



TAPI Pipeline Company Limited

Project Management & FEED Consultancy Services

SPECIFICATION FOR PAINTING, COATING AND INSULATION

30/11/2017

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1 INTRODUCTION

1.1 Project

The TAPI Project was originally conceived in the 1990s with a view to monetise Turkmenistan's vast natural gas reserves through gas exports to Afghanistan, Pakistan and India.

In 2013, the Governments of Turkmenistan, Afghanistan, Pakistan and India respectively nominated state-owned gas companies State Concern "Turkmengas", Afghan Gas Enterprise, Inter State Gas Systems (Private) Limited, and GAIL (India) Limited to promote and invest in the TAPI Project.

The TAPI Project aims to export up to 33 billion cubic meters of natural gas annually for 30 year period through a 1814 km pipeline from Turkmenistan to Afghanistan, Pakistan and India.

In November 2014, with the collaboration of the four abovementioned state-owned gas companies, TPCL was incorporated with the main objective of implementing the TAPI Project.

TPCL is a company limited by shares and incorporated in Isle of Man with a registered office at the following address: Fort Anne, Douglas, Isle of Man, IM1 5PD. The head office of TPCL is located in Dubai, United Arab Emirates.

In June 2015, State Concern "Turkmengas" was unanimously elected as a Consortium Leader for the TAPI Project.

The stone-laying ceremony for the TAPI Project was held in the Mary region of Turkmenistan, near the Galkynysh natural gas field, on 13 December 2015 and was attended by Gurbanguly Berdimuhamedov, the President of Turkmenistan, Nawaz Sharif, the Prime Minister of Pakistan, Ashraf Ghani Ahmadzai, the President of Afghanistan and Mohammad Hamid Ansari, the Vice-President of India.

The Shareholders' Agreement was signed concurrently with the TAPI Project stone-laying ceremony. In April 2016, the Shareholders of TPCL signed the Investment Agreement.

In January 2017, TPCL entered into a Project Management and FEED Development Contract in connection with the Afghanistan and Pakistan section of TAPI Project with ILF Beratende Ingenieure GmbH.

The implementation of the TAPI Project is divided into three main phases:

- a) Natural gas source development;

- b) Turkmenistan portion of the TAPI Project; and
- c) Afghanistan and Pakistan portion of the TAPI Project.

TPCL will act as the employer in relation to the construction works, as well as the owner of the Afghanistan and Pakistan portion of the TAPI Project.

The “Galkynysh” gas field, which is listed among the world’s largest natural gas fields and holds 26.2 trillion cubic meters of gas reserves, will be the source of natural gas for the TAPI Project.

Phase III of the development of the Galkynysh gas field has been initiated by State Concern “Turkmengas” so as to meet its obligations to supply natural gas to the TAPI Project.

The length of the Turkmenistan portion of the TAPI Project is 214 km. State Concern “Turkmengas” has already started the engineering and initial phase of the construction works on this portion of the TAPI Project.

The length of Afghanistan and Pakistan portion of the TAPI Project is 1600 km.

1.2 Purpose of the Document

This specification covers the minimum requirements for surface preparation, methods of application, materials and inspection for:

- painting/coating of piping
- painting/coating of vessels and tanks
- painting/coating of other equipment made out of carbon steel or stainless steel within the Project scope.
- Lining of vessels and tanks

It is considered as painting/coating, the application of one or several protective layers on piping items, tanks, vessels, and equipment.

It is considered as lining, the application of one or several protective layers on the inside surface of piping items, tanks, vessels and equipment.

For underground external protection of piping items refer to “Specification for 3-Layer Polyethylene External Coating of Line Pipe”, K358-ILF-OVA-PLG-ME-SPC-0001.

For internal protection of piping items refer to “Specification for Internal Lining of Line Pipe”, K358-ILF-OVA-PLG-ME-SPC-0002.

Requirements for piping and equipment insulation are also described in this specification.

This specification is not all inclusive and the use of the guidelines set forth does not relieve the Manufacturer of his responsibility to provide a finished product capable of performing its intended service

1.3 Definitions

Company	: TAPI Pipeline Company Limited
Consultant	: ILF Beratende Ingenieure GmbH
Contractor	: Companies under contract with the Company for the performance of works/services for the Overall Project
Manufacturer	: Companies which are designing and fabricating lining and/or coating material. where a Manufacturer is mentioned in this document, the Contractor is responsible for the full scope of work of, and performance by, that Manufacturer.
Overall Project	: Turkmenistan – Afghanistan – Pakistan – India (TAPI) Gas Pipeline Project
Project	: Project Management and FEED Consultancy Services for the Afghanistan and Pakistan portions of the TAPI Pipeline Project
Purchaser	: Companies buying goods.
Subconsultants	: Companies under contract with the Consultant for the execution of the Project
Subcontractor	: Companies under contract with the Contractor for the execution of works/services for the Overall Project

1.4 Abbreviations

DFT	: Dry Film Thickness
H	: Thermal Insulation
MDFT	: Minimum Dry Film Thickness
N	: Acoustic Insulation
PFP	: Passive Fire Protection

QA	: Quality Assurance
QC	: Quality Control
T	: Heat Tracing
TAPI	: Turkmenistan – Afghanistan – Pakistan – India
WFT	: Wet Film Thickness

1.5 Codes and Standards

Document Number : Document Name

ASTM

ASTM A 380	: Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM C 547	: Standard Specification for Mineral Fiber Pipe Insulation
ASTM D 4285	: Standard test method for indication oil or water in compressed air
ASTM D 4541	: Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM D 4752	: Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub
ASTM D 5064	: Standard Practice for Conducting a Patch Test to Assess Coating Compatibility
ASTM E 337	: Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures)

ISO

ISO 11126-7	: Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Part 7: fused aluminium oxide
ISO 11127 (all parts)	: Preparation of steel substrates before application of paints and related products – Test

Document Number	: Document Name
	methods for non-metallic blast cleaning abrasives
ISO 12944-2:2007	: Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 2: Classification of environments
ISO 1461	: Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
ISO 15665	: Acoustics – Acoustic Insulation for Pipes, Valves and Flanges
ISO 17025	: General requirements for the competence of testing and calibration laboratories
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 21809-1:2011	: Petroleum and natural gas industries – External coatings for buried or submerged pipelines used in pipeline transportation systems – Part 1: Polyolefin coatings (3-layer PE and 3-layer PP)
ISO 21809-2:2007	: Petroleum and natural gas industries -- External coatings for buried or submerged pipelines used in pipeline transportation systems - - Part 2: Fusion-bonded epoxy coatings
ISO 21809-3:2008	: Petroleum and natural gas industries -- External coatings for buried or submerged pipelines used in pipeline transportation systems - - Part 3: Field joint coatings
ISO 2409	: Paints and Varnishes - Cross-Cut Test
ISO 2808	: Paints and Varnishes - Determination of Film Thickness
ISO 3549	: Zinc dust pigment for paints. Specifications and test methods
ISO 8501-1	: Preparation of steel substrates before appli-

Document Number	: Document Name
	<p>cation 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 removal of previous coatings</p>
ISO 8501-1	<p>: 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 removal of previous coatings</p>
ISO 8502-3	<p>: Preparation of steel substrates before application of paints and related products. Tests for the assessment of surface cleanliness. Part 3: Assessment of dust on steel surfaces prepared for painting (pressures sensitive tape method)</p>
ISO 8502-4	<p>: Preparation of steel substrates before application of paints and related products. Tests for the assessment of surface cleanliness - Part 4: Guidance on the estimation of the probability of condensation prior to paint application</p>
ISO 8502-6	<p>: Preparation of steel substrates before application of paints and related products. Tests for the assessment of surface cleanliness. Part 6: Extraction of soluble contaminants for analysis - The Bresle method</p>
ISO 8502-9	<p>: Preparation of steel substrates before application of paints and related products. Tests for the assessment of surface cleanliness. Part 9: Field method for the conduct metric determination of water soluble salts</p>
ISO 8504-1	<p>: Preparation of steel substrates before application of paints and related products. Surface preparation methods. Part 1: General principles</p>

Document Number	: Document Name
ISO 8504-2	: Preparation of steel substrates before application of paints and related products. Surface preparation methods. Part 2: Abrasive blast cleaning
ISO 8504-3	: Preparation of steel substrates before application of paints and related products. Surface preparation methods. Part 3: Hand and power tool cleaning
ISO 9001	: Quality Management Systems
ISO 11124-2	: Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives. Part 2: chilled-iron grit
ISO 11124-3	: Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives. Part 3: high-carbon cast-steel shot and grit
ISO 11126-10	: Preparation of steel substrates before application of paints and related products - Specifications for non-metallic blast-cleaning abrasives - Part 10: almandite garnet
ISO 11126-4	: Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Part 4: coal furnace slag
ISO 11126-9	: Preparation of steel substrates before application of paints and related products - Specifications for non-metallic blast-cleaning abrasives - Part 9 : staurolite
ISO 4628-3	: Paints and varnishes Evaluation of degradation of coating Designation of quantity and size of defects, and of intensity of uniform changes in appearance - Part 3: Assessment of Degree of Rusting
ISO 8503-1	: Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned

Document Number	: Document Name
	steel substrates. Part 1: Specification and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces
ISO/IEC 17024	: Conformity assessment - General requirements for bodies operating certification of persons
ISO/TS 29001	: Petroleum, petrochemical and natural gas industries - Sector-specific quality management systems - Requirements for product and service supply organizations
NACE	
NACE RP 0287	: Field Measurement of Surface Profile of Abrasive Blast Cleaning Steel Surfaces Using a Replica Tape
NORSOK	
Norsok M-501	: Surface Preparation and Protective Coating
SSPC	
SSPC-PA 2	: Procedure for Determining Conformance to Dry Coatings Thickness
SSPC-SP 1	: Solvent Cleaning

1.6 Referenced Documents

Document Number	: Document Name
K358-ILF-OVA-GEN-HS-REP-0002	: Firefighting Philosophy
K358-ILF-OVA-GEN-ME-REP-0002	: Material Selection Report
K358-ILF-OVA-PLG-ME-SPC-0001	: Specification for 3-Layer Polyethylene External Coating of Line Pipe
K358-ILF-OVA-PLG-ME-SPC-0002	: Specification for Internal Lining of Line Pipe

2 TECHNICAL REQUIREMENTS

2.1 General

The Contractor is responsible for all Quality Assurance and Control activities and shall be fully responsible for the quality of the work which shall be performed in strict accordance with this Specification and all other relevant documents. Unless specifically excluded in the contract, Contractor's scope of supply shall include the provision of all facilities, equipment, consumables, labour and documentation necessary to complete the work in accordance with the requirements detailed herein.

Skid-mounted assemblies and packaged equipment, and all major items such as vessels and pumps etc., will normally be delivered in the fully coated condition. The Contractor shall carry out any necessary repairs to these coatings in addition to providing coating systems on items within equipment fabricator's own scope.

During preparation and coating, the Contractor shall be responsible for the protection of all structure and equipment surfaces from mechanical damage or coating over-spray and droppings.

The coating systems listed in Appendix B shall be applied. The specific coating products and the paint Manufacturer shall require approval of Company during tendering. Only Manufacturers with a proven track record of supply of equivalent products to the onshore petrochemical industry over at least 10 years, with quality systems certified to ISO 9001 or ISO/TS 29001, and with experienced locally available technical representatives will be acceptable.

The paint Manufacturer shall be able to provide supporting data from exposure tests and/or cyclic weathering testing to confirm the suitability of the materials proposed for the operating and prevailing environmental conditions.

The final colour schedule for equipment, piping and structures, and the identification marking of piping shall be defined during the Detailed Design phase.

For all coatings work, the Contractor shall submit appropriate work plans and a quality plan for implementing the requirements of this specification for review by the Company. Full details of Inspection and Testing requirements are included in Appendix C of this specification.

Different brands or types of paints shall not be intermixed.

To ensure maximum performance of a coating system, its complete shop application is preferred. Where complete paint system application before transport to the site is not possible, primer and second layer application in the shop is recommended prior to top coat painting on site.

During coating works on site, access should be constructed so as to provide easy and sufficient access for surface preparation, painting and inspection of all surfaces. Scaffolding shall be constructed in accordance with local regulations and the requirements of the Company or as otherwise agreed with the Company.

2.2 Coating Material

Manufacturer is responsible for the suitable control of materials. Materials shall be stored in a temperature-controlled environment until required for use.

In case field coating is required, the material shall be delivered to the site in the original containers with labels intact and seals unbroken.

Coating Manufacturer's instructions in respect of storage, shelf life, mixing and thinning, as well as method of application and recommended time limits between coats shall be followed.

Coating materials which have gelled (decreasing viscosity caused by bacterial degradation of the protein binder or other thickening agents) or otherwise deteriorated (e.g.: skinning-formation of a layer of skin on the container; settling- settlement of the pigment to the bottom and failure to re-disperser) during storage shall not be used.

All coating materials shall be premixed by mechanical agitators for a sufficient time to thoroughly mix pigment and vehicle and bring material to a uniform consistency.

Zinc rich epoxy primers shall be based on two pack epoxy media, containing minimum 90% metallic zinc by weight in the dry film.

Epoxy-acrylic or urethane-acrylic topcoats shall be two-pack products formulated to provide either high gloss or sheen finish.

Epoxy-based paint shall be two pack products formulated to provide the specified film build without sagging or running. They shall contain polyamide or amine adduct curing agents.

All paints and other coatings covered in this specification shall be of the best of their types and delivered to the sites in sealed containers. They shall not be thinned down or otherwise adulterated except in strict compliance with the Manufacturer's instructions.

The contents of all containers shall be thoroughly stirred to even consistencies before and during use.

The paint shall be obtained direct from the Manufacturer and shall be of the qualities, types and colours scheduled, each coat being of a different shade.

All coats of a painting system shall be obtained from the same Manufacturer and shall be ordered for use together and wherever possible shall be obtained on one order in suffi-

cient quantity for complete portions of the work, particularly in the case of finishing colours.

Paints which have settled or dried or thickened to such an extent that they cannot be easily mixed or are contained in non-original containers without any seals, shall be rejected by Company.

Safety precautions shall be clearly described on the technical data sheet of paint material supplied.

2.3 Surface Preparation

2.3.1 Surface Condition and Surface Cleaning

Prior to any surface preparation, all sharp edges shall be profiled to a minimum radius of 2 mm by grinding.

All welded areas and appurtenances shall be given special attention for removal of welding flux in crevices. Flame cut areas, welding spatter, slivers, laminations and underlying mill scale not removed during fabrication and exposed before and during blast cleaning operations shall be removed by mechanical means. After removal of all defects, the residual thickness of pipe and components shall comply with the minimum total thickness required by the applicable standard.

The steel surface to be painted shall be free from any oil, grease, or chemical contamination; if present they shall be removed by solvent cleaning in accordance with SSPC-SP-1. Wiping with rags soaked in thinners will not be accepted. When emulsion or detergent type degreasers are used, this treatment shall be followed by copious rinsing using fresh and clean potable water or pressure water/steam wash. All degreasers shall be biologically degradable.

If the surface has been exposed to salt laden atmosphere, any salts shall be removed by high pressure washing with clean fresh water prior to blasting or mechanical cleaning. Applicator shall be required to demonstrate by surface testing that the salt level is not detrimental to the applied coating, see section 2.3.2.1.

Prefabrication primers are allowed. However, after assembly these primers shall be removed by blasting and the surface shall be blasted to the initial specified surface cleanliness.

Where rectification has been necessary on blast-cleaned surfaces, the dressed areas shall be pre-cleaned as initially specified.

2.3.1.1 Cleaning with solvents or grease-dissolving emulsions

Cleaning with chemical solvents shall be only a preliminary stage for the cleaning work described above. Equipment contaminated with oil, grease or other soluble impurities

shall be cleaned with appropriate and approved chemical solvents before mechanical cleaning. If acids or alkaline solutions are used the treated areas have to be cleaned from the cleaning agents and neutralized. Only approved and non-harmful cleaning agents shall be used.

Special attention has to be paid to parts made out of synthetic material and of nonferrous metal not resistant to these cleaning agents. These parts have to be protected against contact with aggressive solvents.

The concentration of the solvents shall be kept to a minimum. Benzene and hydrocarbon solvents shall not be used. Appropriate precautions against burning, cauterization and against contamination of the ground shall be foreseen.

For de-rusting of sheet steel material, pickling with acid may be applied.

Contamination caused by salts, acids and alkali solutions shall be eliminated by rinsing with water up to a pH value of 6-8.

2.3.2 Blast Cleaning Works

Prior to commencing blasting work, blast cleaned steel panels shall be prepared in compliance with the surface preparation requirements above. The surface profile shall be measured by microscopic assessment of replicas taken from the surface.

Blast cleaned surfaces shall be prepared to the required quality of cleanliness by reference to the visual illustrations in ISO 8501-1. Surface profiles shall be continuously checked against surface comparators in accordance with ISO 8503-1 and verified using Testex surface profile tape per NACE RP 0287 or equal at the frequency given in Appendix C. The surface profile shall be in accordance with the coating system sheets given in Appendix B.

Metallic surfaces shall be prepared prior to coating by dry abrasive blast cleaning as outlined in ISO 8504-2. The surface profile and the anchor pattern shall be in accordance with the standard specified for the appropriate coating system in Appendix B.

Blast cleaning shall employ only sharp angular abrasive in accordance with 2.3.3, and must be free from dust, salts and other impurities. The abrasive shall be selected to achieve the specified surface amplitude and shall be regularly checked and sieved to remove fines and impurities. Blast abrasives used on open sites or in facilities not specifically controlled to preserve the cleanliness of spent abrasive shall not be recycled. Expendable abrasive shall not be recycled. Abrasives based on metallic slag shall not contain any free metals.

Blast abrasives shall be free from oil, grease, or moisture. The maximum permissible chloride content shall be 25 ppm.

Sand or silica producing abrasives shall not be used.

Blast cleaning shall not be done in areas close to coating operations and/or wet coated surfaces in order to prevent dust or grit contamination.

Spent abrasive shall be completely removed from the prepared surface by either vacuum cleaning and/or stiff brushing.

Blast cleaning performed on site shall not be carried out under the following conditions:

- Rain or fog
- When the ambient air temperature is below 5°C
- When the relative humidity of the air is greater than 85%
- When temperature of the substrate is less than 3°C above the dew point of the surrounding air
- When the wind velocity is 30 knots or higher.

2.3.2.1 Residual Salt Contamination

The maximum content of soluble impurities on the blasted surface before coating application shall not exceed a conductivity corresponding to a NaCl content of 20 mg/m². Sampling and measurement shall be in accordance with ISO 8502-6 and ISO 8502-9 accordingly.

Testing of the level of salts shall be carried out at each work area and at least once per 100 m². The tests shall be carried out a minimum of three times per day or shift during the progress of the work. Special attention shall be given to areas where water has been trapped and dried out.

No acid washes, cleaning solutions, solvents, chemical treatments, or inhibitor washes (intended to prevent rusting), shall be used on steel surfaces after they have been dry blast cleaned.

2.3.2.2 Surface Dust

The dust level on the blast-cleaned surface at the time of coating shall be rendered dust free in accordance with ISO 8502-3 rating 1 prior to the application of each coat by blowing the surface with clean dry air or by using an industrial vacuum cleaner.

Checks on dust levels shall be made at least once on each component and once per 100 m² of prepared surface and a minimum of three checks per day during the progress of the work.

2.3.2.3 Presence of Millscale

Blast-cleaned steel surfaces shall be tested to ensure they are free of mill scale. The cleaned surfaces shall be examined using magnifying instruments or chemical tests, such as a copper sulphate test as outlined in ASTM A380.

Checks on the presence of mill scale shall be made on each component and at least once per 100 m² of prepared surface and a minimum of three checks per day during the progress of the work.

2.3.3 Abrasives

Abrasives for use in blast cleaning steels shall be in accordance with ISO 8504-2 and Table 2-1. Test methods shall be in accordance with the tests specified in ISO 11127. Each batch of abrasive should be tested to check that the abrasive meets the requirements as specified in the relevant ISO standard. The use of sand is not permitted.

Table 2-1 - Abrasive requirements

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	Staurolite	Iron / Aluminium Silicate	ISO 11126-9
	Specular Haematite	Crystalline Fe ₂ O ₃	
	Garnet	Calcium Iron Silicate	ISO 11126-10
Synthetic Mineral	Coal Slag	Aluminium Silicate	ISO 11126-4
	Aluminium Oxide	Crystalline Corundum	ISO 11126-7

The abrasives shall be free from oil, grease, moisture, chloride contamination etc.

Storage of abrasives shall be in accordance with material Manufacturer's instructions. Blasting abrasives shall be kept dry, clean and free of oil and contamination, as a minimum. When recovered metallic grit systems are used, a working mix of blast cleaning material shall be established. This mix shall be maintained throughout the entire course of the production, by frequent small additions from fresh or cleaned stock at a rate sufficient to replenish consumption. Blasting and other dust producing areas shall be kept separate from coating application areas.

2.3.4 Other Cleaning Procedures

In case of metal surfaces for which abrasive blast cleaning is specified but which, because of their location cannot be so treated, reference shall be made to the appropriate procedure as specified in the referenced standards and as summarised below.

2.3.4.1 General

Alternative surface cleaning shall only be acceptable by written approval of the Company. Restrictions specified in section 2.1 shall be adhered to.

Alternative primers such as surface tolerant primers may be required for alternative methods of surface cleaning. These shall be in accordance with the Manufacturer's recommendations. Alternative primers need the approval of the Company.

2.3.4.2 Power Tool Cleaning

Power Tool Cleaning using power wire brushes shall only be carried out where blast cleaning is impractical and shall be performed in accordance with ISO 8504-3 to achieve the required surface cleanliness in accordance with ISO 8501-1.

Prior to power tool cleaning, all oil, grease etc. shall be removed by solvent cleaning in accordance with ISO 8504-1.

Proper care is to be exercised in the use of power tools to prevent excessive roughening of the surface and the formation of ridges and burrs or conversely, burnishing of the work surface.

If the surface being prepared lies adjacent to a coated surface, the power tool cleaning shall overlap the coated surface by at least 25 mm and the coated surface shall be feathered. Power tool cleaning should be confined to minor areas.

2.3.4.3 Hand Tool Cleaning

Hand Tool Cleaning shall be carried out in accordance with ISO 8504-3 to achieve the required surface cleanliness in accordance with ISO 8501-1. Prior to hand tool cleaning, oil, grease and salts shall be removed by solvent cleaning in accordance with referenced standards and this specification.

Only stainless steel wire brushes shall be used to abrade stainless steel surfaces. Brushes used to abrade carbon steel shall not subsequently be used to abrade stainless steel or other high alloy materials where ferritic contamination would be detrimental.

2.4 Coating Application

2.4.1 General

In general the requirements for the coating systems in this specification cover their application to surfaces prepared by dry blast cleaning.

The paint/coating Manufacturer's product data sheets and specifications for mixing, application and curing shall be considered an integral part of this specification. The Contractor/Contractor shall be responsible for obtaining the product and safety data sheets of each material from the Manufacturer.

Each coat shall be of a contrasting colour to the previous coat.

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

they adjoin a coated surface, the connection to the existing paint film shall be made as described in this section.

The specified primer coating / first coat shall be applied as soon as practicable after completion of blast cleaning (or other approved preparation) of that area. In no case shall the coating be applied to cleaned surfaces showing evidence of fresh rusting or contamination (including condensation). Blast cleaned surfaces shall be coated within a maximum of 4 hours after blast cleaning of carbon steel.

Zinc rich primers shall be applied over abrasive blast cleaned carbon and low alloy steel surfaces only.

Piping items which have to be galvanized shall fully comply with ISO 1461.

2.4.2 Mixing and Thinning

All paint spraying equipment including mixers shall be thoroughly cleaned before the mixing of new materials. All coating materials shall be mixed and thoroughly stirred in accordance with Manufacturer's instructions. Sufficient agitation to maintain good mixing shall be applied until the product is used. If air is entrapped in the product during mixing/stirring, sufficient time should be allowed for the air bubbles to escape before application.

All mixing shall be done in clean containers that are free from traces of grease, paints, and other contaminants.

Only thinners specified by the Manufacturer shall be used.

2.4.3 Compatibility with existing Coating Systems

Before any painting work is commenced, the compatibility with any existing coating systems or layers shall be checked. The Manufacturer shall be consulted. If there is any doubt about compatibility, patch testing in accordance with ASTM D 5064 shall be conducted to evaluate the interfacial adhesion. Over-coating shall only be carried out with products made by the same paint Manufacturer.

2.4.4 Application Method

Coating application shall be airless spray unless otherwise specified and approved by Company.

Spraying is the preferred method of application. Lines and spray equipment shall be thoroughly cleaned with the paint Manufacturer's recommended cleaner before the addition of new coating materials. The Contractor shall supply a complete range of tips with varying spray angles and sizes, as recommended by the paint Manufacturer. The spray pressure shall be uniform and the spray pattern smooth.

Coatings shall be applied in a uniform manner to the specified film thickness without runs, sags or other blemishes and with strict observance of the recommended time intervals between coats.

Brush application ("stripe coating") shall be used to ensure adequate film thickness at corners, edges, bolts, nuts and welds. Typical areas where stripe coats shall be applied include:

- Behind bars;
- Plate edges;
- Cut outs, i.e. scallops, manholes etc.;
- Areas of difficult access;
- Ladders and handrails;
- Small fitments of difficult configuration;
- Bolt fixings.

Roller application shall only be allowed on steel floors and panels inside climate controlled areas. Rollers shall be of good quality to ensure uniformity of the applied coating.

2.4.5 Over-coating Method

Coatings shall be dried and cured in accordance with the paint Manufacturer's recommendations prior to over-coating. Over-runs, drips and smears shall be removed and any coating damage or imperfection shall be repaired before over-coating. If the DFT does not meet the requirements of this specification, corrective action shall be taken.

Where zinc rich primers are applied they shall be over-coated as soon as possible but only after sufficient cure if the primer is an inorganic zinc primer. The paint Manufacturer's maximum over-coating times shall not be exceeded.

Zinc salts (white rust) that have formed during the intervening period shall be removed in accordance with the paint manufacturer's instructions prior to over-coating.

2.4.6 Environmental Conditions

When outdoors coating works are carried out, it shall not take place during the following conditions, unless approved by Manufacturer:

- Under adverse weather conditions, e.g. rain, fog, snow or when such conditions are likely before the coating has become dry;
- When the ambient temperature is below 10°C;
- When the ambient temperature is above 40°C;
- When the relative humidity is > 85%;

- When metal surface temperature is $< 3^{\circ}\text{C}$ above the ambient dew point ($< 5^{\circ}\text{C}$ for sprayed aluminium);
- Outside daylight hours on exterior locations.

Unless otherwise agreed, the Contractor shall supply all the weather protection, scaffolding and any other equipment necessary to ensure that the work is carried out in accordance with this specification and the agreed programme. This includes, for example, heating and air-drying equipment.

Dew point determination shall be done in accordance with ISO 8502-4 and humidity measurement shall be made in accordance with ASTM E 337 or equivalent. Higher substrate temperatures shall only be accepted if the paint Manufacturer has confirmed in writing that this application will not affect the performance of the coating work.

The temperature holding time of the metal shall not result in oxidation of its surface, detrimental of the quality and adhesion of the coating. The temperature of the equipment to be coated shall be monitored using suitable means in order to ensure that application conditions are met.

2.4.7 Holding Primers

A holding or temporary protective primer may be applied to prepared metal surfaces to facilitate shop or site handling procedures. Such primers shall in no way replace the function or film thickness of any part of the specified coating system. Over-coating of zinc epoxy or acrylic based holding primers will not be permitted. These primers shall be completely removed by blast cleaning prior to application of specified primer / first coat. Contractor shall also demonstrate that sufficient controls are in place to ensure adequate cleanliness and condition of the aged primer before over-coating.

In all cases, areas of localised breakdown, and weld areas or damaged areas shall be cleaned to the full specified standard.

2.4.8 Coating Thickness

The coating systems are detailed in Appendix B. The DFT of any coat shall not be greater than 40% above nor 10% below the nominal value specified for flat, regular areas. Areas having complex geometries might show a maximum DFT twice the nominal DFT. The DFT shall be measured in accordance with SSPC-PA 2.

The MDFT is the acceptance thickness for the total applied coating system, based on a 95% probability of this value being exceeded by any individual measurement. In practice, this requires statistical records to be maintained of thickness measurements..

2.4.9 Multi Coat Systems

Sequential coats shall be contrasting colours so that each stage of the work can be readily identified and their film thickness determined.

Intervals between coats shall be kept to the minimum complying with the coating Manufacturer's recommendations at the prevailing temperature in order to avoid contamination between coats. Any contamination between coats shall be removed.

Zinc silicate and zinc rich epoxy primers shall be tie-coated or over-coated within a maximum of seven (7) days.

In the event of specified maximum recoating intervals being exceeded, or for the application of additional coats to existing weathered coatings, the Company shall be informed and the paint Manufacturer's recommendations for surface preparation shall be fully described. This may involve sweep blasting, or water or solvent washing before top coating.

2.4.10 Weld Areas

No coating, except "weldable" grades of zinc based holding primers, shall be applied within a minimum of 50 mm of edges / areas prepared for welding. The zinc based holding primer shall be a grade which is approved by a certifying authority such as Lloyds Register or equivalent as not being detrimental to the resultant weld.

2.4.11 Protection of Applied Coatings

Applied coatings shall be adequately protected and the temperature and humidity controlled in accordance with paint Manufacturer's recommendations to ensure that all coatings are correctly dried and cured.

2.4.12 Protection of Coated Contact Points

At contact points such as where piping rests directly on a support (e.g. a saddle or beam), there is a potential for severe corrosion. Therefore coated surfaces which will be in contact with other surfaces shall be protected with non-metallic inserts or shims such as Teflon straps or preformed self-adhesive shims, usually made from fibre reinforced plastic.

Shims should have a limited contact area and high impact strength, and retain their properties over sustained load and offshore exposure conditions. A corrosion resistant U-bolt coated with a protective non-metallic material should complete the pipe clamps.

Where clamps are not used, shims made from creep resistant plastic materials such as acrylonitrile butadiene styrene are available. These can be adhesive-bonded to the pipe.

The above described protection shall be applied when coatings are fully cured.

2.5 Internal Coating of Tanks, Vessels and Equipment

The generic lining materials identified in Appendix B shall be used.

Each lining system shall be certified by the lining materials Manufacturer that it is resistant to the specified service with specific reference to the maximum operating temperature, and where applicable pressure constraints.

2.6 Repairs

2.6.1 General

Repair of defective areas shall be accomplished in the same manner as the original coating in regard to surface preparation prior to recoating.

Epoxy coatings which have aged to the point where further application may give rise to intercoat adhesion problems, shall be sweep blasted after cleaning prior to further coating.

2.6.2 Insufficient Thickness

In the event that a completely coated surface is found to have insufficient coating thickness, this surface may receive an additional coat or coats until the specific thickness is achieved. The Company may alternatively require the surface to be blast cleaned and recoated. Surfaces to receive additional coating shall be properly cleaned of all foreign matter or contaminants and prepared as recommended by the paint Manufacturer.

2.6.3 Excess Thickness

In the event that a coated surface is found to have excessive thickness, it shall be brought to Company's attention who will decide on the appropriate action to be taken. Acceptance of excessive thickness will be considered only if the measured thickness is confirmed by the paint manufacturer in writing as not being detrimental to the satisfactory service life and performance of the coating system and if testing demonstrates that there is no loss in system or intercoat adhesion.

2.6.4 Film Defects

Defects such as misses, incorrect colour, gloss level and poor hiding power shall be repaired by applying additional coating as required.

Defects such as poor finish, texture, sagging, runs, dry spray and over-spray shall be removed by abrading the film to remove the defect and then applying additional coating as required.

Defects such as poor adhesion, pinholes, holidays and cracking shall be completely removed by blast cleaning to substrate and reapplying the complete system.

Damaged areas, defects in the coating system such as over-runs, drips and smears that have to be removed or areas with inadequate DFT shall be re-cleaned. The re-cleaning shall carry over on to the secure surrounding coating for not less than 250 mm all round and the edges shall be feathered (over a width of at least 70 mm). After surface cleaning, the specified coating system or the required layers of the specified coating shall be re-applied. Any additional coats shall blend in with the final coating on adjoining areas. Paint Manufacturers shall be consulted if the existing coating requires abrading before over-coating to obtain good bonding.

2.6.5 Repairs to Zinc Coated Surfaces

Where repairs are required zinc rich epoxy primer or galvanized surfaces, either with or without topcoats, the following procedure shall be followed:

- Blast clean surface using grit to preparation grade Sa 2½ in accordance with ISO 8504-2;
- Apply 70 µm DFT zinc-rich two-pack epoxy primer in two coats;
- Apply topcoats as required to achieve original system thickness.

Overcoating may be permitted before complete curing of the zinc rich epoxy provided that all volatile material has evaporated.

It shall be noted that the above procedure is for repairs only as well as for pipe supports that require welding on site.

Company may require that Contractor completely removes and re-apply the full coating system where the extent of repairs is considered to be excessive.

Inorganic zinc silicate shall not be overcoated by itself. Insufficient coating thickness shall be re-blasted and recoated.

2.6.6 Coating under Intumescent Fireproofing

All coating which is applied under fireproofing shall be approved by the intumescent fireproofing material Contractor prior to application.

All steel to be fireproofed, plus a continuous band of steel of minimum width 300 mm away from it, shall be primed and overcoated with a system which has been agreed as compatible.

3 INSULATION FOR PIPING AND EQUIPMENT

This chapter covers the minimum requirements for external thermal insulation materials, related accessories, and the methods of application required to provide heat conservation and protection of personnel from hot surfaces of piping and equipment that operate at high temperatures.

In the current Project, insulation is required to conserve heat of piping and equipment and to control process temperatures (avoid condensation, solidification, or excessive viscosity of fluids and materials).

3.1 Insulation Types and Thickness

The Contractor shall conduct the insulation and jacketing operations for the relevant types of insulation and jacketing including valve box; vessel; vessel skirt; jacketing joints and other details in compliance with this specification including its tables, details and references.

The Contractor shall prepare insulation and jacketing details and standards for removable boxes for use at valves, flange joints and special applications as required, showing the quick disconnect toggles, hinges, pins and any other relevant information.

The Insulation Code (H, T, N) is part of the line number, as stated in the relevant Line List.

3.1.1 Heat Conservation (H, T)

Heat insulation shall be applied to minimise heat loss and maximize heat conservation and shall be applied according to the process requirements as indicated in the PIDs.

The required thermal insulation thickness shall be determined by using the insulation thickness charts in this specification as per operating temperature on related equipment or piping system.

Heat tracer and steam-out temperatures shall not be used to determine the appropriate insulation thickness. The insulation thickness shall be based on the Maximum Operating Temperature.

Insulation material shall be Mineral wool (ASTM C547) with aluminized steel jacketing or a material with similar heat conductivity performance.

Insulation thickness for piping and equipment shall be as per Table 3-1.

3.1.2 Acoustic Insulation (N)

Acoustic insulation requirements in general follow the same installation requirements as listed so far within this specification. The appropriate thickness for the acoustic insulation shall be in compliance with Table 3-2 and Table 3-3.

Installation of the acoustic insulation shall ensure that the sheet metal jacketing will not be in direct contact with the pipe metal to avoid transmission of vibration to the jacketing. To prevent direct metal-to-metal contact with the pipe, the support rings shall contain damping elements and direct contact between sheeting and pipe shall be eliminated by the use of anti-vibration seals. Gaps at joints in the sound absorbing material along the pipe shall be avoided.

In case acoustic insulation is required for flanges or valves, it shall be surrounded by an acoustic enclosure with jacketing.

Acoustic enclosures shall be manufactured that all joints shall be sealed to prevent noise leakage.

3.2 Technical Requirements

3.2.1 General

All insulation materials shall be new, weatherproofing, sound of commercial quality and manufactured in accordance with the requirements of the relevant standards.

All insulation materials shall be delivered to site in original packing, containers or bundles, clearly marked with the material manufacturer's name and batch numbers.

All insulation materials and equipment which may be adversely affected by dust, moisture, salt, oil, grease or other contaminants, or by direct sunlight, heat, frost or any other such influence shall be stored away and protected from such effects.

Insulation materials shall be non-corrosive, whether wet or dry, and suitably inhibited for application to steel surfaces.

Insulation materials shall not be applied if the moisture content is more than the stated amount given in the Manufacturer's application data.

All insulation materials shall be protected from damage, moisture and weather before and during application.

Surfaces to be insulated shall be clean, free of oil, grease, dirt, and moisture. All specified coatings shall be applied and allowed to cure before proceeding with the application of insulation materials.

All painting required on steel under insulation shall be successfully completed and certified, prior to application of insulation.

Hydrostatic tests in piping, vessels and machinery (if required) shall be successfully completed and certified, prior to application of insulation.

No welding of attachments of any kind shall be made to any equipment, pipe or lined/ insulated items. Other means of attachment may be used, such as banding, bolting or wiring.

Appropriate metal flashing shall be provided at all protrusions through insulation jacket.

All insulation materials shall be asbestos-free, non-flammable and conform to the relevant safety guidelines and norms.

Dissimilar metals and materials subject to galvanic corrosion shall not be installed in contact with each other.

General arrangements for expansion shall be provided.

3.2.2 Design Life

It is expected that the insulation maintains all thermal and physical properties for a period of 40 years.

3.2.3 Uninsulated Surfaces

The following items shall not be insulated unless otherwise noted on the drawings or herein:

- Code inspection plates
- Dummy supports
- Name plates
- Stampings
- Instrument connections
- Valve actuators and levers
- Rotating motors, drive-shaft and couplings of equipment
- Weepholes
- Vents (depending on the length of the vent spool)
- Gauges
- Equipment cooled by free flowing air
- Remote mounted instruments

3.2.4 Pipe, Fittings, Flanges and Valves Insulation

Single layer pipe insulation shall be applied in a surface with the staggered circumferential joint. Overlapping of the insulation material in this area shall be avoided. The staggered circumferential joints shall be as much as possible prevented from the heat stress.

Insulation shall be secured with wire or bands (15 mm wide) up to 8" NPS, and with bands (20 mm wide) for sizes 10" NPS and above. Wire and bands shall be spaced on 300 mm maximum centres. Securement of fittings shall be as required to hold the insulation segments together tightly, but as a minimum each extreme shall be secured.

The application of insulation adjacent to flanges shall allow the removal of bolts without causing damage to the insulation.

Removable covers for valves shall cover the body, bonnet, and flanges as applicable.

Contractor shall use full sections or pieces of insulation as received from the Manufacturer to minimize the number of insulation joints. When a partial piece of insulation is required, one piece that covers the entire area requiring insulation shall be used. The use of multiple small pieces to make up a larger section shall be avoided.

Metal jacketing section shall be overlapped a minimum of 50 mm width, arranged to shed water, and located over the pipe side. Seams shall be water and weather tight. Overlaps shall be staggered.

Pipe jacketing on insulation shall be secured with screws spaced on 150 mm maximum centers.

This finish shall extend at least 50 mm under the adjacent metal jacketing. No porosity shall exist in the weatherproofing mastic when dry.

3.2.5 Insulation of Vessels and Equipment

Insulation on vessels and tubular equipment shall be applied in a staggered joint arrangement and to fit the contour so that no gaps are evident. The insulation shall be secured in place with bands spaced on 450 mm centers.

A girth ring, made from two bands shall be installed on the shell. Bands shall be run radially from the floating ring to the girth ring.

Insulation covers shall fit tightly over fittings and protrusions. The insulation covers shall be of a sufficient width to overlap the adjacent weatherproofing by a minimum of 125 mm on each side of the fitting.

Each piece of a removable cover shall have an embossed metal tag permanently attached with applicable information such as equipment or pipe line number, size, rating, and fitting type.

3.2.6 Insulation Boxes for Outdoors

Insulation boxes fabricated of aluminium sheet metal with insulation installed inside the box shall be custom fabricated for use over flanges, flanged valves, pumps, and other irregular surfaces in cases where removability is required and removable covers will not be suitable.

3.2.7 Projections

Nozzles shall be insulated following the same procedure as piping and insulation thickness as per the operating temperatures.

Cut-outs shall be made at site on cladding for vent piping, nozzles, etc.. Metal joint sealant would be used to seal all cut-out joints.

3.2.8 Required Insulation Thicknesses

The below figures have to be checked during detailed design, based on insulation material heat transfer coefficients and heat conservation requirements.

3.2.8.1 Heat Insulation

Table 3-1 - Required thickness of heat insulation

Diameter [inch]	Maximum Operating Temperature [°C]		
	up to 50	51 to 100	101 to 150
	Insulation Thickness [mm (in)]		
1	25 (1)	25 (1)	25 (1)
1 1/2	25 (1)	25 (1)	30 (1.2)
2	25 (1)	30 (1.2)	30 (1.2)
3	25 (1)	30 (1.2)	50 (2)
4	25 (1)	40 (1.5)	50 (2)
6	30 (1.2)	40 (1.5)	60 (2.4)
8	30 (1.2)	50 (2)	60 (2.4)
10	30 (1.2)	60 (2.4)	60 (2.4)
12	30 (1.2)	60 (2.4)	60 (2.4)

Diameter [inch]	Maximum Operating Temperature [°C]		
	up to 50	51 to 100	101 to 150
	Insulation Thickness [mm (in)]		
14	40 (1.5)	60 (2.4)	70 (2.6)
16	50 (2)	60 (2.4)	70 (2.6)
18	50 (2)	60 (2.4)	80 (3)
20	50 (2)	60 (2.4)	80 (3)
24	60 (2.4)	60 (2.4)	80 (3)
>24 / flat	60 (2.4)	70 (2.6)	90 (3.5)

3.2.8.2 Acoustic Insulation

Thickness for acoustic insulation shall be as shown in Table 3-2 below.

Table 3-2 - Required thickness of acoustic insulation

Insulation Class	Density range of acoustic Insulation material [kg/m ³]	Minimum thickness of porous layer [mm]	Minimum Mass per unit area of jacket sheet [kg/m ²]
A	50 - 150	50	2
B	65 - 150	100	5
C	65 - 150	100	10

Insulation classes A, B, and C as specified in ISO 15665.

Table 3-3 - Insertion loss related to insulation class

Class	Octave band centre frequency [Hz]					
	150	250	500	1000	2000	4000
	Required insertion loss [dB]					
A	-	-	5	10	15	23
B	-	5	10	20	25	30
C	5	10	15	25	30	35

4 INSPECTION AND TESTING

4.1 General

Contractor shall monitor all work and shall conform to the requirements of this specification against a project specific Inspection and Test Plan, detailed in Appendix C.

The Contractor shall protect all equipment, structures and any other areas from mechanical damage, environmental damage, blockage or obstruction, damage caused by over blasting, dripping paint, paint splashes and overspray.

The Contractor shall be responsible for all inspection and quality control functions necessary to achieve coating standards in accordance with this specification.

All testing and inspection equipment shall be kept accurately calibrated at all times and shall be covered by current calibration certificates issued by the equipment Contractor or a test laboratory accredited to ISO 17025 or equivalent for conducting such work.

It is the Contractor's responsibility to ensure that monitoring and testing work is carried out to show that the coatings comply with this specification. The Company reserves the right to carry out any additional tests at random to ensure compliance and the Contractor shall have suitable calibrated test equipment available for Company use.

All personnel and paint products applied under fireproofing shall be approved by the intumescent fireproofing material Contractor, and the Company.

4.2 Preliminary Inspection

Prior to commencing any work, Manufacturer shall carry out visual inspection of all received items.

The Manufacturer shall record all external damage on equipment against the unique item serial number. This damage shall be brought to the attention of Company and the equipment shall not be coated without prior release by Company.

Bevel protectors at each end of every pipe shall not be removed unless showing signs of damage or if removal is required to facilitate surface preparation, or they would be damaged by coating operations. If the protectors are removed the condition of the bevel shall be recorded against the pipe serial number and any damage shall be brought to the attention of Company. Pipe ends shall be protected from damage and suitably sealed to prevent abrasive from entering the interior of the pipe during external abrasive blasting.

4.3 Inspection of Prepared Surfaces

All blast cleaned or otherwise prepared surfaces shall be visually inspected for conformance to Appendix C and Section 2.3 of this specification.

4.4 Visual Inspection of Coated Surfaces

The completed coating shall be of good visual appearance. All coated surfaces shall be visually examined after application of each coat for deleterious film defects, e.g. bubbles, blisters, pinholes, dry spray, orange peel, runs, sagging, wrinkling, grit, dust inclusions, or other deleterious anomalies. All such defects shall be repaired in accordance with this specification.

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.

4.5 Coating Thickness Measurement

Wet film thickness measurements shall be made throughout the course of application of each coat in order to ascertain the adequacy and uniformity of thickness. These shall be performed according to the procedure described in ISO 2808, Method No.1A – comb gauge.

Coating dry film thickness measurements shall be in accordance with ISO 2808. Digital magnetic induction type gauges are preferred for magnetic substrates and eddy current type gauges for non-magnetic substrates. The magnetic 'banana' type gauges shall not be used. Calibration shall be done in accordance with SSPC-PA 2.

Measurements shall be randomly and evenly taken and the number shall be in accordance with Table 4-1. The number of measurements shall be increased for areas having a difficult configuration with regard to paint application or limitations in accessibility. Special attention shall be given to areas such as welds, edges, corners and parts where coatings are brush applied (these are referred to as "areas requiring special consideration" in ISO 19840).

Table 4-1 - DFT Sampling Plan

Area / Length of Inspection Area (m ² or m)	Minimum Number of Measurements
Up to 1	5
Above 1 to 3	10
Above 3 to 10	15
Above 10 to 30	20

Area / Length of Inspection Area (m ² or m)	Minimum Number of Measurements
Above 30 to 100	30
Above 100	For additional ranges (m ² or m), the corresponding number of measurements shall be added.

Note: Areas above 1,000 m² should be divided into smaller inspection areas

DFT shall be taken covering each coat prior to application of the following coat. The minimum measurement location frequency shall be one (1) per two (2) square metres of flat surface, with additional measurements taken at changes in section, corners or edges. Minimum, maximum and average shall be recorded for each coated item on the inspection record sheets.

Acceptance criteria for the completed coating system, based on the NDFT are stated in Section 2.4.8, and Appendix C.

4.6 Adhesion Tests

Adhesion testing shall be carried out during all coating system qualification trials and as a routine test for atmospheric exposed organic coatings.

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

- a) A self-aligning adhesion tester in accordance with ASTM D 4541. The minimum pull-off force for coating systems with a NDFT greater than 150 µm shall be:
 - 5 MPa for zinc primed coating systems;
 - 7 MPa for non-zinc primed coatings systems.

Or:

- b) A crosscut test in accordance with ISO 2409, Class 0 for coating systems with a maximum total NDFT of 150 µm.

Testing shall be done on fully cured systems only, i.e. not less than 14 days after the application of the final layer.

Adhesion testing shall be carried out on each component and at least once per 100 m² of coated surface. Spots damaged by the adhesion tests shall be repaired in accordance with this specification.

Acceptance criteria for adhesion testing shall depend upon coating type and available test data for equivalent systems. As a minimum, adhesion/cohesion levels of 5 MPa for standard organic coatings and 7 MPa for glass flake epoxy. Lower individual values shall require further investigation and remedial action.

A solvent rub test using Methyl Ethyl Ketone in accordance with ASTM D 4752 or equivalent shall be carried out to ensure inorganic zinc primers are fully cured before overcoating.

4.7 Additional Tests

Company reserves the option to require the Contractor to perform such testing of coating materials as may be necessary to prove that the quality is in accordance with the paint Manufacturer's specifications and data sheets and is fully suitable, without reduction in performance or other detrimental effects, under the prevailing application condition. Qualities to be tested may include, but not be limited to, the following:

- Volume Solids;
- Viscosity;
- Pigment Dispersion;
- Adhesion to Substrate;
- Drying Time;
- Cure Time;
- Percentage Zinc in Dry Film (zinc-rich primers only);
- Percentage Glass flake in Dry Film (glass flake containing coatings only);
- Percentage of epoxy resin in the dry film.

Any batch of materials found inferior in any way to the standards and specifications of the paint Manufacturer's approved data sheets shall not be used.

The Contractor shall provide material samples and test panels of the prepared coated surfaces if required by Company. The test shall be performed where production coating will take place. Company may witness these tests and conduct testing as seen fit.

4.8 Inspection of insulation

The insulation system shall be inspected during the following stages:

- At the time of material receipt
- Before applying the insulation
- During insulation application
- Before and during application of weatherproofing

Quality control activities shall include at least the following activities at the time of receipt of the materials:

- Appropriate checks shall be made to verify materials received at the site are the same as the specified or approved materials. Such checks shall include verification of labels, material safety data sheets, delivery receipts, and thickness. Damaged, unspecified, or, unapproved, insulation and related materials shall be removed from the site.
- Ensure that storage of materials will protect them from being damaged by moisture, temperature, wind or any other atmospheric factors.

Quality control activities shall include at least the following prior to insulation application:

- If the pipe or equipment to be insulated is heat treated, inform the Contractor that welding of insulation supports is prohibited without prior written approval from the Company.
- Verify that pressure tests have been completed.
- Verify that surfaces to be insulated are clean, dry, and coated as required by this Specification.
- Verify that painting at protrusions through insulation has been done.

Quality control activities shall include at least the following during insulation application:

- Make sufficient checks to verify that the materials applied are the same as the specified or approved materials.
- Verify the insulated item, and insulation code is the same as given on the P&ID's and related drawings.
- Verify that the insulation surface is uniform without gaps and voids.
- Inspect for tightness of joints and fasteners.

Quality control activities shall include at least the following prior to and during weather-proofing:

- Ensure that the insulation is clean, dry, and fit for its intended purpose before weatherproofing is applied.
- Inspect for proper overlaps of metal and flashing.
- Verify that the location of bands, screws, S-clips, J-clips, and breather springs is as specified.
- Ensure that moisture protection and weatherproofing at cut-outs, protrusions, and locations where moisture could enter the insulation has been appropriately installed.

5 PRESERVATION, HANDLING, MARKING, PACKING, AND SHIPPING

5.1 Preservation

Insulation materials shall be protected to withstand ocean transit and extended periods of storage at the jobsite for a minimum period of 18 months. Materials shall be protected to safeguard against all adverse environments, such as: humidity, moisture, rain, dust, dirt, sand, mud, salt air, salt spray, and seawater.

5.2 Handling

Coated items shall not be handled until all coatings have been properly dried or cured as required in the coating instructions of the manufacturer.

Coated items shall be handled with equipment selected to prevent damage to the coating. Equipment such as chains, cables, hooks, metal bars and narrow skids shall not be permitted to come in contact with the coating.

Raw materials shall be handled and stored in accordance with the material manufacturer's recommendations, which shall be available for review by Company at the Manufacturer's premises. Materials shall be stored in a temperature controlled environment until required for use.

Coating materials shall be segregated by type and batch during storage and handling. Materials from damaged containers shall be rejected unless otherwise agreed with Company.

5.3 Marking

As a minimum, all packages of raw materials shall be marked with the following data:

- Manufacturer's name,
- product's name,
- batch number,
- shelf life,
- storage instructions,
- date of manufacture,
- product data sheet,
- and material safety data sheet.

Any material not labelled with the above information shall not be used.

5.4 Packing and Shipping

Preparation for shipment shall be in accordance with the Company standards, and project specification. Contractor shall be solely responsible for the adequacy of the preparation for shipment provisions with respect to materials and application.

Adequate protection shall be provided to prevent physical damage and atmospheric damage to insulation or weatherproofing materials in transit and at the jobsite.

Preparation for shipment and packing will be subject to inspection and rejection by the Company.

Coated equipment shall be loaded, padded, and secured for transport in a manner such that the coating will not be damaged in transit. Coated items shall be separated so that the items do not bear against each other.

Coated equipment shall be stacked off the ground using suitable means to avoid damage of the coating.

6 DOCUMENTATION

Prior to the commencement of work the CONTRACTOR shall obtain full details of all coatings materials to be used from the selected Manufacturer(s) including product data sheets and safety sheets. The following properties of the cured coating systems shall be reported using standardized and approved laboratory test methods:

- Adhesion;
- Service temperature, maximum limits;
- Resistance to ageing (UV/salt spray);
- Resistance to mechanical damage, e.g. impact resistance, elongation, tensile strength, abrasion;
- Compatibility of different coatings when such are combined;
- Repair ability during construction, installation and service.

In addition, and as a minimum, all packages of the coating materials shall be marked with the following information:

- Name of manufacturer or recognised trade mark;
- Complete material identification;
- Batch number;
- Place and date of manufacture;
- Shelf life/expiry date;
- Product datasheet;
- HSE instructions;
- Storage instructions;
- Quantity;
- Manufacturing standard.

Pre-qualification tests on coating materials shall be performed in accordance with NORSOK M 501 (Ref. 44).

The Manufacturer's up to date technical and application data sheets shall be obtained by the Contractor for all components of each coating system. Certificate of Conformity for each product and batch to be used shall be issued by Manufacturer with the material. Contractor shall ensure before commencing any painting, that coating materials are within their shelf life.

6.1 Coating Procedures

Prior to the commencement of work, Contractor's coating procedures shall be submitted to Company for approval.

The detailed procedures shall include, but not necessarily be limited to the following:

- Method and equipment for surface preparation;
- Method and equipment for coating application;
- Coating materials data (Manufacturer's product data sheets and application notes);
- Ranges of temperature and relative humidity control methods for surface preparation and coating work;
- Time restrictions between surface preparation and first coat and subsequent coats;
- Number of coats and minimum total dry film thickness;
- Procedure for repair of damaged coating;
- Methods of inspection and testing;
- Frequency of monitoring, inspection and testing;
- Surface preparation and coating record sheets, see Appendix C;
- Finish colours;
- Mixing ratios;
- Use of thinners.

7 QUALITY MANAGEMENT SYSTEM

7.1 General

The Manufacturer/Contractor shall have in effect at all times, a QA/QC program which clearly establishes the authority and responsibility of those responsible for the quality system.

All work must be undertaken in strict accordance with Company and Contractor quality procedures.

The Manufacturer/Contractor shall submit their corporate quality manual for Company's review.

The Company reserves the right to audit the Manufacturer/Contractor in accordance with the requirements of ISO 9001 or equivalent and to require the Manufacturer/Contractor to correct any non-conformances identified to the satisfaction of the Company.

The Manufacturer/Contractor shall be responsible for the determination of the suitability and quantity of materials before tendering inclusive of cost, work required, transportation, delivery and schedule.

The Manufacturer/Contractor is responsible for obtaining all statutory and/or third party certifications and approvals of designs, materials and workmanship.

7.2 Personnel

Only professional skilled blasters and painters shall be used. A certified foreman shall supervise the blasters and painters. Painters and painting supervisors shall be trained in accordance with an internationally recognized organisation such as NACE.

Before any work is commenced the certificates should be submitted to the Contractor for review. Certifying bodies shall comply with ISO 17024.

If not certified, the skill of all proposed blasting and painting personnel shall be verified before commencing any painting or coating works.

7.3 Health Safety and Environment

All work must be undertaken with all laws statutory requirements and regulations and industry Health Safety and Environmental practices.

All work shall be undertaken in a manner such as to eliminate risk, so far as is reasonably practicable, to the health and safety of personnel carrying out the work and to others who may be affected by the work, including the public. To achieve this, risk assessments must be undertaken and safety precautions must be put in place and followed in practice.

All personnel carrying out the work must be equipped with appropriate personnel protective equipment such as safety helmets, safety gloves, safety goggles, overalls and safety boots etc.

8 DEFECT LIABILITY PERIOD REQUIREMENTS

8.1 General

Manufacturer's undertaking painting, coating and/or insulation work which is to be carried out in accordance with this specification shall guarantee the quality of their work.

Before any painting, coating or insulating work shall commence, the defect liability period and associated coating/ insulating condition shall be agreed with the Company.

The coating systems to be used in accordance with this specification shall be suitable for an industrial environment C3 as specified in ISO 12944-2.

The use of coating systems as described in this specification and approved by the Company shall not affect the warranties to be agreed by the contract parties.

Surfaces that have deteriorated beyond the specified level of breakdown within the defect liability period shall be repaired by the Manufacturer and shall bear the cost of materials, equipment, and labour for the repair.

Only surfaces that have suffered from mechanical damage or chemical spillage as a result of operational activities fall outside this defect liability period.

The Manufacturer of the insulation material shall provide the defect liability period of its products. The defect liability period shall be subject to the Company for approval.

In case of a dispute on the condition of the coating work that has been inspected, and agreed, an independent expertise body shall conduct a review inspection at the Manufacturer cost. Both the Company and the Manufacturer shall accept the findings of the inspection by this independent Consultant.

8.2 Defect Liability Period Inspection

Ten (10) years after the acceptance date of the completed coating work:

1. The degree of rusting shall be in accordance with ISO 4628-3 and shall not be worse than Ri 2 (0.5 % rusting) for new construction. This degree of rusting shall only be allowed in localised areas and not be scattered over the total surface area coated;
2. Visual cracking, mud-cracking or flaking of the coating systems is not allowed. Full attention shall be given to areas such as corners where overlaps are difficult to avoid;
3. Blistering is not allowed;
4. No conspicuous discolouration or excessive loss of gloss shall be observed in the topcoats specified for the atmospheric zone.

Appendix A Overview Table of Coating and Lining Systems

SYSTEM NUMBER	MATERIAL	EXPOSURE	APPLICATION
1	Carbon Steel	Non Insulated	Structural Steel, Piping and External Surfaces of Vessels
2	Carbon Steel	Insulated	Piping and External Surfaces of Vessels
3	Carbon Steel	Fireproof	All items
4	Carbon Steel	Lining of equipment	Utility equipment

Appendix B Details of Coating and Lining Systems

SYSTEM 1	NON-INSULATED CARBON STEEL	- Structural Steel, Piping, External Surfaces of Vessels and Process Systems
<p>PRE TREATMENT: Remove all grease and salts and other contaminants with a water miscible detergent and high pressure fresh water washing</p> <p>SURFACE PREPARATION: BLAST CLEAN: Sa 2.5 SURFACE PROFILE: 1A: 30 – 85 µm, 1B: 50 – 85 µm</p>		
GENERIC SYSTEM		
<p>SYSTEM 1A Structural steel</p> <p>1 x 50 µm Epoxy Primer, notes 1 and 2 1 x 175 µm Glass Flake Epoxy, note 3 1 x 75 µm Polyurethane Acrylic</p> <p>TOTAL MDFT 300 µm</p>		<p>SYSTEM 1B Piping, External Surfaces of Vessels and Process Systems</p> <p>1 x 75 µm Zinc rich Epoxy Primer, notes 4 and 5 1 x 200 µm Epoxy Mastic 1 x 75 µm Polyurethane Acrylic</p> <p>TOTAL MDFT 350µm</p>
<p>NOTES:</p> <ol style="list-style-type: none"> 1. Solid content of epoxy shall be > 75 %. 2. The epoxy primer in system 1A is only necessary to maintain the integrity of the blasted steel surface. In situations where the primer is required the MDFT shall increase to 525 µm. 3. The glass flake epoxy (including any primer if used) for the structural steel shall be in accordance with Norsok M-501 Systems 1. 4. Zinc rich Epoxy shall be 2 pack formulations containing minimum 90% zinc dust by mass in the dry film. Zinc dust shall conform to ISO 3549. It shall be overcoated before formation of zinc salts; otherwise these shall be removed completely prior to overcoating. 5. An approved surface tolerant epoxy mastic may be used in place of the zinc primer. 		

SYSTEM 2	INSULATED CARBON STEEL	- Piping and External Surfaces of Vessels
<p>PRE TREATMENT: Remove all grease and salts and other contaminants with a water miscible detergent and high pressure fresh water washing</p> <p>SURFACE PREPARATION: BLAST CLEAN: 2A - 2C: Sa 2.5 SURFACE PROFILE: 2A-2C: 30 – 85 µm</p>		
GENERIC SYSTEM		
<p>SYSTEM 2A Insulated Carbon Steel</p> <p>1 x 50 µm Epoxy Primer, notes 1 and 2 2 x 150 µm Epoxy Mastic</p> <p>TOTAL MDFT 350 µm</p>		
<p>NOTES:</p> <p>1. Solid content of epoxy shall be > 75 %.</p> <p>2. The epoxy primer in system 2A shall not contain any zinc.</p>		

SYSTEM 3	FIREPROOF CARBON STEEL	- Fireproof Structural Steel
<p>PRE TREATMENT: Remove all grease and salts and other contaminants with a water miscible detergent and high pressure fresh water washing</p> <p>SURFACE PREPARATION: BLAST CLEAN: Sa 2.5 SURFACE PROFILE: 30 – 85 µm</p>		
GENERIC SYSTEM		
<p>SYSTEM 3A Epoxy Intumescent PFP system, note 7</p> <p>1 x 50 – 70 µm Zinc rich Epoxy Primer, notes 1 and 2 1 x 75 µm Polyurethane Acrylic, note 6</p> <p>TOTAL MDFT 125-145 µm</p>		<p>SYSTEM 3B Cementitious PFP</p> <p>1 x 60 µm Zinc rich Epoxy Primer, note 1 1 x 200 µm Epoxy MIO, see notes 3 and 4 1 x 75 µm Polyurethane Acrylic,</p> <p>TOTAL MDFT 335 µm</p> <p>notes 5 and 6</p>
<p>NOTES:</p> <ol style="list-style-type: none"> 1. Zinc rich Epoxy shall be 2 pack formulations containing minimum 90% zinc dust by mass in the dry film. Zinc dust shall conform to ISO 3549. It shall be overcoated before formation of zinc salts; otherwise these shall be removed completely prior to overcoating. 2. Under intumescent epoxy fireproofing: The primer shall be approved by fireproofing Contractor based on results of shear strength. 3. Solid content of epoxy shall be > 75 %. 4. Under cementitious fireproofing: Alternative coating system may be offered, subject to fireproofing Contractor's recommendations and subject to Company approval. 5. The specific sealing/topcoat requirements for cementitious fireproofing shall be agreed with Company and the fireproofing Contractor. 6. Repair system shall be approved compatible systems. 7. Intumescent epoxy fireproofing Contractor, grade, qualification data, application and inspection procedures shall be approved by Company. 		

SYSTEM 4	LINING OF EQUIPMENT	-Utility vessels/tanks
<p>PRE TREATMENT: Remove all grease and salts and other contaminants with a water miscible detergent and high pressure fresh water washing</p> <p>SURFACE PREPARATION: BLAST CLEAN: Sa 2.5 SURFACE PROFILE: 50 – 85 µm</p>		
GENERIC SYSTEM		
<p>SYSTEM 4A Water Service, Diesel</p> <p>2 x 100 µm Pure Epoxy 1 x 100 µm Pure Epoxy</p> <p>TOTAL MDFT 300 µm</p>		<p>SYSTEM 4B Closed Drain</p> <p>1 x 60 µm Zinc rich Epoxy Primer, note 1 and 2 3 x 450 µm glass flake reinforced lining</p> <p>TOTAL MDFT 1410 µm</p>
<p>NOTES:</p> <ol style="list-style-type: none"> 1. Zinc rich Epoxy shall be 2 pack formulations containing minimum 90% zinc dust by mass in the dry film. Zinc dust shall conform to ISO 3549. It shall be overcoated before formation of zinc salts; otherwise these shall be removed completely prior to overcoating. 2. Binder shall be solvent-free epoxy 3. Vessels shall be fully lined when indicated in K358-ILF-OVA-GEN-ME-REP-0002 4. The lining used in potable water service shall be certified for human consumption 5. Where applicable, aboveground tanks shall be lined at tank bottom and underside tank roof + 1.5 m side walls from bottom of tank and all piping/attachments in this bottom zone. 		

Appendix C Inspection and Testing Plan Template for Coating Work

Inspection and Test Plan for Coating work of Facilities						
CONTRACTOR:			Project:			
Coating system:			Maintenance type:			
Date:						
Item	Inspection test items	Frequency	Acceptance standard	Report form (1)	Contractor (2)	Company (2)
1.0	Reference Documentation		Company's technical coating specification Contractor's quality manual, Doc No..... Contractor's project quality plan, Doc No.....		R	R
2.0	Material Receipt					
2.1	Coating Material Receipt	All	Company's approved material/coating system		R	W
2.2	Coating Material Receipt	All	Coating material traceability Legible labels clearly identifying: -Manufacturer's name -Product name -Batch number -Shelf life -Storage instructions -Date of manufacture -Product data sheet -Material safety data sheets (MSDS)		M, V, R	W
3.0	Inspection of Surface Condition	All surfaces	Check sharpened edges. Sharp edges to be profiled to a minimum radius of 2 mm by grinding and rough cutting and weld profiles to be smoothed.		R, W	W
3.1	Solvent or Detergent Cleaning	All surfaces	Pre-cleaning, No visible surface contamination from oil or grease etc.		R, W	W, M
3.2	High Pressure Water/Steam Cleaning	All surfaces	Contractor's technical specification		R, W	M
3.3	Climatic Conditions (air Temperature and Dew Point readings)	Every two hours	The surface temperature shall be a minimum of 3 °C above the dew point, the relative humidity of the air shall be max. 85 %, the air or substrate temperature shall not be below 5 °C.		M, W, R	W
3.4	Steel Temperature	Every two hours	Max. 40 °C		R	M
3.5	Compressed Air Supply Blotter test	Twice/12 hours	No indication of oil discolouration, no indication of water contamination, ASTM D 4285		R, W	W, M
3.6	Blast Nozzle Pressure	Every 2 hours	7 bar minimum at nozzle		R	M
3.7	Surface Profile	Once per 100 m ² or three times/ per blaster per day	As per coating system. ISO 8503-1 , Testex tapes		W, R, M	W, M
3.8	Surface Dust	Once per 100 m ² or three times/ per day	Rating 2, ISO 8502-3		W, M, R	W, M
3.9	Presence of Millscale	Once per 100 m ² or three times/ per day	Free of mill scale		W, M, R	W,M
3.10	Soluble Salt Contamination Test (chlorides, etc.)	Once per 100 m ² or three times/ per day	Residual chlorides shall be ≤ 50 mg/m ² ISO 8502-6 and ISO 8502-9 Pitted areas shall be checked for iron salts.		H, V, R	W, H
3.11	Visual Inspection after Abrasive Blasting	All	SA 2½ acc. to ISO 8501-1 Minimum illuminance 500 lx		H, W, V, R	W, H
4.0	Calibration of Inspection Equipment	Start of production then every 3 hours	Dry film thickness gauges: start of shift and thereafter every three hours at the mid-range of the coating thickness. Holiday detection: start of shift and thereafter every four hours. 2500 volts ±100 volts, Adhesion tester: daily		V, W, R	W
5.0	Spray Pressure, Tip Size and Fan Angle.	At start of spraying	To match Manufacturer's recommendations		R	M
5.1	Primer Application	All	As per coating system. Measure wet film thickness (see Product Data Sheet)		W, R	M
5.2	Stripe Coat Application of Primer	All	Brush applied, worked into corners, edges and crevices		V, W, R	W

Inspection and Test Plan for Coating work of Facilities						
CONTRACTOR: Coating system: Date:				Project: Maintenance type:		
Item	Inspection test items	Frequency	Acceptance standard	Report form (1)	Contractor (2)	Company (2)
5.3	Dry Film Thickness	5 per m ²	Equal to or above 80 % of NDFT. Number of readings between 80 % of DFT and NDFT			
5.4	Second Stripe Coat Application	All	Brush applied, worked into corners, edges and crevices		W, R	W
5.5	Second Full Coat Application	All	As per coating system. Measure wet film thickness (see Product Data Sheet)		W, V, R	M
5.6	Visual Inspection	All	Uniform in colour, free from irregularities such as runs, sags, fish-eyes, orange peel etc.		R, W, V	W
5.7	Dry film Thickness	5 per m ²	Equal to or above 80 % of NDFT. Number of readings between 80 % of DFT and NDFT		H, R, W	H, W, M
5.8	Cure Test	2× per sprayer per day	Solvent rub test in accordance with ASTM D 4752 for inorganic zinc primers: No softening		R, W	W
5.9	Adhesion Test	1 per 5 m ²	Test shall be performed using a self-aligning tester in accordance with ASTM D 4541. Minimum acceptable value shall be 5 MPa.		R, V, W	W
5.10	Coating Repair	As required	Pinholes, mechanical damage from destructive adhesion testing etc., repair as per approved procedure. Re-test for thickness and porosity as per original. Under-thicknesses, prepare surface and re-coat as per approved procedure		R, V, W	W
Legend: H Hold M Monitor R Record V Visual W Witness NOTES: (1) Indicate reference to Contractor's Quality Control reporting forms or documents on which the quality data is to be recorded and/or reported. (2) These are examples of actions. Actions and action parties shall be agreed for each coating job.						