coating Appearance	Visual Inspection	100% surface	Uniform appearance, no blister, Barge patches, defects or non-adhering coating.
Coating Thickness	ISO 2808	All surfaces	250 to 500 microns
Coating Adhesion	ISO 4624	At least 3 at random	> 7 MPa (1000 psig / 68.95 barg) Single measurements.
Bend Test	SSPC-CS 23.00 / AWS C2.23M / NACE No. 12	At least 3	Minor cracks, with no coating lifting or spalling.
Sealer	Visual Inspection and Holiday Test	100% of surface	100% coverage, no open pores present at the surface / No holiday.

15.5 Coating Repair

The SUB-CONTRACTOR shall produce a painting repair procedure, to be agreed by the COMPANY. Only qualified painting repair methods shall be used, in compliance with this specification. This repair procedure shall be verified and approved during the qualification trials. If the thermal spray coating has been mechanically damaged and Barge substrate metal is observed, the painting shall be repaired, including the local (repair) application of a new sealer, and / or topcoat, if applicable.

The damaged area shall be pre-cleaned, followed by local blast cleaning to a minimum of Sa 2.5, in compliance with this specification.

Edges of the remaining existing painting system shall be feathered by abrasive blasting, and the remainder of the adjacent coated surface shall be properly protected.

Local repair application of thermal spray coating shall follow this specification, including the application of new sealer and topcoat.

In cases where defect sizes are small, it may be acceptable to use a liquid paint to repair the damage. The maximum defect size allowable for liquid paint repair shall be 10 cm² (1.55 in²). The use of liquid paint repairs shall be approved by the COMPANY.

Where thermal spray coatings show local surface damage, the area shall be pre-cleaned followed by localised sweep blasting. The adjacent coated surface shall be properly protected (masking). The locally restored thermal spray coating, including sealer / topcoat, shall meet the minimum thickness requirements.

Where the sealer or topcoat has been damaged, the surface shall be prepared by abrasion with medium coarse abrasive until a clean bright surface is visible. Edges of the remaining coating at the location of the repair shall be feathered. The re-applied sealer / top-coat system shall be compatible with the existing painting system.

16 INSPECTION RECORDS AND REPORTS

The SUB-CONTRACTOR shall produce a daily report recording all relevant information appertaining to the surface preparation and coating activities. The report shall contain details on the coatings of all coated items, of actual coating materials consumed by product number, description and batch number. The report shall include the names of operators who carried out blast cleaning and coating, the time started and finished, and the number of litres consumed. In the event of a coatings failure, it should be possible to retrieve the relevant surface preparation and coatings data for the item whose coating system has failed.

The SUB-CONTRACTOR shall also keep a daily log of environmental conditions as follows:

- a. Ambient conditions

The above readings shall be recorded every 4 hours during work.

Prior to final acceptance of coating work, COMPANY and CONTRACTOR shall perform a final joint inspection. Inspection results shall be recorded, agreed and signed by both parties. The report shall consist, as a minimum, of the following:

- a. Names of the CONTRACTOR and the responsible personnel.
- b. Dates when work was carried out.
- c. Equipment and techniques used.
- d. Materials receipt condition.
- e. Type and calibration of instruments used.
- f. Weather and ambient conditions.
- g. Painting periods.
- h. Condition of surface before preparation.
- i. Tools and methods used to prepare surface.
- j. Condition after preparation.
- k. Information on systems being applied.
- l. Mixing and testing prior to application.
- m. Paint application techniques.
- n. Batch Certificates from the Coating MANUFACTURER.
- o. Daily Painting report.

17 MAINTENANCE AND PAINTING OPTIONS

COMPANY's operating companies shall use their own dedicated documentation for maintenance purposes, in conjunction with this specification.

17.1 General

The implementation of a maintenance painting option for a coating remedial work should be in accordance with COMPANY policy related to the activities which are undertaken to preserve the integrity or the functionality of structures, process system and equipment.

After the data collected during the inspection of the structures or components are reviewed, the different categories of maintenance operation should be defined.

Based on the requirements reported in this Specification, the categories of maintenance operations listed in the following items may be performed.

For the purpose of this Specification the different maintenance painting options are identified as follows:

- a. Refurbishment:
 - i. Spot Repair
 - ii. Spot Repair and Full Topcoat
- b. Renovation
 - i. Renovation and complete recoat

For interpretation of the requirements listed for each maintenance painting option governed by this Specification, the following definitions related to the rust distribution have been used:

- a. Spot rusting: spot rust occurs when the rust formation is concentrated in a few localized areas of the coated surfaces under examination.
- b. General rusting: general rusting occurs when various size of rust spots is randomly distributed across the surfaces under examination.
- c. Pin-point rusting: pin-pointing rusting occurs when the rust is distributed across the surfaces under examination as very small individual spot of rust.

17.2 Refurbishment

17.2.1 Spot Repair

The spot repair has to be considered refurbishments operation namely repairs of the existing coating, performed by surface preparation and touch-up of localized areas of deteriorated coating and corrosion.

As guideline the spot repair should be considered if the extension of the spot rusting or deteriorated coating is less than 3% localized or when the general rusting, randomly distributed across the surface, is up to rust grade RI2 (0.5%) in accordance with ISO 4628-3.

This type of maintenance painting option shall not be selected if the pattern of the rust is pin-point rusting type, distributed across the surface. Any degree of pin-point rusting shall require renovation as described below.

The presence of other defects such as blistering, cracking, flaking and chalking shall be rated respectively according to ISO 4628-2, ISO 4628-4, ISO 4628-5 and ISO 4628-6. The degree of these defects shall be rated in addition to the rust grade and taking into consideration for the selection of the maintenance painting option intended to be performed. As general guide spot repair should be considered as well in the following circumstances:

- a. The zone and / or areas of the structures to be repaired are hidden or in low-visibility area and thus unimportant to the aesthetics.
- b. Structures are small, not requiring extensive scaffolding or difficult-to-reach areas

17.2.2 Spot Repair and Full Topcoat

The spot repair and full topcoat involves spot repairs of deteriorated coating and corroded areas followed by the application of a topcoat over the entire surfaces, including spot repair areas and intact coating areas.

Spot repair and recoating should be considered if the extension of the spot rusting or deteriorated coating is less than 8% localized or when the general rusting, randomly distributed across the surface is greater than Ri2 (0.5%) and up to rust grade Ri4 (8%) in accordance with standard ISO 4628-3.

This type of maintenance shall not be selected if the pattern is of the pin-pointing rusting type distributed across the surface. Any degree of pinpoint rust shall require renovation as described below.

The presence of other defects such as blistering, cracking, flaking and chalking shall be rated respectively according to ISO 4628-2, 4628-4, ISO 4628-5 and ISO 4628-6. The degree of these defects shall be rated in addition to the rust grade and taking into consideration for the selection of the type of maintenance intended to be performed.

This maintenance painting option should often delay the need to remove the complete existing and intact coating. Spot Repair and Full Topcoat may be considered under the following circumstances:

- a. The intact surfaces of the structures and components intended to be recoated can be easily cleaned, degreased and ready to be top coated.
- b. Adequate evaluation of over coating risk and assessment of the adhesion of the existing coating.

17.2.3 Renovation and Complete Recoat

This type of maintenance shall be performed on the entire surfaces of the components or on extensive localized areas. The renovation operation involves removing the complete existing coating and of all corrosion products followed by the application of the original paint system applied during construction provided by the applicable painting systems listed in this specification.

Renovation should be considered if the extension of the rust areas or deteriorated coating is higher than those described under spot repair and recoating namely spot rusting greater than 8% or general rusting greater than Ri4 (8%) in accordance with ISO 4628-3, including all surfaces affected by pin-pointing rusting type, distributed at any rate across the surface.

As guide, the renovation and complete recoat may be considered as well in the following circumstances:

- a. The overall coating conditions of the structures or components are poor due to the presence of extensive rusted and damaged areas.
- b. When the remaining life of the structures or component justifies this type of maintenance.

17.3 Criteria for Maintenance Coating in Atmospheric Service

Criteria for application of different types of maintenance coating shall confirm to Table 17.1 for atmospheric service.

Table 17.1 Recommended Maintenance Painting System Options

Options	Rust Distribution Type and Adhesion		
	Spot Rusting	General Rusting	Adhesion
Refurbishment			
Spot repairs	< 3 %	≤ Ri2	Not required
Spot repairs and full topcoat	3 ≤ % ≤ 8	2 ≤ Ri ≤ 3	> 2 MPa (300 psig / 20.68 barg) by pull off test as per ASTM D4541 Or > # 2 (knife test) as per ASTM D6677
Renovation			
Renovation and complete recoat	≥ 8 %	> Ri3	Not required

17.4 Spot Repair Procedure

After pre-cleaning, small defects in the existing coating system shall be (spot) blast cleaned.

Carbon steel, low-alloy steels and hot dip galvanized steels shall be spot blasted to the visual standard of SSPC-SP 10 / NACE No. 2 at the time of coating. The cleaned defects shall be touched-up to the specified coating thickness. Spot repair shall be considered if the coated area has localized (spot) rusting only and the remaining coating system is sound and adequate. Coating next to the damaged area shall be lightly abraded by sweep blasting achieving a minimum overlap of 2 inch. Alternatively, if abrasive blasting is infeasible, pneumatic power tool cleaning is allowed. However, in these instances, the recommended power tool is the MBX bristle blaster or equivalent and approved by COMPANY. This specially developed surface preparation tool can achieve the required anchor profile and near white cleanliness required of epoxy coatings. If the area of the repair is less than 30 cm² (1 ft²), the surface shall be abraded by using the MBX bristle blaster. All other requirements above apply.

Repairs to coating systems shall be made using the same materials as the base system. If a paint system is repaired with components that are incompatible with the underlying materials, dis-bonding and under corrosion will result. When recoating existing facilities and the information on the original paint system is unknown, determine whether the repair system is compatible with and will adhere to the existing paint system before using the repair system on a large scale. One or more of the following steps may be required:

- Request recommendations from the repair system Coating MANUFACTURER and the existing system Coating MANUFACTURER (if known).
- Apply the repair material to a test area and determine compatibility and adhesion. This step is always recommended. This is particularly important where:
 - A gloss retention coat was used,
 - The original paint is not readily identifiable,

- iii. Consider using a universal primer Bargrier coat as an intermediate coat. When repairing a paint system with a polyurethane topcoat, first apply epoxy primers and intermediate paint systems to the repair area(s).
- c. Use sweep blasting, or a similar abrading process, to remove the polyurethane topcoat and roughen the sound coating only in the affected area. Roughening ensures the repair system will adhere to the edges of the polyurethane.
- d. Apply surface tolerant epoxy primer only over polyurethane that has been sweep blasted or abraded. Epoxy material applied over the unprepared polyurethane topcoat will disband and cause coating failure.
- e. Once the surface tolerant epoxy primer has been applied to the repair area and cured, polyurethane may be applied over the epoxy with a minimum of 50 mm (2 in) overlap onto the existing topcoat. Final DFT's for all coating work shall be documented and shall not be exceeded to 600 microns.

17.5 Spot Repair and Full Topcoat Procedure

After the complete initially coated surfaces have been pre-cleaned, defects in the existing coating system shall be (spot) blast cleaned. Carbon steel, low-alloy steels and hot dip galvanized steels shall be spot blasted to the visual standard SSPC-SP 10 / NACE No. 2 at the time of coating. If the remaining part of the existing coating system needs sweep-blasting, fine abrasive shall be used to avoid damage to the coating system. The cleaned defects shall be touched-up with the base layers of the specified coating system. Thereafter a full coat of the initial top layer(s) shall be applied. Refurbishment shall be considered if the whole coated area shows more rusting than described under spot repair. Refurbishment shall not be selected if the rusting pattern is of the pinpointed type. Any degree of pinpoint rusting shall require renovation; see below.

17.6 Renovation Procedure

After the complete initially coated surfaces have been pre-cleaned, all surfaces shall be blast cleaned. Carbon steel and low-alloy steels shall be blasted to the visual standard SSPC-SP 10 / NACE No. 2 at the time of coating. After the surface preparation, a completely new coating system shall be applied. Renovation shall be considered if the rusting pattern as described in ISO-4628-3 is pin-pointed over the whole coated area or if the rust grades are higher than those described under refurbishment.

17.7 Stainless Steels

Where coating maintenance to stainless steel surfaces is required, the entire surface shall be thoroughly sweep blasted to remove flaking and poorly adherent paint and to provide a surface roughness to any well-adhered paint surfaces. This shall then be followed by the appropriate, compatible maintenance painting system.

SECTION B PART 2 - TECHNICAL REQUIREMENTS (INTERNAL LINING)

18 GENERAL

This section defines the lining systems intended to be applied to the interior of process / pressure vessels, piping, tanks and equipment for oil and gas production and processing facilities of COMPANY.

Internal lining of vessels is not permitted when operated at pressure ≥ 50 Barg.

If any requirement or operating parameters not covered in following section, the coating system shall be evaluated on individual case by case basis by COMPANY.

19 HANDLING

Preparation for shipment of all lined items shall be in accordance with the Lining MANUFACTURER's and SUB-CONTRACTOR's standards. SUB-CONTRACTOR shall be solely responsible for the adequacy of the preparation for shipment provisions with respect to materials and application, and to provide equipment at the destination in ex-works condition when handled by commercial carriers.

Adequate protection of lined equipment and piping shall be provided to prevent mechanical damage and atmospheric corrosion in transit and at the job site.

Preparation for shipment and packing will be subject to inspection and rejection by COMPANY's / CONTRACTOR's inspectors. All costs of lined equipment occasioned by such rejection shall be to the account of the SUB-CONTRACTOR.

After inspection and test, equipment or piping shall be completely free of water and dry before start of preparation for shipment.

20 EXECUTION

Internal lining shall be with accordance to COMPANY's approved / qualified lining system. Prior to commence the internal lining works, CONTRACTOR / SUB-CONTRACTOR shall submit a detail application procedure with approved lining system.

The SUB-CONTRACTOR is solely responsible for supply of installed and consumable materials, equipment (air compressor, after cooler, blast cleaning, dehumidifying, ventilation, spray etc.), tools, instruments and labour (application, supervision, quality control etc.) and each and every item of expense to supply, apply, cure and check the integrity of the entire lining system in accordance with this specification. Application of the lining system consists of, by way of example but not by limitation, surface conditioning, degreasing, removal of water solubles, blast cleaning, priming (if applicable), lining application, full cure and quality checks and any repairs.

All blast cleaning personnel and lining personnel shall be prequalified at least one week prior to start of work. Each qualified person shall wear an identification badge which shows that he / she has been tested and qualified to perform the work.

The lining work shall be performed when all the following conditions exist:

- a. All blast cleaning and lining personnel are pre-qualified.
- b. All inspection equipment is ready.
- c. All Referenced Panels are ready and approved by CONTRACTOR and COMPANY.
- d. All specified materials are available on site with suitable storage e.g. air conditioning.

- e. Approved specific application procedure and approved ITP from COMPANY.
- f. All Application Data is available to each of the involved personnel at the site.
- g. All welding and pressure test (hydrotest) tasks are completed.
- h. The substrate metal temperature is above 10°C and below 50°C.
- i. The substrate metal temperature is at least 3°C above the dew point.
- j. All the surfaces to be coated are dry.
- k. The relative humidity is below 80%.
- l. Ventilation equipment is properly set-up.
- m. Dehumidifying equipment is ready to operate when necessary.
- n. Adjacent surfaces have been covered or otherwise protected.
- o. All surfaces and equipment which will be adversely affected are protected from abrasives.
- p. When the available light is more than 500 lux.
- q. SUB-CONTRACTOR's method statements are approved by the COMPANY, with due care and attention paid to health, safety and environmental issues.

21 MATERIALS AND EQUIPMENT

Alternate materials of similar quality or better to specified product may be submitted for the approval of the COMPANY.

21.1 Degreaser

The degreaser shall be water based biodegradable cleaner.

21.2 Abrasives

Abrasives shall be composed of clean, hard particles free from foreign substances such as dirt, oil, grease, toxic substances, organic matter, mill scale, soil and water-soluble salts. The pH of the abrasive materials shall not be below 6.2. The moisture content of the selected abrasive shall not exceed 0.5 percent by weight. The conductivity of deionized water extract of the abrasive material shall not exceed 150 micro-siemens/cm.

Abrasive shall be garnet for blast cleaning all surfaces. Steel grit or garnet may be used for blast cleaning tank floors. Silica sand, copper slag, and steel shot shall not be used.

The abrasive shall be capable of producing the degree of cleanliness and surface profile specified in this specification.

The particle size of the abrasive shall be 0.1 mm to 1.5 mm.

21.3 Equipment

Spray equipment shall be maintained in good working order and shall be comparable to that described in the Application Data.

Dehumidifying equipment shall be of a sufficient size to provide the required air changes at the temperature and humidity levels stated in the Application Data.

Ventilation equipment and ducting shall be of a sufficient size to provide the required air changes stated in the Application Data. They shall also be sufficient in size to prevent any solvents being trapped inside the lined item.

Scaffolding / staging shall be erected to permit safe and easy access to all areas of tank for lining surface preparation, application, inspection and testing:

Scaffolding / staging shall also meet the following requirements:

- a. The points of contact with surface to be coated / coated surface shall be kept to minimum. All points of contact on coated surface shall be holiday tested at the first signs and coating damage.
- b. Split boards shall not be used.
- c. Pole ends shall not be sealed.
- d. Staging shall not mask the areas of surface to be coated.
- e. Every care must be taken to avoid damage to the coating.
- f. All scaffold materials shall rest on a rubber pad or a composite pad made of carpeting and plywood with the carpeting facing the coated floor.

21.4 Compressed Air

All air compressors shall be of a sufficient size to deliver 7 kg/cm² at the nozzle. Each compressor shall have two oil / moisture filters, one located at the compressed air exit of the compressor and one located just before the after cooler.

Compressed air used for blasting and lining application must be clean, oil free and dry.

The compressed air shall be passed through a dryer package.

Proper functioning of the in-line moisture and oil traps shall be evaluated daily by allowing the air supply (downstream from the traps) to blow against a clean, white cloth in accordance with ASTM D4285. No moisture or oil should be deposited on the cloth. If contaminants are detected, the equipment deficiencies shall be corrected, and the air stream shall be retested. Surfaces determined to have been blasted since the last successful test shall be degreased and re-blasted with clean air and abrasive. Linings determined to have been applied using contaminated air shall be removed and new linings applied using clean air.

21.5 Lining Materials

Lining materials shall be as stated in APPENDIX A12.

Thinners and cleaners shall be products of the MANUFACTURER of the lining system materials and as recommended in the Application Data. Cleaners shall not be used as thinners.

22 GENERAL REQUIREMENTS

22.1 Surface Conditioning

SUB-CONTRACTOR shall ensure compliance with the following design guidelines and NACE SP0178 prior to surface preparation and lining application:

All edges of clips, plates and other items shall be rounded or chamfered to a minimum radius of 3 mm.

All interior welds shall be continuous seal welds.

Welds shall be free of porosity, pockets and high spots. Welds shall be blast cleaned lightly for the purpose of inspection. If blast cleaning reveals unacceptable weld defects, such as laminations, slivers, pinholes, undercuts or craters, they shall be repaired.

Ripples in weld beads shall be ground smooth and edges blended smoothly into the adjacent plate surface.

Surface quality of welds shall be at least equal to or better than NACE SP0178, Weld Designation D.

All weld slag, splatter and flux shall be removed.

Welding or removal of any temporary attachments and hydrotesting shall be completed before surface preparation and lining application.

22.2 Dehumidification

Surfaces must be maintained at least 3°C above the dew point, immediately before and during the lining installation and remain in this condition during curing. To comply with this requirement, dehumidifying equipment shall be at the site. The capacity of the dehumidifying equipment shall be as recommended by the dehumidifying equipment Lining MANUFACTURER.

The typical minimum dew point differential specified for holding a blast over an extended period of time is 9 to 14°C with a relative humidity not to exceed 40% to 55%. The CONTRACTOR should refer to SSPC-TR 3 / NACE 6A192 - "Dehumidification and Temperature Control during Surface Preparation, Application, and Curing for

Coatings / Linings of Steel Tanks, Vessels, and Other Enclosed Areas" for guidance. The air temperature, relative humidity, dew point and steel temperature are to be recorded hourly throughout the duration of the work through a computerized system as well as verified manually. A detailed method statement on how the CONTRACTOR proposes to maintain the environmental conditions throughout the duration of the work is to be submitted.

22.3 Ventilation

During all blast cleaning operations, ventilation shall be maintained to allow adequate visibility and for safety. Flexible ventilation ducts shall be used to allow the point of extraction to be reasonably close to the blaster. The ventilation ducts shall be arranged so that dead spaces do not exist.

Ventilation must be maintained during the entire lining application and continue while the solvent is released from the lining film during drying. The ventilation system must prevent the vapor concentration from exceeding 10 percent of the lower explosive limit (or less than this if required by the local regulations).

Proper exhaust shall be maintained using ducts of appropriate size at various levels inside the item being lined.

The number of air changes in confined spaces during lining installation and curing shall be 10 air changes per hour. The forced cross air ventilation shall be maintained during the entire curing period of internal lining after the application of the lining system.

To minimize dry spray during application, a lower level of ventilation shall be maintained. The number of air changes shall be determined by the SUB-CONTRACTOR subject to safety considerations.

Provisions shall be made for 24-hour surveillance of any ventilation equipment.

22.4 Lighting

In accordance with SSPC-Guide 12 for illumination of industrial painting projects.

Lighting during blast cleaning and lining application must be electrically safe, explosion-proof and provide suitable illumination for all work. Low voltage lights, approved by the CONTRACTOR, shall be used. High voltage lights shall not be used inside the item being lined. All circuit boxes and switches shall be located outside of the equipment being lined.

Cable Joints shall not be allowed inside the equipment.

22.5 Surface Preparation

All Surfaces shall be degreased with a biodegradable water based cleaner. Degreased Surfaces shall be thoroughly washed to remove any film of the degreaser.

All water-soluble compounds shall be removed by additional washing with potable water. After washing, the Surfaces shall be tested for water soluble salts with a salt testing kit, approved by COMPANY, in accordance with ISO 8502-6 & 9, the Bresle method. If the quantity of water-soluble salts is more than 2 micrograms per square centimetre, washing shall be repeated until the acceptable range of soluble salt is attained.

Surfaces shall be dried with natural ventilation. If forced air is used, the air shall be oil free.

All coatings applied in the shop such as prefabrication shop primers shall be completely removed by blast cleaning.

All Surfaces shall be blast cleaned with clean, dry premium grade garnet to white metal. Floor Surfaces may be cleaned with steel grit if a vacuum blast cleaning unit is used.

Garnet shall not be recycled for blast cleaning. Steel grit may be reused for floor surfaces when a vacuum blast cleaning unit is used provided the grit is checked for oil contamination at least once per every 100 square meters of floor surface and recyclable unit is available. If oil contamination is suspected, the grit shall be immediately discarded, and 100 percent of the cleaned floor surface shall be checked for oil contamination using a black light. Any contamination on the floor shall be completely removed.

Before initial blast inspection, the bulk of the spent abrasive shall be removed. Any substandard areas including burrs, slivers, scabs and weld splatter shall be identified and repaired. All marking paint, chalk, etc. shall be removed after repairs.

All Surfaces shall be thoroughly cleaned to remove all embedded materials from the surface. Industrial vacuum cleaners fitted with non-metallic brushes shall be used to remove surface dust and embedded materials. Blowing the dust with compressed air is not permitted.

Cleaning shall be carried out on all areas on which debris or dust can collect. This shall include but is not limited to scaffolding, underside of the lowered floating roofs, support columns, etc.

The steelworks for lining application shall be checked after the final cleaning process is finished in accordance with applicable ISO.

During blast cleaning operations, the spent abrasive shall be periodically removed. Before the end of day, all spent abrasive shall be removed, and floor surface shall be kept tidy.

22.6 Care of Cleaned and Coated Surfaces

Surfaces shall be protected from contamination. All personnel shall wear clean coveralls, gloves and shoes. Surfaces shall be protected from contamination due to fingerprints, foreign material on workers' clothes and shoes, dust, lint or moisture.

Once a Surface has been cleaned or at any stage during the lining sequence, surfaces must be kept in a clean condition. A clean area shall be established outside the tank, where footwear may be cleaned, or preferably changed before entering the tank.

If rusting occurs, the surfaces shall be recleaned to the degree specified in the previous sections.

The surfaces shall be maintained free of moisture, dust and any contamination until the lining cures.

If contaminants are present on the surface to be lined or relined, the contamination shall be fully removed before applying the subsequent coats. If such removal is not feasible, the surface shall be completely recleaned or contaminated lining shall be completely removed, and the lining process shall be repeated.

23 LINING MATERIAL APPLICATION

23.1 General Requirements

Lining application shall not commence when the substrate temperature is higher than 50°C or as required by Application Data where this is more stringent.

If specified as a part of the lining system, a prime coat or the first coat of the lining system shall be applied within a maximum of four hours after the abrasive blast cleaning operation is completed or, before blasted surfaces start to rust, whichever is sooner. Surfaces that change colour or rust bloom begins to form shall be re-blast and cleaned to the specified degree of cleanliness.

All weld lanes, edges of support steel, steel plate laps, or other irregular surfaces, where spray application of material may result in holidays or inadequate dry film thickness, shall have the first coat applied by brush.

Roller application of the lining is not allowed.

The applied lining shall not have any surface defects such as cracking, runs, sags, voids, drips, overspray, dry spray, pinholes, blisters, craters, orange peel, fisheyes and other defects.

The bond strength between the substrate, the lining and between coats shall not be less than the requirements stated in Section 26.6. Testing shall be in accordance with ISO 4624 after full cure and at the time of holiday testing.

The dry film thickness of each coat shall be within the minimum and maximum limits stated in APPENDIX A12 or as required by Application Data where this is more stringent.

23.2 Lining Systems

Surfaces shall be lined in accordance with the Lining Schedules within APPENDIX A11, the Lining Systems within APPENDIX A12, and Tank Data Sheets. The systems are specified by generic type and approved by COMPANY.

23.3 Service and Lining Systems Schedule

Storage tanks in the services listed in the attached APPENDIX A12, shall be lined with the linings systems indicated therein. Unless otherwise indicated in this specification or on the tank data sheets / drawings, all the entire interior surfaces shall be fully lined, cured and tested. The lining shall extend beyond the full face of all flanges of nozzles and manholes unless otherwise noted.

23.4 Mixing of Materials

Mixing of materials shall be completed using power type mixers and always in the proportions and the order specified in the Application Data. Mixing shall be completed at moderate speeds so that air bubbles and / or moisture is not introduced into the lining materials. Any lining materials into which either air or moisture are inducted shall be discarded.

The addition of thinners shall not be permitted for internal lining work.

When performing repairs, materials in smallest commercially available factory packaged kits shall be used. Mixing of materials which are approximately proportioned at the worksite is not allowed. Only complete, premeasured units shall be mixed.

After mixing the components of two-part linings, rinse hardener can with thinner to ensure that correct proportions are kept. Lining materials shall be thoroughly mixed and strained until they are smooth and free of lumps.

After mixing, induction times of the lining materials shall be maintained, and mixed materials applied within the time limits stated in the Application Data.

23.5 Number of Coats and Thickness of Lining

The number of coats shall be as noted for each specific lining system.

Each coat shall be gradually built-up by multiple vertical and horizontal passes with each pass overlapping the previous pass by 25 to 50 percent without runs, sags and dry spray.

The colour of each coat, specific to RAL and based on the application, shall contrast with succeeding coat and shall be factory tinted. Onsite tinting is not permitted.

Inter-coat contamination shall be minimized by maintaining proper cleanliness. Contaminants shall be fully removed before applying the subsequent coats. If such removal is not feasible, the contaminated lining shall be completely removed, and the lining process repeated.

Compensation of higher or lower thickness of any coat by adjusting the thickness of the succeeding coat is not permitted.

Dry film thickness measurements shall be made in accordance with ISO 2808.

Allowable errors of margins in instrument readings are +25 percent for thin films of 25 to 100 microns thick and +10 percent for films of 125 to 500 microns thick. Gauges used must have adequate range in order that the anticipated dry film thickness will be read mid-range on the gauge scale.

23.6 Recoating

Drying times between coats shall be in accordance with the Application Data.

Unless otherwise approved by COMPANY, the minimum recoating time shall be at least 24 hours and the maximum recoating time shall not exceed 75 percent of the longest recoating time stated in the Application Data.

23.7 Curing

The SUB-CONTRACTOR is solely responsible for full curing of the lining system including repaired areas.

The curing shall be in accordance with this specification.

The SUB-CONTRACTOR shall transfer custody and control of the vessels, piping, tanks or equipment to the CONTRACTOR after full cure of the lining systems and linings are in the ready-to-use condition.

23.8 Continuity Testing of The Lining

The SUB-CONTRACTOR shall inspect 100 percent of the lined surface for the presence of discontinuities in the lining at the voltage levels calculated in accordance with NACE SP0188 or according to the Lining MANUFACTURER. The entire surface shall be 100 percent free from discontinuities, holidays and pinholes.

The continuity testing shall be made after full cure of the lining system. All holidays shall be repaired and rechecked. Repairs shall be made in accordance with a repair procedure approved by COMPANY.

24 LINING IDENTIFICATION

All tanks, pressure vessels, and equipment that have been internally lined shall be marked as follows:

The Interior of This Equipment Is Lined with (Lining Brand Name and Catalogue Number).

Lining MANUFACTURER's Address (City, Country).

Do Not Weld.

Date of Application.

The marking letters shall be at least 150 mm high and in contrasting colour. Marking shall be applied at all nozzles and shall be in English and Arabic.

25 LINING REPAIR

The decision to repair lining defects shall be made on a case-by-case basis by the COMPANY.

Lining repairs shall be allowed, provided that the repair area is less than 5% of the total area. If repairs exceed 5% of the total area, the entire tank shall be relined. COMPANY shall make the final decision on repairs versus total relining.

The repairs described in the following paragraphs are intended only as guidelines.

Surfaces adjacent to repair areas shall be protected from damage. Suitable protective cover shall be cardboard or similar material.

Damaged surface lining shall be removed unless it is tightly bonded to the substrate metal. The surface shall be wiped with a clean rag to remove all dust and loose materials. Oil, grease or other foreign matters present shall be washed with a water based biodegradable cleaner followed by further rinsing with potable water to remove all traces of the cleaner. The surface shall be dried.

Areas with spot rust, burnt residue, weld spatter and other solid adherent foreign material shall be cleaned using portable vacuum blast cleaning unit. Other methods of surface conditioning may be acceptable with prior agreement by the CONTRACTOR.

Surfaces with pinholes may be cleaned using pencil-head type grinding wheel. Pinholes shall be repaired as follows:

- a. Grind back to the steel substrate at the pinholes and feather the edges of the existing lining with clean sandpaper back for a radius of 3 to 5 cm, ensuring that the steel substrate does not become polished.
- b. All dust shall be removed with a vacuum cleaner equipped with a brush.
- c. Brush full system (except primer) on to the prepared surface.
- d. Allow the material to cure to a tack-free state and recoat as necessary to bring thickness to that specified.
- e. Allow the material to cure and retest the repaired area for pinholes.

Primer material shall not be used as a repair material as it will affect the integrity of the lining system in the areas where primer material overlaps the existing lining.

Repair materials shall be the same as the lining system materials with the exception of primer materials. Repair system shall be the complete lining system less the primer material.

Areas under and over thickness shall be repaired as follows:

For Under Thickness (Spot Work):

- a. Uniformly abrade all surfaces so at least 75% of the surface area is randomly roughened and wipe with acetone to remove dust and contamination.
- b. Apply one coat of topcoat, checking wet film thickness during application to achieve necessary thickness.
- c. After cure, recheck dry film thickness of the repaired areas.

For Over Thickness (Spot Work):

- a. Abrade the area to an acceptable thickness using suitable equipment.
- b. Holiday test the sanded area.
- c. All other repair requirements shall be in accordance with NACE RP0184.

26 INSPECTION

26.1 General Inspection

Prior to commencement of internal lining activities, the SUB-CONTRACTOR shall submit an inspection procedure indicating inspection and tests to be conducted during surface preparation and application of the lining system for approval by COMPANY.

The SUB-CONTRACTOR is solely responsible for all the tasks of quality control and quality assurance including maintaining the necessary documentation for a period of five years to verify compliance with this specification regardless of partial, full, intermittent or continuous inspection by the CONTRACTOR.

The applied lining shall be free of runs, sags, voids, drips, overspray, pinholes, loss of adhesion, blistering, peeling, inadequate cure, spot rust, localized rusting and any other defects.

All defects shall be repaired and re-inspected:

- a. As a minimum, inspection hold points for Third Party Agency (TPA) shall be established as follows:
- b. Prior to start of work.
- c. Immediately following the surface preparation.
- d. Immediately prior to the application of each coat.
- e. Following the application of each coat.
- f. Following the curing of the lining.
- g. To witness holiday testing.

Prior to using compressed air, the quality of the air downstream of the separator shall be tested in accordance with ASTM D4285. This test shall be performed at the beginning and end of each shift and at not less than four-hour intervals. The test also shall be made after any interruption of the compressor operation or as required by the CONTRACTOR.

The air shall be used only if the test indicates no visible contamination, oil, or moisture. If contaminants are evident, the equipment deficiencies shall be corrected, and the air stream shall be retested. Separators shall be bled

continuously. All lines shall be tested individually prior to use. Surfaces which are determined to have been blast cleaned or blown down with contaminated air shall be recleaned and re-blasted with clean air and abrasive. Coatings which have been determined to have been applied using contaminated air shall be removed and reapplied using clean air.

The temperature, dew point, and relative humidity shall be determined with a sling psychrometer or an accepted equal following procedure in ASTM E337 or other procedures permitted by the CONTRACTOR. Surface temperature shall be determined using surface temperature thermometers. Readings are required at the start of work and every four hours or at time intervals designated by the CONTRACTOR.

26.2 Surface Preparation

NACE SP0178 shall be used for inspection of Surfaces before blast cleaning.

SSPC-VIS 1 Visual Standards shall be used to verify the degree of surface cleaning. They shall not be used to compare surface profile depth. Profile depth shall be verified in accordance with NACE SP0287.

Tests indicating the extent of substrate contamination as a result of iron, chlorides and dust shall be performed in accordance with ISO 8502-1, ISO 8502-2 and ISO 8502-3 respectively.

Abrasives for blast cleaning shall be sharp, angular, clean, dry and free of oil or contaminants. The particle size shall be capable of producing the specified surface profile. The degree of cleanliness and depth of profile shall be recorded.

Recirculated grit used for vacuum blast abrasive cleaning shall be tested for the presence of oil by immersing a sample in water and checking for oil flotation. Tests shall be made at the start of blast cleaning, every four hours thereafter, and at the end of blast cleaning. If oil is evident, the contaminated abrasive shall be cleaned or replaced. All surfaces blasted since the last successful test shall be re-blasted using clean abrasive.

All surfaces shall be inspected immediately prior to the application of the first coat of lining material to ensure compliance with the specified degree of cleanliness and limits set forth for water soluble salts on the surfaces to be coated.

Verify welds are acceptable relating to roughness, continuity, porosity and sharp edges.

Grease-free chalk shall be used to mark local areas which do not meet the specified requirements and later removed during repairs.

26.3 Application of Lining

The SUB-CONTRACTOR shall request the Lining MANUFACTURER to supply three reference panels with lining material applied by the Lining MANUFACTURER at least fifteen days prior to the start of the work in accordance with the Application Data and requirements stated in this specification. The reference panels, at least 300 mm by 300 mm, shall be used to compare the workmanship of the finished lining inside the tank. Each panel shall be of step wise construction showing the degree of blast cleaning and all succeeding coats. SUB-CONTRACTOR shall notify the CONTRACTOR when the panels will be prepared so that the CONTRACTOR may witness such preparation. All reference panels shall be approved by the CONTRACTOR for compliance with this specification before they can be used as inspection standards. One panel shall be used by the SUB-CONTRACTOR, one panel by the CONTRACTOR and the third panel shall be kept by the CONTRACTOR as a reserve set.

The SUB-CONTRACTOR shall also prepare three reference panels (300 mm x 300 mm) under site conditions in accordance with the approved lining procedure. These panels shall be compared with the panels supplied by the Lining MANUFACTURER for workmanship. Subsequent to approval of workmanship, the adhesion of the primer

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

The acceptance criteria for these tests shall be proposed by Lining MANUFACTURER and approved by the CONTRACTOR / COMPANY.

26.4 Lining Inspection

Verify that the lining material is stored in a pre-assigned area at the temperature range specified in the Application Data.

Record batch numbers of the lining material.

Verify that the shelf life of the lining material has not been exceeded.

Verify that the mixing of the lining materials and amount and type of thinner is in accordance with the Application Data.

Verify that substrate, ambient, and material temperatures are within the range specified in the Application Data. Work shall not proceed unless humidity and dew point are within the specified limits.

Verify the lined surface is free of abrasives, contaminates, runs, and sags and other lining defects prior to the application of successive coats.

Verify the method of application, time interval between coats, number of coats applied, and the minimum cure time to put the lining into service, are in accordance with the Application Data.

The required dry film thickness of each coat shall be in accordance with the requirements stated in this specification. Verify the gauges are properly calibrated and the readings obtained are recorded.

Five separate spot measurements (average of three individual readings) spaced evenly over each 9.3 square meters shall be taken. The average of five spot measurements for each 9.3 square meters shall be within the specified thickness. The DFT measurements shall be in accordance with SSPC-PA 2.

All lined steel shall be 100 percent inspected for holidays after full cure of the lining system and in accordance with the requirements of NACE SP0188. Voltage settings shall be as recommended by the Lining MANUFACTURER and approved by the CONTRACTOR and COMPANY.

26.5 Inspection Instruments

The following inspection instruments shall be supplied, calibrated and maintained by the SUB-CONTRACTOR and available to the CONTRACTOR or their authorized representative:

- a. 100 power illuminated inspection microscope.
- b. Binoculars (for visual inspection of high points).
- c. Calibration standards for dry film thickness gauge.
- d. Dry film thickness gauge with computer interface.
- e. Elcometer adhesion tester Model 106/2.
- f. Salt contamination Bresle Kit.
- g. Testex Press-O-Film Kit.
- h. NACE SP0178 surface finish weld replica.

- i. pH strips.
- j. Reference Panels.
- k. Sling psychrometer.
- l. Surface profile gauge and accessories.
- m. Surface thermometer.
- n. Temperature and humidity records (seven-day type).
- o. Low voltage holiday detector.
- p. High voltage holiday detector.
- q. Tooke gauge.
- r. Wet film thickness gauge.

26.6 Inspection Acceptance Criteria

Prior to painting activities commence the CONTRACTOR shall submit an Inspection and Testing procedure with Inspection and Test Plan (ITP) for CONTRACTOR / COMPANY approval.

Frequency of inspection and criteria for acceptance of lining work shall be in accordance with the following table:

Table 26.1 Inspection Acceptance Criteria for Lining Work

Test Type	Method	Extent / Frequency	Acceptance Criteria
Preliminary Tests			
Storage of coating materials	Visual	All	Specification Requirements
Container's integrity	Visual	All	Specification Requirements
Shelf life	Visual	All	Product Data Sheet Requirements
Fabrication and Design Requirements			
Fabrication and design requirements	100%	All	Specification Requirements
Steel imperfections	ISO8501-3	100%	Grade P3
Welding Imperfections	NACE SP0178	100%	Weld Preparation Designation "C" Sharp edges grounded up to 3mm
Surface Preparation			
Environmental conditions	ISO 8502-4	Before start of each shift and every 2 hours	Specification Requirements
Welding flux removal	Distilled water and litmus paper	100%	pH neutral (6.5 - 7.5)

Test Type		Method	Extent / Frequency	Acceptance Criteria
Pre-cleaning of surfaces		SSPC-SP 1	100%	Free of oil, grease and other contaminants
Protection of fittings and accessories		Visual	100%	Specification Requirements
Compressed air		ASTM D4285	Every Shift	Free of oil and moisture
Abrasive materials		ASTM D4940	Every Batch	$\leq 300 \mu\text{mS/cm}$ at 20°C
Abrasive blast cleaning		SSPC-VIS 1	100%	According to SSPC-SP 5
Roughness		NACE SP0287	Spot Checks ⁽¹⁾	Conform to grade specified in the applicable painting systems
Dust test		ISO8502-3	Spot Checks ⁽¹⁾	Maximum rating "1" and dust class "1"
Water soluble salts		ISO8502-6 ISO8502-9	Spot Checks ⁽¹⁾	$\leq 2 \mu\text{mg/cm}^2$ (20 mg/m ²)
Lining Application				
WFT		Metallic "Comb Gauge"	Methodically during application	According to specified DFT
Cleaning of each coat	Dust test Water soluble salts	ISO8502-6 ISO8502-9	Spot Checks ⁽¹⁾	$\leq 2 \mu\text{mg/cm}^2$ (20 mg/m ²)
Mixing ratio		Weighing or volume measurement	Random	According to Lining MANUFACTURER's instructions
Over coating time		Time measurement	All	According to Lining MANUFACTURER's instructions
Curing Test		Bargcol Hardness	Spot Checks	Conform to Data Sheet
DFT of each coat and of complete lining system		ISO19840 and "90/10" rule	100% of surfaces	According to specified DFT
Visual examination		Visual and ISO 4628-1 to 6	100% of surfaces	No sagging, contaminations, orange peel, cracking, blistering, rust, damages and any other defects
Adhesion			ASTM D4541	Spot Checks
Holiday Testing			NACE SP0188	100% surface ⁽²⁾
Stripe Coating by Brush			N/A	Prior to each coat
Curing of the Applied Lining			Forced cross ventilation	100% of surface
Note: 1. Shall be carried out by Bresle procedure. Number and location shall be defined and agreed during pre-job meeting. 2. The 100% holiday testing shall be performed as well on the internal surfaces of all lined nozzles.				

SECTION B PART 3 - TECHNICAL REQUIREMENT (INTERNAL COATING OF LINE PIPE FOR NON-CORROSIVE SALES GAS TRANSMISSION)

27 INTRODUCTION

This section describes the minimum requirements for the internal coating of line pipe for non-corrosive sales gas transmission.

The application of Internal flow coating systems promotes two primary functions:-

- a. Reduced gas friction by provision of a very smooth surface profile.
- b. The inhibiting of Black Powder* formation within the gas pipeline.

The term "Black Powder" is a colour descriptive term used to describe a blackish material (very small, jagged and very hard particles) that can develop within the gas pipelines) due to a reaction of Fe with condensed moisture, containing O₂, H₂S and CO₂) which leads to erosion failures and damage to pipeline operational valves, lowers efficiency of compressors and clogs instruments. This is a world-wide problem that affects most gas Pipeline operators.

The coating may also offer short term corrosion protection during transport and storage, however additional preservation measures may still be required.

It specifies the requirements for coating materials, coating application, inspection and testing and gives procedures for the qualification of coating materials and SUB-CONTRACTORS.

General coating qualification is performed for the purpose of an overall qualification of coating system and SUB-CONTRACTOR but is not necessarily related to a specific project.

With this process, a list of qualified coating systems and SUB-CONTRACTORS is developed, from which the COMPANY may select a coating system and SUB-CONTRACTOR for a specific project. It saves time and avoids re-qualification for similar projects. The general qualification is given independent of line pipe diameter and wall thickness. When required for specific projects, additional testing should be performed on different line pipe diameters and wall thicknesses.

28 COATING AND SUB-CONTRACTOR QUALIFICATION

28.1 General

The coating material shall typically be two-pack epoxy paint. It shall not contain any substances which will be released from the paint film after it has cured and are proven to be detrimental to the operation of the pipeline and the quality of the gas.

Unless otherwise agreed, the coating material shall be qualified in accordance with 28.3 and 28.4 and shall not be changed after qualification.

The MANUFACTURER of the coating material shall provide on request infrared spectrograms of the base component and the curing agent component (see 28.3.8).

In addition, the Coating MANUFACTURER shall provide a product data sheet (see 28.6), a health and safety data sheet and a certificate stating the test results obtained in accordance with 28.3 and 28.4 respectively and, if applicable, deviating test conditions.

The Coating MANUFACTURER shall also provide with every batch of the coating material a batch test certificate stating the information as given in 28.8.

Before a coating system may be applied in a production run, the CONTRACTOR shall submit all the data specified in (28.6) and (28.7) and shall ensure that both the coating system and the SUB-CONTRACTOR have been qualified in accordance with the procedures in (28.4) and (0).

28.2 Coating Material Qualification

Qualification shall be carried out according to the following procedures:

Where it states Annexure, please refer to Document ISO 1574 for explanation

The CONTRACTOR or the Coating MANUFACTURER shall show that samples of the coating system applied on panels of the specified material have been successfully subjected to the tests as specified in Table 28.4. The tests shall be carried out by an independent and certified test laboratory or, if approved by the COMPANY, by the Coating MANUFACTURER. The COMPANY shall witness the application and the tests.

The number of panels to be tested and the test procedures are also given in Table 28.4.

If agreed by the COMPANY, previous qualification data can be used provided that the referred tests have been carried out using the same coating system and the same coating process as specified in the contract. With the approval of the COMPANY, tests carried out in accordance with other coating standards may be used insofar as their procedures are the same as or more stringent than the procedures in this specification.

Such information shall include full reports on test procedures and results and be signed by the laboratory representatives and certification body.

Where, subsequently, external coatings have to be applied, care shall be taken not to allow the internal coating to be damaged by the elevated temperatures which may occur.

28.3 Requirements for Qualification of the Coating Material

28.3.1 General

The following clauses describe the laboratory test methods and requirements for qualification of the individual coating components.

28.3.2 Non-volatile Matter (by mass)

When determined in accordance with ISO 3251, the non-volatile matter (by mass) of the coating material shall comply with the value specified by the Coating MANUFACTURER in the qualification certificate (Table 28.2).

28.3.3 Non-volatile Matter (by volume)

When determined in accordance with ISO 3233, the non-volatile matter (by volume) of the coating material shall comply with the value specified by the Coating MANUFACTURER in the product data sheet (Table 28.1).

28.3.4 Viscosity

When determined by the method specified by the Coating MANUFACTURER, the viscosity of the ready-mixed coating material shall comply with the value specified by the Coating MANUFACTURER in the qualification certificate (Table 28.2).

The viscosity should preferably be measured in accordance with ISO 2431.

28.3.5 Density

When determined in accordance with one of the parts of ISO 2811, the density of the coating material shall comply with the value specified by the Coating MANUFACTURER in the product data sheet (Table 28.1).

28.3.6 Ash (residue on ignition)

When determined in accordance with the method described in annex A, the ash (residue on ignition) of the coating material shall comply with the value specified by the Coating MANUFACTURER in the qualification certificate (Table 28.2).

28.3.7 Pot Life

The pot life is considered to be the time taken by the ready-mixed coating material to reach a condition at which it can no longer be applied satisfactorily. The pot life shall be specified in the product data sheet (see 28.6).

28.3.8 Infrared Spectrograms

Infrared spectrograms of the base component and the curing agent component shall be submitted.

28.3.9 Appearance

The appearance and continuity of the coating shall be inspected visually without any magnification.

28.4 Coating Requirements for the Qualification of the Applied Coating System

28.4.1 Preparation of Test Panels

Perform the tests specified in 28.4.3 to 28.4.13 on coatings applied to the required film thickness specified in 28.4.3 by spraying onto the test panels (steel or glass). Prepare the glass panels as specified in Section 30.

The steel panels shall be grit-blasted to achieve a preparation grade meeting ISO 8501-1 Sa 2.5. The surface profile shall be measured in accordance with ISO 8503-2 or ISO 8503-4 and shall be within 25 and 50 μm , unless otherwise agreed. Both the preparation grade and the surface profile of the test panels shall be included in the qualification test report.

Apply the coating in accordance with the instructions of the Coating MANUFACTURER.

The numbers of test panels to be tested are given in Table 28.4.

28.4.2 Conditioning of Test Panels

The test panels shall be air dried for 10 days at 25°C, followed by 24 hours drying in a circulating-air oven at 50°C. Relative humidity during the drying shall not exceed 80%.

After completing the schedule of conditioning outlined above, panels may be stored at room temperature until needed for testing, but not longer than 90 days.

All testing shall be performed on test panels conditioned according this clause.

28.4.3 Film Thickness

The WFT shall be as specified by the Coating MANUFACTURER's data sheet for the material, either directly or from calculation to achieve the specified DFT. WFT measurement shall be made in accordance with ISO 2808.

28.4.4 Adhesion

When determined in accordance with ISO 2409, the cross-cut classification of the coating applied on steel panels and conditioned (see 28.4.2) shall be equal to or lower than 1.

28.4.5 Buchholz Hardness

When determined in accordance with ISO 2815, the Buchholz hardness of the coating, applied on glass or steel panels and conditioned using cycle B or C (see 28.4.2) shall have a value of 94 or more.

28.4.6 Resistance to Neutral Salt Spray

The coating applied on steel panels with a dry film thickness of 60 μm to 100 μm and with an X-cut down to the substrate located at least 20 mm from any edge, shall be tested in accordance with ISO 9227 for 480 hours. After the test, allow the test panels to dry for at least at to and relative humidity.

The coating shall be free from any signs of deterioration, for example blistering (except in the area within 2, 0 mm from the X-cut), cracking and staining. Any corrosion shall extend not more than 2 mm at the most from the X-cut.

It shall not be possible to remove by means of clear plastic tape more than 3 mm of the coating in any direction from the area around the X-cut.

28.4.7 Resistance to Artificial Ageing

The test panels shall be aged at 80°C in a circulating oven for 100 hours, followed by conditioning for 24 hours at 18°C to 25°C and < 80% relative humidity. After ageing, subject the test panels to a bend test in accordance with 28.4.8.

28.4.8 Bend Test (Conical Mandrel)

Prepare steel panels and condition them (see 28.4.2). When the panels are tested in accordance with ISO 6860, the maximum extent of cracking along the panel from the small end of the mandrel shall be less than or equal to 13 mm, and there shall be no loss of adhesion.

28.4.9 Resistance to Gas Pressure Variations

Prepare steel panels and condition them (see 28.4.2). When the panels are tested in accordance with Section 30, they shall have a generally good appearance when examined in accordance with 28.3.9 and shall not show any blistering. The adhesion value shall fulfil the requirements as given in 28.4.4 after conditioning for and at to and relative humidity.

28.4.10 Resistance to Water Immersion

Prepare steel panels and condition them (see 28.4.2). When the panels are tested in accordance with ISO 2812-2 for 480 hours, the coating shall not show any blistering or appreciable softening. The examination shall be carried out 3 min after the panels have been removed from the test liquid.

28.4.11 Resistance to Chemicals

Prepare steel panels and condition them (see 28.4.2). When the panels are tested in accordance with ISO 2812-1, Method No. 1, Procedure A, for 168 hours, the coating shall not show any blistering or appreciable softening. Use the following test liquids: cyclohexane; 95% by volume diethylene glycol solution in water; hexane; methanol;

toluene and lubricating oil (e.g. compressor seal oil in accordance with ISO 6743-4). The test panels shall be completely immersed in the test liquid.

The examination shall be carried out at 18°C to 25°C and < 80% relative humidity 3 min after the panels have been removed from the test liquid. After conditioning for 24 hours at 18°C to 25°C and < 80% relative humidity, the adhesion value shall fulfil the requirements given in 28.4.4.

A change in the colour of the coating shall not be considered as an indication of inferior coating quality.

28.4.12 Resistance to Hydraulic Blistering

Prepare steel panels and condition them (see 28.4.2). When the panels are tested in accordance with Annex D, the coating shall not show any blistering. The examination shall be carried out at 18°C to 25°C and < 80% relative humidity after the panels have been removed from the test liquid. The adhesion value shall fulfil the requirements given in 28.4.4 after conditioning at to and relative humidity for.

28.4.13 Curing Test

The test is carried out on test panels that are immersed for 4 hours at ambient temperature in the coating thinner recommended by its Coating MANUFACTURER.

The coating is considered acceptable if:

- a. There are no coating blisters (Grade 0 or 1, in accordance with ISO 4628-2) observed on the surface of the coating examined within 3 min of the steel test panel being removed from the thinner.
- b. There are no wrinkles.
- c. There is no significant softening (rating from 0 to 2 in accordance with ISO 4628-1) observed 30 min after removal from the thinner.

28.4.14 Appearance

The coating shall be free from blisters, visual holidays, scratches or any other irregularities and shall have a uniform colour and gloss.

28.4.15 Coating Roughness

The final cured coating shall have a maximum surface roughness of 10 µm over the specified blast cleaned surface profile. The surface roughness shall be determined in accordance with ISO 4287.

28.4.16 Porosity

The porosity of the coating shall be checked on glass panels by the method given in ISO 15741 (Annex E). The coating shall show no pinholes.

28.5 Packaging, Labelling and Storage

All material shall be supplied in the Coating 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, HSE guidelines and the Coating MANUFACTURER's name or recognized trademark. The storage and preparation of coating materials shall be in accordance with the Coating MANUFACTURER's instructions.

Different brands or types of coating materials shall be stored separately.

28.6 Product Data Sheet

The Coating MANUFACTURER's product data sheet shall give information regarding at least the items listed in Table 28.1

Table 28.1 Minimum Information to be Included in Product Data Sheet

Date of issue	
Name of coating material	
Name of coating material MANUFACTURER	
Colour of coating material	
Type of curing agent	
Shelf life	
Non-volatile matter by volume (a)	Test Method used (See 28.3.3)
Density (b)	Test Method used (See 28.3.5)
Pot life (a)	(See 28.3.7)
Flash point (a) and (c)	
Time to complete curing.	
Recommended thinner.	
Maximum allowed quantity of thinner, in %.	
Recommended surface preparation grade.	
Recommended method of application.	
Recommended maximum/minimum dry film thickness of the applied coating.	
Recommended cleaning solvent (for the application equipment).	
Recommended application conditions (air and steel temperature and relative humidity).	
Recommended minimum curing conditions.	
Recommended maximum/minimum service temperature.	
Recommended storage conditions.	
Reference to instructions and warnings regarding health, safety and environmental protection.	
Theoretical spreading rate (1/m ² or kg/m ²) for a given dry film thickness.	
(a) Only for the mixed coating material.	
(b) Give separately for base component and curing agent component (if pigmented).	
(c) Give separately for base component, curing agent component and mixed coating material.	

28.7 Qualification Certificate

The qualification certificate shall give, as a minimum, the values of the properties listed in Table 28.2.

Table 28.2 Minimum Information to be Included in Qualification Certificate

Date of issue			
Name of coating material			
Name of coating material MANUFACTURER			
Required surface profile			
Overcoating intervals (if applicable)			
Curing time			
Date of issue			
Authority for issue			
Property	Test Method	Section	
Non-volatile matter by mass (a)	ISO 3251	See 28.3.2	
Ash (b)	ISO 15741 (Annex A)	See 28.3.6	
Viscosity (c)		See 28.3.4	
Adhesion	ISO 2409	See 28.4.4	
Buchholz hardness	ISO 2815	See 28.4.5	
Resistance to neutral salt spray	ISO 9227	See 28.4.6	
Resistance to artificial ageing		See 28.4.7	
Bend test (conical mandrel)	ISO 6860	See 28.4.8	
Resistance to gas pressure variations	ISO 15741 (Annex C)	See 28.4.9	
Resistance to water immersion	ISO 2812-2	See 28.4.10	
Resistance to chemicals			
Resistance to 95% by volume diethylene glycol solution in water	ISO 2812-1	See 28.4.11	
Resistance to hexane			
Resistance to methanol			
Resistance to toluene			
Resistance to lubricating oil (e.g. compressor seal oil)			
Resistance to hydraulic blistering	ISO 15741 (Annex D)	See 28.4.12	
a. Separately for base component, curing agent component and mixed coating material.			
b. Separately for base component and curing agent component (if pigmented).			
c. Only for the mixed coating material.			

28.8 Batch Test Certificate

The batch test certificate shall give, as a minimum, the information and test results for the items listed in Table 28.3

Table 28.3 Minimum Information to be Included in Batch Test Certificate

Item	Test Method	Information from Coating Material MANUFACTURER	Test Result
Date of issue			
Batch number			
Name of coating material			
Name of coating material MANUFACTURER			
Production date			
Expiry date for use			
Non-volatile matter by mass - base component	See 28.3.2		
Non-volatile matter by mass - curing agent component (a)	See 28.3.2		
Viscosity - base component (b)			
Viscosity - curing agent component (b)			
Density - base component	See 28.3.5		
Density - curing agent component	See 28.3.5		
Ash - base component (c)	See 28.3.6		
Ash - curing agent component (c) and (d)	See 28.3.6		
Infrared spectrogram (d) and (e)	See 28.3.8		
The non-volatile matter by mass of the curing agent component shall not be used for any purposes other than batch consistency checks.			
As specified by the Coating MANUFACTURER.			
If required.			
If pigmented.			
Separately for base component and curing agent component.			

28.9 SUB-CONTRACTOR Qualification

28.9.1 General

Before production application of a coating system may commence, the SUB-CONTRACTOR shall be qualified to apply the coating system. The qualification shall be carried out according to the following procedures:

28.9.2 Coating Process and SUB-CONTRACTOR Selection

The CONTRACTOR shall submit to the COMPANY information on the required coating process and recommended SUB-CONTRACTORS. The information shall include:

- a. Description of the coating process for line pipe, bends and fittings.
- b. Pipe cleaning and surface preparation (cleanliness, profile, chemical pre-treatment, etc.).
- c. Required surface and material application temperatures.
- d. Recommended SUB-CONTRACTORS.
- e. Coating repair procedures.

28.9.3 Coating plant

To demonstrate that the available equipment is capable of applying the specified coating according to the required standards, each recommended SUB-CONTRACTOR shall submit full details of the coating plant, including:

- a. Layout diagram of the coating plant and plant flow scheme;
- b. General description of the equipment available to carry out the coating process;
- c. Details of process control and inspection equipment required for the coating process such as temperature control, thickness control, holiday testers, laboratory equipment, etc.;
- d. Details on the line pipe marking, handling, storage and transport equipment and procedures;
- e. SUB-CONTRACTOR's quality control procedures.

28.9.4 Qualification

With approval of the process and plant details 28.9.2 and 28.9.3 and before production starts, the SUB-CONTRACTOR shall submit evidence that he has successfully applied the coating system before on pipes of the specified material, and that the product complied with the requirements of this specification for the tests indicated in Table 28.4.

The SUB-CONTRACTOR shall coat at least 5 pipes with the proposed coating system and shall subject samples from these pipes to the tests given in Table 28.4. These tests may be carried out in the SUB-CONTRACTOR's own laboratory, or by an independent laboratory. The COMPANY shall witness the application and the tests. The results of the tests shall be reported to the COMPANY, signed by the head of the laboratory and the witness.

The tests described in the last column of Table 28.4 shall be performed on panels which have been attached inside the sample pipes at both pipe ends. The test panels shall be prepared in accordance with 28.4.1.

The test panels shall be fixed on the inside of the pipes or on a temporary pipe extension specifically designed for holding the test coupons using appropriate adhesive tape, at a distance of between 100 mm and 300 mm from the pipe ends; the ground face of the glass panels shall face outwards. The adhesive tape shall overlap the long ends of the test samples by approximately 12 mm.

The test panels shall be removed 10 min after application of the coating on the pipe, with precautions being taken to prevent coating damage. The panel coating shall be dried and cured in an identical manner as the coating applied to the pipe.

When this specification is used for the coating of bends and / or fittings, the SUB-CONTRACTOR shall coat at least one fitting or bend as agreed with the COMPANY and subject this coating to the same qualification tests.

Table 28.4 Requirements and Test Samples Required for Qualification of Coating System and the SUB-CONTRACTOR

Property	Requirement and Test Method	Coating System Qualification on Panels	SUB-CONTRACTOR Qualification on Pipes	SUB-CONTRACTOR Qualification on Panels
Cleanliness of blast cleaned surface	See 0	5	5	3
Chloride and dust contamination	See 0	5	5	3
Surface profile	See 0	5	5	3
Appearance	See 28.4.14	5	5	3
Coating thickness	See 28.4.3	5	5	3
Porosity	See 28.4.16	5	5	3
Coating roughness	See 28.4.15	5	5	3
Bend testing	See 28.4.8	5	-	3
Adhesion	See 28.4.4	5	-	3
Hardness (Buchholz)	See 28.4.5	5	-	3
Curing test	See 28.4.13	5	-	3
Salt spray test	See 28.4.6	5	-	-
Water immersion	See 28.4.10	5	-	-
Resistance to chemicals	See 28.4.11	5	-	-
Hydraulic blistering	See 28.4.12	5	-	-
Resistance to gas pressure variations	See 28.4.9	5	-	-
Artificial ageing followed by bend test	See 28.4.7	5	-	-
System identification	-	Submit to COMPANY	-	-
MANUFACTURER data	-	Submit to COMPANY	-	-
Coating process and plant data	-	-	Approved by COMPANY	-

29 APPLICATION OF THE COATING MATERIAL

29.1 General

Table 29.1 Minimum Items to be Checked and Recorded During the Coating Process

Property	Requirement and Test Method	Minimum Frequency
Coating material Name of product Name of MANUFACTURER Batch number		At every change of shift
Environmental conditions during blasting and coating Ambient temperature Steel temperature Relative humidity Dew point	See 30.1.2	Every 2 h
Surface condition before surface preparation	See 30.1.3	Every pipe
Surface condition after surface preparation Surface cleanliness Surface profile Surface contamination	See 30.1.4	Every pipe Three pipes per shift evenly spaced. Tests performed on both ends
Wet paint (mixed) Viscosity and temperature	See 29.3	Every time paint is mixed, and every time painting is interrupted
Testing coating on pipes Appearance Dry film thickness Coating roughness Holiday detection (wet sponge)	See 28.4.14 See 28.4.3 See 28.4.15	Every pipe 10 pipes per shift, evenly spaced Three pipes per shift, evenly spaced (a)
Testing coating on panels Adhesion Buchholz hardness Bend test Curing test Porosity (glass panels)	See Table 30.1	Three pipes per shift, evenly spaced
a. The wet-sponge test shall be carried out if the porosity tests on glass panels constitute a failure		

29.2 Pipe Surface Preparation

Before blast cleaning and application of the coating system, the internal pipe surface shall be free of all surface contamination. Oil, grease, and other contaminants shall be removed, before blast cleaning, by a suitable solvent or detergent. Salt contamination, chemical cleaning agents and remaining detergents shall be washed off using potable water.

The pipe surface shall be cleaned of mill scale, rust and other foreign matter by a blast cleaning or another abrasive cleaning method to achieve a minimum surface cleanliness of Sa 2½ in accordance with ISO 8501-1.

For stainless steel pipes, stainless steel abrasives or non-ferrous abrasives shall be used for blast cleaning. The surface profile shall be measured in accordance with ISO 8503-2 or ISO 8503-4 and shall be within 25 μm and 50 μm , unless otherwise agreed. During blast cleaning the pipe surface temperature shall be simultaneously higher than 5°C and more than 3°C above the ambient dew point. The ambient relative humidity shall not exceed 85%.

The maximum residual chloride level on the blast-cleaned surface shall be 20 mg/m², in accordance with ISO 8502-2.

The dust level on the blast-cleaned surface shall be of Class 2 or better in accordance with ISO 8502-3.

Immediately after blast cleaning, all remaining weld spatter and irregularities shall be removed from the pipe surface by chiseling and / or grinding. Any treated surface with an area larger than 25 cm² shall be re-blasted to the cleanliness and roughness as specified above.

No repairs to the pipe shall be made without a procedure agreed by the COMPANY.

After any grinding or mechanical repairs, the remaining wall thickness shall be checked and compared with the minimum requirements of the code / specification. Pipes not meeting the minimum wall thickness shall be rejected.

Before coating, the pipe surface shall be cleaned from all dust and foreign matter using clean dry compressed air or vacuum cleaning. The compressed air shall be free of any trace of oil.

If heating is employed for pipe drying, the maximum pipe temperature shall be 50°C. The temperature shall be monitored using digital contact thermometers.

Suitable abrasives shall be selected from those defined in ISO 8504-2. Each batch of abrasive shall be traceable and shall be certified as being in accordance with the appropriate part of ISO 11124 or ISO 11126. Batch certificates shall be available for review by the Inspector. Abrasives without batch certificates shall not be used. Abrasives may be recycled only when indicated as being suitable for recycling by the Abrasive MANUFACTURER.

Fresh abrasives shall be stored in the original packaging in suitable storage buildings, which will prevent them from becoming damp or contaminated. Damp or contaminated fresh and recycled abrasives shall not be used and shall be removed from the site.

29.3 Paint Preparation

Before removing each component from its container, stir or agitate it until it is homogeneous, using equipment which is capable of homogenizing the entire contents of the container without excessively entraining air into the material.

Mix the two components (base component and curing agent component) thoroughly and, if necessary, dilute in accordance with the Coating MANUFACTURER's instructions. After the material has been homogenized; it shall be continuously mixed at a slow speed. The mixed paint shall be free of any lumps and pieces of skin. Measure the viscosity in accordance with the method recommended by the Coating MANUFACTURER and record. Check whether it complies with the value specified by the Coating MANUFACTURER and keep it constant during the application procedure.

The SUB-CONTRACTOR shall batch-test the materials for:

- a. Density, in accordance with ISO 2811.
- b. Non-volatile content (mass), in accordance with ISO 3251.

- c. Pigment dispersion (fineness of grind), in accordance with ISO 1524.
- d. Viscosity (mixed), in accordance with ISO 2431.

The values shall be within the ranges specified by the Coating MANUFACTURER.

If either the SUB-CONTRACTOR or the Inspector finds the sample to be outside of the material specification, the SUB-CONTRACTOR shall remove all applied non-conforming coating from the pipe.

The pipe shall then be recoated with a verified batch of material.

The sequence of use of the batches of coating materials should be in order in which they were manufactured, i.e. first-in / first-out from the warehouse to coating operation. All coating materials shall be used or discarded prior to the expiration date.

Coating material shall be rejected if any defective or contaminated material is found. The coating material shall be such that it can be easily mixed into a homogeneous state free from skinning, curdling and other irregularities.

Any material which has exceeded its pot life shall be rejected.

29.4 Paint Application

Check the surface to be coated to see whether it still complies with the specified surface preparation grade and profile (see 0). Pipes showing any visible rust or stains shall be blasted again.

Apply the paint in a covered or enclosed space, shielded from wind, blowing dust and inclement weather, using the application parameters recommended by the Coating MANUFACTURER and approved by the SUB-CONTRACTOR.

Coating application shall not be performed when the relative humidity exceeds 85%, or when the substrate temperature is less than 5°C, or less than 3°C above the determined atmospheric dew point. Substrate temperature shall not exceed 50°C. In locations with consistent high humidity, the COMPANY may agree atmospheric criteria based on ISO 8502-4; in which case, continued coating operations shall be subject to the agreement of the Inspector.

Unless a specific accelerated curing schedule is defined in the Coating MANUFACTURER's data sheet and qualified during laboratory testing, heating shall not be used to accelerate curing of the applied coating.

Spray the paint continuously and uniformly on to the whole surface to be coated. The coating shall be uniform, and particular attention shall be given to achieving the specified dry film thickness. Unless otherwise specified or agreed, maintain a cutback length of (20 ±5) mm.

29.5 Health and Safety and Protection of the Environment

It is the duty of clients, specifiers, CONTRACTORS, Coating MANUFACTURERS, inspectors and all other personnel involved in the undertaking to carry out the work for which they are responsible in such a manner that they do not endanger the health and safety of themselves or others.

In pursuance of this duty, each person shall ensure that all the statutory requirements of the country in which their work, or any part of the work, is carried out are complied with.

30 PRODUCTION CONTROL

30.1 Assessment of Coating on the Pipes

30.1.1 General

During production application of the coating, the SUB-CONTRACTOR shall carry out all quality control activities needed to ensure that the coating is being applied in accordance with the approved coating application procedures and that the final product complies with the requirements of this specification.

The minimum quality control tests to be performed shall be as indicated in Table 29.1.

Records of all coating application and quality control test results shall be kept in accordance with Section 33.

30.1.2 Ambient Conditions

The SUB-CONTRACTOR shall measure the ambient conditions at regular intervals during blasting and coating and keep records of prevailing temperature, humidity and dew point. If the conditions are outside the limits specified in this specification, the process shall be suspended until the requirements are met.

30.1.3 Inspection of Uncoated Pipes before Blasting

Before surface preparation starts, each pipe shall be visually examined for dents, laps, defective bevels and any other defects to avoid coating unusable pipes. Defective pipes shall be removed from the coating line for repair or, if repair is not possible, rejection.

The pipe surface shall be visually checked for contamination with salts, oil or grease. Contaminated pipes shall be cleaned again.

30.1.4 Inspection After Blasting

Each pipe shall be inspected for surface cleanliness. Pipes that do not comply with the requirements of 0 shall be rejected and cleaned again.

The surface profile shall be measured on three pipes per shift (evenly spaced) and on the first 5 pipes following each change of blast-cleaning material. If the surface profile is outside the specified limits, the blasting material shall be checked and replaced as necessary. The affected pipes shall be re-blasted.

Three pipes per shift (evenly spaced) shall be checked for chloride and dust contamination on the blasted surface. If the surface is contaminated, the quality of the blast cleaning material and process shall be examined. If the conductivity of the blasting material is greater than 50 $\mu\text{mS/cm}$, the blasting material shall be replaced.

Compressed air for drying and blast cleaning shall be free from water and aerosol oil when tested in accordance with ASTM D4285. The testing frequency shall be once per day.

30.1.5 Appearance, Thickness and Holidays

Immediately following coating application, coated pipes shall be visually checked for imperfections and irregularities of the coating, for coating thickness and roughness and if required for the number of holidays. Pipes that do not comply with the requirements shall be marked and removed from the coating line for repair or recoating. If subsequent pipes do not comply with the requirements, the coating process shall be checked or stopped to eliminate the cause of the problem.

The maximum allowable area per repair is 40 cm² and maximum 6 repairs are allowed per single pipe. Pipes with damages area larger than the maximum permitted repair areas shall be rejected, stripped and recoated.

Each pipe shall be checked for cleanliness of the pipe ends and for damage to the beveled ends. Damaged bevels shall be repaired by means of procedures approved by the COMPANY.

30.2 Assessment of Coating on Steel Panels

30.2.1 General

Three test panels per shift, from the start, middle, and end, shall be prepared and evaluated. Each test shall be performed at least twice.

Table 30.1 Required Frequency of, and Acceptance Criteria for, the Production-control Tests

Test	Method	Frequency	Acceptance Criteria
Adhesion	ISO 2409	Twice per shift	Classification ≤ 1
Bend test	ISO 6860	Twice per shift	No loss of adhesion
Buchholz hardness	ISO 2815	Twice per shift	Hardness ≥ 94
Curing test	ISO 15741 (Annex F)	Twice per shift	No softening, wrinkling or blistering
Porosity Test	ISO 15741 (Annex E)	Twice per shift	More than five pinholes shall constitute a failure.

30.2.2 Preparation of Test Panels

Metal test panels shall be used and shall receive identical surface preparation to that of the pipe using production equipment.

The panel coating shall be dried and cured in an identical manner to the coating applied to the pipe.

The test frequency as specified in Table 30.1 shall be changed as specified in 30.2.1

30.2.3 Test Failures

In the event of test panels failing to meet the specified acceptance criteria, the coating shall be removed from the pipe used to support the test panels and the pipe recoated. The CONTRACTOR and the COMPANY shall then agree the further testing necessary to satisfy the COMPANY that the coating applied after the preceding acceptable test meets the requirements of this specification.

Applied coating which fails to comply with this specification shall be removed from the pipe. The pipe shall then be re-prepared and the coating re-applied and inspected in accordance with this specification. Application of a second coat for thickness build shall only be performed if a two-coat system has been qualified in accordance with Table 28.2.

31 COATING REPAIRS

Defective coatings, or areas with insufficient dry film thickness, shall be repaired in accordance with the Coating MANUFACTURER's recommendations

Defective or damaged coating shall be repaired by the SUB-CONTRACTOR. The maximum allowable area per repair is 40 cm² and maximum 6 repairs are allowed per single pipe. Pipes with damaged areas larger than the maximum permitted repair areas shall be rejected, stripped and recoated.

The CONTRACTOR shall submit detailed procedures for coating repairs. All coating repair procedures shall be qualified.

32 HANDLING STORAGE AND TRANSPORT

The SUB-CONTRACTOR is responsible for ensuring that all pipes delivered to the purchaser are correctly coated and the coating is properly cured.

Coated pipes shall be prepared for transport or shipment in accordance with API RP 5L1 or API RP 5LW, whichever is applicable. During transportation, pipes shall be stacked and secured such as to prevent movement, abrasion and / or peening.

32.1 Records and Repairs

The CONTRACTOR shall take receipt of the pipes delivered by the Pipe MANUFACTURER / SUPPLIER and shall keep a record of the serial numbers of the delivered pipes. Upon receipt, the pipes shall be inspected for transport damage or other defects. Damaged pipes shall be separately stored, and their damage shall be reported to the COMPANY.

33 DOCUMENTATION

33.1 Pre-Manufacturing Documentation

The CONTRACTOR's contract-specific quality plan shall be submitted to the COMPANY for agreement within an agreed time period.

The format and issue of the quality plan shall be consistent with the document control requirements of the CONTRACTOR's quality system.

The content of the quality plan should be based on ISO 10005 and shall include the following:

- a. Identification of the product and contract to which the plan is to be applied.
- b. Reference to ISO 15741 and this specification.
- c. Location of coating application.
- d. Identification of the individuals responsible for controlling the activities defined in the plan.
- e. Identification of the individuals with the authority to interface directly with the COMPANY.
- f. Identification of all SUB-CONTRACTORS.
- g. The quality plans of all SUB-CONTRACTORS.
- h. All sequenced activities for the contract, and references to the quality system procedures and work instructions which will be applied to these activities.

- i. Copies of all the quality system procedures and work instructions covering production, test and inspection, special processes, control of non-conforming product, handling, storage, packing, and shipping as requested for agreement by the COMPANY.
- j. Test and inspection frequency and acceptance criteria including the upper and lower process control limits where statistical process control is employed.
- k. The location of each inspection and test point in the process sequence.
- l. Points where the COMPANY has established witnessing or verification requirements.
- m. Coating MANUFACTURER's data sheets and qualification test report.

33.2 Certification

The CONTRACTOR shall provide the COMPANY with a certificate of compliance with the order prior to shipment of the pipe. If the COMPANY has deployed an Inspector, the certificate of compliance with the order shall be issued after the inspection records have been reviewed and approved by the Inspector.

The certificate of compliance with the order shall be drawn up on the basis of specific inspection and testing on the product supplied.

SECTION D - APPENDICES

APPENDIX A1. PAINTING SCHEDULES FOR EXTERNAL SURFACES

Appendix Table 1.1 Painting Schedules for External Surfaces

Item Description	Substrate	Service Temperature Range	Coating System Number
Submerged Structure - Equipment / Piping / Pipe Fittings / Structures	CS	-20°C ≤ T ≤ 100°C	A-1
Splash Zone Structure / Offshore Islands - Equipment / Piping / Pipe Fittings / Structures	CS	-20°C ≤ T ≤ 100°C	A-1
Marine Jetty - Splash Zone	CS	-20°C ≤ T ≤ 100°C	A-2
Atmospheric Zone for Offshore (above splash zone)	CS	-20°C ≤ T ≤ 100°C	A-26
Atmospheric Zone for Offshore (above splash zone)	SS	-20°C ≤ T ≤ 100°C	A-27
Marine Jetty - Platform / Structures / Ladders	CS	-20°C ≤ T ≤ 100°C	A-3
Marine Jetty - Immersion Zone	CS	-20°C ≤ T ≤ 100°C	A-1
From MSL to Underside of First Deck (Offshore)	CS	-20°C ≤ T ≤ 100°C	A-2
Conductor Casing (Outer and Inner) - Submerged / Buried / Splash Zone	CS	-20°C ≤ T ≤ 100°C	A-4
		-20°C ≤ T ≤ 100°C	A-5
All Buried Steel - Piping / Equipment	CS	-20°C ≤ T ≤ 100°C	A-6
All Buried Steel - Piping / Equipment	SS / CRA	T ≤ 200°C	A-25
All Buried Steel - Tanks	CS	-20°C ≤ T ≤ 100°C	A-7
Anti-Fouling System - Submerged Zone of Offshore Structures	CS	-20°C ≤ T ≤ 100°C	A-8
Crane Deck Floor / Working Floors / Solid Deck Floors on Super Complex (Offshore)	CS	-20°C ≤ T ≤ 100°C	A-9
Solid Deck Floors on WHTs (Offshore)	CS	-20°C ≤ T ≤ 100°C	A-11
Helideck - Steel	CS	-20°C ≤ T ≤ 100°C	A-10
Helideck - Aluminium	AL	-20°C ≤ T ≤ 100°C	A-10
Carbon Steel Structural for Granular Sulphur Handling Services	CS	T ≤ 70°C	A-12
Structural Steel to be Fireproofed with Concrete	CS	Amb ≤ T ≤ 100°C	A-13
Uninsulated - Piping / Pipe Fittings / Structures / Equipment / Flares	CS	-20°C ≤ T ≤ 100°C	A-14
	CS	101°C ≤ T ≤ 200°C	A-15

Item Description	Substrate	Service Temperature Range	Coating System Number
	CS	201°C ≤ T ≤ 600°C	A-16
Insulated - Piping / Pipe Fittings / Structures / Equipment	CS	-45°C ≤ T ≤ 200°C	A-15
	CS	201°C ≤ T ≤ 600°C	A-16
	CS	Cyclic Service -20°C ≤ T ≤ 200°C	A-17
Uninsulated - Piping / Pipe Fittings / Structures / Equipment / Flares	SS	-160°C ≤ T ≤ 100°C	A-22
	SS	101°C ≤ T ≤ 600°C	A-23
Insulated - Piping / Pipe Fittings / Structures / Equipment	SS	-160°C ≤ T ≤ 100°C	A-24
	SS	101°C ≤ T ≤ 600°C	A-23
Galvanized Components HDG Gratings are generally excluded in new construction until specifically recommended by COMPANY	GS	-20°C ≤ T ≤ 100°C	A-18
Underside of Bottom Plates of Storage Tanks and Spheroids	CS	T ≤ 100°C	A-19
COS Tanks Double Shell Annulus Area (Bottom Plates and Shell 2 Metres High)	CS	T ≤ 100°C	A-20
External Shop Primer	CS	Amb ≤ T ≤ 100°C	A-21
Single Wall Storage Tanks External - Shell External - Roof Top Side - Wind Girders / Stair Tower / All CS Accessories / Structures at this Level	CS	-20°C ≤ T ≤ 100°C	A-14
Single Wall Storage Tanks Internal - Shell Internal Top 2 Metres			
Double Wall - Outer Tank Shell Internal and External / Inner Tank External and Internal Top Metres / Wind Girders / Stair Towers / All CS Accessories and Structures at this Level (Except Annulus Area Bottom Plate / Both Shells Lower 2 Metres and All CS Components at this Level)	CS	-20°C ≤ T ≤ 100°C	A-14
Double Wall - Outer Tank Shell Internal / Inner Tank Internal Top 2 Metres			
COS Tanks Double Shell Annulus Area - Bottom Plate / Both Shells Lower 2 Metres and All CS	CS	-20°C ≤ T ≤ 100°C	A-18

Notes for Appendix Table 1.1.

- For certain items (e.g. small bore "≤ 2 NPS" piping and tubing that are supplied as part of an equipment package and / or items not listed within Appendix Table 1.1). CONTRACTOR may adopt an applicable coating system previously used at COMPANY's existing facility. CONTRACTOR may propose suitable coating system for COMPANY review and approval.

APPENDIX A2. PAINTING SYSTEMS FOR EXTERNAL SURFACES

Appendix Table 2.2 Painting Systems for External Surfaces

Coating System Number	Substrate	Surface Preparation and Blast Profile	Coat	Generic System Details	DFT
A-1	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	Epoxy Primer (Optional, See Note 1)	50 μm
			2nd	Glass Flake Epoxy / Modified Epoxy	375 μm
			3rd	Glass Flake Epoxy / Modified Epoxy	375 μm
A-2	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	Epoxy Primer (Optional, See Note 1)	50 μm
			2nd	Glass Flake Epoxy / Modified Epoxy	375 μm
			3rd	Glass Flake Epoxy / Modified Epoxy	375 μm
			4th	Polyurethane	40 μm
Additional Notes for Coating Systems A-1 and A-2.					
a. New Construction: Conductor pipes shall be coated from Xmas tree top flange till sea bed. b. Site Maintenance: Conductor pipes shall be coated from Xmas tree top flange till lowest water level on the application day. c. Primer is an optional and shall be applied to facilitate mechanical works during site maintenance campaign only. Preferred method is to apply Epoxy directly on fully blasted surface on same day. d. Holiday testing shall be carried out to new construction components and for buried components. e. Total DFT of 750 microns Can be applied in a single coat application through wet on-wet technique, if required. f. Splash Zone description for UZF / SATF / UADF up to underside of the 1st deck level. g. Splash Zone description For USF / LZF / UL / NASR up to 5m above the MSL or underside of the 1st deck level.					
A-3	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	Inorganic Zinc Silicate	75 μm
			2nd	Epoxy MIO	100 μm
			3rd	Epoxy MIO	100 μm
			4th	Polyurethane	50 μm
A-4	CS	Sa 3 / SSPC-SP 5 50 μm - 75 μm	1st	Phenolic Novolac Epoxy	900 μm
Additional Notes for Coating System A-4.					
a. Fully cured coating shall be 100% holiday tested according to NACE RP0274 and shall be free of holidays. b. Coating shall be stripped and recoated when the number of holidays exceeded 10 in one conductor pipe. c. Detail application procedure and project specific ITP shall be submitted for COMPANY’s approval prior to commencement. d. The approved application procedure shall be qualified by PQT.					

Coating System Number	Substrate	Surface Preparation and Blast Profile	Coat	Generic System Details	DFT
e. Coated pipes shall be protected by appropriate means during storage against UV for approximate one year. f. Collar / sleeve passing test over the coated casings shall be carried to control the maximum 1100 μm DFT. g. Colour shade other than Black is acceptable. h. Outer conductor pipes shall be coated from Xmas tree top flange till sea bed.					
A-5	CS	Sa 3 / SSPC-SP 5 50 μm - 75 μm	1st	FBE Primer	350 μm
			2nd	FBE Abrasion Resistance	550 μm
			3rd	FBE Non-Slip Thermosetting Epoxy	100 μm
Additional Notes for Coating System A-5.					
a. Fully cured coating shall be 100% holiday tested according to NACE RP0274 and shall be free of holidays. b. Coating shall be stripped and recoated when the number of holidays exceeded 10 in one pipe. c. Detail application procedure and project specific ITP shall be submitted for COMPANY's approval prior to commencement. d. The approved application procedure shall be qualified by PQT. e. Coated well casings shall be protected by appropriate means during storage against ultraviolet rays for approximately one year. f. Application procedure for dual layer FBE shall be qualified by PQT. g. Collar / sleeve passing test over the coated Inner casings shall be carried to control the maximum 1100 μm DFT. h. Outer conductor pipes shall be coated from Xmas tree top flange till sea bed.					
A-6	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	High Build Glass Flake Epoxy / Modified Epoxy	200 μm
			2nd	High Build Glass Flake Epoxy / Modified Epoxy	200 μm
			3rd	Densopol 80 HT (or equivalent) Wrap	1.85 mm
A-7	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	High Build Glass Flake Epoxy / Modified Epoxy	300 μm
			2nd	High Build Glass Flake Epoxy / Modified Epoxy	300 μm
Additional Notes for Coating Systems A-6 and A-7.					
a. When the coating has fully cured, all of the coated surface shall be tested for imperfections and defects (holidays) to the NACE Standard SP-0188. b. Total DFT of 400 microns Can be applied in a single coat application through wet on-wet technique, if required. c. Apply Densopol 80 HT self-adhesive, bitumen based anti- corrosive tape that has a heavy duty PVC backing over the coated section plus 1 meter at both protruding ends to act as a backfill protective coating. Overlap each turn of wrapping tape by at least 1" (25 mm) or 55% to achieve double thickness. Ensure that entire surface is covered with no gaps and air pockets.					

Coating System Number	Substrate	Surface Preparation and Blast Profile	Coat	Generic System Details	DFT
d. Holiday testing as per NACE SP0188 shall be conducted for all of the Denso wrapped surface with a set voltage recommended by Denso Tape MANUFACTURER.					
A-8	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	Glass Flake Epoxy / Modified Epoxy	300 μm
			2nd	Glass Flake Epoxy / Modified Epoxy	300 μm
			3rd	Sealer Coat	75 μm - 100 μm
			4th	Anti-Fouling	75 μm - 125 μm
			5th	Anti-Fouling	75 μm - 125 μm
Additional Notes for Coating System A-8.					
a. Application shall note that some Coating MANUFACTURER's recommend that the tie-coat or the anti-foulant coat should be applied into the corrosion protection coat while tacky. Coating MANUFACTURER's recommendation in this regard shall be strictly observed.					
A-9	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	Surface Tolerant Epoxy	150 μm
			2nd	Anti-Skid HB Abrasion Resistant Coating	2000 μm
			3rd	Polyurethane	50 μm
A-10	CS	Sa 2.5 / SSPC-SP 10 75 μm - 100 μm	1st	Surface Tolerant Epoxy	150 μm
			2nd	Anti-Skid HB Abrasion Resistant Coating	1000 μm - 3000 μm
			3rd	Polyurethane	50 μm
	AL	Sa 1 / SSPC-SP7 25 μm - 35 μm	1st	Surface Tolerant Epoxy	150 μm
			2nd	Anti-Skid HB Abrasion Resistant Coating	1000 μm - 3000 μm
			3rd	Polyurethane	50 μm
Additional Notes for Coating System A-10.					
a. Coating MANUFACTURER / SUB-CONTRACTOR shall ensure that the applied anti-skid coating system meets the requirements of CAAP 071 and the friction values of 0.85 is achieved.					
b. In case, the friction values are lower than the desired value of 0.85, then Coating MANUFACTURER / SUB-CONTRACTOR shall repair the system to achieve the desired friction properties.					
c. Only, GCAA approved organisation shall be allowed to conduct and certify the friction values.					
d. Helideck marking / visual aids shall be in accordance to CAAP 071 requirement.					
e. Specific marking sketch to be submitted to COMPANY for review / approval prior to commencement of project.					

Coating System Number	Substrate	Surface Preparation and Blast Profile	Coat	Generic System Details	DFT
A-11	CS	Sa 2.5 / SSPC-SP 10 40 μm - 65 μm	1st	Glass Flake Epoxy	200 μm
			2nd	Glass Flake Epoxy	200 μm
			3rd	Coarse Texture Non-Spark Aggregate	0.8mm - 1.2mm
			4th	Polyurethane	60 μm
Additional Notes for Coating System A-11.					
a. Anti-skid material shall be applied during application of the 2nd coat.					
A-12	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	High Chemical Resistance Paint (Resistance to 98% Sulphuric Acid)	Refer Coating MANUFACTURER
A-13	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	Zinc Rich Primer	75 μm
			2nd	Polyamide Epoxy MIO	125 μm
			3rd	Polyurethane	75 μm
A-14	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	Inorganic Zinc Silicate	75 μm
			2nd	Polyamide Epoxy MIO	100 μm
			3rd	Polyamide Epoxy MIO	100 μm
			4th	Polyurethane	50 μm
Additional Notes for Coating System A-14.					
a. Prior to the application of intermediate coat, the surface of inorganic zinc silicate primers shall be sealed by application of a tie coat by mist coat / wet on wet method to seal off the surface of the zinc and to avoid solvent entrapment and post application blistering.					
b. Maximum DFT of inorganic zinc silicate shall be 90 μm to avoid any mud-cracking.					
A-15	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	Phenolic Epoxy	150 μm
			2nd	Phenolic Epoxy	150 μm
Additional Notes for Coating System A-15.					
a. The applied coating system shall be free of any defects and shall perform satisfactory during the entire construction stage till commissioning at ambient temperature.					
b. Perform satisfactorily during non-operative phase in CX environment.					
A-16	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	Inert Multi Polymeric Matrix	150 μm
			2nd	Inert Multi Polymeric Matrix	150 μm
Additional Notes for Coating System A-16.					
a. The applied coating system shall be free of any defects and shall perform satisfactory during the entire construction stage till commissioning at ambient temperature.					
b. Perform satisfactorily during non-operative phase in CX environment.					

Coating System Number	Substrate	Surface Preparation and Blast Profile	Coat	Generic System Details	DFT
A-17	CS	Sa 2.5 / SSPC-SP 10 50 μm - 85 μm	1st	Thermally Sprayed Aluminium	200 μm
	SS	SSPC-SP 16 35 μm - 50 μm	1st	Thermally Sprayed Aluminium	200 μm
A-18	CS / GS	SSPC-SP 16 35 μm - 50 μm	1st	Surface Tolerant Epoxy Primer	125 μm
			2nd	HB Epoxy	125 μm
			3rd	Polyurethane	50 μm
Additional Notes for Coating System A-18.					
a. Unless specifically mentioned by COMPANY, HDG gratings are excluded from over coating in new constructions.					
A-19	CS	Sa 2.5 / SSPC-SP 10 50 μm - 75 μm	1st	Surface Tolerant HB Glass Flake Epoxy	300 μm
			2nd	Surface Tolerant HB Glass Flake Epoxy	300 μm
Additional Notes for Coating System A-19.					
b. Coating shall only be applied in combination with effective cathodic protection and shall be consulted with COMPANY prior to application.					
A-20	CS	Sa 2.5 / SSPC-SP 10 40 μm - 65 μm	1st	Epoxy Primer (Optional, See Note 1)	50 μm
			2nd	Epoxy Glass Flake - Reinforced	150 μm
			3rd	Epoxy Glass Flake - Reinforced	150 μm
			4th	Polyurethane	50 μm
A-21	CS	Sa 2.5 / SSPC-SP 10 10 μm - 25 μm	1st	Weldable Inorganic Zinc	25 μm
A-22	SS	SSPC-SP 16 35 μm - 50 μm	1st	Phenolic Epoxy	125 μm
			2nd	Phenolic Epoxy	125 μm
			3rd	Polyurethane	40 μm
A-23	SS	SSPC-SP 16 35 μm - 50 μm	1st	Inert Multi Polymeric	125 μm
			2nd	Inert Multi Polymeric	125 μm
A-24	SS	SSPC-SP 16 35 μm - 50 μm	1st	Phenolic Epoxy	125 μm
			2nd	Phenolic Epoxy	125 μm
A-25	SS / CRA	SSPC-SP 16 35 μm - 50 μm	1st	Glass Flake Epoxy	200 μm
			2nd	Glass Flake Epoxy	200 μm

Coating System Number	Substrate	Surface Preparation and Blast Profile	Coat	Generic System Details	DFT
A-26	CS	Sa 2.5 / SSPC-SP 10 45 μm - 70 μm	1st	Inorganic Zinc Silicate	75 μm
			2nd	Polyamide Epoxy MIO	100 μm
			3rd	Polyamide Epoxy MIO	100 μm
			4th	Polyurethane	50 μm
Additional Notes for Coating System A-26.					
a. Prior to the application of intermediate coat, the surface of inorganic zinc silicate primers shall be sealed by application of a tie coat by mist coat / wet on wet method to seal off the surface of the zinc and to avoid solvent entrapment and post application blistering.					
b. Maximum DFT of inorganic zinc silicate shall be 90 μm to avoid any mud-cracking.					
A-27	SS	SSPC-SP 16 35 μm - 50 μm	1st	Non Inhibitive Epoxy Primer	35 μm
			2nd	HB Epoxy	100 μm
			3rd	Polyurethane	40 μm
Additional Notes for Coating System A-27.					
a. The primer shall be zinc free and non-inhibitive Epoxy type.					
b. The coating for stainless steel surfaces, nickel based alloys and copper based alloys and elements shall not contain any zinc and a chloride content shall be less than 25 ppm.					

Notes for Appendix Table 2.2.

1. Epoxy Primer shall be an optional, recommended practice is to apply Glass Flake Epoxy direct to blasted substrate.
2. For PQT requirements for Systems A4 and A5, see APPENDIX A3.
3. Potable water to be used for washing with high pressure of minimum 3500 psig / 241.32 barg.
4. Where applicable, the acceptance criteria for potable water used for washing shall contain maximum 50 ppm chlorides and pH value of 6.5 to 8.
5. Coating MANUFACTURER shall provide test certificate of zinc content level tested by third party laboratory. The metallic zinc content in DFT shall be at least 85% by weight and complies with the compositional requirements for SSPC Paint 20 Type II level 1, ISO 12944-5 or equivalent.
6. Coating MANUFACTURER shall provide test certificate of MIO content level tested by third party laboratory. The minimum MIO shall be 80% by weight in total pigment.
7. The minimum glass flake level shall be 15% on total pigmentation by weight. Coating MANUFACTURER shall provide third party laboratory test certificate for the glass flake level in the high build epoxy paint.

APPENDIX A3. PQT REQUIREMENTS FOR SYSTEMS A4 AND A5

Appendix Table 3.3 Painting System A4 Epoxy Novolac Coating System Requirements

Parameter	Test Method	Minimum Required Value
Compressive Strength	ASTM C109	> 12000 psig / 827.37 barg
Dielectric Strength	ASTM D149	> 485 vols / mil
Adhesion to Barge Steel	ASTM D4541	> 2500 psig / 172.37 barg
Impact Resistance (film thickness 40 mils)	ASTM G14	> 50 inch-lbs
Taber Abrasion Resistance Wear Cycles CS-17 Wheel, 1 k g	ASTM D4060	≤ 90 mg / 1000 cycles
Hardness Shore D	ASTM D2240	> 80
Cathodic Disbondment 30 Days @ 23°C 30 Days @ 95°C	ASTM G8 ASTM G42	< 5 mm <10 mm

Appendix Table 3.4 Painting System A5 PQT Requirements

Activity Description	PQT Frequency
Pipe Receipt and Visual Inspection	Pipe Number Recorded for All 5 Pipes
Washing of Casing Thread and Thread Protector	All Pipes
Visual Inspection of the Casing Thread and Seal Area After Washing	All 5 Pipes
Storage of Washed Pipes	All 5 Pipes
Visual Inspection	All 5 Pipes
Hot Water Bath	All 5 Pipes
Check Pipe Temperature and Climatic Conditions	All Pipes
Abrasive Material Contamination Test	Once per shift
Abrasive Material Conductivity Test	Once per shift
Thread Protector Insertion Prior to Abrasive Blast Cleaning	All Pipes
Compressed Air Supply	Start of PQT
Cleaning of Internal Surface of Blast Cleaned Pipe.	All Pipes
Surface Profile	5 Pipes
Inspection of Thread and Seal Area (After Blast Cleaning)	5 Pipes
Abrasive Blast Cleaned Pipe Surface Visual Standard	5 Pipes
Steel Surface Defects	5 Pipes
Inspection of Internal Surface of the Pipe	5 Pipes

Activity Description	PQT Frequency
Non-conforming Steel Surface	If required
Surface Dust Level	5 Pipes
Surface Chlorides (Salt Test)	5 Pipes
Elapsed Time From Abrasive Blast to Acid Application	5 Pipes
Contact Time of the Phosphoric Acid Treatment	Start of PQT
pH of the Phosphoric Acid Treatment	Start of PQT
pH of the Rinse Water on the Pipe	Start of PQT
Conductivity of the Rinse Water	Start of PQT
Pre-Heat	All 5 Pipes
Dry Film Thickness of the Two Combined Layers	All 5 Pipes
Installation of Centralizers and Stop Collars	All 5 Pipes
Holiday Detection	All 5 Pipes
Visual Inspection of the Finished Coating and Ensure Contamination free from Pin End and Box End Threads	All 5 Pipes
Visual Inspection of the Casing Thread and Seal Area After Coating	All Pipes
Final Inspection of Thread and Seal Area and Installation of Thread Protector	All Pipes
Adhesion Test	1 test / joint. To be done in all PQT pipes
DSC Test	1 test
Cathodic Disbondment	1 Test - PQT Only
Repair	If required
Installation of Separators (Polypropylene Ropes)	All coated pipes
Impact Resistance	1 Test - PQT Only
Flexibility	1 Test - PQT Only
24 Hour Cathodic Disbondment	1 Test - PQT Only

Notes for Appendix Table 3.3 and

Appendix Table 3.4.

1. The fully cured coating shall be 100% holiday tested according to NACE SP0188 and shall be free of holidays.
2. A detailed application procedure, coating repair procedure and project specific ITP shall be submitted for COMPANY's approval prior to commencement.
3. The approved application procedure and coating products shall be qualified by PQT.

4. The coated pipes shall be protected by appropriate means during storage against UV for approximately one year.
5. The collar / sleeve passing test over the coated casings shall be carried to control the maximum 1100 µm DFT.
6. Defects in the finished coating due to holiday testing, application process, transportation, handling and storage in the coating plant or in the storage area as well as those which have been subjected to destructive testing shall be repaired to approve repair procedure.
7. The defect area shall not exceed 10 cm² and the total number of defects / holidays being repaired shall not exceed one defect per meter length of pipe unless otherwise specified. If the size or number of defects exceeds these limits the affected pipe shall be stripped and recoated.
8. Holidays and areas requiring small spot repairs shall be cleaned by a surface grinder or by disc sanding the areas with medium grit (80 to 100) Carborundum Emery Cloth, to remove dirt, scale, rust, damaged coating or any other foreign material. All dust produced by the cleaning and feathering shall be wiped off with an appropriate solvent soaked cloth before patching commences.
9. All pipes that have been repaired shall be fully re-examined in accordance with the ITP and QC procedures.
10. Any colour shade other than Black is acceptable.
11. The outer conductor pipes shall be coated from Xmas tree top flange till sea bed.

APPENDIX A4. EXTERNAL PROTECTION FOR FASTENERS

Applicable ADNOC Business Group specifications shall form part of 0 where they are specifically indicated as applicable in the Purchase Order. Otherwise, the following shall apply.

A4.1. External Fastener Coating

External fasteners (bolts, studs and nuts) shall be coated with a fluorocarbon polymer system to be approved by COMPANY. Bolting shall be accomplished using the special tools and the instructions as supplied by the approved VENDOR. It is the CONTRACTOR's responsibility to perform the necessary investigation and to advise the outcome to COMPANY. General clarification as to the extent to which the requirement is applicable is as follows:

Included:

- a. All external flanged connections with carbon steel and stainless steel bolting (shop and field assembled), including insulated flange bolting where the service temperature is less than 200°C.
- b. Equipment bolting that requires removal for scheduled maintenance and inspection.

Excluded:

- a. All structural bolting.
- b. Fasteners / bolts used in assembly of various components within MANUFACTURER's standard equipment, miscellaneous standard valve assemblies and instrumentation. CONTRACTOR shall review MANUFACTURER's standard coating for its suitability in the specified jobsite conditions, on case-by-case basis.
- c. CRA fasteners.
- d. Insulated flange bolting above 200°C.

APPENDIX A5. POWDER COATING

A5.1. Powder Coating

Powder coating is included as an alternative where approved by COMPANY, and shall be highly durable.

Powder Coating for an external setting shall be suitable for a CX environment and be a minimum of 100 µm DFT.

Powder Coating within an internal setting shall be MANUFACTURER's / SUPPLIER's standard, and approved by COMPANY.

APPENDIX A6. SAFETY COLOUR CODING AND IDENTIFICATION - GAS PROCESSING

A6.1. Equipment and Piping

Safety colour coding and identification of equipment and piping shall be in accordance with this specification. Finish colours shall match the following standard colours for the designated items. Coating MANUFACTURERS shall use the German colour standard numbers, RAL 840-HR, for selecting the appropriate finish colours.

The following Appendix Table 6.5 lists basic piping systems, equipment, and the required finish colour for that particular piping system and major equipment type. Any item that is not listed below, but is part of this project, shall be brought to the attention of the CONTRACTOR for selection of the finish colour and exact colour coding and marking requirements.

Before execution of painting work for colour coding, specified colour codes including letter sizes, safety slogans, and logos, the COMPANY's approval shall be obtained before applying colour codes.

There shall be no cost impact to the COMPANY due to discrepancies or changes in the colour scheme, lettering, or logo, as specified being different from actual site requirements as this work shall be considered part of detailed engineering.

Appendix Table 6.5 Required Safety and Identification Colour Coding - Gas Processing

Description	Colour	Colour Number
Piping		
Process and Utility Piping (other than services listed below)	Light Grey	RAL 7035
Instrument and Plant Air (plant air shall have a Pure White (RAL 9010) band 150 mm long @ 30 M intervals)	Light Blue	RAL 5012
Potable Water (potable water shall have a Gentian Blue (RAL 5010) band 150 mm long @ 30 M intervals)	May Green	RAL 6017
Fire Water	Vermillion	RAL 2002
Sea Water	Pine Green	RAL 6028
Acids and Alkalis	Red Lilac	RAL 4001
Control Valves (Actuator Only) and Relief Valves	Golden Yellow	RAL 1004
Gas Transmission Piping	Pure White	RAL 9010
Liquid Transmission Piping	White Aluminium	RAL 9006
Equipment - Furnaces		
Furnace Casing and Attached Steel Work	Light Grey	RAL 7035
Steel Work Not Connected	Tarpaulin Grey	RAL 7010
Stacks and Flue Duct (Note 3)	White Aluminium	RAL 9006
Top of Stack (Note 3)	Vermillion	RAL 2002
Ladders and Walkways	Tarpaulin Grey	RAL 7010
Handrail Assemblies	Golden Yellow	RAL 1004

Description	Colour	Colour Number
Equipment - Air Coolers		
Surfaces Operating from Ambient to 93°C	Tarpaulin Grey	RAL 7010
Surfaces Operating from 94°C to 538°C	White Aluminium	RAL 9006
Equipment - Miscellaneous		
Columns, Vessels, Exchangers, Boilers and N2 Storage Vessels (COMPANY Owned)	Light Grey	RAL 7035
Spheres	Signal White	RAL 9003
H2 Storage Vessels (COMPANY Owned)	Ochre Yellow	RAL 1024
Ejectors and Filters	Pure Orange	RAL 2004
Relief Valves	Golden Yellow	RAL 1004
Actuators of Control Valves	Golden Yellow	RAL 1004
Gas Storage (COMPANY Owned)	Light Grey	RAL 7035
Nitrogen (Temp. Above 80°C)	Signal White and	RAL 9003 and
	Golden Yellow Band	RAL 1004
Filling Station, Chain Blocks, Overhead Crane Assembly and Body, Guide Beam, Mobile Cranes and Forklifts, Push Buttons	Golden Yellow	RAL 1004
Fire Trucks	Vermillion	RAL 2002
Truck Loading Arms	Light Grey	RAL 7035
Air Conditioning System	Pale Green	RAL 6021
Workshop Equipment	Leaf Green	RAL 6002
Extinguishers - Water	Vermillion	RAL 2002
Extinguishers - Dry Chemical Powder	Gentian Blue	RAL 5010
Extinguishers - Carbon Dioxide (CO2)	Jet Black	RAL 9005
Extinguishers - Halon	Pale Green	RAL 6021
Extinguishers - Foam	Cream	RAL 9001
Structural Steel		
External Steel Work	Tarpaulin Grey	RAL 7010
Ladders, Walkways and Supports	Signal Grey	RAL 7004
Handrail Assemblies	Golden Yellow	RAL 1004
Protective Shelters	Pigeon Blue	RAL 5014
Flare, Stack Ladders, Platforms, etc.	Light Grey	RAL 7035
Steel Work Not Connected to Casing	Tarpaulin Grey	RAL 7010
Machinery		
Pumps (Operating up to 93°C and Uninsulated), Compressors, Motors, Blowers	Reseda Green	RAL 6011

Description	Colour	Colour Number
Pumps (Insulated and Uninsulated Operating Above 93°C)	White Aluminium	RAL 9006
Turbines and Associated Power Generators	Pure White	RAL 9010
Filters of Turbines	Golden Yellow	RAL 1004
Cranes and Lifting Tackle	Lemon Yellow	RAL 1012
Workshop Machinery	Leaf Green	RAL 6002
Coupling Guards	Yellow Orange	RAL 2000
A/C Equipment except ducts	Concrete Grey	RAL 7023
Tanks		
Shell - Fixed and Floating Roof (Note 1)	Signal White	RAL 9003
Roof - Fixed Roof Tanks	Signal White	RAL 9003
Roof - Floating Roof Tanks	Signal White	RAL 9003
Mechanical Mixers	Reseda Green	RAL 6011
Electrical Equipment		
Switch Boards	Pale Green	RAL 6021
Junction Boxes, Conduit Lamp Standards, Push Buttons	Golden Yellow	RAL 1004
Transformers and Motors	Reseda Green	RAL 6011
Street Light Posts and Lighting Poles (On Structures)	Light Grey	RAL 7035
Instrumentation		
Boards	Pale Green	RAL 6021
Instruments	Reseda Green	RAL 6011
Cable Trays and Instrument Boxes Sunshade	Pure White	RAL 9010
Actuators of Fail Close Control Valves	Golden Yellow	RAL 1004
Actuators of Fail Open Control Valves	Light Grey	RAL 7035
ESD and On - Off Valves: Fail Open	Vermillion	RAL 2002
ESD and On - Off Valves: Fail Close	Golden Yellow	RAL 1004
Motor Operated Valves	Golden Yellow	RAL 1004
Actuator of Control Valves Fail Open (For Ruwais Plant)	Grass Green	RAL 6010
Actuator of Control Valves Fail Close (For Ruwais Plant)	Sky Blue	RAL 5015
Control and Itemized Valves (Valve Body) Operating Temperature Below 93° C (For Ruwais Plant)	Light Grey	RAL 7035
Control and Itemized Valves (Valve Body) Operating Temperature Above 93° C (For Ruwais Plant)	White Aluminium	RAL 9006
Secured Instrument. Air Buffer Vessel of Actuator (For Ruwais Plant)	Light Grey	RAL 7035
Actuator of On / Off Valves (For Ruwais Plant)	Light Grey	RAL 7035
Instrumentation Cable Trays / Ladles / Covers	Reseda Green	RAL 6011

Description	Colour	Colour Number
Instrument Panels	Light Grey	RAL 7035
Cathodic Protection Test Stations		
Pipe for Test Station / Post	Golden Yellow	RAL 1004
Head of Station / Post (FINK)	Yellow Orange	RAL 2000
Transformer Rectifier Unit	Light Grey	RAL 7035
Junction Box	Golden Yellow	RAL 1004

Notes for Appendix Table 6.5.

1. Stripes shall be applied at the top in a format as specified by the COMPANY. COMPANY logos / safety slogans shall be painted and subject to approval by the COMPANY.
2. Stack size up to 3 m diameter shall be painted with 3 bands of 0.5 m width at a gap 2.0 m. For larger diameter stack the band gap will be 1.0 m.
3. Taller stack shall have blinking warning light as per Aviation Authority requirement.

Appendix Table 6.6 Gas Cylinders - Gas Processing

Gas	Cylinder Body	Cylinder Neck	Cylinder Head
Acetylene	Oxide Red RAL 3009	Oxide Red RAL 3009	Oxide Red RAL 3009
Air	Reed Green RAL 6013	Reed Green RAL 6013 /	Reed Green RAL 6013 /
		Signal White RAL 9003 Dia Sectors	Signal White RAL 9003 Dia Sectors
Ammonia	Jet Black RAL 9005	Zinc Yellow RAL 1018	Vermillion RAL 2002
Argon	Water Blue RAL 5021	Water Blue RAL 5021	Water Blue RAL 5021
Chlorine	Zinc Yellow RAL 1018	Zinc Yellow RAL 1018	Zinc Yellow RAL 1018
Carbon Dioxide	Jet Black 9005	Reed Green RAL 6013	Reed Green RAL 6013
Hydrogen	Vermillion RAL 2002	Vermillion RAL 2002	Vermillion RAL 2002
Nitrogen	Reed Green RAL 6013	Jet Black RAL 9005	Jet Black RAL 9005
Oxygen	Jet Black RAL 9005	Jet Black RAL 9005	Jet Black RAL 9005
Inergen Low CFC	Vermillion RAL 2002	Jet Black RAL 9005	Light Grey RAL 7035

Notes for Appendix Table 6.6.

1. Cylinder contents can also be easily identified by stencilling the chemical symbol or name of the gas.
2. If desired either or both methods together can be used to identify gases.
3. Red indicates flammable gases. Yellow denotes toxic gases.
4. Repainting is necessary when external colour has faded visually.

A6.2. Piping Colour Coding

Selected process and utility piping will require additional colour identification to be placed directly on the coated piping or on insulation jacketing. Following is a list of such piping and the additional colour requirements:

Appendix Table 6.7 Piping Colour Coding - Gas Processing

Contents	Identification Colour Band	Colour Number	Contents Code
Utility Water	Ultramarine Blue	RAL 5002	UW
Treated Water	Light Blue	RAL 5012	TW
Low Pressure Steam	Two Tomato Red Stripes	RAL 3013	STL
Superheated Low-Pressure Steam	Five Tomato Red Stripes	RAL 3013	SLH
High Pressure Steam	Three Tomato Red Stripes	RAL 3013	STH
Superheated High-Pressure Steam	Four Tomato Red Stripes	RAL 3013	STS
Steam Condensate	Ultramarine Blue	RAL 5002	SC
	and Signal White	and RAL 9003	
High Pressure Steam Condensate	Ultramarine Blue	RAL 5002	SCH
	and Signal White	and RAL 9003	
Medium Pressure Steam Condensate	Ultramarine Blue	RAL 5002	SCM
	and Signal White	and RAL 9003	
Low Pressure Steam Condensate	Ultramarine Blue	RAL 5002	SCL
	and Signal White	and RAL 9003	
Fuel Gas	Golden Yellow	RAL 1004	FG
	and Jet Black	and RAL 9005	
Low Pressure Fuel Gas	Golden Yellow	RAL 1004	FGL
	and Jet Black	and RAL 9005	
Medium Pressure Fuel Gas	Golden Yellow	RAL 1004	FGM
	and Jet Black	and RAL 9005	
Fuel Gas Sour	Golden Yellow	RAL 1004	FGX
Hydrocarbon	Sulphur Yellow	RAL 1016	HC
Hydrocarbon Sour	Mahogany Brown	RAL 8016	HCX
Process Liquid	Mahogany Brown	RAL 8016	PL
Lean Solvent (Lean Amine)	Ochre Brown	RAL 8001	LS
Lean Solvent (Lean MDEA)	Ochre Brown	RAL 8001	LSM

Contents	Identification Colour Band	Colour Number	Contents Code
Acid Gas	Ochre Yellow	RAL 1024	AG
Acid Gas Sulphur	Ochre Yellow	RAL 1024	AGS
Acid Gas Sour	Ochre Yellow	RAL 1024	AGX
Sulphur Liquid	Honey Yellow	RAL 1005	SL
Flare (Hot)	Signal Violet	RAL 4008	FL
Blow Down to Liquid Flare	Red Lilac	RAL 4001	BD
Acid Gas Flare	Ochre Yellow	RAL 1024	FAG
Lube Oil System	Yellow Orange	RAL 2000	LO
Nitrogen (Gas)	Signal White	RAL 9003	N2
Plant Air	Signal White	RAL 9003	PA
Instrument Air	Signal White	RAL 9003	IA
Potable Water	May Green	RAL 6017	PW
Boiler Feed Water	Light Blue	RAL 5012	BFW
Boiler Water Sewer	Light Blue	RAL 5012	BWS
Closed Drain	Ochre Brown	RAL 8001	CD
Closed Drain Cryogenics	Golden Yellow and Traffic Purple	RAL 1004 and RAL 4006	CDC
Chemical	Red Lilac	RAL 4001	CH
Cooling Water	Green Blue	RAL 5001	CW
Cooling Water Return	Ultramarine Blue	RAL 5002	CWR
Cooling Water Supply	Sapphire Blue	RAL 5003	CWS
Demineralised Water	Ultramarine Blue	RAL 5002	DMW
Irrigation Water	Light Blue	RAL 5012	IW
Liquid Nitrogen	Signal White	RAL 9003	LN
Methanol	Signal White	RAL 9003	MOH
Open Drain	Golden Yellow and Vermillion	RAL 1004 and RAL 2002	OD
Refrigerant (Propane)	Golden Yellow	RAL 1004	RF
Rich Solvent Sour (Rich Amine)	Mahogany Brown	RAL 8016	RSX
Rich Solvent Sour (Rich MDEA)	Mahogany Brown	RAL 8016	RSM
Solvent Drain (MDEA)	Ochre Brown	RAL 8001	SDM
Solvent Drain	Ochre Brown	RAL 8001	SD
Sour Water	May Green	RAL 6017	SW

Contents	Identification Colour Band	Colour Number	Contents Code
Vent	Traffic Purple	RAL 4006	VE
Water Disposal	Golden Yellow	RAL 1004	WD
Water Disposal Sour	Light Blue	RAL 5012	WDX
Diesel Fuel	Yellow Orange and Gentian Blue	RAL 2000 and RAL 5010	DF
NGL	Mahogany Brown	RAL 8016	NGL
Chlorine Gas	Golden Yellow	RAL 1004	CG
Regeneration Gas	Golden Yellow	RAL 1004	RG
Regeneration Gas (Hot and Wet / Sour)	Mahogany Brown	RAL 8016	RGX
Cold Flare	Red Lilac	RAL 4001	FLC
Fire Water	No identification colour band, full pipe Vermillion	RAL 2002	FW
Fire Deluge	No identification colour band, full pipe Vermillion	RAL 2002	FD
Chilled Water	Black Blue	RAL 5004	AC
Area Drain (Surface Drainage)	Light Blue	RAL 5012	AD
Ammonia	Red Lilac	RAL 4001	AV
Blanket Gas	Pure White	RAL 9010	BG
Caustic Concentrated			CAC
Caustic Diluted	Red Lilac	RAL 4001	CAD
Process Combustion Air	Ochre Yellow	RAL 1024	CBA
Caustic Closed Drain	Red Lilac	RAL 4001	CCD
Sodium Hypochlorite	Red Lilac	RAL 4001	CL
Glycol Drain Light	Clay Brown	RAL 8003	GD
Amine / Glycol	Clay Brown	RAL 8003	AM / GL
Glycol Sour	Mahogany Brown	RAL 8016	GLX
HC Drain to Solvent Recovery	Golden Yellow	RAL 1004	HR
Raw Water	Brilliant Blue	RAL 5007	RW
Sewage	Light Blue	RAL 5012	SE
Fresh Solvent (Fresh MDEA)	Ochre Brown	RAL 8001	SM
Seal Oil	Yellow Orange	RAL 2000	SO
SRU Solvent	Clay Brown	RAL 8003	SSM
Treated Acid Gas	Ochre Yellow	RAL 1024	TAG

Contents	Identification Colour Band	Colour Number	Contents Code
Wet Fluid	Golden Yellow	RAL 1004	WF
Wet Fluid Sour	Golden Yellow	RAL 1004	WFX

Notes for Appendix Table 6.7.

1. The width of the identification colour band shall be:
 - a. Up to 4" NPS - 100 mm
 - b. Above 4" NPS - Pipe Diameter x 2

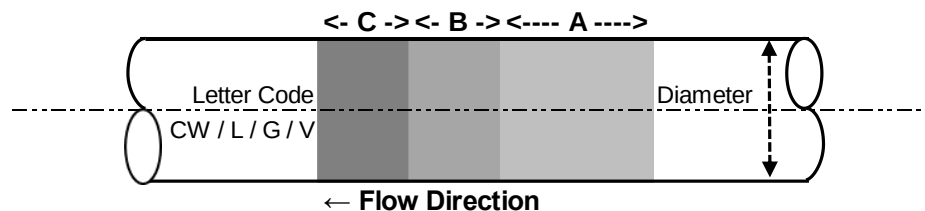
A6.3. Flow Direction

Flow direction shall be indicated by bands as described in Direction by Bands, below. Arrows can also be used to indicate the flow direction as described in Directions by Arrows.

A6.4. Direction by Bands

The coding shall be arranged as indicated in the example shown in Appendix Figure 6.1

Appendix Figure 6.1 Piping Colour Coding Arrangement - Gas Processing



A6.5. Letter Code

First two letters of this example indicate contents (see Appendix Table 6.7). Last letter indicates phase:

L = Liquid phase

G = Gas phase

V = Vapour phase

- a. For Dia > 4", A = Dia x 2, B = Dia x 1/2 and C = Dia x 1/2 up to maximum widths equivalent to 18".
- b. For piping above 18 inches diameter width, shall be 18".
- c. For Dia < 4", A = 100 mm, B = 50 mm and C = 25 mm.

Colour Band C is located on downstream side of Colour Band and indicates direction of flow.

In case of bi-directional flow, flow Band C will be located on each side of Band A.

Where two colours are used for quick identification (such as for steam, fuel gas, hydrogen, etc.) the following procedure will be adopted:

- a. Up to 4" Dia Piping, Band A shall be in alternating circumferential bands and Band C shall be the predominant colour.

- b. Above 4" Dia Piping, Band A and Band C shall be in alternating bands.

A6.6. Directions by Arrows

Arrows shall be used to indicate the flow direction of commodities contained in piping.

The arrows shall be white or black in colour to contrast with the basic colour of the pipe. The following sizes are recommended:

- a. Pipe 2" to 6" NPS, arrow to fit in a 25 mm x 100 mm rectangle.
- b. Pipe 8" NPS and larger, arrow to fit in a 50 mm x 150 mm rectangle.
- c. Where flow of the commodity is possible in either direction, two arrows shall be indicated pointing in opposite directions.

Arrows and band markings shall be made at the unit battery limits and at the COMPANY designated locations.

A6.7. Colour

The code indications shall be painted either in white or in black in order to contrast clearly with the colour of paint on the pipe or equipment. For insulated lines, the code indications shall be painted over the insulation jacket.

A6.8. Labelling Requirements

For piping and equipment, full name or abbreviations of chemical and symbol of fluid flowing inside a pipeline shall be indicated. The line number shall also be painted on the pipelines.

Line numbering labels shall be applied to all pipes every 30 m.

For equipment, the name, tag number and service are required to be painted.

For support columns, Code indication in the form of serial numbers shall be adopted for supporting columns of concrete or structural steel. Numbers shall be provided by the CONTRACTOR.

A6.9. Size

The size of lettering used for code indications on insulated and un-insulated piping is as follows. The following are suggested sizes only and may be varied by the COMPANY.

<u>Item</u>	<u>Size</u>	<u>Letter Size</u>
Pipe	2" NPS and below	25 mm letters
Pipe	3" to 6" NPS	50 mm letters
Pipe	8" NPS and above	80 mm letters
Process Equipment	All sizes	100mm to 300 mm letters
Tanks and Spheres	All sizes	500mm to 1000 mm letters

APPENDIX A7. SAFETY COLOUR CODING AND IDENTIFICATION - REFINING

A7.1. Equipment and Piping

Safety colour coding and identification of equipment and piping, for the Ruwais Refinery, shall be in accordance with the existing plant standards and this specification. Finish colours shall match the following standard colours for the designated items. Coating MANUFACTURERS shall use the German colour standard numbers, RAL 840-HR, for selecting the appropriate finish colours.

The following chart lists basic piping systems, equipment, and the required finish colour for that particular piping system and major equipment type. Any item that is not listed below, but is part of this project, shall be brought to the attention of the CONTRACTOR for selection of the finish colour and exact colour coding and marking requirements.

Before execution of painting work for colour coding, specified colour codes including letter sizes, safety slogans, and logos shall be compared with the existing plant piping and equipment. COMPANY approval shall be obtained before applying colour codes.

There shall be no cost impact to the COMPANY due to discrepancies or changes in the colour scheme, lettering, or logo, as specified being different from actual site requirements as this work shall be considered part of detailed engineering.

SUB-CONTRACTOR standard painting systems are not exempt for the safety colour requirements specified in this Appendix.

Appendix Table 7.8 Required Safety and Identification Colour Coding - Refining

Description	Colour	Colour Number
Piping		
Process and Utility Piping (other than services listed below)	Light Grey	RAL 7035
Instrument and Plant Air (plant air shall have a Pure White (RAL 9010) band 150 mm long @ 30 M intervals)	Light Blue	RAL 5012
Potable Water (potable water shall have a Gentian Blue (RAL 5010) band 150 mm long @ 30 M intervals)	May Green	RAL 6017
Fire Water	Vermillion	RAL 2002
Sea Water	Pine Green	RAL 6028
Acids and Alkalis	Red Lilac	RAL 4001
Control Valves (Actuator Only) and Relief Valves	Golden Yellow	RAL 1004
Gas Transmission Piping	Pure White	RAL 9010
Liquid Transmission Piping	White Aluminium	RAL 9006
Equipment - Furnaces		
Furnace Casing and Attached Steel Work	Light Grey	RAL 7035
Steel Work Not Connected	Tarpaulin Grey	RAL 7010
Stacks and Flue Duct (Note 3)	White Aluminium	RAL 9006
Top of Stack (Note 3)	Vermillion	RAL 2002

Description	Colour	Colour Number
Ladders and Walkways	Tarpaulin Grey	RAL 7010
Handrail Assemblies	Golden Yellow	RAL 1004
Equipment - Air Coolers		
Surfaces Operating from Ambient to 93°C	Tarpaulin Grey	RAL 7010
Surfaces Operating from 94°C to 538°C	White Aluminium	RAL 9006
Equipment - Miscellaneous		
Columns, Vessels, Exchangers, Boilers and N2 Storage Vessels (COMPANY Owned)	Light Grey	RAL 7035
Spheres	Signal White	RAL 9003
H2 Storage Vessels (COMPANY Owned)	Ochre Yellow	RAL 1024
Ejectors and Filters	Pure Orange	RAL 2004
Relief Valves	Golden Yellow	RAL 1004
Actuators of Control Valves	Golden Yellow	RAL 1004
Gas Storage (COMPANY Owned)	Light Grey	RAL 7035
Nitrogen (Temp. Above 80°C)	Signal White and	RAL 9003 and
	Golden Yellow Band	RAL 1004
Filling Station, Chain Blocks, Overhead Crane Assembly and Body, Guide Beam, Mobile Cranes and Forklifts, Push Buttons	Golden Yellow	RAL 1004
Fire Trucks	Vermillion	RAL 2002
Truck Loading Arms	Light Grey	RAL 7035
Air Conditioning System	Pale Green	RAL 6021
Workshop Equipment	Reseda Green	RAL 6011
Extinguishers - Water	Vermillion	RAL 2002
Extinguishers - Dry Chemical Powder	Gentian Blue	RAL 5010
Extinguishers - Carbon Dioxide (CO2)	Jet Black	RAL 9005
Extinguishers - Halon	Pale Green	RAL 6021
Extinguishers - Foam	Cream	RAL 9001
Structural Steel		
External Steel Work	Tarpaulin Grey	RAL 7010
Ladders, Walkways and Supports	Signal Grey	RAL 7004
Handrail Assemblies	Golden Yellow	RAL 1004
Protective Shelters (Ruwais Refinery)	Pigeon Blue	RAL 5014
Protective Shelters (Umm Al Nar Refinery)	Gentian Blue	RAL 5010
Flare, Stack Ladders, Platforms, etc.	Light Grey	RAL 7035
Steel Work Not Connected to Casing	Tarpaulin Grey	RAL 7010

Description	Colour	Colour Number
Machinery		
Pumps (Operating up to 93°C and Uninsulated), Compressors, Motors, Blowers	Reseda Green	RAL 6011
Pumps (Insulated and Uninsulated Operating Above 93°C)	White Aluminium	RAL 9006
Turbines and Associated Power Generators	Pure White	RAL 9010
Filters of Turbines	Golden Yellow	RAL 1004
Cranes and Lifting Tackle (Ruweis Refinery)	Lemon Yellow	RAL 1012
Cranes and Lifting Tackle at (Umm Al Nar Refinery)	Golden Yellow	RAL 1004
Workshop Machinery	Leaf Green	RAL 6002
Coupling Guards	Yellow Orange	RAL 2000
A/C Equipment except ducts (Ruweis Refinery)	Concrete Grey	RAL 7023
A/C Equipment except ducts (Umm Al Nar Refinery)	Pale Green	RAL 6021
Tanks		
Shell - Fixed and Floating Roof (Note 1 and Note 2) (Ruweis Refinery)	Light Blue	RAL 5012
	Pebble Grey	RAL 7032
	Cobalt Blue	RAL 5013
Shell - For fuel oil and gas oil tanks the shell will have a 150cm wide black blue (RAL 5004) stripe painted along the height of shell near gauge hatch (Umm Al Nar Refinery)	Signal White	RAL 9003
Roof - Fixed Roof Tanks	Signal White	RAL 9003
Roof - Floating Roof Tanks	Signal White	RAL 9003
Mechanical Mixers	Reseda Green	RAL 6011
Electrical Equipment		
Switch Boards	Pale Green	RAL 6021
Junction Boxes, Conduit Lamp Standards, Push Buttons	Golden Yellow	RAL 1004
Transformers and Motors	Reseda Green	RAL 6011
Street Light Posts and Lighting Poles (On Structures)	Light Grey	RAL 7035
Instrumentation		
Boards	Pale Green	RAL 6021
Instruments	Reseda Green	RAL 6011
Cable Trays and Instrument Boxes Sunshade	Pure White	RAL 9010

Notes for Appendix Table 7.8.

Ruweis Refinery

1. Straight Strip Design: From top of the tank shell a 4.2 m wide grey stripe shall be applied followed by a 1.65 m dark blue stripe. The rest of the storage tank shell shall be painted light blue.

2. The above noted stripe pattern, location, shape and colour shall coincide with existing storage tanks at the Ruwais Refinery. COMPANY approval shall be received before application of tank stripes. ADNOC Refining logos and safety slogans shall be painted and subject to approved by COMPANY.
3. Storage tanks ≥ 58 metres in diameter shall have a wavy stripe pattern similar to existing tanks painted on them. ADNOC Refining logos / safety slogans shall be painted and subject to approval by COMPANY.
4. Special stripes shall be applied at the top in a format similar to the existing colour code system.

Umm Al Nar Refinery

1. The tanks shall be a COMPANY logo painted in a most visible place.
2. Tank numbers shall be painted on yellow background with black capital letters in a most visible place.
3. The size of the logo and letters shall be in proportion to the tank size.
4. The shell of tanks could have a different colour and be provided with coloured stripes or bands to indicate service or product stored or to meet laid down statutory requirements.
5. Very tall stacks require blinking warning lights to be installed by civil aviation authorities.
6. Some owners also like to have red bands painted on upper 7.0 m of height.

Appendix Table 7.9 Gas Cylinders - Refining

Gas	Cylinder Body	Cylinder Neck	Cylinder Head
Acetylene	Oxide Red RAL 3009	Oxide Red RAL 3009	Oxide Red RAL 3009
Air	Reed Green RAL 6013	Reed Green RAL 6013 /	Reed Green RAL 6013 /
		Signal White RAL 9003 Dia Sectors	Signal White RAL 9003 Dia Sectors
Ammonia	Jet Black RAL 9005	Zinc Yellow RAL 1018	Vermillion RAL 2002
Argon	Water Blue RAL 5021	Water Blue RAL 5021	Water Blue RAL 5021
Chlorine	Zinc Yellow RAL 1018	Zinc Yellow RAL 1018	Zinc Yellow RAL 1018
Carbon Dioxide	Jet Black 9005	Reed Green RAL 6013	Reed Green RAL 6013
Hydrogen	Vermillion RAL 2002	Vermillion RAL 2002	Vermillion RAL 2002
Nitrogen	Reed Green RAL 6013	Jet Black RAL 9005	Jet Black RAL 9005
Oxygen	Jet Black RAL 9005	Jet Black RAL 9005	Jet Black RAL 9005
Inergen Low CFC	Vermillion RAL 2002	Jet Black RAL 9005	Light Grey RAL 7035

Notes for Appendix Table 7.9.

1. Cylinder contents can also be easily identified by stencilling the chemical symbol or name of the gas.
2. If desired either or both methods together can be used to identify gases.

3. Vermillion (Red) indicates flammable gases. Zinc Yellow denotes toxic gases.
4. Repainting is necessary when external colour has faded visually.

A7.2. Piping Colour Coding

Selected process and utility piping will require additional colour identification to be placed directly on the coated piping or on insulation jacketing. Following is a list of such piping and the additional colour requirements:

Appendix Table 7.10 Piping Colour Coding - Refining

Contents	Identification Colour Band	Colour Number	Contents Code
Process Water	Dark Blue	RAL	PW
Treated Water	Light Blue	RAL	TW
LP Steam	One Red	RAL	LPST
MP Steam	Two Red	RAL	MPST
HP Steam	Three Red	RAL	HPST
Steam Condensate	Dark Blue and White	RAL	SC
Fuel Oil	Black	RAL	FO
Fuel Gas	Yellow and Black	RAL	FG
Process Gas H/C	Yellow	RAL	PG
Gas Condensate	Dark Brown	RAL	PL
Hydrogen	Yellow and Red	RAL	H
Amine/Glycol	Light Brown	RAL	AM / GY
Acid Gas	Yellow Ochre	RAL	AG
Sulphur	Mustard	RAL	SU
HP Flare	Dark Violet	RAL	HFL
Blow Down to Liquid Flare	Light Violet	RAL	BD
Acid Gas Flare	Yellow Ochre	RAL	AF
Lube Oil System	Orange	RAL	LO
Seal Oil System	Orange	RAL	SO
Transfer Oil	Orange	RAL	TO
NGL	Dark Brown	RAL	NGL
Nitrogen	White	RAL	N
Liquid Petroleum Gas	Red and Green	RAL	LPG
Kerosene Aviation Fuel	Light Blue and Yellow	RAL	KER
Motor Gasoline	Brown and Violet	RAL	BNZ
Gas Oil	Orange and Blue	RAL	GOL

Contents	Identification Colour Band	Colour Number	Contents Code
HVGO	Dark Blue and Black	RAL	HVG
LVGO	Dark Blue and Black	RAL	LVG
Residue	Black and Green	RAL	RES
Diesel	Orange and Blue	RAL	DSL
Raffinate	Brown and Violet	RAL	RAF
Benzene	Light Green and Orange	RAL	BZE
Paraxylene	Light Green and Light Blue	RAL	PXE

Notes for Appendix Table 7.10.

1. The width of the identification colour band shall be:
 - a. Up to 4" NPS - 100 mm
 - b. Above 4" NPS - Pipe Diameter x 2

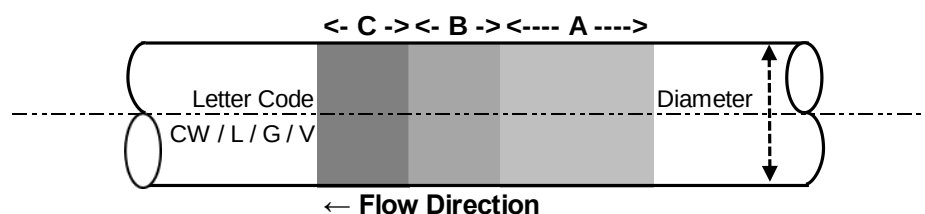
A7.3. Flow Direction

Flow direction shall be indicated by bands as described in Direction by Bands, below. Arrows can also be used to indicate the flow direction as described in Directions by Arrows.

A7.4. Direction by Bands

The coding shall be arranged as indicated in the example shown in Appendix Figure 7.2

Appendix Figure 7.2 Piping Colour Coding Arrangement - Refining



A7.5. Letter Code

First two letters of this example indicate contents (see Appendix Table 6.7). Last letter indicates phase:

L = Liquid phase

G = Gas phase

V = Vapour phase

- a. For Dia > 4", A = Dia x 2, B = Dia x 1/2 and C = Dia x 1/2 up to maximum widths equivalent to 18".
- b. For piping above 18 inches diameter width, shall be 18".
- c. For Dia < 4", A = 100 mm, B = 50 mm and C = 25 mm.

Colour Band C is located on downstream side of Colour Band and indicates direction of flow.

In case of bi-directional flow, flow Band C will be located on each side of Band A.

Where two colours are used for quick identification (such as for steam, fuel gas, hydrogen, etc.) the following procedure will be adopted:

- a. Up to 4" Dia Piping, Band A shall be in alternating circumferential bands and Band C shall be the predominant colour.
- b. Above 4" Dia Piping, Band A and Band C shall be in alternating bands.

A7.6. Directions by Arrows

Arrows shall be used to indicate the flow direction of commodities contained in piping.

The arrows shall be white or black in colour to contrast with the basic colour of the pipe. The following sizes are recommended:

- a. Pipe 2" to 6" NPS, arrow to fit in a 25 mm x 100 mm rectangle.
- b. Pipe 8" NPS and larger, arrow to fit in a 50 mm x 150 mm rectangle.
- c. Where flow of the commodity is possible in either direction, two arrows shall be indicated pointing in opposite directions.

Arrows and band markings shall be made at the unit battery limits and at the COMPANY designated locations.

A7.7. Colour

The code indications shall be painted either in white or in black in order to contrast clearly with the colour of paint on the pipe or equipment. For insulated lines, the code indications shall be painted over the insulation jacket.

A7.8. Labelling Requirements

For piping and equipment, full name or abbreviations of chemical and symbol of fluid flowing inside a pipeline shall be indicated. The line number shall also be painted on the pipelines.

Line numbering labels shall be applied to all pipes every 30 m.

For equipment, the name, tag number and service are required to be painted.

For support columns, Code indication in the form of serial numbers shall be adopted for supporting columns of concrete or structural steel. Numbers shall be provided by the CONTRACTOR.

A7.9. Size

The size of lettering used for code indications on insulated and un-insulated piping is as follows. The following are suggested sizes only and may be varied by the COMPANY.

<u>Item</u>	<u>Size</u>	<u>Letter Size</u>
Pipe	2" NPS and below	25 mm letters
Pipe	3" to 6" NPS	50 mm letters
Pipe	8" NPS and above	80 mm letters

Process Equipment	All sizes	100mm to 300 mm letters
Tanks and Spheres	All sizes	500mm to 1000 mm letters

APPENDIX A8. SAFETY COLOUR CODING AND IDENTIFICATION - ONSHORE

A8.1. Colour Coding and Marking

Colour coding and marking shall be according to the requirements below, unless the project has specific requirements. In any case, the painting works carried out by the SUB-CONTRACTOR shall include all colour coding and marking required for service identification.

A8.2. Colour Coding

Colour coding does only apply to aboveground installations. The colour coding requirements are based upon BS 1710.

Three methods of identification are included:

- Basic identification colours only,
- Basic identification colours and code indications,
- Basic identification colours used in conjunction with an ADNOC Onshore colour coding scheme.

A8.2.1 General

All methods of identification shall be compatible with pipe and operating conditions.

This finish colour is the protective or decorative colour.

The basic identification shall be applied at all junctions, at both sides of every valve, entry into or from every piece of equipment or vessel, bulkhead and wall penetration and any other place where identification is necessary.

In firefighting service all the piping, valves and flanges shall be painted Signal Red.

A8.2.2 Finish Colour

All pipework, vessels, tanks and other components shall be having their full surface painted with the topcoat finish colour as below.

Appendix Table 8.11 Finish Colours - Onshore

Description	Colour	Colour Number
Tanks	Pure White	RAL 9010
Pipework, Vessels, Columns and Rotating Equipment	Light Grey	RAL 7035
Firewater Systems	Signal Red	RAL 3001

Additional colours are listed below for special components.

Appendix Table 8.12 Reference Colours for Equipment - Onshore

Description	Colour	Colour Number
Structural Steel and Support		
Ladders, Walkways and Supports	Tarpaulin Grey	RAL 7010
External Steel Works	Tarpaulin Grey	RAL 7010
Handrail Assemblies	Golden Yellow	RAL 1004
Protective Shelters	Gentian Blue	RAL 5010
Fencing Works	Moss Green	RAL 6005
Stacks and Flue Ducts	White Aluminium	RAL 9006
Sunshades	Pure White	RAL 9010
Electrical / Instrument		
Switch Board	Light Grey RAL 7035 for Indoor Applications	
Panels		
Junction Boxes	Pebble Grey RAL 7032 for Outdoor Applications	
Transformers and Motors		
Instrument Boards		
Equipment		
Relief Valves	Golden Yellow	RAL 1004
Control Valves (Actuator only)	Golden Yellow	RAL 1004
Air Conditioning System	Pale Green	RAL 6021
Blocks	Golden Yellow	RAL 1004
Cranes	Golden Yellow	RAL 1004
Special Small Items, Filters and Ejectors	Pure Orange	RAL 2004
Cathodic Protection Equipment		
Transformer Rectifier Units, Junction Boxes	Platinum Grey	RAL 7036

A8.3. Methods of Application

A8.3.1 Basic Identification Colour Only

Where only indication of the basic nature of the fluid is required the basic identification colour shown in Appendix Table 8.13 shall be applied by one of the following methods:

- Painted on the pipe over the whole length.
- Painted on the pipe, as a band round the complete circumference, over a length of 150mm at points specified (General) above, and at least every 50 meters.

- c. Applied by wrapping around the pipe, at points specified (General) above, and at least every 50 meters, an adhesive band of the basic identification colour over a length of 150 mm. This is the preferred method for insulated pipework where the insulation is covered by protective cladding.

Appendix Table 8.13 Basic Identification Colours - Onshore

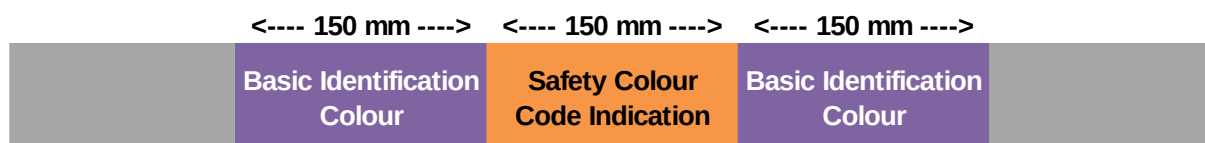
Pipe Contents	Colour	Colour Number
Water	May Green	RAL 6017
Fire Extinguishing Fluids	Vermilion	RAL 2002
Steam	Grey White	RAL 9002
Oils and Combustible Liquids	Fawn Brown	RAL 8007
Gases in either Gaseous or Liquefied condition (except Air and Inert Gasses)	Maize Yellow	RAL 1006
Acids and Alkalis	Red Lilac	RAL 4001
Inert Gas / Nitrogen	Carmine Red	RAL 3002
Air	Light Blue	RAL 5012
Other Liquids	Jet Black	RAL 9005
Electrical Services and Ventilation Ducts	Pastel Orange	RAL 2003
Supercritical CO ₂	Grass Green	RAL 6010

A8.3.2 Basic Identification Colours and Code Indications

Code indications may be applied to the basic identification colours described above to give more specific information about the nature of the fluid or the hazard. Code indications shall be:

- The safety colours shall be applied as bands 150mm wide if the pipe is painted in the base identification colour. If the base identification colour is applied as bands, the safety colour shall be applied between two bands of base identification colour each 150mm long. Safety colours in the form of colour banding.
 - Yellow for warning.
 - Auxiliary blue in conjunction with green basic colour for fresh water.
- Information shall be given regarding the nature of the contents of the pipe by using one or more of the following systems
 - Name either in full or an accepted abbreviation.
 - Chemical symbol.
 - Hazard symbol to be applied over the yellow warning safety colour.
 - Direction of flow using arrows or bands with decreasing length (thinner band on the downstream side).

Appendix Figure 8.3 Example of Application of Safety Colour and Coding - Onshore



Names, chemical symbols and flow arrows shall be in black or white in order to contrast clearly with the colour of the pipe or with the basic identification colour.

They shall be placed directly on the pipe or on a label fixed to the pipe near the basic identification colour. Where labels are to be used on an installation in conjunction with a safety colour the background colour of the label shall be that of the safety colour.

Appendix Table 8.14 Safety Colours - Onshore

Colour	Colour Number
Colza Yellow	RAL 1021
Sky Blue	RAL 5015

Appendix Table 8.15 Reference Colours - Onshore

Reference colours (if other than safety colours) not previously specified in Appendix Table 8.13 and Appendix Table 8.14.

Colour	Colour Number
Zinc Yellow	RAL 1018
Carmine Red	RAL 3002
Rose	RAL 3017
Red Lilac	RAL 4001
Gentian Blue	RAL 5010
Pine Green	RAL 6028

A8.3.3

A8.3.4 Basic Identification Colours with Onshore Coding Systems

The basic identification colours only designate broad categories of fluids and it will often be necessary to break these down further depending upon function. For example, the basic identification colour for all oils is brown, but it may be necessary to differentiate between the live crude, stabilized crude, lubrication oil, seal oil etc. In this case the same principles apply, in that the base identification colour will identify the prime nature of the pipe contents and supplementary banding will provide further identification.

The base colour will be applied in two bands 150mm in length applied either side of the colour code indication. The colour code indication will consist of one band 150mm in length or three bands of 50mm in length as shown in Appendix Table 8.16

Additional information about the nature of the contents of the pipe may be given as shown above.

Appendix Table 8.16 Colour Code Guide - Onshore

Pipe Contents	Basic Identification Colour 150 mm	Colour Code Indication 1 x 50 mm or 3 x 50 mm	Basic Identification Colour 150 mm
Water			
Untreated	May Green (RAL 6017)		
Drinking / Fresh	May Green (RAL 6017)	Sky Blue (RAL 5015)	May Green (RAL 6017)
Produced	May Green (RAL 6017)	Fawn Brown (RAL 8007)	May Green (RAL 6017)
Injection	May Green (RAL 6017)	Rose (RAL 3017)	May Green (RAL 6017)
Cooling	May Green (RAL 6017)	Pure White (RAL 9010)	May Green (RAL 6017)
Heating	May Green (RAL 6017)		
Oil			
Stabilised Crude	Fawn Brown (RAL 8007)		
Unstabilised Crude	Fawn Brown (RAL 8007)	Zinc Yellow (RAL 1018)	Fawn Brown (RAL 8007)
Gas Condensate	Fawn Brown (RAL 8007)	Maize Yellow (RAL 1006)	Fawn Brown (RAL 8007)
Diesel Fuel	Fawn Brown (RAL 8007)	Pure White (RAL 9010)	Fawn Brown (RAL 8007)
Hydraulic	Fawn Brown (RAL 8007)	Rose (RAL 3017)	Fawn Brown (RAL 8007)
Seal	Fawn Brown (RAL 8007)	Pine Green (RAL 6028)	Fawn Brown (RAL 8007)
		Pure White (RAL 9010)	
		Pine Green (RAL 6028)	
Lubrication	Fawn Brown (RAL 8007)	Pine Green (RAL 6028)	Fawn Brown (RAL 8007)
Transformer	Fawn Brown (RAL 8007)	Carmine Red (RAL 3002)	Fawn Brown (RAL 8007)
Gas			
Process Gas	Maize Yellow (RAL 1006)	May Green (RAL 6017)	Maize Yellow (RAL 1006)
Fuel Gas	Maize Yellow (RAL 1006)	Pine Green (RAL 6028)	Maize Yellow (RAL 1006)
Injection Gas	Maize Yellow (RAL 1006)	Pine Green (RAL 6028)	Maize Yellow (RAL 1006)
		Pure White (RAL 9010)	
		Pine Green (RAL 6028)	
Acid Gas	Maize Yellow (RAL 1006)	Maize Yellow (RAL 1006)	Maize Yellow (RAL 1006)
		Red Lilac (RAL 4001)	
		Maize Yellow (RAL 1006)	
Vent / Flare Gas	Maize Yellow (RAL 1006)	Carmine Red (RAL 3002)	Maize Yellow (RAL 1006)
Inert Gas			
Inert Gas	Carmine Red (RAL 3002)		

Pipe Contents	Basic Identification Colour 150 mm	Colour Code Indication 1 x 50 mm or 3 x 50 mm	Basic Identification Colour 150 mm
Air			
Plant Air	Light Blue (RAL 5012)	Pure White (RAL 9010)	Light Blue (RAL 5012)
Instrument Air	Light Blue (RAL 5012)		
Steam			
Steam	Grey White (RAL 9002)		
Drain			
Open Drain	Jet Black (RAL 9005)	Pure White (RAL 9010)	Jet Black (RAL 9005)
Closed Drain	Jet Black (RAL 9005)	Carmine Red (RAL 3002)	Jet Black (RAL 9005)
Services			
Electrical Services and Ventilation Ducts	Pastel Orange (RAL 2003)		
Chemicals			
Injection Chemicals	Red Lilac (RAL 4001)		
Glycol	Jet Black (RAL 9005)		

A8.4. Painting of Tag Numbers and Identification Strings

A8.4.1 General

This section details the minimum requirements for painting of tag numbers on main vessels and storage tanks and painting of identification strings on pipelines.

A8.4.2 Vessels and Storage Tanks

Vessels which are of larger size and all storage tanks shall be identified by painting the tag number on the surface. The tag number shall be clearly visible from normal access routes to the equipment.

Typical examples of equipment are:

- Test Separators.
- Production Separators.
- Flow Suction Tanks.
- Storage Tanks.
- Degassing Tanks.
- Knock-Out Vessels.
- Equipment / Manifold Skids.

The minimum character heights for painting of tag numbers shall be as follows:

- | | |
|--------------------------------------|--------|
| a. Storage Tanks | 500mm |
| b. Separators and Flow Suction Tanks | 400mm |
| c. Knock Out Vessels | 200 mm |
| d. Skids | 150mm |

A8.4.3 Piping and Pipelines

All piping and pipelines of nominal size 2" and above shall be identified by painting the identification string at minimum three locations. The painting shall preferably be on the side in the 3 or 9 o'clock position and shall be clearly visible from normal access routes. Piping and pipelines which are closely grouped, shall be painted on the top 12 o'clock position.

The piping shall also be identified at the 6 o'clock position when installed on an overhead rack.

The minimum character heights for painting of identification strings shall be as follows:

- | | |
|---------------------|------|
| a. NPS 4" and above | 70mm |
| b. NPS 2" and 3" | 25mm |

The alphanumerical characters forming the identification string shall be painted by using pre-cut stencils inserted in a suitable holding frame. Care shall be taken to ensure that the string is properly positioned and dimensioned.

A8.5. Paint Type and Colour

The colour of paint for the characters forming the tag numbers and identification strings shall be black.

The type of paint to be used shall be a recoatable urethane finish.

APPENDIX A9. SAFETY COLOUR CODING AND IDENTIFICATION - OFFSHORE

Offshore has established a background-coding scheme for its offshore and onshore operating facilities. This scheme unifies the finish colour of similar structures or differentiates between groups of operating facilities from another depending upon its field origin. Unlike colour identification of pipework and services as detailed within this Appendix, the following colour coding does not identify a particular service.

In the Appendix Table 9.17 and

Appendix Table 9.18, unless otherwise specified during project stage, the final colours of structures, equipment and machinery surfaces, included or installed on offshore structures are defined.

A9.1. Colour Coding for Umm Shaif / Lower Zakum / Nasr / Umm Lulu Offshore Structures

The colours specified in Appendix Table 9.17 shall be used as an overall finish of the external surfaces of the relevant plant, pipework or structure offshore.

Appendix Table 9.17 Colour Coding for Umm Shaif / Lower Zakum / Nasr / Umm Lulu - Offshore

Application	Colour to BS 4800	Colour Coding to BS 4800
Complex Structures		
Submerged zone and Splash zone up to 5 m above the MSL or underside of the 1st deck level	Black	00 E 53
Intermediate zone, cellar and lower deck areas (up to the next deck level)	Poppy Red	04 E 53
Top Zone	Ivory	10 C 31
Piping, Fittings, Valves, Actuators and Supports	Nimbus Grey	10 A 07
Vessels Exchangers, Tanks and Equipment	Nimbus Grey	10 A 07
Handrails, Ladders and Stanchions (Atmospheric and Splash Zones)	Golden Yellow	08 E 51
Wellhead Towers Structures - USF / LZF / UL / Nasr		
Submerged zone and Splash zone up to 5m above the MSL	Black	00 E 53
Topside Zone - All surfaces above 5m above the MSL to the top of the structure	Poppy Red	04 E 53
Piping, Fittings, Valves, Vessels and Tanks	Nimbus Grey	10 A 07
Handrails, Ladders and Stanchions (Atmospheric and Splash Zones)	Golden Yellow	08 E 51

Appendix Table 9.18 Colour Coding for Upper Zakum / SATF / UADF - Offshore

Application	Colour to BS 4800	Colour Coding to BS 4800
Central Complex Structures		

Application	Colour to BS 4800	Colour Coding to BS 4800
Submerged zone and Splash zone up to underside of the 1st deck level	Black	00 E 53
Top Zone (above splash zone till top of structure)	Golden Yellow	08 E 51
Super Complex (ZCC and Satellites) including Offices and control Rooms Buildings, workshops, etc, Accommodation Platforms (ACPTs)	White	00 E 55
Piping, Fittings, Valves, Actuators and Supports	White	00 E 55
Vessels Exchangers, Tanks and Equipment	White	00 E 55
Handrails, Ladders and Stanchions (Atmospheric and Splash Zones)	Golden Yellow	08 E 51
Wellhead Towers Structures - UZF / SATF / UADF		
Submerged zone and Splash zone up to 13m above the MSL OR underside of the 1st deck level.	Black	00 E 53
Topside Zone - All surfaces above 13 m above the MSL to the top of the structure	Golden Yellow	08 E 51
Pipework, Valves, Vessels and Tanks	White	00 E 55
Handrails, Ladders and Stanchions, (Atmospheric and Splash Zone)	Golden Yellow	08 E 51

A9.2. Colour Coding of Onshore Plants

The colours specified in following Appendix Table 9.19 and Appendix Table 9.20 shall be used as an overall finish of the external surfaces of the relevant plant, pipework or structure related to onshore.

Appendix Table 9.19 Colour Coding of Das Island - Offshore

Plant	Colour to BS 4800	Colour Coding to BS 4800
Umm Shaif related Facilities	Bright Green	14 E 51
Zakum related Facilities	Duck Egg Blue	16 C 33
Bunduq related Facilities	Cornflower Blue	20 E 51
Shared related Facilities	Ivory	10 C 31
Zirku Gas related Facilities	Black	00 E 53
Satah Al-Razboot related Facilities	White	10 A 01
Tidal Zone related Facilities (Foreshore and Flares)	Black	00 E 53
Buried related Facilities	Black	00 E 53
Sattah related facilities	Purple	04 E 58
Handrails	Golden Yellow	08 E 51

Appendix Table 9.20 Colour Coding of Zirku, Arzanah and Artificial Islands - Offshore

Plant	Colour to BS 4800	Colour Coding to BS 4800
Structure, Vessels, Exchangers, (except Rotating)	Goose Grey	00 A 05
Piping, Valves and Actuators	White	00 E 55
Handrails, Ladders and Stanchions	Golden Yellow	08 E 51
Electrical Substations, Battery rooms (Artificial Islands)	Canary Yellow	10 E 55
Local Control Rooms / Machine Technical Rooms (Artificial Islands)	Cornflower Blue	20 E 51
Buildings (MSW, Warehouse, Harbour, etc. (Artificial Islands)	Goose Grey	00 A 05
Diesel Storage tanks (Artificial Islands)	White	00 E 55
Accommodation Clusters (Artificial Islands)	White	00 E 55

A9.3.

A9.4. Colour Coding of General Items

The items listed in Appendix Table 9.21 shall be top coated with the specified unified Colours wherever they are located within Offshore owned facilities.

Appendix Table 9.21 Colour Coding of General Items - Offshore

Application	Colour to BS 4800	Colour Coding to BS 4800
Pumps, Compressors Generators and Drivers	Dawn Grey	10 A 03
Instrument and Electrical Equipment	Dawn Grey	10 A 03
Dangerous Exposed Points of Electrical Equipment	Cobalt Blue	18 E 53
Dangerous Exposed Points of Machinery Equipment	Mandarin Orange	06 E 51
First Aid Equipment	Holly Green	14 C 39
Runway Beams, Overhead and Ground Level Obstructions	Canary Yellow and	10 E 55 and
	Black Stripes	00 E 53
Crane Booms and Derricks	Poppy Red and	04 E 53 and
	White Stripes	00 E 55
Push Buttons, Machinery Controls, Shutdown Buttons Chain Hoists, Guards, Coupling etc.	Canary Yellow	10 E 55
HDG Gratings, if Painted	Black	00 E 53
Valve Handles	Black	00 E 53
Escape Route Marking (Directional Arrows at 5 m interval and at Changes of Directions)	Canary Yellow and	10 E 55
	Black Arrows	00 E 53

Application	Colour to BS 4800	Colour Coding to BS 4800
Safety Net Supports (WHTs)	Poppy Red	04 E 53
Fire Fighting Facilities	Poppy Red	04 E 53
Navigation Aid	Nimbus Grey	10 A 07
Solid Decks (Excluding Gratings)	Irish Green	14 E 53
Solid Decks (Muster Area)	Canary Yellow 300mm Wide Bands Canary Yellow within Boundary 30mm Wide Chevrons	10 E 55
Solid Decks (Lay down Area)	Orange 300mm Wide Boundary Band	06 E 55
Control Panels (Electrical and Instrumentation)	Dawn Grey	10 A 03
Control and Process Rooms / Cabins	Dawn Grey	10 A 03
Helideck Marking	See APPENDIX A13 and CAAP 071	Helideck Marking
Safety Net Support - Complexes	Ivory	10 C 31
Safety Net	Irish Green	14 E 53

A9.5. Colour Identification of Pipework and Services

All known pipework conveying fluids in liquid and / or gaseous states are covered by this Specification. Pipelines in services, which are not covered by this scheme and required to be colour identified, shall refer to the authorised Offshore group to advise appropriate colour identification.

A9.6. Colour Identification Scheme

The transported fluids in the pipe shall be identified with the basic or with the additional identification colours according respectively to the Appendix Table 9.22 and Appendix Table 9.23.

Commodity having properties in common are grouped under one basic colour e.g. oil, water, gas, chemicals.

Appendix Table 9.22 Basic Identification Colours for Fluids - Offshore

Group of Fluid	Colour to BS 4800	Colour Coding to BS 4800
Steam	Dawn Grey	10 A 03
Water	Dark Laurel	12 D 45
Crude oil	Saddle Brown	06 C 39
Petroleum Gases	Butterscotch	08 C 35
Kerosene, Diesel Oil, Jet Fuel, etc.	Black	00 E 53

Group of Fluid	Colour to BS 4800	Colour Coding to BS 4800
Instrument and Industrial Air, Nitrogen, Oxygen, Halon and Vacuum	Cornflower Blue	20 E 51
Chemicals	Mandarin Orange	06 E 51
Acid and Alkali	Purple	22 D 43
Fire Protection	Poppy Red	04 E 53
Vents, Drains and Slops	Linden Green	12 E 53

Individual characteristics of different services within the common group are distinguished by a secondary colour. Any pipework originally painted (background colour coded) along its entire length with one of the basic colours, an aluminium contrast band shall be used as an additional outer most colour to distinguish between the decorative colour and the basic colour identification of this particular pipework.

Appendix Table 9.23 Additional Identification Colours - Offshore

Group of Fluid	Colour to BS 4800	Colour Coding to BS 4800
Assigned only as Secondary Colour	Violet	02 D 44
Assigned only as Secondary Colour	White	00 E 55
Assigned only as Secondary Colour	Sunflower Yellow	10 E 53
Contrast Band	Aluminium	N.A.
Assigned only as Secondary Colour	Cobalt Blue	18 E 53

A9.7. Application of the Pipeline Identification Colours

A9.7.1 Colour Identification Band Lay-Out

The colour identifying all pipeline contents within Offshore facilities are listed in Appendix Table 9.26. The colour coding shall consist of three bands, the outside colour bands shall be the basic identification colour for a particular family of commodity, and the central band shall represent the secondary colour allocated for characterizing further the type of fluid within this major family or group (see Appendix Figure 9.4).

A9.7.2 Contrasting Bands

The protective or background colour code of the pipe shall not account for the basic identification colours. If the decorative colour interacts with the basic colour, a strip of aluminium band (50 mm) wide shall be applied at the outer edges of the basic colours (see Appendix Figure 9.4).

A9.7.3 Surface Preparation

Prior to the application of the colour identification bands, directional flow arrows, contrasting band and line numbers, all surfaces shall be degreased, high pressure fresh water washed and allowed to dry. If required the relevant surfaces, prior to the application of the colour identification bands may be slightly abraded using fine emery paper.

A9.7.4 Marking Lines in Close Proximity

In instances where a run of multiple lines exist e.g. pipe racks or major pipe supports, the colour identification, flow direction arrows and line numbers shall be positioned directly in line with one another on individual pipes and shall be easily visible.

A9.7.5 Safety Related Pipework

Pipework related to safety, such as fire protection, firewater, foam piping, etc. when specified for colour coding should be entirely coated from origin to all extremities in Poppy Red (04 E 53).

A9.8. Materials

The application of the colour identification shall be employed using approved Polyurethane paint applied over a contrasting high build undercoat matching British colour BS 4800. The former materials shall be chosen from COMPANY Approved Paint products.

Appendix Table 9.24 Bands for Pipeline - Offshore

Pipe Diameter	Basic Colour Band	Secondary Colour Band
Less than or equal to 6"	75 mm	50 mm
Above 6" to 14"	100 mm	75 mm
Above 14"	150 mm	100 mm

A9.8.1 Location of Colour identification

Colour coding should be applied to the pipe as follows:

- On all sides of and adjacent to valves, and other important fittings.
- Where pipes enter and emerge from walls, roads and walkway overpasses.
- Upstream and downstream lines from vessels, tanks, compressors, pumps and other major equipment.
- At uniform intervals not exceeding 20m along horizontal or vertical section of pipework.

A9.9. Additional Details for Colour Identification of Pipe Works

A9.9.1 Direction of Flow

The flow direction shall be shown on all pipelines in conjunction with the colour identification. This shall be indicated by an arrow stencilled on the line. The base of the arrow should be situated 400 mm away from the colour identification and in the most visible position (see Appendix Figure 9.4).

All markers should be positioned such that they are visibly pleasing.

A9.9.2 Line Number

All lines 2" NPS and larger shall be marked / identified with the line number by stencilling. Line number shall be applied at the start and end of the line (minimum requirement) and at intervals not exceeding 20m along horizontal or vertical section of pipework (see Appendix Figure 9.4).

A9.10. Work Identification Number (WIN)

All equipment vessels, tanks, rotating machinery and any other plant equipment, which is assigned a WIN/UTC number must show this number stencilled, in the most visible position.

A9.11. Size of Lettering and Numerals

Lettering and numeral height shall be equivalent to half pipe diameter with a minimum of 2" and a maximum of 6".

A9.12. Colour Coding of Storage Tanks Exterior and Components

Offshore has established a background coding scheme for its offshore and onshore operating facilities. This scheme unifies the finish colour of similar structures or differentiate between a group of operating facilities from another depending upon its field origin. Unlike colour identification of pipework and services as detailed in this Appendix of this of this Specification, the following colour coding does not identify a particular service.

In Appendix Table 9.25, unless otherwise specified during project stage and submitted to the COMPANY for approval, are defined the final colours of storage and process tanks exterior included or installed on onshore structures related to the field of origin.

Appendix Table 9.25 Colour Coding of Storage Tanks Exterior - Offshore

Application	Colour and Colour Coding According to Filed of Origin						
	Umm Shaif	Zakum	Bundiq	Shared	Zirku Gas	Sarb	Zirku / Arzanah / UZ Artificial Island / UAD / UZ Towers Complexes / SATF
Gasoline	Bright Green 14 E 51	Duck Egg Blue 16 C 33	Cornflower Blue 20 E 51	Ivory 10 C 31	Black 00 E 53	White 10 A 01	Goose Grey 00 A 05
Diesel Oil	Bright Green 14 E 51	Duck Egg Blue 16 C 33	Cornflower Blue 20 E 51	Ivory 10 C 31	Black 00 E 53	White 10 A 01	White 00 E 55
Fuel Oil Bitumen	Bright Green 14 E 51	Duck Egg Blue 16 C 33	Cornflower Blue 20 E 51	Ivory 10 C 31	Black 00 E 53	White 10 A 01	Black 00 E 53
Crude Oil	Bright Green 14 E 51	Duck Egg Blue 16 C 33	Cornflower Blue 20 E 51	Ivory 10 C 31	Black 00 E 53	White 10 A 01	Magnolia 08 B 15
Water	Bright Green 14 E 51	Duck Egg Blue 16 C 33	Cornflower Blue 20 E 51	Ivory 10 C 31	Black 00 E 53	White 10 A 01	Goose Grey 00 A 05
Sulphuric Acid	Bright Green 14 E 51	Duck Egg Blue 16 C 33	Cornflower Blue 20 E 51	Ivory 10 C 31	Black 00 E 53	White 10 A 01	Goose Grey 00 A 05
Glycol	Bright Green 14 E 51	Duck Egg Blue 16 C 33	Cornflower Blue 20 E 51	Ivory 10 C 31	Black 00 E 53	White 10 A 01	Goose Grey 00 A 05

A9.13. Pipeline Identification Colours

Appendix Table 9.26 Pipeline Identification Colours - Offshore

Pipe Content	Basic Identification Colour	Secondary Identification Colour			Basic Identification Colour
Crude Oil (Live)	Saddle Brown 06 C 39	Sunflower Yellow 10 E 53			Saddle Brown 06 C 39
Crude Oil (Stabilized)	Saddle Brown 06 C 39	Dark Laurel 12 D 45			Saddle Brown 06 C 39
Crude Oil (Export)	Saddle Brown 06 C 39	Cornflower Blue 20 E 51			Saddle Brown 06 C 39
Separated Oil	Saddle Brown 06 C 39	Mandarin Orange 06 E 51			Saddle Brown 06 C 39
Recovered Oil	Saddle Brown 06 C 39	Deep Purple 22 D 45			Saddle Brown 06 C 39
Oily Water (OW)	Saddle Brown 06 C 39	Violet 02 D 44			Saddle Brown 06 C 39
Sludge (SL)	Saddle Brown 06 C 39	Cobalt Blue 18 E 53			Saddle Brown 06 C 39
Sour Gas (Wet)	Butterscotch 08 C 35	Poppy Red 04 E 53	Dawn Grey 10 A 03	Poppy Red 04 E 53	Butterscotch 08 C 35
Sour Gas (Dry)	Butterscotch 08 C 35	Poppy Red 04 E 53	Saddle Brown 06 C 39	Poppy Red 04 E 53	Butterscotch 08 C 35
Sweet Gas (Wet) < 100 ppm H ₂ S	Butterscotch 08 C 35	Dark Laurel 12 D 45	Dawn Grey 10 A 03	Dark Laurel 12 D 45	Butterscotch 08 C 35
Sweet Gas (Dry) < 100 ppm H ₂ S	Butterscotch 08 C 35	Dark Laurel 12 D 45	Saddle Brown 06 C 39	Dark Laurel 12 D 45	Butterscotch 08 C 35
Flare Gas	Butterscotch 08 C 35	Deep Purple 22 D 45			Butterscotch 08 C 35
Condensate	Butterscotch 08 C 35	Violet 02 D 44			Butterscotch 08 C 35
Gas Condensate	Butterscotch 08 C 35	Violet 02 D 44	White 00 E 55	Violet 02 D 44	Butterscotch 08 C 35
HP / LP Fuel Gas (HFG / LFG)	Butterscotch 08 C 35	Black 00 E 53			Butterscotch 08 C 35
Propane	Butterscotch 08 C 35	Cornflower Blue 20 E 51			Butterscotch 08 C 35
Pilot Gas to Flare	Butterscotch 08 C 35	White 00 E 55			Butterscotch 08 C 35
Reboiler Vent Gas	Butterscotch 08 C 35	White 00 E 55	Dark Laurel 12 D 45	White 00 E 55	Butterscotch 08 C 35

Pipe Content	Basic Identification Colour	Secondary Identification Colour			Basic Identification Colour
Gas to Atmosphere	Butterscotch 08 C 35	White 00 E 55	Deep Purple 22 D 45	White 00 E 55	Butterscotch 08 C 35
Process Gas (P)	Butterscotch 08 C 35	White 00 E 55	Sunflower Yellow 10 E 53	White 00 E 55	Butterscotch 08 C 35
HP Relief (HRV)	Butterscotch 08 C 35	Deep Purple 22 D 45	Dawn Grey 10 A 03	Deep Purple 22 D 45	Butterscotch 08 C 35
LP Relief Gas (LRV)	Butterscotch 08 C 35	Dark Laurel 12 D 45			Butterscotch 08 C 35
Gas Injection (GJ)	Butterscotch 08 C 35	Saddle Brown 06 C 39			Butterscotch 08 C 35
Relief Gas (RV)	Butterscotch 08 C 35	Cobalt Blue 18 E 53	Saddle Brown 06 C 39	Cobalt Blue 18 E 53	Butterscotch 08 C 35
Halon	Cornflower Blue 20 E 51	Dark Laurel 12 D 45			Cornflower Blue 20 E 51
Inergen	Cornflower Blue 20 E 51	Dark Laurel 12 D 45	Butterscotch 08 C 35	Dark Laurel 12 D 45	Cornflower Blue 20 E 51
Vacuum	Cornflower Blue 20 E 51	Sunflower Yellow 10 E 53			Cornflower Blue 20 E 51
Nitrogen	Cornflower Blue 20 E 51	Mandarin Orange 06 E 51			Cornflower Blue 20 E 51
Oxygen	Cornflower Blue 20 E 51	Poppy Red 04 E 53			Cornflower Blue 20 E 51
Instrument Air	Cornflower Blue 20 E 51	Black 00 E 53			Cornflower Blue 20 E 51
Industrial Air	Cornflower Blue 20 E 51	White 00 E 55			Cornflower Blue 20 E 51
Chlorine Gas	Cornflower Blue 20 E 51	Deep Purple 22 D 45			Cornflower Blue 20 E 51
Carbon Dioxide	Cornflower Blue 20 E 51	Saddle Brown 06 C 39			Cornflower Blue 20 E 51
Plant Utility Air (PA)	Cornflower Blue 20 E 51	Violet 02 D 44			Cornflower Blue 20 E 51

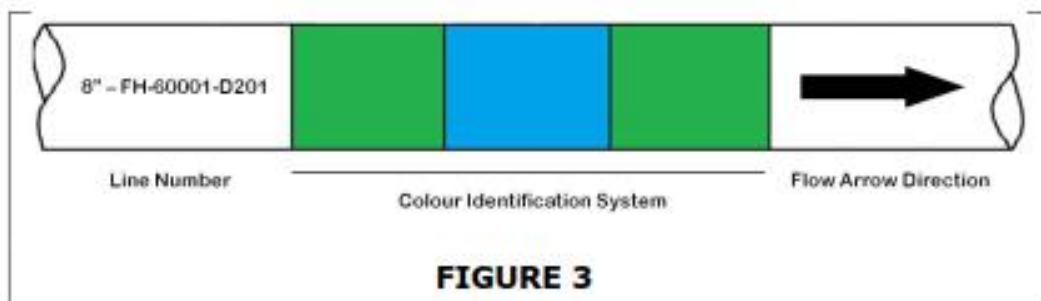
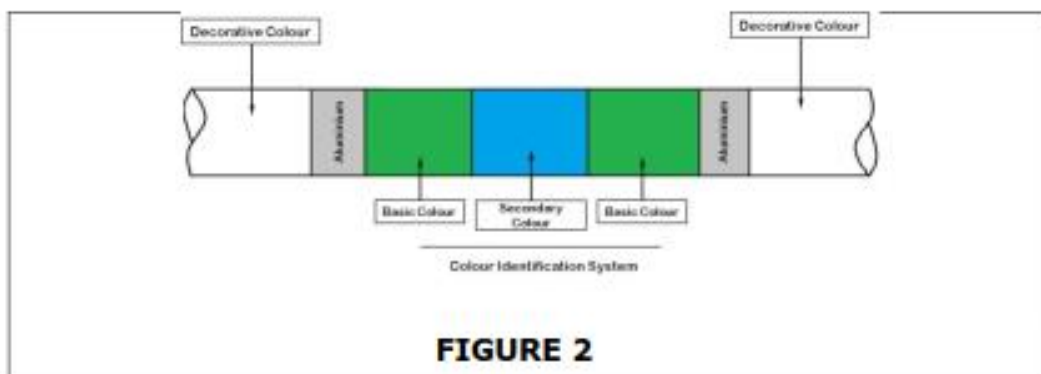
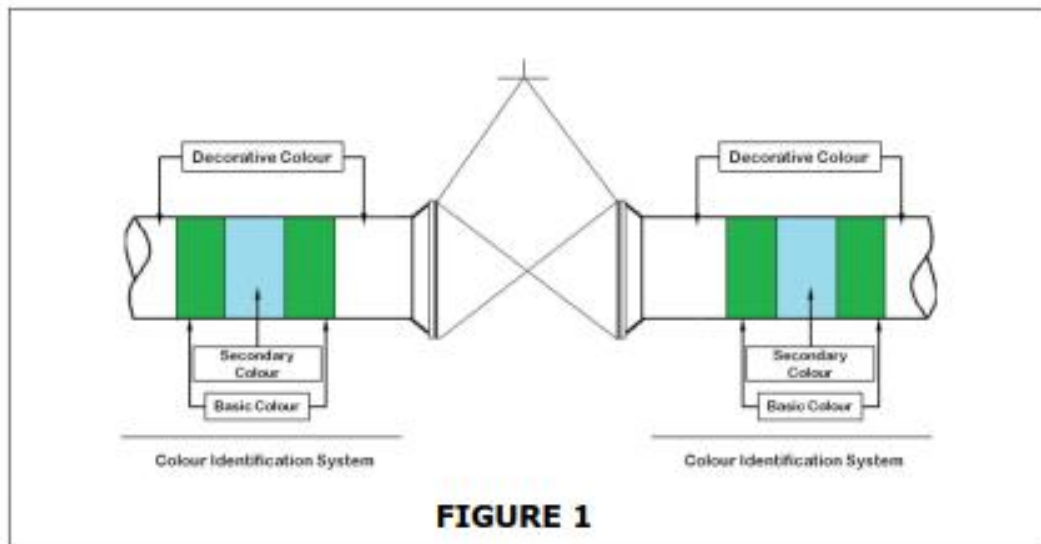
Pipe Content	Basic Identification Colour	Secondary Identification Colour			Basic Identification Colour
Fire Water	Poppy Red 04 E 53				
Foam (Fire Fighting)	Poppy Red 04 E 53	Butterscotch 08 C 35			Poppy Red 04 E 53
Acid Gas (AG)	Deep Purple 22 D 45	White 00 E 55			Deep Purple 22 D 45
Caustic Soda	Deep Purple 22 D 45	Black 00 E 53			Deep Purple 22 D 45
Sodium Hypochlorite	Deep Purple 22 D 45	Dark Laurel 12 D 45			Deep Purple 22 D 45
Steam	Dawn Grey 10 A 03				
Steam Condensate	Dawn Grey 10 A 03	Dark Laurel 12 D 45			Dawn Grey 10 A 03
Bunker Fuel	Black 00 E 53	Cornflower Blue 20 E 51			Black 00 E 53
Aviation Fuel	Black 00 E 53	Deep Purple 22 D 45			Black 00 E 53
Furnace Fuel	Black 00 E 53	Poppy Red 04 E 53			Black 00 E 53
Kerosene	Black 00 E 53	Mandarin Orange 06 E 51			Black 00 E 53
Gasoline	Black 00 E 53	Sunflower Yellow 10 E 53			Black 00 E 53
Diesel Oil	Black 00 E 53	White 00 E 55			Black 00 E 53
Lube Oil	Black 00 E 53	Dark Laurel 12 D 45			Black 00 E 53
Hydraulic Oil	Black 00 E 53	Violet 02 D 44			Black 00 E 53
Hot Oil (HO)	Black 00 E 53	Dawn Grey 10 A 03			Black 00 E 53
Recovered Oil (RO)	Black 00 E 53	Butterscotch 08 C 35			Black 00 E 53
Water	Dark Laurel 12 D 45				
Sea Water (SW)	Dark Laurel 12 D 45	White 00 E 55			Dark Laurel 12 D 45
Sea Water Return (SWR)	Dark Laurel 12 D 45	White 00 E 55	Poppy Red 04 E 53	White 00 E 55	Dark Laurel 12 D 45

Pipe Content	Basic Identification Colour	Secondary Identification Colour			Basic Identification Colour
Hot Water	Dark Laurel 12 D 45	Dawn Grey 10 A 03			Dark Laurel 12 D 45
Sour Water	Dark Laurel 12 D 45	Sunflower Yellow 10 E 53			Dark Laurel 12 D 45
Cooling Water	Dark Laurel 12 D 45	Mandarin Orange 06 E 51			Dark Laurel 12 D 45
Utility Water	Dark Laurel 12 D 45	Saddle Brown 06 C 39			Dark Laurel 12 D 45
Potable Water	Dark Laurel 12 D 45	Cornflower Blue 20 E 51			Dark Laurel 12 D 45
Ballast Water	Dark Laurel 12 D 45	Poppy Red 04 E 53			Dark Laurel 12 D 45
Injection Sea Water	Dark Laurel 12 D 45	Black 00 E 53			Dark Laurel 12 D 45
Boiler Feed Water	Dark Laurel 12 D 45	Butterscotch 08 C 35			Dark Laurel 12 D 45
Effluent Water / Sewage (SW)	Dark Laurel 12 D 45	Violet 02 D 44			Dark Laurel 12 D 45
Deoxygenated Sea Water / Treated Water (TW)	Dark Laurel 12 D 45	Deep Purple 22 D 45			Dark Laurel 12 D 45
Demin Water (DMW)	Dark Laurel 12 D 45	Cobalt Blue 18 E 53	Saddle Brown 06 C 39	Cobalt Blue 18 E 53	Dark Laurel 12 D 45
Fresh Water (FW)	Dark Laurel 12 D 45	Cornflower Blue 20 E 51	White 00 E 55	Cornflower Blue 20 E 51	Dark Laurel 12 D 45
Desalter Wash Water (DWW)	Dark Laurel 12 D 45	Saddle Brown 06 C 39	Cobalt Blue 18 E 53	Saddle Brown 06 C 39	Dark Laurel 12 D 45
Produced Water (PW)	Dark Laurel 12 D 45	Mandarin Orange 06 E 51	Saddle Brown 06 C 39	Mandarin Orange 06 E 51	Dark Laurel 12 D 45
Seawater Supply (SWS)	Dark Laurel 12 D 45	Sunflower Yellow 10 E 53	Poppy Red 04 E 53	Sunflower Yellow 10 E 53	Dark Laurel 12 D 45
Open Drain	Linden Green 12 E 53	Saddle Brown 06 C 39	White 00 E 55	Saddle Brown 06 C 39	Linden Green 12 E 53
Closed Drain	Linden Green 12 E 53	Butterscotch 08 C 35	White 00 E 55	Butterscotch 08 C 35	Linden Green 12 E 53
Drains to Sea	Linden Green 12 E 53	Cornflower Blue 20 E 51	White 00 E 55	Cornflower Blue 20 E 51	Linden Green 12 E 53
Relief Vent	Linden Green 12 E 53	Deep Purple 22 D 45	White 00 E 55	Deep Purple 22 D 45	Linden Green 12 E 53

Pipe Content	Basic Identification Colour	Secondary Identification Colour			Basic Identification Colour
Slops	Linden Green 12 E 53	Poppy Red 04 E 53	White 00 E 55	Poppy Red 04 E 53	Linden Green 12 E 53
Injection Chemical (CIN)	Mandarin Orange 06 E 51	White 00 E 55			Mandarin Orange 06 E 51
Oil Corrosion Inhibitor Chemical Injection Biocide (BCD)	Mandarin Orange 06 E 51	White 00 E 55	Dark Laurel 12 D 45	White 00 E 55	Mandarin Orange 06 E 51
Gas Corrosion Inhibitor (Chemical Injection Anti-form (ANF)	Mandarin Orange 06 E 51	White 00 E 55	Deep Purple 22 D 45	White 00 E 55	Mandarin Orange 06 E 51
pH Controller	Mandarin Orange 06 E 51	White 00 E 55	Saddle Brown 06 C 39	White 00 E 55	Mandarin Orange 06 E 51
Chemical Injection Methanol (MNL)	Mandarin Orange 06 E 51	White 00 E 55	Cobalt Blue 18 E 53	White 00 E 55	Mandarin Orange 06 E 51
Scale Inhibitor	Mandarin Orange 06 E 51	Deep Purple 22 D 45			Mandarin Orange 06 E 51
Chemical Injection Oxygen Scavenger (OSC)	Mandarin Orange 06 E 51	Dawn Grey 10 A 03			Mandarin Orange 06 E 51
Catalyst (Cobalt Chloride)	Mandarin Orange 06 E 51	Cobalt Blue 18 E 53			Mandarin Orange 06 E 51
Chemical Injection Demulsifier (DMF)	Mandarin Orange 06 E 51	Violet 02 D 44			Mandarin Orange 06 E 51
Polyelectrolyte	Mandarin Orange 06 E 51	Dark Laurel 12 D 45			Mandarin Orange 06 E 51
Bentonite	Mandarin Orange 06 E 51	Sunflower Yellow 10 E 53			Mandarin Orange 06 E 51
Biocide	Mandarin Orange 06 E 51	Saddle Brown 06 C 39			Mandarin Orange 06 E 51
Methanol	Mandarin Orange 06 E 51	Poppy Red 04 E 53			Mandarin Orange 06 E 51

Pipe Content	Basic Identification Colour	Secondary Identification Colour			Basic Identification Colour
Diethanolamine	Mandarin Orange 06 E 51	Cornflower Blue 20 E 51			Mandarin Orange 06 E 51
Amine - Cyclohexylamine	Mandarin Orange 06 E 51	Butterscotch 08 C 35			Mandarin Orange 06 E 51
Glycol (MEG)	Mandarin Orange 06 E 51	Black 00 E 53	White 00 E 55	Black 00 E 53	Mandarin Orange 06 E 51
Glycol (TEG)	Mandarin Orange 06 E 51	Black 00 E 53	Poppy Red 04 E 53	Black 00 E 53	Mandarin Orange 06 E 51
Refrigerant	White 00 E 55	Mandarin Orange 06 E 51			White 00 E 55

Appendix Figure 9.4 Application of Colour Identification System - Offshore



APPENDIX A10. SAFETY COLOUR CODING AND IDENTIFICATION - LNG

All colour references for BS 1710 "Identification of Pipelines and Services" LNG adopted safety colours shall be taken from BS 4800, unless otherwise stated.

All plant equipment, piping and structure shall be coated the same colour, Goose Grey (BS 00 A 05) and shall be known as the general site background colour.

All colours used for the basic identification colours and colour code indications used in conjunction with the ADNOC particular colour coding scheme shall be BS 4800 Colour Reference in general in accordance with BS 1710.

Additional information such as Line Nos., Contents, or Equipment / Tag Numbers shall be stencilled in black or white on the safety colour code or on yellow information panels.

A10.1. Piping Identification Colour Scheme

Appendix Table 10.27 Pipeline Identification Colours - LNG

Pipe Contents	Identification Colour	Safety Colour Code	Identification Colour
Gas			
Sour Gas	Butterscotch 08 C 35	Poppy Red 04 E 53	Butterscotch 08 C 35
Sweet Gas	Butterscotch 08 C 35	Dark Laurel 12 D 45	Butterscotch 08 C 35
Sour Flare Gas	Butterscotch 08 C 35	Purple Heather 22 C 37	Butterscotch 08 C 35
Sweet Flare Gas	Butterscotch 08 C 35	Cornflower Blue 20 E 51	Butterscotch 08 C 35
Propane	Butterscotch 08 C 35	Black 00 E 53	Butterscotch 08 C 35
Multi Component Refrigerant	Butterscotch 08 C 35	White 00 E 55	Butterscotch 08 C 35
Air			
Plant Air	Cornflower Blue 20 E 51	White 00 E 55	Cornflower Blue 20 E 51
Instrument Air	Cornflower Blue 20 E 51	Black 00 E 53	Cornflower Blue 20 E 51
Halon / CO ₂	Cornflower Blue 20 E 51	Dark Laurel 12 D 45	Cornflower Blue 20 E 51
Nitrogen	Cornflower Blue 20 E 51	Mandarin Orange 06 E 51	Cornflower Blue 20 E 51
Oxygen	Cornflower Blue 20 E 51	Poppy Red 04 E 53	Cornflower Blue 20 E 51
Hypochlorite	Cornflower Blue 20 E 51	Purple Heather 22 C 37	Cornflower Blue 20 E 51

Pipe Contents	Identification Colour	Safety Colour Code	Identification Colour
Oil			
Lube Oil	Black 00 E 53	Dark Laurel 12 D 45	Black 00 E 53
Hydraulic Oil	Black 00 E 53	Regal Violet 24 C 39	Black 00 E 53
Diesel Oil	Black 00 E 53	White 00 E 55	Black 00 E 53
Sour Oil	Black 00 E 53	Poppy Red 04 E 53	Black 00 E 53
Water			
Sea Water C.W. Inlet	Dark Laurel 12 D 45	White 00 E 55	Dark Laurel 12 D 45
Dirty Condensate	Dark Laurel 12 D 45	Golden Yellow 08 E 51	Dark Laurel 12 D 45
Clean Condensate	Dark Laurel 12 D 45	Poppy Red 04 E 53	Dark Laurel 12 D 45
Sea Water CW Outlet Higher Temp	Dark Laurel 12 D 45	Mandarin Orange 06 E 51	Dark Laurel 12 D 45
Process / Jacket Water	Dark Laurel 12 D 45	Saddle Brown 06 C 39	Dark Laurel 12 D 45
Potable Water	Dark Laurel 12 D 45	Cornflower Blue 20 E 51	Dark Laurel 12 D 45
Sour Water	Dark Laurel 12 D 45	Regal Violet 24 C 39	Dark Laurel 12 D 45
Boiler Feed Water	Dark Laurel 12 D 45	Butterscotch 08 C 35	Dark Laurel 12 D 45
Desalinated Water	Dark Laurel 12 D 45	Black 00 E 53	Dark Laurel 12 D 45
Dematerialized Water	Dark Laurel 12 D 45	Purple Heather 22 C 37	Dark Laurel 12 D 45
Fire Fighting			
Fire water	Goose Grey 00 A 05	Poppy Red 04 E 53	Goose Grey 00 A 05
Foam (Fire Fighting)	Poppy Red 04 E 53	Butterscotch 08 C 35	Poppy Red 04 E 53
Steam			
Steam	Dawn Grey 10 A 03		
Steam Condensate	Dawn Grey 10 A 03	Dark Laurel 12 D 45	Dawn Grey 10 A 03
Chemicals			

Pipe Contents	Identification Colour	Safety Colour Code	Identification Colour
K ₂ CO ₃ Carbonate	Golden Yellow 08 E 51	Purple Heather 22 C 37	Golden Yellow 08 E 51
UCON + Antifoam	Golden Yellow 08 E 51	Poppy Red 04 E 53	Golden Yellow 08 E 51
Di-ethylamine DEA	Golden Yellow 08 E 51	Cornflower Blue 20 E 51	Golden Yellow 08 E 51
OCENOL Antifoam	Golden Yellow 08 E 51	Regal Violet 24 C 39	Golden Yellow 08 E 51
Acids / Alkalis			
Acid	Purple Heather 22 C 37	White 00 E 55	Purple Heather 22 C 37
Alkalis	Purple Heather 22 C 37	Black 00 E 53	Purple Heather 22 C 37

Appendix Table 10.28 BS 1710 (BS 4800) Colour Reference - LNG

Identification Colour	BS Colour Reference	Piping and Equipment
Piping Colour		
Goose Grey	00 A 05	Carbon steel
Dark Cherry	04 D 45	Stainless steel
Safety Colour		
Dark Laurel	12 D 45	Water
Dawn Grey	10 A 03	Steam
Butterscotch	08 C 35	Gases
Purple Heather	22 C 37	Acid and Alkalis
Cornflower Blue	20 E 51	Air
Mandarin Orange	06 E 51	Electrical
Black	00 E 53	Oil
Poppy Red	04 E 53	Fire Fighting
White	00 E 55	General Service
Saddle Brown	06 C 39	General Service
Golden Yellow	08 E 51	General Service
Cobalt Blue	18 E 53	General Service
Sunflower Yellow	10 E 53	General Service
Regal Violet	24 C 39	General Service

Appendix Table 10.29 Plant and Equipment Colour Scheme - LNG

Plant and Equipment	Identification Colour	BS Colour Reference
Process Piping and Equipment Stainless Steel	Dark Cherry	04 D 45
Process Piping Carbon Steel	Goose Grey	00 A 05
All Structural steelwork, equipment, including pipe supports, hangers, Storage Tanks, Vessels, Columns, Exchangers, Panels and Cladding.	Goose Grey	00 A 05
Active Fire Fighting equipment, Hydrants, Stang Monitors, loose boxes	Poppy Red	04 E 53
Rotating equipment, Pumps, Strainers and their supporting plinths	Antelope	08 B 21
Electrical motors with switch gear 440v, 3.3 Kv and 11 Kv	Mandarin Orange	06 E 51
Lifting Equipment / Runway Beams	Sunflower Yellow	10 E 53
Safety Ladders and Handrails	Black	00 E 53
	Golden Yellow	08 E 51
Platform Gate Guards	Poppy Red	04 E 53
Deck Gratings Onshore / Offshore (MIO)	M.I.O - Micaceous Iron Oxide Grey R8047	

Appendix Table 10.30 Schedule of Process Code Identification - LNG

Code	Description	Code	Description
K	Chemicals	LDEA	Lean DEA Solution
LECA	Lean Carbonate K_2CO_3	LNG	Liquefied Natural Gas
LNGL	LNG Liquid	LNGV	LNG Vapour Sweet
LNIT	Liquid Nitrogen	LOSO	Lube / Seal Oil
LPG	Liquid Petroleum Gas	LPGV	LPG Vapour
LTHC	Light H.C. Vapours	LU	Lube Oil
MCR	Mixed Component Refrigerant	MCRV	MCR Vapour
METH	Methane	MPFG	M.P. Feed Gas
MR	Mixed Refrigerant	N ₂	Nitrogen
NGAC	Natural Gas Condensate	NGAS	Natural Gas
OVAP	Overhead Vapour	OW	Oily Water
PD	Process Hydrocarbons (Sweet and Dry)	PENT	Pentane
PENV	Pentane Vapour	PG	Product Gas
PR	Process Refrigerant	PROL	Propane Liquid
PROP	Propane C ₃	PROV	Propane Vapour

Code	Description	Code	Description
PROW	Process Water	PS	Process Hydrocarbons (Sour and Wet)
PW	Process Hydrocarbons (Sweet and Wet)	R12	Freon 12
R22	Freon 22	RDEA	Rich DEA Solution
RGAS	Reactivation Gas	RGGA	Regeneration Gas
S	Molten Sulphur	SB	Steam SB 8.6 Barg
SCH	SH Steam Condensate	SCL	SL Steam Condensate
SEAW	Sea Water	SH	Steam 62.5 Barg
SL	Steam 4.2 Barg	SM	Steam 34.5 Barg
SO	Seal Oil	SOG	Sour Gas
SOW	Sour Water	SPRW	Spray Water
SS	Sulphur Plant Steam	ST	Steam
SU	Steam 1.5 Barg	SULF	Sulfamic Acid
SWG	Sweet Gas	SWGE	Sewage
TC	Equip. Trim Lines	TE	Equip. Trim Line
TEMW	Tempered Water	TIPB	TIP Priming Blue
TIPG	TIP Priming Green	TIPR	TIP Priming Red
TSP	Tri-Sodium Phosphate	TT	Equip. Trim Line
WB	Boiler Feed Water	WC	Cooling Water (Salt)
WD	Water Potable	WF	Fire Water
WFG	Wet Fuel Gas	WGAS	Waste Gas
WHCV	Wet HC Vapour	WHYD	Wet Hydrocarbon
WJ	Cooling Water (Jacket)	WP	Flushing Water (Process and Pump)
WR	Raw Water (Desalinated)	WT	Treated Water
WU	Utility Water	WV	Water Vapour

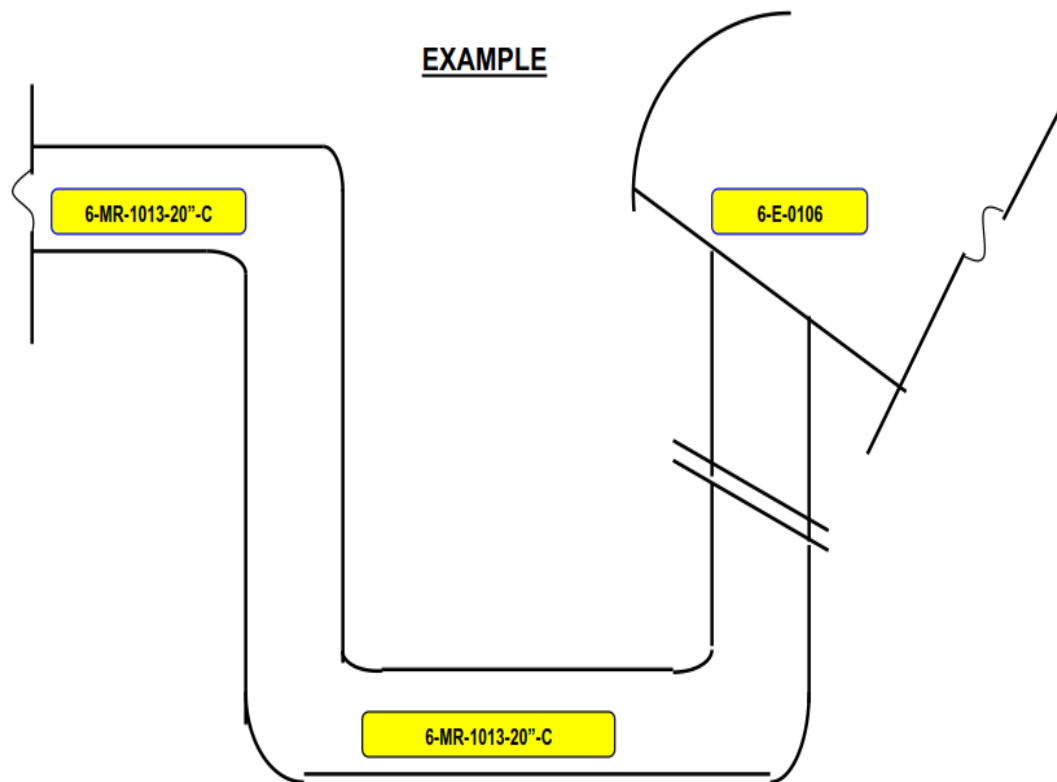
A10.2.

A10.3. Line Numbers

Line number shall be adopted to give assistance and clarity to the complex geometrical piping layout of the plant.

Line numbers (where adopted) shall be Black (BS 00 E 53) stencilling on Golden Yellow (BS 08 E 51) information panels, these shall be shown immediately after inlet / outlet nozzles (where possible) of all equipment, vessels and columns, and shall be repeated every 30 meters on straight line configuration of pipework, at change of direction they shall be repeated immediately after bends and elbows, located below the centre line of the pipe making it easily and clearly visible from ground level.

Appendix Figure 10.5 Line Numbers - LNG



APPENDIX A11. LINING SCHEDULES FOR INTERNAL SURFACES

Appendix Table 11.31 Lining Schedules for Internal Surfaces

Item Description	Substrate	Service Temperature Range	Lining System Number
COS Tank:- All Internal Pipework / Structural / Manhole / Nozzles within 1.65 Metre / 2.15 Metre up Shell (Where GFRE Not Applied)	CS	$T \leq 60^{\circ}\text{C}$	B-1
Underside and Sides of Floating Pontoons for Crude Oil Storage Tanks Guide and Anti-Rotation Poles (Except Lower Tank GFRE Lining Level and Above Roof Maximum Level)	CS	$T \leq 80^{\circ}\text{C}$	B-2
Internal Surfaces of Crude Oil Tanks (Bottom Plate within 2.15 Metre / 1.65 Metre up Shell) - GFRE Lining	CS	$T \leq 70^{\circ}\text{C}$	B-4
Internal Surfaces of Sea Water / Distilled and Deionized Water / Biocide / Oxygen Scavenger / Corrosion Inhibitor / Slug Catcher / Sand Filters / Vacuum Tower / Separators / Open and Closed Drain Drums / Amine Absorbers / KO Drums / Desalters / Dehydrators / Sewage Tanks / Spheroids / Sour and Oily Water Tanks	CS	$T \leq 80^{\circ}\text{C}$	B-6
Internal Surfaces of Fresh and Potable Water Tanks	CS	$T \leq 60^{\circ}\text{C}$	B-7
Internal Surfaces of Ethanol, Methanol and Alcohol Tanks	CS	$T \leq 80^{\circ}\text{C}$	B-15
Internal Surfaces of Jet Fuel Tanks / Diesel Tank	CS	$T \leq 80^{\circ}\text{C}$	B-8
Internal Surfaces of Void Spaces	CS	$T \leq 80^{\circ}\text{C}$	B-9
Internal Surfaces of Swimming Pool	CS	$T \leq 60^{\circ}\text{C}$	B-10
Internal Surfaces of Vessels / Equipment / Piping Operating at Elevated Pressure	CS	$T \leq 80^{\circ}\text{C} / 25 \geq P \leq 70 \text{ Barg}$	B-11
Tanks - Sea Water / Brackish Water / Utility Water / Treated Water	CS	$T \leq 80^{\circ}\text{C}$	B-12
Tanks - Demin Water	CS	$T \leq 80^{\circ}\text{C}$	B-3
Tanks – Hydro-Carbon Condensate	CS	$T \leq 80^{\circ}\text{C}$	B-14
Tanks - Caustic Soda 45-50%	CS	$T \leq 80^{\circ}\text{C}$	B-13
Tanks - HCL $\leq 37\%$	CS	$T \leq 80^{\circ}\text{C}$	B-5
Tanks - Sulphuric Acid 98%	CS	$T \leq 80^{\circ}\text{C}$	B-16

APPENDIX A12. LINING SYSTEMS FOR INTERNAL SURFACES

Appendix Table 12.32 Lining Systems for Internal Surfaces

Lining System Number	Substrate	Surface Preparation and Blast Profile	Coat	Generic System Details	DFT
B-1	CS	Sa 3 / SSPC-SP 5 40 μm - 50 μm	1st	Solvent Free Epoxy	150 μm
			2nd	Solvent Free Epoxy	150 μm
B-2	CS	Sa 3 / SSPC-SP 5 50 μm - 75 μm	1st	Epoxy Phenolic	150 μm
			2nd	Epoxy Phenolic	150 μm
B-3	CS	Sa 3 / SSPC-SP 5 50 μm - 75 μm	1st	Epoxy Phenolic	200 μm
			2nd	Epoxy Phenolic	200 μm
B-4	CS	Sa 3 / SSPC-SP 5 75 μm - 100 μm	1st	Epoxy Primer	20 μm - 30 μm
			2nd	Epoxy Caulk	N/A
			3rd	Epoxy - Hand Lay Up Glass Fibre Laminate (450 g/m2)	1000 μm
			4th	Epoxy - Hand Lay Up Glass Fibre Laminate (450 g/m2)	1000 μm
			5th	Tissue (27 - 30g/m2)	500 μm
			6th	Gel Coat	300 μm
Additional Notes for Lining System B-4.					
a. Only approved glass fibre laminate and tissue material shall be used: i. Glass Fibre Laminate - Owens Corning M705 ii. Tissue - Fiberill 1777 b. CONTRACTOR shall submit detail application procedure for COMPANY review / approval prior to commence any internal GFRE lining. c. PQT with approved material shall be completed prior to commence any internal GFRE lining works. d. Internal GFRE lining shall be carried out by COMPANY qualified SUB-CONTRACTORS only. e. Primer shall be considered only in case of failure in dehumidification system for short period and shall be strictly in the recommended DFT range. f. GFRE lining shall be applied at shell height of 2.15m for DAS Island and 1.65 m for Zirku Island COS tanks.					
B-5	CS	Sa 3 / SSPC-SP 5 50 μm - 75 μm	1st	Glass Flake Reinforced Vinyl Ester	500 μm
			2nd	Glass Flake Reinforced Vinyl Ester	500 μm

Lining System Number	Substrate	Surface Preparation and Blast Profile	Coat	Generic System Details	DFT
B-6	CS	Sa 3 / SSPC-SP 5 75 µm - 100 µm	1st	Glass Flake Reinforced Vinyl Ester	750 µm
			2nd	Glass Flake Reinforced Vinyl Ester	750 µm
B-7	CS	Sa 3 / SSPC-SP 5 75 µm - 100 µm	1st	Solvent Free Epoxy (Local Authority Potable Water Approved)	200 µm
			2nd	Solvent Free Epoxy (Local Authority Potable Water Approved)	200 µm
Additional Notes for Lining System B-7.					
a. The lining system shall be certified and suitable for drinking water and shall have local (Municipality / ADWEA) statutory authority approval for potable / drinking water.					
B-8	CS	Sa 3 / SSPC-SP 5 50 µm - 75 µm	1st	Phenolic Epoxy, Polyamine Cured (Energy Institute / UK EI 1541 Requirements)	125 µm - 150 µm
			2nd	Phenolic Epoxy, Polyamine Cured (Energy Institute / UK EI 1541 Requirements)	125 µm - 150 µm
B-9	CS	Sa 2.5 / SSPC-SP 5 45 µm - 75 µm	1st	Surface Tolerant Epoxy - Aluminium	100 µm
			2nd	Surface Tolerant Epoxy - Aluminium	100 µm
B-10	CS	Sa 3 / SSPC-SP 5 50 µm - 75 µm	1st	Solvent Free Epoxy (Potable Water Approved)	200 µm
			2nd	Solvent Free Epoxy (Potable Water Approved)	200 µm
Additional Notes for Lining System B-10.					
a. The lining system shall be resistant to chemicals, suitable for use in permanent contact with water and not affects the quality of water. Lining MANUFACTURER shall provide the relevant certification that shall be submitted to COMPANY for approval.					
B-11	CS	Sa 3 / SSPC-SP 5 50 µm - 75 µm	1st	Phenolic Novolac Epoxy	150 µm
			2nd	Phenolic Novolac Epoxy	150 µm
B-12	CS	Sa 3 / SSPC-SP 5 50 µm - 75 µm	1st	Epoxy Primer	50 µm
			2nd	High Build Epoxy	250 µm
			3rd	High Build Epoxy	250 µm
B-13	CS	Sa 3 / SSPC-SP 5 50 µm - 75 µm	1st	Epoxy Novolac	125 µm
			2nd	Epoxy Novolac	125 µm
B-14	CS		1st	Epoxy Novolac	150 µm

Lining System Number	Substrate	Surface Preparation and Blast Profile	Coat	Generic System Details	DFT
		Sa 3 / SSPC-SP 5 50 µm - 75 µm	2nd	Epoxy Novolac	150 µm
B-15	CS	Sa 3 / SSPC-SP 5 25 µm - 50 µm	1st	Phenolic Novolac Epoxy	150 µm
			2nd	Phenolic Novolac Epoxy	150 µm
B-16	CS	Sa 3 / SSPC-SP 5 50 µm - 75 µm	1st	Solvent Two Hybridized Epoxy	400 µm

Notes for Appendix Table 12.32

1. All relevant QA / QC steps and specific ITP to be developed in accordance with this specification, and shall be approved by COMPANY along with specific procedures, prior to commence of any lining activity.
2. If any requirement or operating parameters not covered in this specification, the lining system shall be evaluated on individual case by case basis by COMPANY.

APPENDIX A13. OFFSHORE HELIDECK IDENTIFICATION

The information / dimensions in this Appendix are for illustrative purposes only and may differ based on the dimension and layout of Helidecks, therefore, CONTRACTOR shall consult with COMPANY's Technical Authorities for applicable Helideck Markings in accordance with Civil Aviation Advisory Publication, CAAP 71 requirement prior to commencement of project.

A13.1. Visual Aids

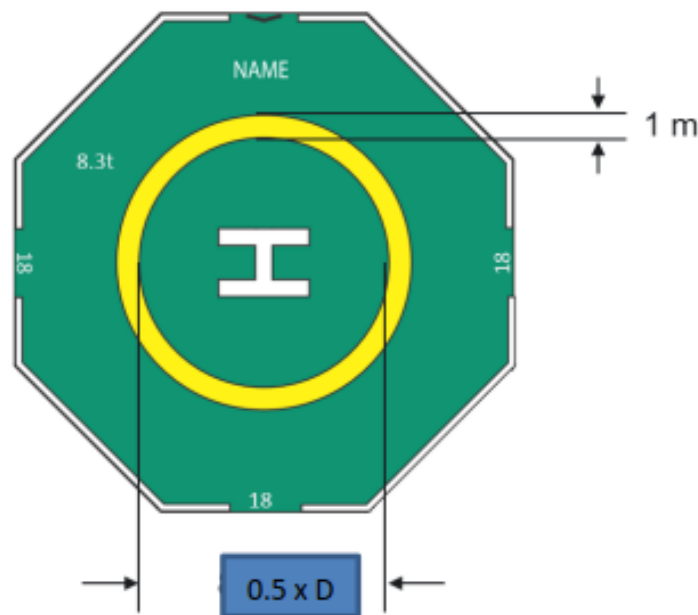
Offshore is committed to provide the required visual aids in all its helidecks, manned and unmanned, to satisfy the regulatory requirements for offshore helidecks in the UAE as established in General Civil Aviation Authority's (GCAA) CAAP 71.

A13.2. Touchdown / Positioning Marking Circle

A13.2.1 Dimension

The touchdown / positioning marking is defined as a circle of $0.5 \times D$ inner radius and a line width of at least 1 m.

Appendix Figure 13.6 Touchdown / Positioning Marking Circle - Offshore



A13.3. Location

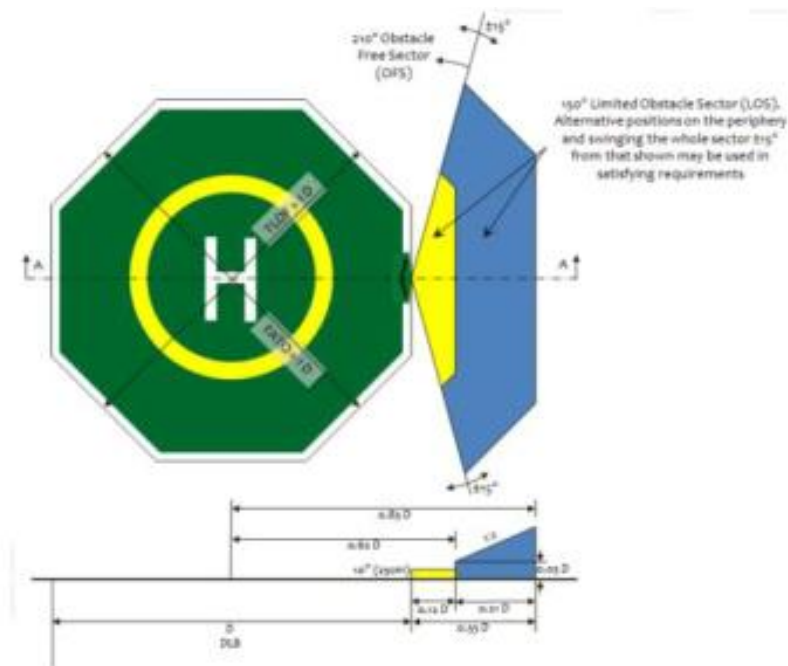
The touchdown / positioning marking circle should be ideally located in the centre of the Final Approach and Take-off (FATO), except where the results of an aeronautical survey indicates that an offset marking may be beneficial to the safety of helicopter operations and not detrimental to the safe movement of personnel.

In case of offset, the centre of the circle may be moved up $0.1 \times D$.

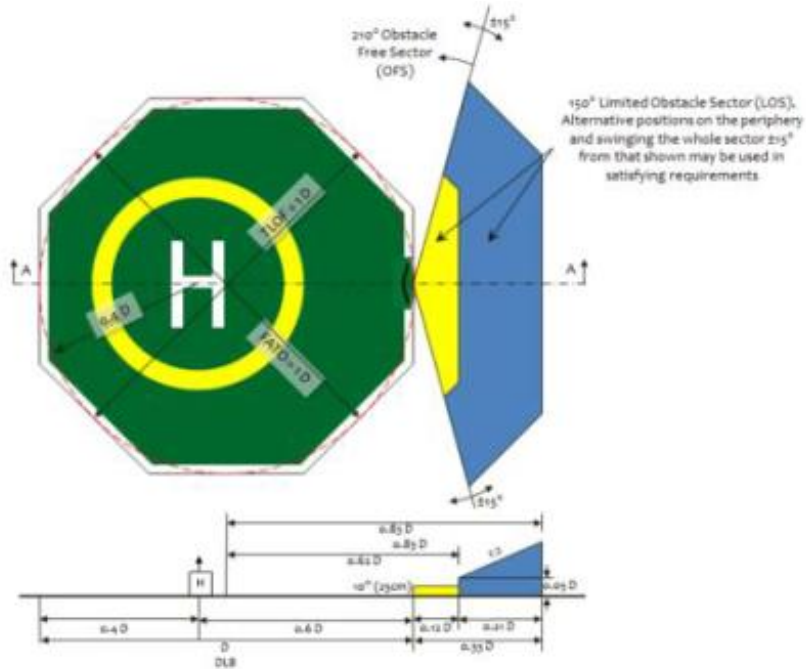
A13.3.1 Characteristics

The circle must be painted in yellow, as illustrated below:

Appendix Figure 13.7 Location of Touchdown Markings - Centralised Touchdown Markings - Offshore



Appendix Figure 13.8 Location of Touchdown Markings - Fully Offset Touchdown Markings - Offshore



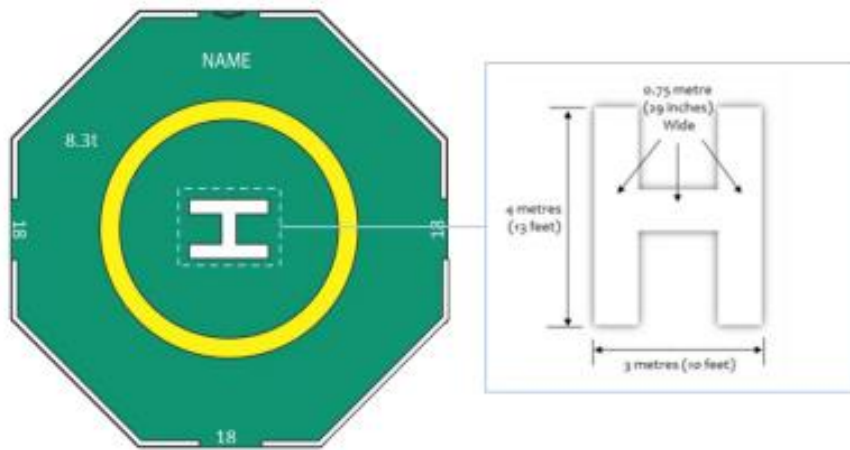
A13.4. Helideck Identification (H) Marking

A13.4.1 Dimension

A helideck identification marking must be provided in the form of an “H” with:

- Height of 4 m
- Width not exceeding 3 m
- Stroke width not exceeding 0.75 m

Appendix Figure 13.9 Dimensions of the Helideck Identification “H” Marking (Standard Size) - Offshore



A13.4.2 Location

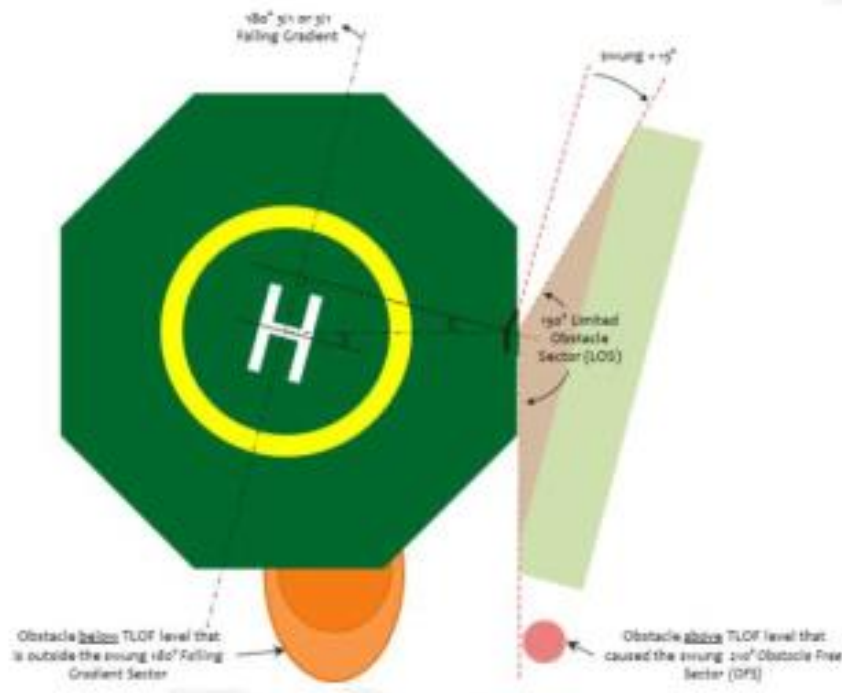
Helideck identification “H” marking must be located in the centre of the touchdown / positioning circle.

The centreline of the cross Bar of the “H” should pass through by the bisector of the Obstacle Free Sector (OFS). Where necessary to clear an obstacle, the H marking can be swung by an angle not exceeding ± 15 degrees from the normal for the OFS as illustrated below.

A13.4.3 Characteristics

The “H” marking must be painted white.

Appendix Figure 13.10 Helideck Identification Marking Reflecting a Swung Obstacle Free Sector) - Offshore



A13.5. Maximum Allowable Mass Marking

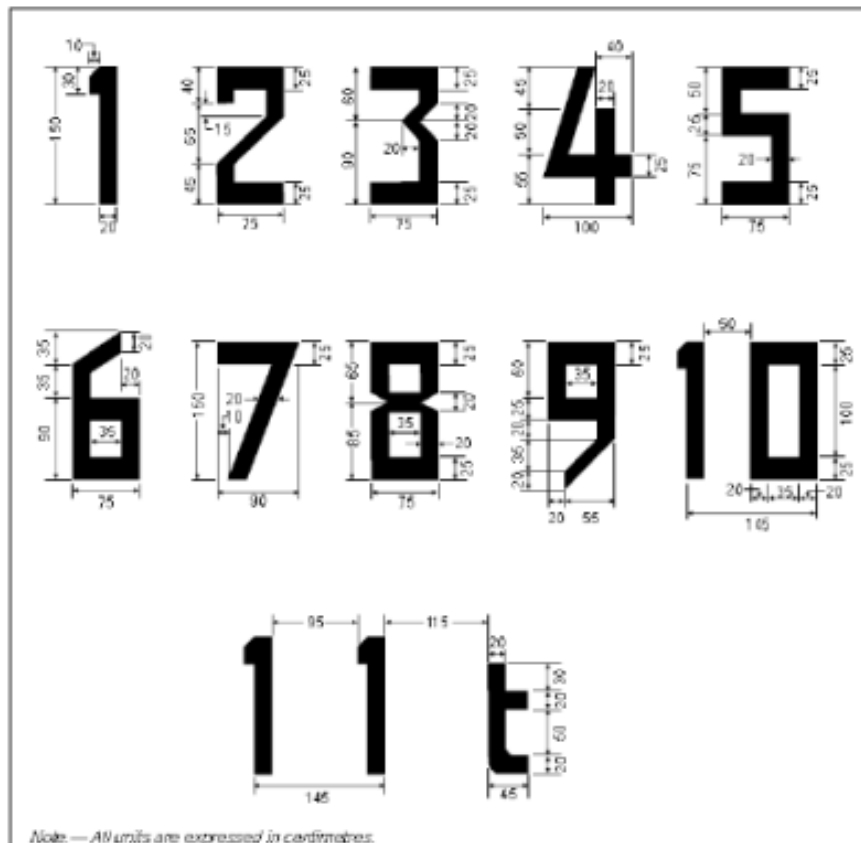
A13.5.1 Location

A maximum allowable mass marking has to be arranged so as to be readable from the preferred final approach direction. This is usually a direction lining up with the prevailing wind direction for the facility.

A13.5.2 Dimension

The size (height) of the characters must be at least 90 cm with decimal point of 18cm². The form and proportions of numbers and letters must follow the following form and proportions.

Appendix Figure 13.11 Form and Proportions of Numbers and Letters - Offshore

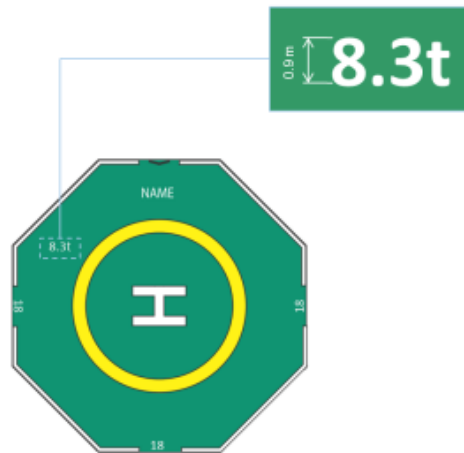


A13.5.3 Characteristics

The maximum allowable mass marking has to be expressed with one decimal value followed by the units' abbreviation (t). All existing helidecks must be painted with the t-value corresponding to its maximum bearing capacity as established in the Helideck Landing Limitation (HLL).

The numbers and the letter of the marking and the decimal point must be painted in white and outlined with black to improve colour contrasting with the background.

Appendix Figure 13.12 Maximum Allowable Mass Marking (Typical) - Offshore



A13.6. FATO / TLOF Perimeter Marking

A13.6.1 Location

A Final Approach and Take-off / Touchdown and Lift-off (FATO / TLOF) perimeter marking denoting the extent of the FATO / TLOF must be painted around the edge of the FATO / TLOF.

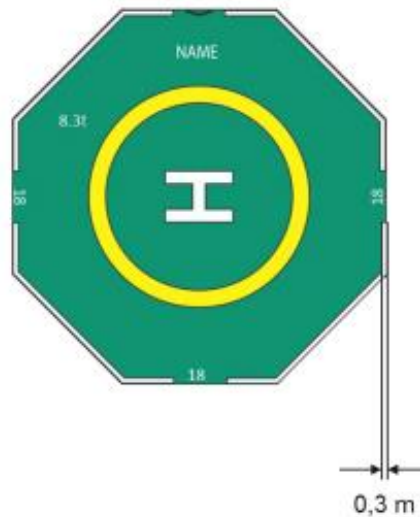
A13.6.2 Dimension

The FATO / TLOF perimeter marking must be painted using a continuous line having a thickness of at least 30 cm.

A13.6.3 Characteristics

The FATO / TLOF perimeter marking must be painted white.

Appendix Figure 13.13 FATO / TLOF Perimeter Marking (Typical) - Offshore

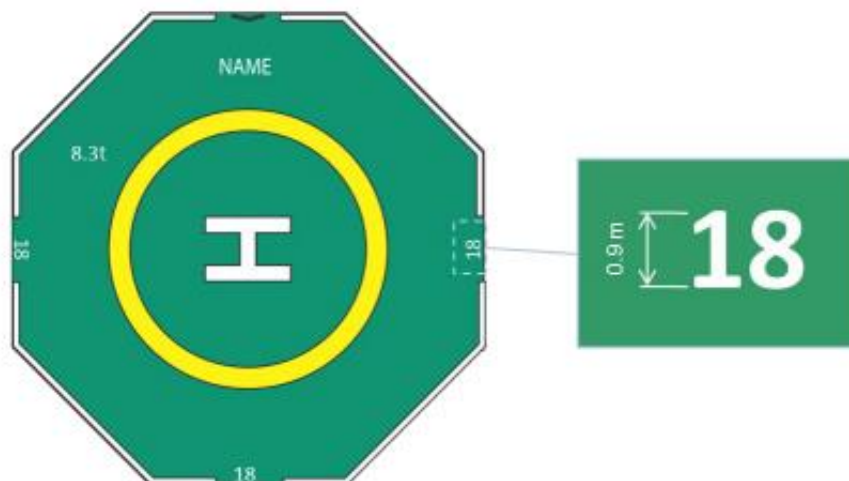


A13.7. D-Value Markings

A13.7.1 Location

D-value markings have to be displayed within the broken white FATO / TLOF perimeter line at three locations as shown below, so that at least one marking is readable from the final approach direction.

Appendix Figure 13.14 D-Value Markings Typical - Offshore



A13.7.2 Dimension

The size of the characters must be at least 90 cm.

A13.7.3 Characteristics

The D-value marking must be painted in white and outlined in black and must be expressed to the nearest whole number (rounded).

A13.8. Helideck Obstacle Free Sector (Chevron) Marking

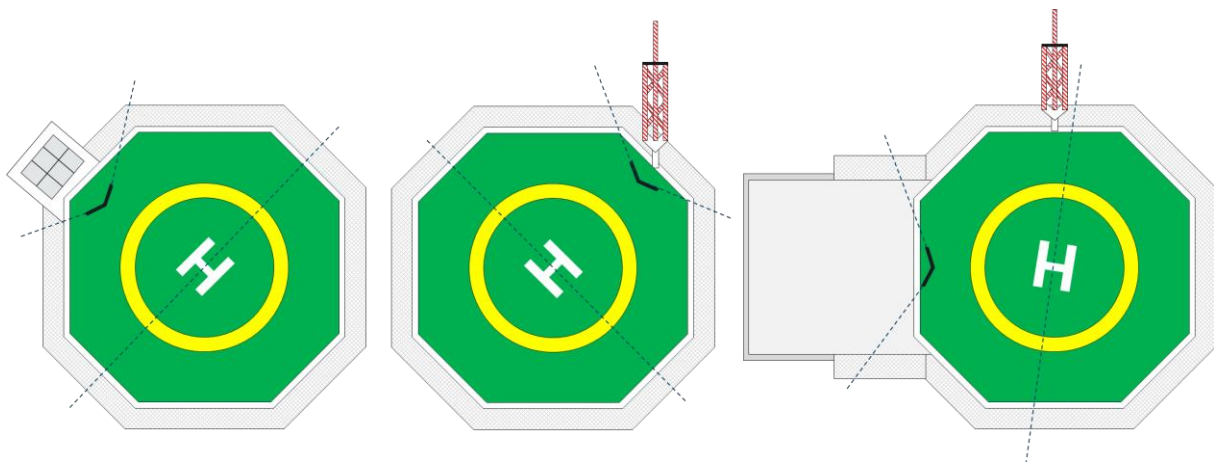
A helideck with obstacles above the level of the FATO / TLOF is required to display an obstacle free sector (chevron) marking to denote the origin of the obstacle free sector.

A13.8.1 Location

The apex of chevron is located in the perimeter of the FATO / TLOF. Typical locations of the chevron include:

- Nearby solar panels or other equipment installed in proximity to the FATO and outstanding the level of the FATO
- Upon vent booms installed below the FATO.
- Strategically located to clear both obstacles above the FATO and below it

Appendix Figure 13.15 Chevron Examples at Offshore Facilities - Offshore



A13.8.2 Dimension

The origin of the obstacle-free sector must be marked on the helideck by a chevron, each leg forming the angle of the obstacle-free sector and being:

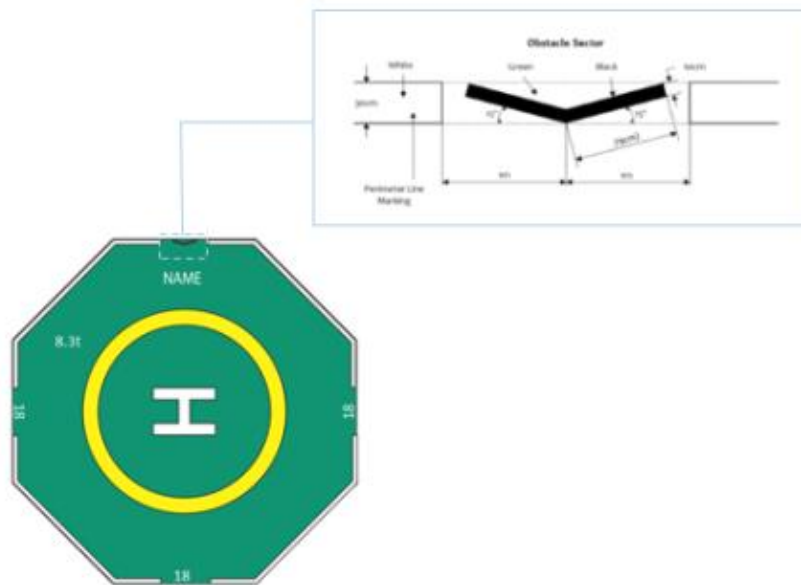
- 79 cm long
- 10 cm wide

Where the OFS is swung then the chevron must be swung as well accordingly.

A13.8.3 Characteristics

The chevron must be painted in black.

Appendix Figure 13.16 Helideck Chevron - Offshore



A13.9. Helideck Name Marking

A13.9.1 Location

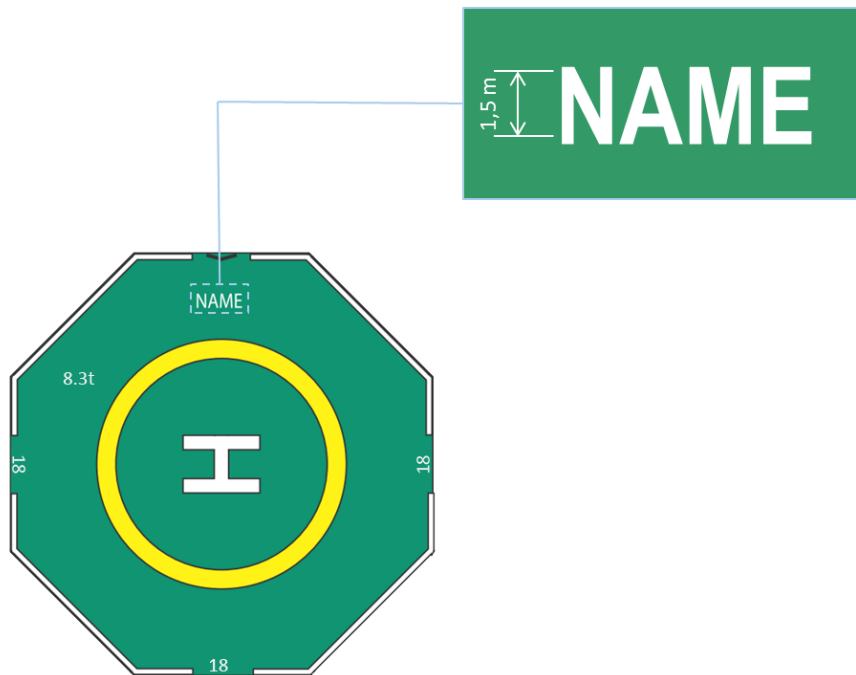
The helideck name marking must be painted between the chevron and the touchdown / positioning marking circle.

A13.9.2 Dimension

The helideck name marking must have a height of 1.5 m.

Where the helideck name marking consists of more than one word it is recommended that the space between words be approximately 50% of character height.

Appendix Figure 13.17 Helideck Name Marking - Offshore



A13.9.3 Characteristics

The helideck name marking must be painted in white.

The helideck name marking must consist of the name or the alphanumeric designator of the helideck as used in the radio (R/T) communications.

Providing a name that is unique and simple helps to keep to a minimum pilots' concentration during final approach and landing manoeuvre.

The character widths and stroke widths of nominal 1.2 m characters should be 80% of those prescribed by International Civil Aviation Organisation (ICAO) Annex 14. Where the character height is 1.5 m, the character widths and stroke widths should be in accordance with ICAO Annex 14.

A13.10. Surface Marking

Surface background marking is provided to assist pilots to identify the location during an approach and to emphasise the position of the markings.

A13.10.1 Characteristics

The helideck surface encapsulated by the white FATO / TLOF perimeter marking must be:

- Dark green in steel surface helidecks.
- Light grey in aluminium surface helidecks.

The conspicuity of white and yellow markings on light grey helideck surfaces should be outlined with a 10 cm black line or by overlaying white or yellow markings on a painted black background.

A13.11. Prohibited Landing Sector (PLS) Marking

A13.11.1 Location

The PLS must be located in a way that ensures that a helicopter cannot land towards an obstacle which is not within the pilot's field of view.

The PLS has to be located on the touchdown / positioning circle, opposite from the personnel access point.

A13.11.2 Dimension

The arc of coverage should be sufficient to ensure that the tail rotor system will be positioned clear of the obstruction when hovering above, and touching down on, the yellow circle at any location beyond the PLS marking.

The minimum PLS marking should cover an arc of at least 30 degrees, extending by a minimum 10 to 15 degrees either side of the edge of the obstacle.

A13.11.3 Characteristics

There is two different ways to define a PLS:

- By a hatched marking overlaid on the portion of the yellow touchdown / positioning marking circle, and extending out to the FATO / TLOF perimeter marking within the relevant headings
- "No Nose" arc into a touchdown / positioning marking circle bordered in red with the words "No Nose" clearly marked in red on a white background

Appendix Figure 13.18 Examples of an Alternative Prohibited Landing Sector (PLS) Marking – Offshore



A13.12. Visual Aids for Denoting Obstacles

Fixed obstacles which present a hazard to helicopters should be readily visible from the air. Alternate black and white, black and yellow, or red and white bands should be painted with not less than 0.5 metres, or more than 6 metres wide. The colour should be chosen to contrast with the background to the maximum extent.

Obstacles to be marked in these contrasting colours include any lattice tower structures and crane booms which are close to the helideck or to the Limited Obstacle Sector (LOS) boundary. Similarly, parts of the leg (or legs) of a self-elevating jack-up unit that are adjacent to the helideck and which extend, or can extend above it, should also be marked in the same manner. Illustrative examples of Offshore helideck marking

The figures below illustrate standard helideck marking in some of Offshore facilities:

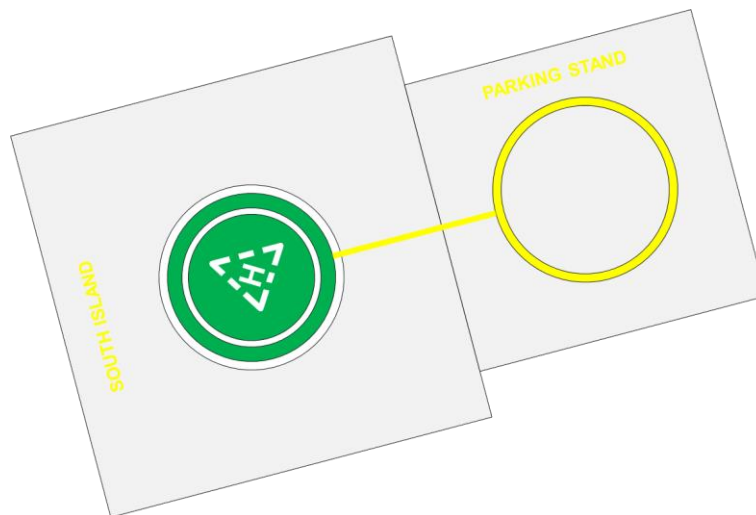
A13.12.1 UZ-Corniche (ACPT-2)

Appendix Figure 13.19 Example of Helideck Marking in ACPT-2 Corniche Typical - Offshore



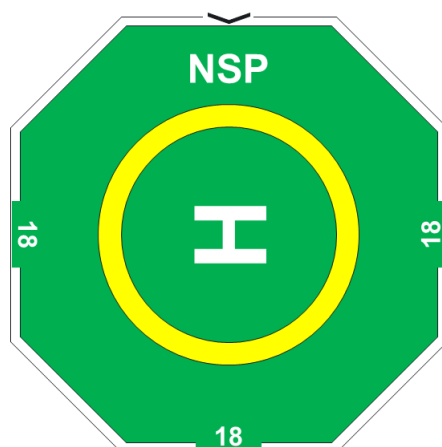
A13.12.2 UZ-Artificial Island

Appendix Figure 13.20 Example of Helideck Marking in South Artificial Island Typical – Offshore



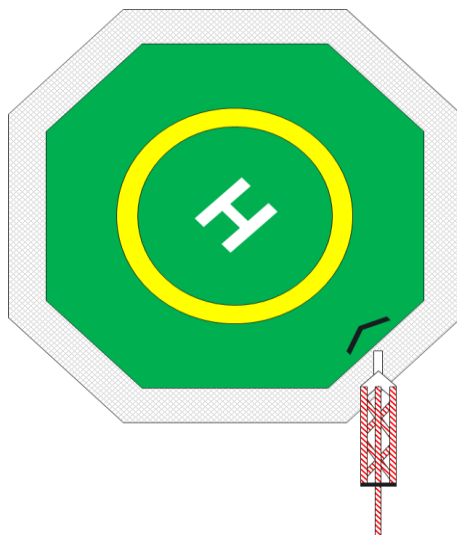
A13.13. Satellites and Complexes

Appendix Figure 13.21 Example of Helideck Marking in North Satellite Typical - Offshore



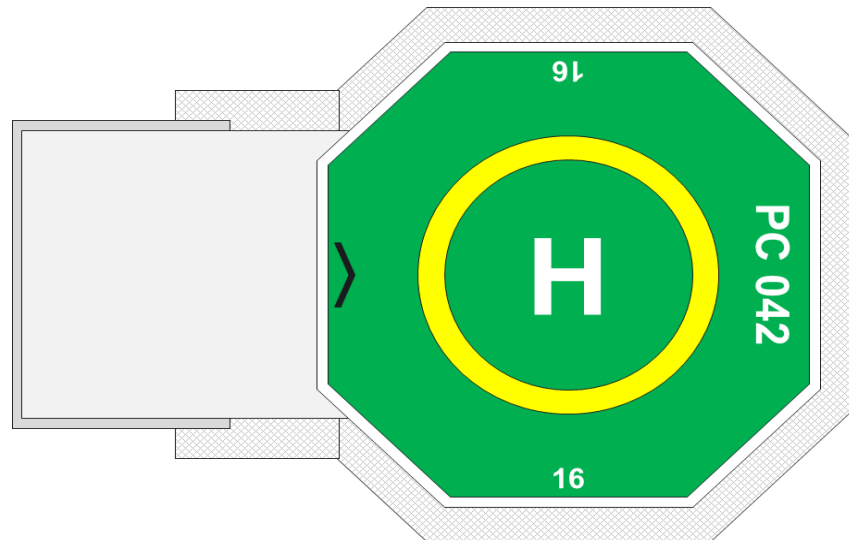
Wellhead Platform (Type 1)

Appendix Figure 13.22 Example of Helideck Marking in PC 063 - Offshore

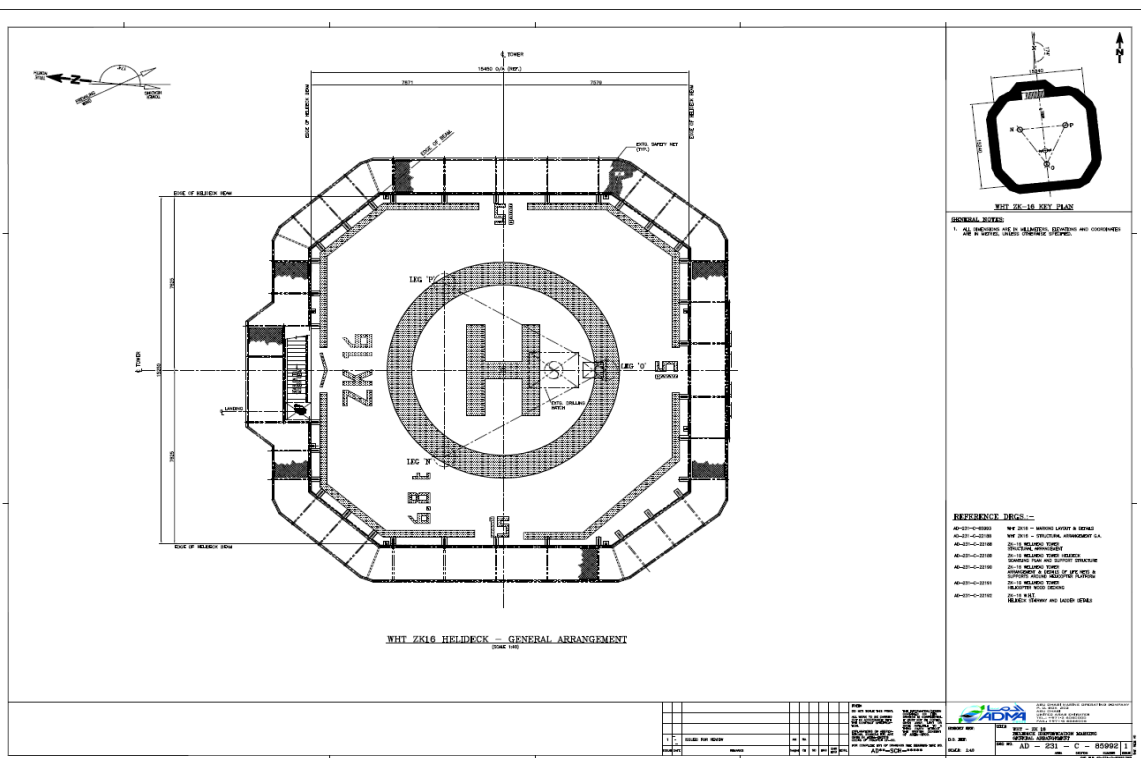


Wellhead Platform (Type 2)

Appendix Figure 13.23 Example of helideck marking in PC 042 - Offshore



Appendix Figure 13.24 Example of Helideck Marking in LZ / US Field - Offshore



(Number / Dimension for Illustrative Purposes Only)

APPENDIX A14. FIBERGLASS REINFORCED EPOXY LININGS FOR BOTTOM OF CRUDE OIL STORAGE TANKS

Requirements for GFRE Linings Application with Hand lay-up Glass Fibre Reinforced Epoxy System

A14.1. General

This section covers COMPANY minimum requirements for abrasive blasting and lining of internal steel surface of the tank bottom, a minimum of level as follows:

Appendix Table 14.33 Minimum Level of Internal Steel Surface of Tank Bottom

Location	Bottom	Height Upright Shell
ADNOC Offshore (Das Island)	100%	2.15 m
ADNOC Offshore (Zirku Island)	100%	1.65 m
ADNOC Offshore (SARB)	100%	1.15 m
ADNOC Onshore	100%	2.0 - 2.5 m
ADNOC Refining	100%	1 m

The system described in this specification consists of 2 mats (450 g/m²) plus one tissue (27-30 g/m²) embedded in an epoxy resin with a final DFT of not less than 2800 microns.

Prior to commencement of any blasting work, all grease, oil, dirt and any other contamination shall be removed in accordance with the requirements of SSPC-SP 1.

On completion of the degreasing / cleaning all surfaces shall be high pressure fresh water washed (3500 psig / 241.32 barg). All surfaces shall be allowed to dry.

Following washing down, Chloride levels shall be measured on the shell, underside of the roof and the tank floor and recorded. Bresle method shall be used to determine soluble salt levels.

Prior to commencement of any GFRE work, all surface irregularities including weld spatters, weld fluxes, rough capping, surface lamination and underlying mill scale shall be removed using mechanical tools.

Any surface irregularity which may become apparent after surface preparation shall be similarly treated.

A14.2. Environmental and Working Conditions

The typical minimum dew point differential specified for holding a blast over an extended period of time is 9 to 14°C with a relative humidity not to exceed 40 to 55%. The CONTRACTOR should refer to SSPC-TR 3 / NACE 6A192 - "Dehumidification and Temperature Control during Surface Preparation, Application, and Curing for Coatings / Linings of Steel Tanks, Vessels, and Other Enclosed Areas" for guidance.

The air temperature, relative humidity, dew point and steel temperature are to be recorded hourly throughout the duration of the work through a computerized system as well as verified manually.

A detailed method statement on how the CONTRACTOR proposes to maintain the environmental conditions throughout the duration of the work is to be submitted.

Suitable enclosed changing areas shall be provided for personnel to change PPE prior to entering the tank through an air lock.

Entrance and exit of personnel to the tank must be controlled to reduce possible contamination.

All ducting to be sealed at manholes and no manhole shall be left open to the atmosphere. The roof shall be sealed and shaded from direct sunlight. Additionally, tarpaulin shall be used to seal the area between the roof edge and the shell to prevent contamination from falling onto the tank shell and bottom.

The CONTRACTOR should refer to SSPC-Guide 12 to determine the quantity and quality of lighting that is conducive to achieving quality surface preparation, coating application, inspection and accident prevention. All lighting shall conform to COMPANY Safety Regulations.

A14.3. Degree of Cleanliness and Surface Profile

Surface preparation to Sa 3 with a surface profile of 75 - 100 microns

A14.4. Open Blasting

Blasting shall start on nozzles, pipes, shell, around the legs and the annular plate by means of open blasting. Appropriately sized abrasives shall be used. Following the completion of the open blasting, spent abrasives shall be removed and the roof underside blown down with compressed air to remove residual dust; this should be followed by a complete vacuum cleaning of the tank floor using industrial vacuum cleaners.

A14.5. Vacuum Blasting

Following the completion of all open blasting of the shell and associated components, the floor shall be blasted using fully enclosed shot blasting machines (vacuum blasting - dust free blasting). In order to reduce the possibility of contamination by using hydraulically powered machines electrically powered machines are to be used. A full Risk Assessment covering the use of electrically powered blasting machines must be submitted by the CONTRACTOR.

A mixture of a steel grit and shot shall be utilized to produce the desired angular surface profile. Vacuum blasting shall only commence following the completion of the open blasting.

All abrasive material used for both open and vacuum blasting shall meet the requirements of this specification.

A14.6. Priming (in case of Dehumidification Failure)

In case of dehumidification failure and before rust blooming occurs, all abrasive blasted surfaces (open and vacuum) are to be immediately coated with an approved holding primer. The holding primer shall be spray applied at a thickness not to exceed 30 µm. If the holding primer is applied to a thickness that visibly masks the anchor pattern, it shall be removed by abrasive blast cleaning and reapplied.

A14.7. Hand Lay-up Application

Only COMPANY approved GFRE systems applied by approved application CONTRACTORS shall be considered for this work. Primers, caulking / coving materials, laminating resin, and topcoats shall be supplied by one Lining MANUFACTURER.

Once the entire leg landing plates have been treated as described in this specification clause 8.9.8 below, the laminate for shell and floor can be laid.

The glass fibre hand lay-up application to the floor may start only after the following progress has been achieved:

- a. All open blasting / lining / painting / inspection of the shell and nozzles is completed.
- b. Minimum 50% of the floor vacuum blasted.
- c. Minimum 20% of the landing legs laminated plates are in place.

A14.8. Landing Legs Reinforcing Plates

A number of pre-cut plates (striker plates) shall be cut to size (a nominal diameter of approximately 1" less than the in-situ plate). The edges of the pre-cut plates shall be ground smooth and abrasive blast the plates to Sa 3 with a surface profile of 75-100 microns.

The plates shall be prepared in the following manner:

- a. Apply the approved catalysed epoxy resin to plate and lay-in the approved glass reinforcing mat.
- b. Apply further catalysed epoxy resin.
- c. Consolidate with a metal washer roller.
- d. Lay in a second layer of the glass reinforcing mat. The whole to be consolidated with a metal washer roller to ensure that no air is trapped within the mat.
- e. Apply the gel coat in the approved manner. The plates are then left allowed to attain full cure. Once cured, the edges are to be trimmed.

Support the weight of the roof around each leg in turn following this procedure:

- a. For roof legs - remove leg completely, for landing pads, and bleeder vents raise leg / pad a minimum of 25 mm.
- b. Using solvent soaked rags, clean away any sludge trapped directly under the leg, if any. Allow to dry.
- c. Abrasive blast, using a vacuum system, to Sa 3.
- d. Prepare epoxy mortar compound and apply to the welds of the in-situ plates under each leg forming a fillet, allow to cure.
- e. Apply catalysed epoxy resin to the in-situ plate and consolidate two layers of 450 gm/square meter mat into the resin. The resin and mat must overlay the edges of the epoxy mortar fillet of the in-situ plate by at least 150 mm.
- f. Insert the pre-prepared GFRE coated plate (striker plates), cured laminated side up, under the leg, ensuring the plate is centred.
- g. Allow the leg to gently settle on the plate, this will force the plate into the wet glass fibre reinforced epoxy system.
- h. Fit a split protective PVC / steel cover of adequate dimension over the reinforcing plate to protect the GFRP, and then make good any damaged surfaces.
- i. After curing, the edge between the pre-prepared plated and the in-situ plate is to be filled with an epoxy mortar.
- j. When applying the GFRE treatment to the remainder of the tank floor the resin and glass mat reinforcement shall overlap the new base plates by 10 cm minimum all around.

The above work may be carried out on a limited number of legs simultaneously, but the CONTRACTORS shall not attempt to jack up or remove the load from adjacent supports without the prior knowledge and consent of

COMPANY's representative. The CONTRACTORS shall provide jacks and packing of the temporary support of roof legs.

When laminate and epoxy mortar fillet have cured, protect with polyethylene sheet held in place with mastic tape.

A14.9. Epoxy Mortar / Caulking

After abrasive blasting, prepare epoxy mortar as per Lining MANUFACTURER / SUPPLIER instructions and apply to all floor and shell welds, forming a smooth fillet between plates, leaving no step or ledge. This is completed to ensure the GFRE does not encounter rough edges and minimizes the risk of entrapped air.

All welds, plate laps, reinforcing plates, roof support plates, rivets, holes and corrosion pits are to be caulked, to a clean smooth finish, with the epoxy mortar.

A fillet of epoxy mortar shall be applied at the shell / annular plates internal weld around the circumference of the tank to establish a smooth transition of the laminate.

Caulking between floor plates and shell to annular plates shall be applied directly before lamination and while the epoxy mortar is within the curing time i.e. wet.

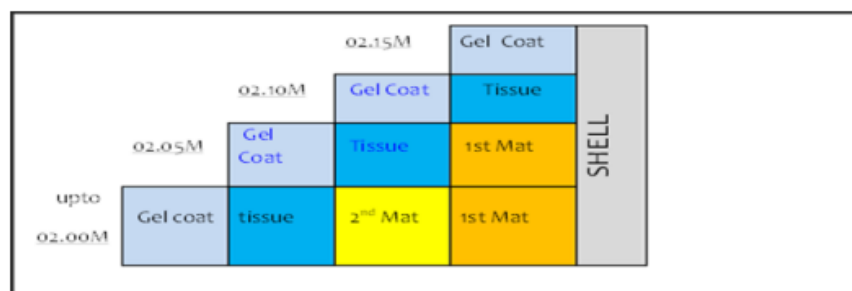
The epoxy mortar compound required to fill small fillet shall be made / mixed as per Lining MANUFACTURER / SUPPLIER requirements.

A14.10. Hand Lay-up Application

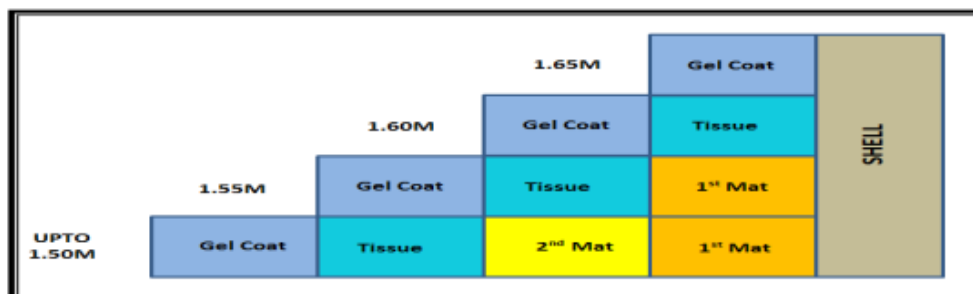
A14.10.1 Main Laminate

- The lay-up operation across the tank bottom shall be completed in successive parallel strips of reinforcing mat. The work direction shall start from one side of the tank and progress toward the other end across the tank floor plates, ending at the main access manway. Each single layer of mat is to be completed separately prior to application of the second layer.
- The interface area between the GFRE system and the Barge steel, at the end of the limit on the up shell, shall be completed and finished off in a layered, chamfered edge as per Appendix Figure 14.25 for Dad Island COS Tanks and for Appendix Figure 14.26 Zirku Island COS Tanks.

Appendix Figure 14.25 Appendix Interface Area Between the GFRE System and Barge Steel - Das Island COS Tanks



Appendix Figure 14.26 Interface Area Between the GFRE System and Barge Steel - Zirku Island COS Tanks



- c. The catalysed epoxy resin applied to the shell areas should not run or sag.
- d. Catalysed epoxy resin shall be laid down to the primed steel surface by brush or roller.
- e. The glass reinforcing mat (450 g/m²) be embedded into the resin using a metal roller to remove entrapped air, folds and wrinkles and ensure the complete wetting of the glass mat.
- f. Additional resin should be applied and rolled as required to ensure that the glass mat is fully saturated, and no entrapped air remains.
- g. Each strip of reinforcement should overleap the adjoining strip to a minimum of 5 cm within the over-coating internal otherwise 10 cm overlap shall be considered after adequate sanding down of the overlapped strip.
- h. The second (450 g/m²) mat shall be laid as per explained and with a 50% overlap with the first layer ensuring that the joints are staggered from all directions.
- i. Immediately apply the glass reinforced tissue to the wet application, workout using metal roller.
- j. The embedding of the surfacing tissue shall be staggered so as not to correspond with the joints of the glass reinforcement mat.
- k. The glass reinforced laminate system, when dry enough to walk on, shall be inspected at all stages by both the CONTRACTOR and the COMPANY representative. Any defects shall be made good by the CONTRACTOR in accordance with the approved repair procedure. Repair procedure shall be submitted to COMPANY by the CONTRACTOR prior to the commencement of the work for approval.
- l. The minimum laminate thickness prior to the gel coat application shall be 2,500 microns.

A14.10.2 Gel Coat

Apply by spray technique or roller a final gel coat of catalysed epoxy resin as required to ensure complete embedding of the surface tissue in the resin.

The final gel coat of catalysed epoxy resin shall completely cover the surfacing tissue.

The final gel coat shall be applied to a nominal thickness of 300 microns. The final thickness of the completed laminate system shall be not less than 2800 microns.

The system shall be allowed to reach full cure (as per Lining MANUFACTURER's / SUPPLIER's recommendation) prior to the tank being introduced into service.

A14.11. Materials

A14.11.1 General

All material shall be chemically pure, and free from foreign contaminants. The age of the primer, resin and catalyst shall not exceed the recommended shelf life as specified by the Lining MANUFACTURER.

The primer and resin must be delivered to the site in unopened containers with batch number and date of manufacture clearly marked thereon.

Primers, caulking / coving materials, laminating resin, and topcoats shall be supplied by one Lining MANUFACTURER, unless otherwise approved by the owner.

A14.11.2 Reinforcement Mat

The reinforcement mats and surfacing veils shall not exceed 1250 mm in width.

A14.11.3 Resin

The resin shall be 100% pure epoxy resin. It should consist of resin and catalyst only. The resulting catalysed mixture shall be transparent.

Approved Material:

- a. Glass Fibre Laminate - Owens Corning M705
- b. Tissue - Fiberill 1777

A14.11.4 Reference Plates

Prior to the commencement of any laminate work the CONTRACTOR shall prepare reference plates sized 0.4 m x 0.4 m (a minimum of two in number) of the GFRE system to be used. One plate should show the GFRE lining stepwise from primer (if required), laminate(s) and gel coat. The second plate should show the complete GFRE lining system as it will be applied in the tank.

A14.12. Inspection

A14.12.1 Dry Film Thickness

- a. All routine dry film thickness (DFT) measurements shall be recorded using any electro-magnetic resistance or eddy current principal film gauges.
- b. CONTRACTOR's dry film thickness gauge required for final joint inspection shall be similar to COMPANY standard instrument provided with a printout facility. DFT instruments shall be calibrated at least twice daily. Measurement print outs shall be retained by COMPANY for future assessment.
- c. The total dry film thickness of the completed laminate system shall not be less than 2,800 microns. The main laminate thickness, prior to gel coat application shall be a minimum of 2,300 microns, with a final gel coat applied to a nominal thickness of 300 microns.
- d. At least (4) four DFT readings per square meter shall be taken and recorded to verify the applied thickness.
- e. Measurement for conformance to a thickness specification.

Measure twenty (20) separate spot measurements (average of 4 readings per spot of 4-cm diameter) spaced evenly over an area of 20 square meters. This area corresponds to the surface area of one complete floor plate, which can be considered the unit area for the subject application.

The average of the twenty (20) spot measurements for each full plate shall not be less than the minimum specified thickness. No more than two single spot measurements (the average of 4 readings at each spot) in any unit area shall be less than 20% of the specified minimum; this value is defined as the critical dry film thickness.

The critical dry film thickness of the main laminate system is 2,000 microns, beyond which repair work shall be considered.

The critical dry film thickness of the complete laminate system (i.e. the main laminate and gel coat) is 2,240 microns, beyond which repair work shall be considered.

A14.13. Holiday Detection

- a. The main laminate system shall be holiday tested using high voltage spark tester at 6 KV. However, the completed laminate system shall be holiday detected at 10 KV.
- b. Any spot which fail the high voltage spark test at the prescribed voltage shall be repaired and re-tested at the same voltage.

A14.13.1 Pull-off and Hardness Tests

- a. COMPANY shall retain the right to request and or conduct, destructive adhesion testing as and where it is considered necessary. The values obtained from the test shall in no case be lower than the values obtained during the pre-qualification test carried out by COMPANY. A minimum value of 5.0 N/mm² would be acceptable.
- b. Bargcol Hardness test shall be carried out on the test plates as per ASTM D2583.