

SPECIFICATION FOR SURFACE PREPARATION AND PROTECTIVE COATING SYSTEM - NEW CONSTRUCTION

PROJECT : GANDHAR COMPRESSOR PROJECT
OWNER : GAIL (INDIA) LIMITED
JOB NO. : B240

0	08.04.2019	Issued For Tender	S S Pandey	P Chowdhary	H K Parmar
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1.0 GENERAL

- 1.1** This technical specifications shall be applicable for the work covered by the contract, and without prejudice to the provisions of various international codes of practice, standard specifications etc. It is understood that contractor shall carry out the work in all respects with the best quality of materials and workmanship and in accordance with the best engineering practice and instructions of Engineer-In-Charge.
- 1.2** Wherever it is stated in the specification that a specific material is to be supplied or a specific work is to be done, it shall be deemed that the same shall be supplied or carried out by the contractor. Any deviation from this standard without written deviation permit from appropriate authority will result in rejection of job.
- 1.3** This specification covers the requirement for protective coating for new construction.

2.0 SCOPE

- 2.1** Scope of work covered in the specification shall include, without being limited to the following.

- 2.1.1** This specification defines the requirements for surface preparation, selection and application of primers and paints on external surfaces of equipment, vessels, machinery, piping, ducts, steel structures, external & internal protection of storage tanks for all services and chimneys if any. The items listed in the heading of tables of paint systems is indicative only, however, the contractor is fully responsible for carrying out all the necessary painting, coating and lining on external and internal surfaces as per the tender requirement.

2.2 Extent of Work

- 2.2.1** The following surfaces and materials shall require shop, pre-erection and field painting:
- All uninsulated Carbon Steel & Alloy Steel equipments like vessels, Columns, storage Tanks, Exchangers if any, parts of boilers etc.
 - All uninsulated carbon steel and low alloy plant and related piping, fittings and valves (including painting of identification marks), furnace ducts and stacks.
 - All insulated parts of vessels, boilers, chimneys, stacks, piping and steam piping and if any other insulated items present.
 - All items contained in a package unit as necessary.
 - All structural steel work, pipe, structural steel supports, walkways, handrails, ladders, platforms etc.
 - Flare lines, external surfaces of MS chimney with or without refractory lining and internal surfaces of MS chimney without refractory lining. (If present)
 - Identification of colour bands on all piping as required including insulated aluminium clad, galvanized, SS and nonferrous piping.
 - Identification lettering/ numbering on all painted surfaces of equipment/piping insulated aluminium clad, galvanized, SS and non-ferrous piping.

- Marking / identification signs on painted surfaces of equipment/piping including hazardous service.
- Supply of all primers, paints and all other materials required for painting (other than Owner supplied materials)
- Over insulation surface of equipments and pipes wherever required.
- Painting under insulation for carbon steel, alloy steel and stainless steel as specified.
- Painting of pre-erection/fabrication and Shop primer.
- Repair work of damaged pre-erection/ fabrication and shop primer and weld joints in the field/site before and after erection as required.
- All CS Piping, equipments, storage tanks and internal surfaces of RCC tanks in ETP plant.
- Quality control, testing and inspection during all stages of work (surface preparation, application of coating and testing of furnished coating).

2.2.2 The following surfaces and materials shall not require painting in general. However, if there is any specific requirement by the Owner, the same shall be painted as per the relevant specifications:

- a. Uninsulated austenitic stainless steel.
- b. Plastic and/or plastic coated materials
- c. Non-ferrous materials like aluminum, Cu-Ni alloy.

2.3 Documents

2.3.1 The contractor shall perform the work in accordance with the following documents issued to him for execution of work.

- a. Bill of quantities for piping, equipment, machinery and structures etc.
- b. Piping Line List.
- c. Painting specifications including special civil defence requirements.

2.4 Unless otherwise instructed, final paint coating (i.e., application of field primer, wherever required, intermediate and top coats) on pre-erection/ shop primed equipments shall be applied at site, only after all welding, testing on systems are completed as well as after completion of steam purging wherever required.

2.5 Changes and deviations required for any specific job due to clients requirement or otherwise shall be referred to EIL for deviation permit.

3.0 REFERENCE CODES & STANDARDS

3.1 Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, latest editions of the following codes and standards are applicable for the work covered under this specification.

ISO-12944	:	Corrosion Protection of steel Structures by Protective Paint System
NACE 0198	:	Control of Corrosion under Thermal Insulation and Fireproofing Materials
ISO 14713-2	:	Zinc Coatings – Guidelines and Recommendations for the Protections against Corrosion of Iron and Steel in Structures, Part-2: Hot Dip Galvanizing
ASTM Vol. 6.01&6.03	:	American standard test methods for Paints and Coatings
IS-101	:	Methods of test for ready mixed paints and enamels
IS-5	:	Colours for ready mixed paints and enamels.
IS-2379	:	Indian Standard for Pipe line identification-colour code
RAL DUTCH	:	International Standard for colour shade (Dutch Standard)
ANSI A 13.1	:	Scheme for identification of piping systems: American National Standards Institution
SSPC	:	Steel Structures Painting Council

3.2 Surface Preparation Standards

The latest editions of any of the following standards shall be followed for surface preparation:

- 3.2.1 ISO 8501-1 / SIS-05 59 00: ISO standard for Preparation of steel substrates before application of paints and related products. This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-In-Charge.
- 3.2.2 Steel Structures Painting Council, U.S.A. (Surface Preparation Specifications (SSPC-SP)).
- 3.2.3 National Association of Corrosion Engineers, U.S.A., (NACE).
- 3.2.4 Various International Standards equivalent to Swedish Standard for surface preparations are given in Table-I.
- 3.3 The contractor shall arrange, at his own cost, to keep a set of latest edition of above standards and codes at site.
- 3.4 The paint manufacturer's instructions shall be followed as far as practicable at all times for best results. Particular attention shall be paid to the following:
 - a. Instructions for storage to avoid exposure as well as extremes of temperature.
 - b. Surface preparation prior to painting shall carried out as per this standard
 - c. Mixing and thinning.
 - d. Application of paints and recommended limit on time intervals in between coats.

4.0 EQUIPMENT

- 4.1 All tools, brushes, rollers, spray guns, blast material, hand power tools for cleaning and all equipments, scaffolding materials, shot & grit blasting equipments & air compressors etc. required to be used shall be suitable for the work and all in good order and shall be arranged by the contractor at site and in sufficient quantity. The

manufacturer's test certificates / data sheets for all the above items shall be reviewed by Engineer-in-charge at site before start of work.

- 4.2** Mechanical mixer shall be used for paint mixing operations in case of two pack systems except that the Engineer-In-Charge may allow the hand mixing of small quantities at his discretion in case of specific requirement for touch up work only.

5.0 SURFACE PREPARATION, SHOP PRIMER COATING APPLICATION & REPAIR

5.1 General

- 5.1.1** In order to achieve the maximum durability, one or more of following methods of surface preparation shall be followed, depending on condition of surface to be painted and as instructed by Engineer-In-Charge. Adhesion of the paint film to surface depends largely on the degree of cleanliness of the metal surface. Proper surface preparation contributes more to the success of the paint protective system.

- a. Abrasive blast cleaning
- b. Mechanical or power tool cleaning

- 5.1.2** Mill scale, rust, rust scale and foreign matter shall be removed fully to ensure that a clean and dry surface is obtained. Unless otherwise specified, surface preparation shall be done as per provisions of relevant tables given elsewhere in this specification. The minimum acceptable standard, in case of thermally sprayed metal coatings, in case of mechanical or power tool cleaning it shall be St. 3 or equivalent. In case of blast cleaning it shall be Sa 2-1/2 as per Swedish Standard SIS-055900 (latest edition) or SSPC-SP or ISO 8501-01. Blast cleaning shall be Sa 3 as per Swedish Standard in case thermally sprayed metal coatings.

Before surface preparation by blast cleaning, the surface shall be degreased by aromatic solvent to remove all grease, oil etc.

- 5.1.3** Irrespective of whether external or internal surface to be coated, blast cleaning shall not be performed where dust can contaminate surfaces undergoing such cleaning or during humid weather conditions having humidity exceed 85%. In case of internal coating of storage tanks, dehumidifier shall be used, to control humidity level below 60%. Dehumidifier should depress the dew point of air in the enclosed space, sufficient enough so as to maintain it 3°C below the metal substrate temperature during centre period of blasting and coating application. During the interval time between application of primer coat and subsequent intermediate and top coats or between blast cleaning completion and start of application of primer coat, dehumidifier unit should be in continuous operation to ensure that no condensation occurs on substrate.

Dehumidifier should be able to maintain grain drop (moisture removal) at the rate of 25 grains per pound of air per hour. Dehumidifier should have capacity of at least 2 air changes per hour of the enclosed space. All necessary psychometric data should be collected by contractor for the given site conditions before starting operation of dehumidifier to ensure that desired values of dew point, moisture content in enclosed scope is achieved.

Dehumidification to be maintained round the clock for surface preparation and painting till the total coating application is over.

Dehumidifier shall not be stopped under any condition till the entire blasted surface is primed to the satisfaction of the technical representative of the paint manufacturer interested with quality assurance for the work. In case the dehumidifier breaks down in middle of the job, the same shall be replaced at the risk and the cost of the contractor and the entire unfinished work shall be repeated.

- 5.1.4 The Engineer in-charge shall have the right to disallow usage of dehumidifier if the performance is not meeting the specified requirements. Under such circumstances the contractor shall remove the equipment and replace the same with another equipment to provide satisfactory results without any additional cost to the owner.
- 5.1.5 Irrespective of the method of surface preparation, the first coat of primer must be applied by airless spray/ air assisted conventional spray if recommended by the paint manufacturer on dry surface. This should be done immediately and in any case within 4 hours of cleaning of surface. However, at times of unfavorable weather conditions, the Engineer-In-Charge shall have the liberty to control the time period, at his sole discretion and/or to insist on re-cleaning, as may be required, before primer application is taken up. In general, during unfavorable weather conditions, blasting and painting shall be avoided as far as practicable.
- 5.1.6 The external surface of R.C.C. chimney to be painted shall be dry and clean. Any loose particle of sand, cement, aggregate etc. shall be removed by scrubbing with soft wire brush. Acid etching with 10-15% HCL solution for about 15 minutes shall be carried and surface must be thoroughly washed with water to remove acid & loose particles and then dried completely before application of paint.

5.2 Procedure for Surface Preparation

5.2.1 Air Blast Cleaning with abrasives

The surfaces shall be blast cleaned using one of the abrasives like angular chilled cast iron or steel grit, copper slag or Nickel slag, Al_2O_3 particles at pressure of $7kg/cm^2$ at an appropriate distance and angle depending of nozzle size maintaining constant velocity and pressure. Chilled cast iron or steel shall be in the form of shot or grit of size in the range of G16 – G42 conforming to SSPC AB1 and S250 grade size of steel shots (maximum) to obtain a desired surface profile of 35-50 microns trough to peak. For all other abrasives, size shall be in the range of G16 – G24. The combination of steel grits and shots shall be normally in the ratio of 3:1. The quality of abrasives shall be free from contaminants and impurities and shall meet the requirements of SSPC AB1. Compressed air shall be free from moisture and oil. The blasting nozzles should be venturi style with tungsten carbide or boron carbide as the materials for liners. Nozzles orifice may vary from 3/16" to 3/4". On completion of blasting operation, the blasted surface shall be clean and free from any scale or rust and must show a grey white metallic luster. Primer/first coat of paint shall be applied within 4 hours of surface preparation. Blast cleaning shall not be done outdoors in bad weather without adequate protection or when there is dew on the metal, which is to be cleaned. Surface profile shall be uniform to provide good key to the paint adhesion (i.e. 35 to 50 microns). If possible vacuum collector shall be installed for collecting the abrasives and recycling.

5.2.2 Mechanical or Power Tool Cleaning

Power tool cleaning shall be done by mechanical striking tools, chipping hammers, grinding wheels or rotating steel wire- brushes. Excessive burnish of surface shall be avoided as it can reduce paint adhesion. On completion of cleaning, the detached

rust mill scale etc. shall be removed by clean rags and /or washed by water or steam and thoroughly dried with compressed air jet before application of paint.

5.3 Non-Compatible Shop Coat Primer

For equipments on which application of total protective coating (Primer + Intermediate + top coat) is carried out at shop, compatibility of finish coat with primer should be checked with paint manufacturer. If the shop coat is in satisfactory condition showing no major defect upon arrival at site, the shop coat shall not be removed.

5.4 Shop coated equipments (coated with Primer & finishing coat) should not be repainted unless paint is damaged. Repair shall be carried out as per this specification depending upon compatibility of paint.

5.5 Shop primed equipment and surfaces will only be 'spot cleaned' in damaged areas by means of power tool brush cleaning or hand tool cleaning and then spot primed before applying one coat of field primer unless otherwise specified. If shop primer is not compatible with field primer then shop coated primer should be completely removed before application of selected paint system for particular environment.

5.6 For Package units/equipment, shop primer should be as per the paint system given in this specification. However, manufacturer's standard can be followed after review.

As mentioned in section 2.4, all coating application at field (field primer, intermediate and top coat) on equipments, structures, piping, etc., shall be carried out only after its erection and all welding, testing, steam purging (wherever carried out) have been completed.

5.7 Coating Procedure and Application

All paint coatings shall be applied by airless spray excepting at the following special cases where application can be carried out by brush subject to suitability of the application of the paint product by brush.

- Spot repair
- Stripe coating on edges
- Small bore parts not suitable for spray application.

Irregular surfaces such as sharp edges, welds, small brackets, and interstices may stripe coated to ensure specified DFT is achieved. Paint manufacturer recommendation should be followed before deciding for brush application.

5.7.1 Surface shall not be coated in rain, wind or in environment where injurious airborne elements exists, when the steel surface temperature is less than 5°F above dew point when the relative humidity is greater than 85% or when the temperature is below 40°F and when the ambient/substrate temp is below the paint manufacturer's recommended temperature of application and curing. De-humidifier equipment shall be used to control RH and Dew point. The paint application shall not be done when the wind speed exceeds 20 km per hour.

5.7.2 Blast cleaned surface shall be coated with one complete application of primer as soon as practicable but in no case later than 4 hrs. of the same day.

5.7.3 To the maximum extent practicable, each coat of material shall be applied as a continuous film uniform thickness free of probes. Any spots or areas missed in application shall be recoated and permitted to dry before the next coat is applied. Applied paint should have the desired wet film thickness.

- 5.7.4 Each coat shall be in proper state of cure or dryness before the application of succeeding coat. Material shall be considered dry for recoating when an additional coat can be applied without the development of any detrimental film irregularities, such as lifting or loss of adhesion of the under coat. Manufacturer instruction shall be followed for inter-coat interval.
- 5.7.5 When the successive coat of the same colour have been specified, alternate coat shall be tinted, when practical, sufficiently to produce enough contrast to indicate complete coverage of the surface. The tinting material shall be compatible with the material and not detrimental to its service life and shall be recommended by the original paint manufacturer.
- 5.7.6 Airless spray application shall be in accordance with the following procedure: as per steel structure paint Manual Vol.1 & Vol.2 by SSPC, USA, Air less spray relies on hydraulic pressure rather than air atomization to produce the desired spray. An air compressor or electric motor is used to operate a pump to produce pressures of 1000 to 6000 psi. Paint is delivered to the spray gun at this pressure through a single hose within the gun, a single paint stream is divided into separate streams, which are forced through a small orifice resulting in atomization of paint without the use of air. This results in more rapid coverage with less over spray. Airless spray usually is faster, cleaner, more economical and easier to use than conventional air spray.

Airless spray equipment is mounted on wheels, and paint is aspirated in a hose that sucks paint from any container, including drums. The unit shall have in built agitator that keep the paint uniformly mixed during the spraying. The unit shall consist of in built strainer. Usually very small quantity of thinning is required before spray. In case of high build epoxy coating (two pack). 30:1 pump ratio and 0.020-0.023" tip size will provide a good spray pattern. Ideally fluid hoses should not be less than 3/8" ID and not longer than 50 feet to obtain optimum results.

In case of gun choking, de-choking steps shall be followed immediately.

- 5.7.7 Brush application of paint shall be in accordance with the following:
- a. Brushes shall be of a style and quality that will enable proper application of paint.
 - b. Round or oval brushes are most suitable for rivets, bolts, irregular surface, and rough or pitted steel. Wide flat brushes are suitable for large flat areas, but they shall not have width over five inches.
 - c. Paint shall be applied into all corners.
 - d. Any runs or sags shall be brushed out.
 - e. There shall be a minimum of brush marks left in the applied paint.
 - f. Surfaces not accessible to brushes shall be painted by spray, doublers, or sheepskin.
- 5.7.8 For each coat the painter should know the WFT corresponding to the specified DFT and standardize the paint application technique to achieve the desired WFT. This has to be ensured in the qualification trial.

5.8 Drying of Coated Surfaces

- 5.8.1 No coat shall be applied until the preceding coat has dried. The material shall be considered dry for re-coating when another coat can be applied without the development of any film irregularities such as lifting or loss of adhesion of undercoats.

Drying time of the applied coat should not exceed maximum specified for it as a first coat; if it exceeds the paint material has possibly deteriorated or maxing is faulty.

- 5.8.2 No paint shall be force dried under conditions which will cause chalking, wrinkling, blistering formation of pores, or detrimentally affect the conditions of the paint.
- 5.8.3 No drier shall be added to paint on the job unless specifically called for in the manufacturer's specification for the paint.
- 5.8.4 Paint shall be protected from rain, condensation, contamination, snow and freezing until dry to the fullest extent practicable.

5.9 Spot Repair of Damaged Primer

- 5.9.1 Where pre erection shop primer has been damaged at isolated localized spots during handling and transportation, or after erection / welding, the repair of damaged coating of pre-erection / pre-fabrication or shop primer shall be done as given below and as per the Table given at Clause no. 9.1 of this specification.
- 5.9.2 Repair of damaged inorganic zinc silicate pre-erection / pre-fabrication or shop primer (F9) after erection / welding in the design temperature of -90°C to 400°C and damaged silicone aluminium (F-12) pre-erection / pre-fabrication or shop primer after erection / welding for design temperature range of 401 – 550 °C.

Surface Preparation: Quickly remove the primer from damaged area by mechanical scraping and emery paper conforming to SSPC-SP-3 to expose the white metal. Blast clean the surface, if possible. Feather the primed surface over the intact adjacent surface surrounding the damaged area by emery paper.

Primer coating: One coat of F-9 shall be applied wherever damage was observed on pre-erection / pre fabrication or shop primer of inorganic zinc silicate coating (F-9). Similarly one coat of F-12 shall be applied wherever damage observed on pre-erection / pre-fabrication shop primer of silicone aluminium (F-12).

- 5.9.3 Wherever if damaged areas are found extensive and spread over large areas, then entire pre-erection / pre-fabrication or shop primer shall be removed by blasting to achieve SSPC-SP-10 then entire blasted surface shall be primed again with F-9 or F-12 as applicable for the intended design temp.

5.10 Paint Application

- 5.10.1 Shop priming/pre-erection priming with F9 or F12 shall be done only on blasted surface (SSPC-SP-10)
- 5.10.2 Shop priming / pre-erection priming with F9 or F12 shall be done only with airless spray.
- 5.10.3 Assessment of Painting Requirement:

The paint system to be applied for a specific job shall be arrived at sequentially as given below:

- Identify the environment from area classification details and chose the appropriate table.
- Identify the design temperature from the technical documents

- Identify the specific field paint system and surface preparation requirement from the above identified table and temperature range.
- Identify the shop priming requirement from clause 9.1 based on compatibility of the above paint system.
- Identify the need of repair of shop primer and execute as per clause 9.1.

6.0 DOCUMENTATION/ RECORDS

- 6.1 A written quality plan with procedure for qualification trials and for the actual work including test and inspection plan & procedure for approval before start of work.
- 6.2 Daily progress report with details of weather conditions, particular of applications, no of coats and type of materials applied, anomalies, progress of work versus program.
- 6.3 Results of measurement of temperatures relative humidity, surface profile, film thickness, holiday detection, adhesion tests with signature of appropriate authority.
- 6.4 Particulars of surface preparation and paint application during trials and during the work.
- 6.5 Details of non-compliance, rejects and repairs.
- 6.6 Type of testing equipments and calibration.
- 6.7 Code and batch numbers of paint materials used.

The coating applicator must maintain a job record consisting of all the information as per 6.2 - 6.7 above as well as the approved procedure of work (6.1 above). The job record consisting of information as required in accordance to 6.2 - 6.7 shall be entered on daily basis and should be daily signed by Engineer-in-charge.

7.0 SURFACE PREPARATION STANDARDS

Sr. No.	Description	Various International Standards (Equivalent)			Remarks
		ISO 8501-1/ SIS-05 59 00	SSPC-SP, USA	NACE, USA	
1	<u>Manual or hand tool cleaning</u> Removal of loose rust, loose mill scale and loose paint, chipping, scrapping, standing and wire brushing. Surface should have a faint metallic sheen	St 2	SSPC-SP-2	-	This method is applied when the surface is exposed to normal atmospheric conditions when other methods cannot be adopted and also for spot cleaning during maintenance painting.
2	<u>Mechanical or power tool cleaning</u> Removal of loose rust loose mill scale and loose paint to degree specified by power tool chipping, de-scaling, sanding, wire brushing and grinding, after removal of dust, surface should have a pronounced metallic sheen.	St 3	SSPC-SP-3	-	
3	<u>Dry abrasive blast cleaning</u> There are four common grades of blast cleaning				
3.1	<u>White metal</u> Blast cleaning to white metal cleanliness. Removal of all visible rust. Mill scale, paint & foreign matter 100% cleanliness with desired surface profile.	Sa 3	SSPC-SP-5	NACE No. 1	Where extremely clean surface can be expected for prolong life of paint system.
3.2	<u>Near white metal</u> Blast cleaning to near white metal cleanliness, until at least 95% of each element of surface area is free of all visible residues with desired surface profile.	Sa 2½	SSPC-SP-10	NACE No. 2	The minimum requirement for chemically resistant paint systems such as epoxy, vinyl, polyurethane based and inorganic zinc silicate paints, also for conventional paint systems used under fairly corrosive conditions to obtain desired life of paint system.
3.3	<u>Commercial Blast</u> Blast cleaning until at least two-third of each element of surface area is free of all visible residues with desired surface profile.	Sa 2	SSPC-SP-6	NACE No. 3	For steel required to be painted with conventional paints for exposure to mildly corrosive atmosphere for longer life of the paint systems.

Sr. No.	Description	Various International Standards (Equivalent)			Remarks
		ISO 8501-1/ SIS-05 59 00	SSPC-SP, USA	NACE, USA	
3.4	<u>Brush-off Blast</u> Blast cleaning to white metal cleanliness, removal of all visible rust, mill scale, paint & foreign matter. Surface profile is not so important	Sa 1	SSPC-SP-7	NACE No. 4	

8.0 PAINT MATERIALS

Typical characteristics and codes of various paint materials used in this specification are as follows:

Table: Paint Materials Characteristics

Description	P-2	P-4	P-6	P-7
Technical name	Chlorinated rubber Zinc Phosphate primer.	Etch primer/wash primer	Epoxy zinc phosphate primer	Cold Galvanizing
Type and composition	Single pack, air drying chlorinated rubber based medium plasticized with unsaponifiable plasticizer, pigmented with zinc phosphate.	Two pack polyvinyl butyral resin medium cured with phosphoric acid solution pigmented with zinc tetroxy chromate.	Two component polyamine cured epoxy resin medium, pigmented with zinc phosphate.	One pack Synthetic Resin based zinc galvanizing containing min 92% of electrolytic zinc dust of 99.95% purity.
Volume Solids %, Minimum	37	9	49	37
DFT per coat, μ	40-45	8-10	40-50	40-50
Theoretical covering capacity in m^2 /coat/litre	8-10	8-10	8-10	4 m^2 /kg
Weight per litre in Kg/litre	1.3 $\pm$ 0.05	1.2 $\pm$ 0.05	1.4 $\pm$ 0.05	2.67 kg at 15°C
Touch dry at 30°C (max.)	30 min.	2 hrs.	30 min.	10 min.
Hard dry at 30 °C (max.)	8 hrs.	24 hrs.	8 hrs.	24 hrs.
Over-coating interval	Min.: 8 hrs	Min: 4-6 hrs.	Min.:8hrs.	Min.:4 hrs
Pot life at 30 °C for two component paints	NA	NA	6 - 8 hrs.	NA
Adhesion (ASTM D4541)	NA	NA	>7 MPa	NA
Temperature Resistance (min.), °C (ASTM D 2485) *Note 8	60 (Method A)	NA	80 (Method A)	50 (Method A)

Table: Paint Materials Characteristics (Contd.)

Description	F-2	F-3	F-6A/B	F-6C	F-7
Technical name	Acrylic Polyurethane finish paint	Chlorinated rubber based finish paint	Epoxy-High Build coating	Solvent less epoxy coating	High build coal tar epoxy coating.
Type and composition	Two-pack aliphatic isocyanate cured acrylic finish paint.	Single pack plasticized chlorinated rubber based medium with chemical and weather resistant pigments.	F-6A Two-pack Aromatic amine cured epoxy resin medium suitably pigmented. F-6B: polyamide cured epoxy resin medium suitably pigmented	Two pack, cured with Amine Adduct; catalyzed epoxy resin suitably pigmented	Two pack polyamide cured epoxy resin blended with coaltar medium, suitably pigmented
Volume Solids %, (Min.)	40	36	57	98	62
DFT per coat, μ	30-4	30-40	100-125	250-500	100-125
Theoretical covering capacity in M^2 /coat/litre	10-15	11-15	5-6	2-3	5.2-6.5
Weight per liter in kgs/litre	1.15 $\pm$ 0.03	1.15 $\pm$ 0.03	1.42 $\pm$ 0.03	1.40 $\pm$ 0.03	1.40 $\pm$ 0.03
Touch dry at 30 °C, (Max.)	30 min.	30 min.	3 hrs.	3 hrs.	4 hrs.
Hard dry at 30 °C, (Max.)	8 hrs.	8 hrs.	16 hrs.	16 hrs.	48 hrs.
Full cure at 30 °C (for immersion/ high temperature service)	NA	NA	5 days	5 days	5 days
Over-coating interval	Min.12 hrs.	Min. Overnight	Min. Overnight, Max. 5 days	Min. 8 hrs., Max. 48 hrs.	Min. 24 hrs., Max. 5 days
Pot life (approx.) at 30 °C for two component paints	5-8 hrs.	NA	3-6 hrs.	30 min.	4-6 hrs.
Adhesion (ASTM D4541)	>5 MPa	>4 MPa	>7 MPa	>8 MPa	>5 MPa
Abrasion Resistance (ASTM D4060) For 1000 g load	<300 mg /1000 cycles/CS17 or <100 mg /1000 cycles/CS10	NA	NA	NA	NA
Temperature Resistance (min.), °C (ASTM D 2485) *Note 8	80 (Method A)	60 (Method A)	80 (Method A)	120 (Method A)	125 (Method A)

Table: Paint Materials Characteristics (Contd.)

Description	F-8	F-9	F-11	F-12
Technical name	Self-priming type surface tolerant high build epoxy coating (complete rust control coating)	Inorganic zinc silicate coating	Heat resistant synthetic medium based two pack Aluminium paint suitable upto 250°C dry temp.	Heat resistant silicone Aluminium paint suitable upto 540°C dry temp.
Type & composition	Two pack epoxy resin based suitable pigmented and capable of adhering to manually prepared surface and old coating.	A two pack air drying self-curing solvent based inorganic zinc silicate coating with minimum 80% zinc content on dry film. The final cure of the dry film shall pass the MEK rub test ASTM D4752.	Heat resistant synthetic medium based two pack Aluminium paint suitable upto 250°C.	Single pack silicone resin based medium with Aluminium flakes.
Volume Solids %, Min.	75	57	35	18
DFT per coat, μ	100-125	65-75	15-20	15-20
Theoretical covering capacity in m^2 /coat/litre	6.0-7.2	8-9	10-12	8-10
Weight per liter in kgs/litre	1.41 $\pm$ 0.03	2.3 $\pm$ 0.03	0.95 $\pm$ 0.03	1.00 $\pm$ 0.03
Touch dry at 30 °C (max.)	3 hrs.	30 min.	3 hrs.	30 min.
Hard dry at 30 °C (max.)	24 hrs.	12 hrs.	12 hrs.	24 hrs.
Full cure 30°C (for immersion /high temperature service)	5days	NA	NA	NA
Over-coating interval	Min. 10 hrs.	Min. 12 hrs. at 20 °C & 50% Relative Humidity	Min. 24 hrs.	Min. 24 hrs.
Pot life at 30 °C for two component paints	90 min.	4-6 hrs.	NA	NA
Adhesion (ASTM D4541)	>5 MPa	>5 MPa	NA	NA
Temperature Resistance (min.), °C (ASTM D 2485) *Note 8	80 (Method A)	400 (Method B)	250 (Method A)	540 (Method B)

Table: Paint Materials Characteristics (Contd.)

Description	F-14	F-15	F-16	F-17	F-20
Technical name	Polyamine cured coal tar epoxy	Two-component Epoxy phenolic coating cured with Polyamine adduct hardener	Ambient temperature curing Poly Siloxane coating/ High build cold applied inorganic copolymer based aluminium coating suitable for under insulation of CS and SS	Novolac epoxy phenolic coating cured with Polyamine adduct hardener	Glass flake reinforced vinyl ester coating
Type & composition	Specially formulated polyamine cured coal tar epoxy suitable for application under insulation	Two pack ambient temperature curing epoxy phenolic coating system suitable for application under insulation	Suitable for high temperature service and under insulation coating for CS, alloy steel and SS	Novolac epoxy phenolic coating cured with Polyamine adduct hardener	Two component glass flake filled vinyl ester lining for under immersion services upto 90 °C.
Volume Solids %, Min.	67	67	58	98	98
DFT per coat, μ	100-125	75-100	75-100	300-450	500-600
Theoretical covering capacity in m^2 /coat/ litre	5-8	4-5	7- 9	6.5- 8	1.6 minimum
Weight per liter in kgs/litre (mix paint)	1.45 $\pm$ 0.03	1.65 $\pm$ 0.03	1.3	1.7	>1.2
Touch dry at 30 °C (max.)	4 hrs.	3 hrs.	1 hr.	2 hrs.	2 hrs.
Hard dry at 30 °C (max.)	24 hrs	24 hrs	16 hrs	24 hrs	4 hrs.
Full cure 30 °C (for immersion /high temp. service)	7 days	7 days	NA	7 days	4 days
Over-coating interval	Min. 6 hrs., Max.5 days	Min. 36 hrs., Max. 21 days	Min.16 hrs., Max. NA	Min. 16 hrs., Max. 21 days	Min. 4 hrs., Max.3 days
Pot life at 30 °C (for two component paints)	4 hrs.	4-6 hrs.	1 hr.	1 hr.	50 min-1 hr.
Adhesion (ASTM D4541)	>6 MPa	>7 MPa	>8 MPa for Polysiloxane	>8 MPa	>7, Tensile strength >20N/mm ² (ASTM D 638)
Temperature Resistance (min.), °C (ASTM D 2485) *Note 8	125 (Method A)	150 (Method A)	550 (Method B)	150 (Method A)	90 (Method A)

Notes:

1. Covering capacity and DFT achieved per coat depends on method of application. Covering capacity specified above is theoretical. For estimation of actual quantity of paints required, include the losses during application. Minimum specified DFT should be maintained in any case.
2. All primers and finish coats should be ambient temperature curing and air drying unless otherwise specified.
3. All paints shall be applied in accordance with manufacturer's instructions for surface preparation, intervals, curing and application. The surface preparation, quality and workmanship should be ensured. Wherever a deviation is noticed from the specification in manufacturer data sheet, more stringent one between the data sheet and the specification shall prevail e.g. if this specification recommends Sa2½ and the manufacturer data sheet requires Sa3, the surface preparation shall be done as per Sa 3. However in another case if this specification requires the surface preparation of Sa 2½ and the manufacturer data sheet recommends only Sa 2 as minimum, the surface preparation shall be done as per Sa 2½.
4. Technical data sheets for all paints shall be supplied at the time of submission of quotations.
5. Higher specific gravity of F-9 is also acceptable.
6. Internationally recognized & acceptable testing method shall be used for lab testing wherever testing standards are not mentioned.
7. Theoretical covering capacity, hard dry, pot life, full cure period, & over coating interval shall be as per manufacturer's data sheets and no testing is required. Slight variation in the values of these parameters along with *weight per liter* may be permissible with the discretion of engineer-in-charge only.
8. Temperature resistance tests (ASTM D2485) shall be carried out for minimum required temperature resistance indicated.
9. Wherever *ASTM D 2485 method B* is applicable, test results of the panels *subjected to salt spray (ASTM B 117) after muffle furnace exposure* shall be submitted for pre-qualification purpose.
10. F-6A shall be suitable for immersion services.
11. F-6C shall be suitable for immersion services of hydrocarbons and DM water.
12. F-7 shall be suitable for immersion service of hydrocarbons & underground service up to 80 °C minimum.
13. F-14 shall be suitable for under insulation service up to 125 deg C.
14. F-15 shall be suitable for high temperature immersion & under insulation services.
15. F-17 shall be suitable for high temperature immersion service and underground services

9.0 COATING SYSTEMS

Corrosivity category C5-I (very high – industrial) in accordance with ISO 12944-2 and other International Standards/Practices are considered for selecting the Coating Systems for bare steel surfaces exposed to atmosphere. Atmospheric zone coating systems are designed for a high durability (approx. 15 years). For insulated surfaces, coating selection is based on NACE 0198 guidelines and other successful international practices.

9.1 Repair of pre-erection/pre-fabrication or shop primer after erection/welding for all un-insulated CS, LTCS & low alloy steel items

Sr. No.	Design Temp. in °C	Surface Preparation	Coating System	Total DFT in Microns (min.)	Remarks
1	-90 to 400	SSPC-SP-3	1 coat of F-9	65-75	See Note below and Clause 5.9.1
2	401 to 550	SSPC-SP-3	1 coat of F-12	20	

Note: The application and repair of pre-erection/pre-fabrication or Shop Primer given in above tables shall be done for all the items to be painted. In case the damages of primer are severe and spread over large area, entire primer shall be removed by blasting to achieve SSPC-SP-10 and surfaces to be primed again with F-9 or F-12 as applicable.

9.2 Coating system for Gratings (Note 5), Rolling & Stationery Ladders, Spiral Stairways, Hand Rails

Sr. No.	Design Temp., °C	Coating System	Total DFT in Microns (min.)
1	Up to 60	Hot Dip Galvanizing to 80-85 microns as per ISO 14713-2/ ISO 1461 + 1 coat of P-6 @ 40μ DFT/coat + 1 coat of F-2 @ 40 microns DFT/coat	80 microns of finish coat (excluding the thickness of galvanizing)

Notes:

1. No galvanized specimen shall have thickness less than 80 microns.
2. Repair of the damaged areas of galvanized coatings due to welding during erection shall be carried out as per recommended practice ASTM A 780, using cold galvanizing spray process. Organic paint systems are not acceptable for the repair.
3. After repair of damaged galvanized coating by cold galvanization (P-7), the repaired area shall be top coated with paint system as given in table above (i.e. 1 coat of P-6 @ 40μ DFT/coat + 1 coat of F-2 @ 40μ DFT/coat).
4. Suggested cold galvanizing manufacturers are ZINGA, LOCTITE, ZRC etc.
5. Galvanized gratings don't require painting in general except for safety reason such as escape routes, walkways. Hence. Galvanized gratings shall be painted for indication escape routes or walkways only as per table above (i.e. 1 coat of P-6 @ 40μ DFT/coat + 1 coat of F-2 @ 40μ DFT/coat).

9.3 Coating System for uninsulated and above ground (atmospheric zone) CS, LTCS & low alloy steel surfaces

(Structural steel, piping, vessels, columns, reactors, pumps, compressors, exchangers, valves & other equipment etc.)

Sr. No.	Design Temp., °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total DFT, μ (min.)	Remarks
			Primer	Finish Coat		
1	-90 to -15	SSPC-SP-10; 1 coat of F-9 @ 65-75 μ DFT/Coat	None	None	65-75	a) No over-coating to be done on F-9 as it will lead to mud cracking. b) F-12 shall be ambient temperature curing type
2	(-)14 to 80	SSPC-SP-10; 1 coat of F-9 @ 65-75 μ DFT/Coat	1 coat of P-6 @ 40 μ DFT/coat (Tie/ Mist Coat)	2 coats of F-6A @ 100 μ DFT/coat + 1 coat of F-2 @ 40 μ DFT/Coat	345-355	
3	81 to 400	SSPC-SP-10; 1 coat of F-9 @ 65-75 μ DFT/Coat	None	2 coats of F-12 @ 20 μ DFT/Coat	105-115	
4	401 to 540	SSPC-SP-10; 1 coat of F-12 @ 20 μ DFT/Coat	None	2 coats of F-12 @ 20 μ DFT/Coat	60	

NOTES:

- The list of items given in the heading of the above table is not exhaustive. There may be more items for a particular contract where these specifications are used. The Contractor is fully responsible for completing painting including prefabrication primer for all the items supplied and fabricated through his scope of work as per tender document.
- If the Pre-erection/Pre-fabrication & Shop Primer has already been completed, the same shall not be repeated again in the field. In case the damages of primer are severe and spread over large areas, the engineer-in-charge may decide & advise re-blasting and priming again. Repair of pre-fabrication/pre-erection primer, if required, shall be done as per this specification.
- Flare line within unit or offsite areas shall be coated as per Sr. No. 3 of above table
- For external surface of MS chimney with or without refractory lining and for internal surface without refractory lining, paint system as per Sr. No. 3 of above table shall be followed.
- For external surface of RCC Chimney, 2 coats of F-6B @ 100 μ DFT/coat to obtain total DFT of 200 μ shall be applied after proper surface preparation as per clause no. 5.1.6.
- In case of paint systems where finish (top) coat is F-12, the colour bands shall be applied over the Aluminum paint as per the Color coding requirement for specific service of piping.
- For piping, equipment, vessels, columns & valves etc., scope of surface preparation, application of primers to finish coat including repair shall be as per applicable contractual documents like SOR, MR, and PR etc.

9.4 Coating system for effluent treatment plant (ETP)

Sr. No.	Design Temp., °C	Surface Preparation	Coating System		Total DFT, μ (min.)	Remarks
			Primer	Finish Coat		
1	For External Surfaces of C.S./M.S. items: Screens, Walk way bridges, Baffles, Dual media filters, Vertical pumps, piping in treated effluent sump, bio sludge pump, Screw pump and pump house, CS tanks, sumps and vessels.					
	-14 to 80	SSPS-SP-10	1 coat of F-9 @ 65-75μ DFT/coat	2 coats of F-6A @100μ DFT/coat + 1 coat of F-2 @ 40μ DFT/coat; (2x100+40=240)	305-315	-
2	For Internal Surfaces of CS/MS Items: Bio-sludge sump, Filter feed sump, Process sump, Sanitary sump, Transfer sump, Sludge, Slop oil tank, scrapping mechanism in Clarifier					
	-14 to 80	SSPS-SP-10	1 coat of F-9 @ 65-75μ DFT/coat.	3 coats of F-6A @100μ DFT/coat (3x100=300)	365-375	Note:1
3	All R.C.C./concrete surfaces exposed to effluent water / liquid such as tanks, structures, drains etc. in Process sump, TPI separator (Process and Oil), Aeration Tank and Transfer sump etc.					
	-14 to 80	Blast cleaning to SSPC-SP guide lines and Acid etching with 10-15% HCl acid followed by thorough water washing.	Epoxy Screed lining		3mm	Epoxy screed lining shall be applied as per specific manufacturer and Engineer-in-Charge instructions
4	C.S/M.S Dual media filters (Internal), Chemical dosing tanks (internal) such as Di-Ammonium Phosphate (DAP) and Urea					
	Up to 60	SSPC-SP-10	Natural Rubber Lining (As per IS 4682, Part 1)		4.5mm	Natural Rubber lining shall be applied as per specific manufacturer and Engineer-in-Charge instructions

Notes:

- Coating manufacturers shall provide their Quality control test certificate of coating materials (F-6A) for immersion service of the exposed effluent.

9.5 External coating systems for uninsulated carbon steel and low alloy steel Storage Tanks

Sr. No.	Design Temp., °C	Surface Preparation (Field)	Coating system		Total DFT, μ (min.)	Remarks
			Primer	Finish Coat		
a	All external surfaces of shell, wind girders, appurtenances, roof tops of all above ground tank including top side of external and internal floating roof and associated external structural works.					
1	-14 to 80	SSPC-SP-10	1coat of F-9 @ 65-75μ DFT/coat + 1coat of P-6 @ 40μ DFT/ coat ;	2 coats of F-6A @ 100μ DFT /coat + 1 coat of F-2 @ 40μ DFT/ coat;	345-355	F-6 should be suitable for occasional water immersion
2	81 to 150	SSPC-SP-10	1 coat of F-15 primer @ 80μ DFT/ coat + 1 coat of F-15 intermediate coat @ 80μ DFT/coat ;	1 coat of F-15 finish coat @80μ DFT/ coat + 1 coat of F-2 @ 40μ DFT/ coat;	280	-
3	151 to 400	SSPC-SP-10	1coat of F-9 @ 65-75μ DFT/coat	2 coats of F-12 @20 μ DFT/ coat Or 1 coat of F-16 @ 125 μ DFT / coat	105-115 Or 190-200	For higher design temperatures, system as per Sr. No. c (1) of this table is applicable
b	External surfaces of bottom plate (soil side) for all storage tanks					
1	-14 to 80	SSPC-SP-10	1 coat of F-7 @ 125μ DFT/ coat	2 coats of F-7@ 125μ DFT/coat	375	F-7 should be suitable for immersion service of the products given
2	81 to 150	SSPC-SP-10	1 coat of F-15 primer @ 80μ DFT/ coat + 1 coat of F-15 intermediate coat @ 80μ DFT/coat	1 coat of F-15 finish coat @ 80μ DFT/ coat	240	-

3	151 to 550	SSPC-SP-10	1 coat of F-16 @ 125 μ DFT /coat	1 coat of F-16 @ 125 μ DFT /coat	250	-
c	For underside of the bottom plate (in case tank is not lifted during PWHT) (see Note 2c)					
1	-180 to 650	For CS, SSPC SP 10	1 coat of inert polymeric matrix coating @ 125 μ	1 coats of inert polymeric matrix coating @ 125 μ	250	.
		For SS SSPC-SP-7 (15-25 μ surface profile)				

Notes

- All paint coating application including primer for tankage shall be carried out at field after erection and completion of all welding.
- For underside of bottom plate :
 - Painting shall be carried out before laying of bottom plate for tanks with Non-Post Weld Heat Treatment (PWHT).
 - For tanks with PWHT, painting shall be carried out after PWHT.
 - In case tank is not lifted during PWHT then painting shall be applied before laying of bottom plate, clause no. 12.3.1 shall be followed.

Caution: PWHT temperature shall not exceed 650 °C.

9.6 Internal coating systems for carbon steel and low alloy Storage Tanks

Sr. No.	Design Temp., °C	Surface Preparation	Coating system		Total DFT, μ (min.)	Remarks
			Primer	Finish Coat		
a	Crude Oil, ATF, Turpentine Oil, Lubricating Oil & Vegetable Oil					
	Underside of floating roof, internal surface of cone roof, inside of bottom plate, Internal surfaces of Shell - including wetted and free board height, oil side surfaces of deck plates, oil side surfaces of pontoons, roof structures, structural steel, ladders and other CS internals					
1	-14 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80μ DFT/ coat	1 coat of F-15 intermediate coat @ 80μ DFT/coat + 1 coat of F-15 finish coat @ 80μ DFT/ coat;	240	-
b	Petroleum Products & Intermediates like LDO, HSD , Gas Oil, Feeds of FCC-PC, FCC-LCO, VGO-HDT, ISOM, DHDT, Reformate, DCU, NHT & Gasoline, Naphtha, Isomerate & Kerosene					
	Underside of Floating roofs, internal surface of cone roof, inside of bottom plate, internal surfaces of Bare shell for full height, underside of floating roof, oil side surfaces of deck plates, oil side surfaces of pontoons, support structures and ladders etc.					
1	-14 to 45	SSPC-SP-10	1 coat of F-9 @ 75 μ DFT/coat	-	65-75	
2	46 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80μ DFT/ coat	1 coat of F-15 intermediate coat @ 80μ DFT/coat + 1 coat of F-15 finish coat @ 80μ DFT/ coat;	240	-
c	Potable, Raw & Fire Water					
	All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-14 to 60	SSPC-SP-10	1 Coats of F-6A @ 100 μ DFT/coat;	2 Coats of F-6A @ 100μ DFT/ Coat	300	Note-1
d	De-Mineralized (DM) Water					
	All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-14 to 60	SSPC-SP-10	1 Coats of F-6A @ 100μ DFT/coat;	2 coats of F-6C @ 200μ DFT/ coat;	500	-
2	61 to150	SSPC-SP-10	1 coat of F-15 primer @ 80μ DFT/ coat	1 coat of F-15 intermediate coat @ 80μ DFT/coat + 1 coat of F-15 finish coat @ 80μ DFT/ coat; (80+80=160)	240	-

e	Hydrochloric Acid (HCl) 10 % All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-14 to 60	SSPC-SP-10	1 Coat of clear two component solvent free vinyl ester primer @ 100μ DFT/ Coat	2 Coats of F-20 @ 500μ DFT/ Coat	1100	-
f	Aggressive Solvents like Hexane, Hexene, Benzene, Xylene & Toluene All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-14 to 65	SSPC-SP-10	1 coat of F-9 @ 65-75μ DFT/ coat	---	65-75	-
g	Ethylene Glycol (EG) Tanks Internal shell-full height, bottom plate, underside of roof and all accessories					
1	All	SSPC-SP-10	None	3 coats of vinyl chloride co-polymer @ 75μ /Coat; (3x75=225)	225	-
h	Inside Pontoon and Inside of Double Deck of all Floating Roofs					
1	-14 to 80	SSPC-SP-3	1 coat of F-8 @ 100μ DFT/coat	1 coat of F-8 @ 100μ DFT/coat	200	-
i	Wet Slops, Amine Solutions, Sour Water , Water Draw Off All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-14 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80μ DFT/ coat	1 coat of F-15 intermediate coat @ 80μ DFT/coat + 1 coat of F-15 finish coat @ 80μ DFT/ coat;	240	-
j	Vacuum Residue, Fuel Oil , Dry Slop, Bitumen & Other High Temperature Hydrocarbon Liquids Underside of floating roof, internal surface of cone roof, bottom plate, inside of bare shell – including wetted and non-wetted surfaces, oil side surfaces of deck plates, oil side surfaces of pontoons, roof structures, structural steel and ladders					
1	Up to 150°C	SSPC-SP-10	-	1 coat of F-17 @ 375μ DFT/ coat;	375-475	-
k	Alkalis upto 50 % Concentration All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	Up to 60°C	SSPC-SP-10	1 coat of F-15 primer @ 80μ DFT/ coat	2 Coats of F-6 A @ 100μ DFT/coat;	280-100	-

Notes

1. F-6 A shall be suitable for drinking water service and should have competent authority certification.

9.7 Coating systems for external side of underground carbon steel plant piping and underground Vessels

Sr. No.	Design Temp., °C	Surface Preparation & Shop Primer	Coating system		Total Final DFT, μ (min.)	Remarks
			Surface Preparation & Primer	Finish Coat		
a	Underground carbon steel plant piping					
1	25 to 65		SSPC-SP-10; 1 coat of synthetic fast drying primer 25 @μ DFT/ coat	1 layer of coal tar tape coating @ 2mm +1 coat of synthetic fast drying primer 25 @μ DFT/ coat + 1 layer of coal tar tape coating @ 2mm /layer as per ANNEXURE-II (EIL Std. Spec. 6-79-0011)	-	-
2	65 to 150	---	SSPC-SP-10; 1 coat of F-17 primer @ 400μ DFT/ coat	1 coat of F-17 intermediate coat @ 400μ DFT/coat	800	-
3	151 to 450	---	SSPC-SP-10; 1 coat of F-16 primer @ 125μ DFT/ coat	1 coat of F-16 finish coat @125μ DFT/ coat	250	This system is suitable up to 550 °C
b	External side of uninsulated underground storage vessels					
1	-40 to 80	SSPC-SP-10; 1 coat of F-7 @ 125μ DFT/ coat	---	2 coats of F-7 @ 125μ DFT/coat	375	-
2	81 to 150	SSPC-SP-10; 1 coat of F-17 primer @ 400μ DFT/ coat	---	1 coat of F-17 @ 400μ DFT/coat	800	-
3	151 to 400	SSPC-SP-10; 1 coat of F-16 primer @ 125μ DFT/ coat	---	1 coat of F-16 finish coat @125μ DFT/ coat	250	This system is suitable up to 550 °C

9.8 Coating System for Insulated CS, LTCS, Low Alloy Steel & Stainless Steels Surfaces

(Insulated Piping, Equipments, Storage vessels, tanks, Columns etc.)

Sr. No.	Design Temp., °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total Final DFT, μ (min.)	Remarks
			Primer/ Intermediate	Finish Coat		
a	Carbon steel, LTCS and Low Alloy Steel Piping, Storage tanks, Vessels, Equipments etc.					
1	-45 to 125	SSPC-SP-10; 1coat of F-15 @ 75μ DFT/coat	-	2 coats of F-15 @ 75μ DFT/coat;	225	-
2	126 to 540	SSPC-SP-10; 1coat of F-12 @ 20μ DFT/coat	-	2coat of F-12 @ 20μ DFT/coat;	60	Note-3
b	Stainless Steel, Alloy-20 Piping, Vessels & Equipments (Note:2)					
1	-45 to 125	SSPC-SP-7 (15-25μ surface profile); 1 coat of F-15@ 75 μ DFT/coat	-	2 coat of F-15 @ 75 μ DFT/coat;	225	
2	126 to 550	SSPC-SP-7 (15-25μ surface profile); 1 coat of F-16 @ 125 μ DFT/coat	-	1 coat of F-16 @ 125 μ DFT/coat	250	
c	Cyclic Service of Carbon Steel, LTCS, Alloy Steels & Stainless Steel					
1	- 45 to 150	SSPC-SP-10 For CS, LTCS & Low Alloy Steel, SSPC-SP-7 for SS (15-25μ surface profile); 1 coat of F-15 @ 75 μ DFT/coat	-	2 coat of F-15 @ 75 μ DFT/coat;	225	Note-4

2	-180 to -45 and 150 to 650	SSPC-SP-10 For CS, LTCS & low Alloy Steel; SSPC-SP-7 for SS (15-25 μ surface profile) ; 1 coats of inert polymeric matrix coating @ 125 μ	-	1 coats of inert polymeric matrix coating @ 125 μ	250	
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Notes

1. "Cyclic Service" is characterized by rapid temperature fluctuation.
2. The blast cleaning abrasives for SS and Alloy steel surfaces shall be Aluminium oxide grits/shots or garnet.
3. Alternatively, for Tanks, Vessels & Equipments, thermally sprayed aluminium coating (TSAC) @ 300 μ as per ANNEXURE-I is also acceptable.
4. Alternatively, for this temperature range, 1 coat of F-17 @ 300 μ is also acceptable.
5. For insulated vessels & equipment scope of surface preparation, application of primers to finish coat including repair shall be as per applicable contractual documents like SOR, MR, PR etc.

9.9 Internal Coating System for carbon steel components of coolers/ condensers for fresh water service

(Water boxes, channels, partition plates, end covers and tube sheets etc.)

Sr. No.	Design Temp. in °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total Final DFT, μ (min.)	Remarks
			Primer	Finish paint		
1	Up to 80 °C	SSPC-SP-10	1 coat of F-15 @ 80 microns	2 coats of F-15 @ 80 μ DFT/coat;	240	-
2	80 to 140	SSPC-SP-10	---	1 coat of Glass Fibre Reinforced Novolac Epoxy	1500	-

Note: Above table is applicable in line with the data sheets of the respective exchangers.

9.10 Internal Coating System for galvanized or non-ferrous or stainless steel/ duplex stainless steel components of coolers/ condensers for fresh water service

Sl. No.	Design Temp., °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total DFT (min.), μ	Remarks
			Primer	Finish paint		
1	Up to 80	Sweep Blasting	1 coat of F-15 @ 80 μ DFT/coat;	1 coat of F-15 @ 80 μ DFT/coat;	160	-
2	80 to 140	Sweep Blasting	-	1 coat of Glass Fibre Reinforced Novolac Epoxy	1500	-

Note: Above table is applicable in line with the data sheets of the respective exchangers.

10.0 STORAGE

All paints and painting materials shall be stored only in rooms to be arranged by contractor and approved by Engineer-in-charge for the purpose. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separate from adjacent building. A signboard bearing the word "PAINT STORAGE – NO NAKED LIGHT – HIGHLY INFLAMMABLE" shall be clearly displayed outside. Manufacturer's recommendation shall be followed for storage of paint materials.

11.0 COLOUR CODE

The colour coding of OWNER is applicable. It is in the applicators/contractors scope to obtain confirmation for applicable colour coding from the OWNER/ EIL.

Alternatively, contractor shall prepare color code scheme of structures, equipment, pipings etc. in line with international practices and get the same approved from the Owner.

Note for color coding

- All LPG service PSVs shall be painted in Deep Blue.
- All drains & Vents shall be painted in Main line colour.
- The colour code scheme is for identification of piping service group. It consists of a ground colour and 1 or more colour bands.

11.1 Identification

The system of colour coding consists of a ground colour and secondary colour bands superimposed over the ground colour. The ground colour identifies the basic nature of the service and secondary colour band over the ground colour distinguishes the particular service. The ground colour shall be applied over the entire length of the un-insulated pipes. For insulated lines ground colour shall be provided as per specified length and interval to identify the basic nature of service and secondary colour bands to be painted on these specified length to identify the particular service. Above colour code is applicable for both unit and offsite pipelines.

11.2 Ground Colour

On uninsulated pipes, the entire pipe has to be painted in ground colour., and on metal clad insulated lines, minimum 2M long portion should be painted.

11.3 Colour Bands

Location of colour bands:

- At Battery Limits
- Intersection points & change of direction points in piping
- Midway of piping section, near valves, across culverts
- At 50 M interval on long stretch pipes
- At starting and termination points.

Minimum width:

NB	Width
3" and below	75 mm
Above 3" to 6"	NB X 25 MM
Above 6" to 12"	NB X 18 MM
Above 12"	NB X 15 MM

For insulated pipes, NB indicates OD of the insulation.

Sequence:

Colour bands shall be arranged in sequence showing Table above and the sequence follows the direction of flow. The width of the 1st Band to 2nd band is 4:1,

Wherever deemed required by Process Department or Safety, pipes handling hazardous substances will be given hazard marking of 30 mm wide diagonal stripes of Black and Golden Yellow as per IS : 2379.

11.4 Special Camouflage Painting for Uninsulated Crude and Product Storage Tanks.

Coating System shall be as per this specification.

Camouflage painting scheme for Defense requirement in irregular patches will be applied with 3-colours:

Dark Green	:	Light green	:	Medium Brown
5	:	3	:	2

- The patches shall be irregular and asymmetrical and inclined at 30 to 60 Degrees.
- Patches should be continuous at surface meeting lines / points.
- Slits / holes shall be painted in dark green shade.
- Width of patches shall be 1 to 2 meters.

11.5 Identification Markings on Equipment / Piping

Equipment tag Numbers shall be Stenciled / neatly painted using normal 'Arial' Lettering Style on all equipment and piping (Both insulated & uninsulated) after completion of all paint works. Lettering colour shall be either BLACK or WHITE, depending upon the background, so as to obtain good contrast.

Operations Group shall specify location.

Sizes shall be:

Columns, Vessels, Heaters:	150 mm
Pumps and other M/c	50 mm
Piping	OD/2 with Maximum 100 mm
Storage Tanks	(As per Drawings)

11.6 Colour Coding for Control Valve

- a) Carbon steel body - Light grey

Alloy steel body - Canary yellow

Stainless steel body - Natural

- b) The actuator of the Control valve shall be painted as:

Direct action (open on air failure) valves - Green

Reverse acting (close on air failure) valves - Red

The painting Status shall be comprehensively updated every 6 months for compliance

12.0 IDENTIFICATION OF VESSELS, PIPINGS etc.

12.1 Equipment number shall be stencilled in black or white on each vessel, column, equipment & machinery (insulated or uninsulated) after painting. Line number in black or white shall be stencilled on all the pipe lines of more than one location as directed by Engineer-In-Charge; Size of letter printed shall be as below:

Column & Vessels	-	150mm (high)
Pump, compressor & other machinery	-	50mm (high)
Piping	-	40-150 mm

12.2 Identification of Storage Tanks

The storage tanks shall be marked as detailed in the drawing.

13.0 PAINTING FOR CIVIL DEFENCE REQUIREMENTS

13.1 Following items shall be painted for camouflaging if required by the client.

- All Columns
- All tanks in Offsites
- Large Vessels
- Spheres

13.2 Two coats of selected finishing paint as per defense requirement shall be applied in a particular pattern as per 13.3 and as per the instructions of Engineer-In-Charge.

13.3 Method of Camouflaging

13.3.1 Disruptive painting for camouflaging shall be done in three colours in the ratio of 5:3:2 (all matte finish).

Dark Green		Light Green		Dark Medium Brown
5	:	3	:	2

13.3.2 The patches should be asymmetrical and irregular.

13.3.3 The patches should be inclined at 30° to 60° to the horizontal.

13.3.4 The patches should be continuous where two surfaces meet at an angle.

13.3.5 The patches should not coincide with corners.

13.3.6 Slits and holes shall be painted in dark shades.

13.3.7 Width of patches should be 1 to 2 meters.

14.0 QUALITY CONTROL, INSPECTION AND TESTING

14.1 All painting materials including primers and thinners brought to site by contractor for application shall be procured directly from manufactures as per specifications and shall be accompanied by manufacturer's test certificates. Paint formulations without certificates are not acceptable (see section 24.0).

14.2 The contractor must produce Test Certificate from Pre-Qualified Paint Manufacturer for various tests as detailed out in section 25.1 of this document. The Engineer-in-Charge shall have the right to test wet samples of paint from each batch at random for verifying quality of paint supplied. Contractor shall arrange to have such tests,

when called for by Engineer-in-Charge, performed at his cost at any one of the NABL accredited laboratories under witness of NACE CIP Level-2 (min.) / Qwner/ Owner's representative.

Samples for the test will be drawn at random in presence Engineer-in-Charge or his representations. Following tests to be carried out if called for by Engineer-in-Charge:

- Specific Gravity
- % solids by weight (% zinc content in case of inorganic or organic zinc primer)
- Drying time (touch dry & full curing)
- Adhesion
- Flexibility
- Hardness
- Storage stability (pot life)

Test methods for above tests shall be as per relevant ASTM or ISO Standard.

14.3 The painting work shall be subject to inspection by Engineer-In-Charge at all times. In particular, following stage-wise inspection will be performed and contractor shall offer the work for inspection and approval of every stage before proceeding with the next stage. The record of inspection shall be maintained in the registers. Stages of inspection are as follows:

- (a) Surface preparation
- (b) Primer application
- (c) Each coat of paint

14.4 Surface preparation: Following tests are to be carried out during surface preparation.

- i) Test for presence of oil/ grease and contamination

The steel substrate after degreasing as per SSPC-SP 1 shall be tested as per following procedure to validate absence of oil and grease contamination:

- Visual inspection: Continue degreasing until all visible signs of contamination are removed.
- Conduct a solvent evaporation test by applying several drops or a small splash of residue-free tri-chloromethane on the suspect area especially pitting, crevice corrosion areas or depressed areas. An evaporation ring formation is indicative of oil and grease contamination.
- Continue degreasing and inspection till test is passed.

ii) Tests for surface finish of blasted surface shall be done by visual inspection using SSPC-VIS1. Clear cellophane tape test as per ISO 8502-3 shall be used to confirm absence of dust on blasted surface. Checks shall be done on each component atleast once per 200 m² of blasted surface and minimum of 3 checks per shift.

iii) Test for presence of soluble salt as per method ISO 8502-9. Maximum allowable salt content shall be considered 20 mg/m². Checks shall be done on each component atleast once per 200 m² of blasted surface and minimum of 3 checks per shift. In case salt exceeds specified limit, the contaminated surface shall be cleaned by method as per Annexure-C of IS 12944-4 (water cleaning). After cleaning surface shall be retested for salt after drying.

iv) Blast Profile Measurement

The angular profile depth measurement shall be done by profile tape as per method NACE Standard RP 0287 or ASTM D 4417 method B (Profile depth gauge micrometer). Spot measurement shall be carried out every 15m² of blasted surface. At each spot three measurements shall be taken over an area of 10 cm² and average of measurements to be recorded and reported. If desired profile (35-50 μ or as recommended by paint manufacturer) is not achieved, blasting shall continue to get the required profile.

v) Test for Blasting Media (for every fresh batch of media and one random test during blasting):

- Blasting Media shall be visually inspected for absence of contamination and debris using 10X magnification.
- Inspection for the absence of oil contamination shall be conducted using following procedure:
 - Fill a small clean 200 ml bottle half full of abrasive.
 - Fill the bottle with potable water, cap and shake the bottle.
 - Inspect water for oil film/slick. If present, the blasting media is not to be used.
- Soluble salt contamination if suspected shall be verified by method ASTM D 4940. If present, media to be replaced.
- Clean blasting equipment, especially pot and hoses, and then replace blasting media and retest.

vi) Test for Blasting Air (once daily before start of blasting and once at random during blasting):

The air for blasting shall be free from moisture and oil. The compressor air shall be checked for oil and water contamination per ASTM D 4285.

In addition to above, record should include type of shop primer already applied on equipment e.g. zinc silicate, zinc rich epoxy or zinc phosphate etc. Any defect noticed during the various stages of inspection shall be rectified by the contractor to the entire satisfaction of Engineer-In-Charge before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work, contractor shall be responsible for making good any defects found during final inspection/guarantee period/ defect liability period as defined in general condition of contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and extra coat of paint should be applied to make-up the DFT specified without any extra cost to owner, the extra coat should have prior approval of Engineer-in-charge.

14.5 Primer Application

After surface preparation, the primer should be applied to cover the crevices, corners, sharp edges etc. in the presence of inspector nominated by Engineer-In-Charge. The shades of successive coats should be slightly different in colour in order to ensure application of individual coats, the thickness of each coat and complete coverage should be checked as per provision of this specification. This should be approved by Engineer-In-Charge before application of successive coats.

The contractor shall provide standard thickness measurement instrument with appropriate range(s) for measuring dry film thickness of each coat, surface profile

gauge for checking of surface profile, holiday detectors and pinhole detector and protector whenever required for checking in case of immersion conditions.

Prior to application of paints on surfaces of chimneys, the thickness of the individual coat shall be checked by application of each coat of same paint on MS test panel. The thickness of paint on test panels shall be determined by using gauge such as 'Elkometer'. The thickness of each coat shall be checked as per provision of this specification. This shall be approved by Engineer-In-Charge before application of paints on surface of chimney.

At the discretion of Engineer-In-Charge, the paint manufacturer must provide the expert technical service at site as and when required. This service should be free of cost and without any obligation to the owner, as it would be in the interest of the manufacturer to ensure that both surface preparation and application are carried out as per their recommendations. The contractor is responsible to arrange the same.

14.6 Inspection of finished coating: Inspection of applied coatings shall consist of measurement of the following:

i) Coating Dry Film Thickness Check: DFT measurement shall be as per ISO 2808. Type II electromagnetic gauges should be used for ferrous substrates. DFT gauge calibration, number of measurement shall be as per SSPC-DA 2. Measured DFT shall be within + 10% of the dry film thickness, specified in the specifications.

ii) Adhesion Testing: Adhesion of the primer to the steel substrate and inter-coat adhesion of the subsequent coat(s) after curing for at least a week after application of the topcoat shall be examined by a knife test in accordance with ASTM D 6677. For the knife test, if the rating is better than 8, the adhesion is considered acceptable. The adhesion is destructive and tested areas shall be repaired afterward using the spot repair procedure. Alternatively, the applicator may perform the adhesion test on a steel coupon coated using the same surface preparation and coating application procedure as the work piece. Adhesion testing shall be carried out for each component at least once per 200 m² of coated surface.

iii) Holiday Testing: Holiday testing shall be conducted in accordance with NACE SP 0188. For immersion services, 100% of coated area shall be inspected for holidays. For atmospheric exposure, 10% of coated area which must include weld seams, corners and edges to be holiday tested. Voltage at which test is to be carried out will depend upon DFT of coating being tested and shall be as per NACE SP 0188. Any holiday is unacceptable and should be marked and repaired immediately.

14.7 The contractor shall arrange for spot checking of paint materials for Specific gravity, glow time (ford cup) and spreading rate.

14.8 Final Inspection of coating system

A final inspection shall be conducted prior to the acceptance of the work. The coating contractor and the facility owner shall both be present and they shall sign an agreed inspection report. Such reports shall include:

General

- Names of the coating contractor and the responsible personnel
- Dates when work was performed

Coating Materials

- Information on coating materials being applied

- Condition of coating materials received

Environmental Conditions

- Weather and ambient conditions
- Coating periods

Surface Preparation

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

Coating Application

- Equipment used
- Mixing procedure prior to application
- Coating application techniques used

Testing

- Type and calibration of inspection instruments used
- Type of quality control tests performed, and results

15.0 GUARANTEE

The contractor shall guarantee that the chemical and physical properties of paint materials used are in accordance with the specifications contained herein/to be provided during execution of work.

16.0 QUALIFICATION CRITERIA OF PAINTING CONTRACTOR/ SUB-CONTRACTOR

Painting contractor who is awarded any job for EIL, Projects under this standard must have necessary equipments, machinery, tools and tackles for surface preparation, paint application and inspection. The contractor must have qualified, trained and experienced surface preparator, paint applicator, inspector and supervisors. The contractor supervisor, inspector, surface preparator and paint applicator must be conversant with the standards referred in this specification.

17.0 QUALIFICATION/ ACCEPTANCE CRITERIA FOR COATING SYSTEM

17.1 Pre-Qualification of Paint Coating Manufacturer and his Products

Paint Coating manufacture meeting the following requirements shall be considered for supply of their products:

- Manufacturer should have been in continuous business of paint coating formulation and manufacture for at least past 5 years.
- Manufacturer should possess past experience of supplying his products to hydrocarbon, petrochemical, fertilizer. Chemical processing industry or offshore platforms in the past 5 years.
- Coating manufacturer should have supplied at least 10000 litre of an individual product to hydrocarbon, petrochemical, fertilizer, chemical processing industry or offshore platforms.

- The manufacturer's manufacturing procedure & QA/QC system shall meet ISO 9001 requirements and preferably should possess ISO 14000 certificate.
- The Quality control set up should be manned by qualified paint technologists whose bio data should be sent along with quality control organization chart.

CONTRACTOR shall procure the paint materials from the qualified manufacturer meeting above requirements and after obtaining prequalification testing approval as per requirements mentioned in clause 17.2 below.

17.2 Pre-Qualification Testing Procedure:

The paint manufacturer engaged by the mechanical contractor shall carry out the tests in reputed Government Laboratories (like National Test House Mumbai, National Test House Kolkata, Institute of Chemical Technology Mumbai, HBTI Kanpur, IICT Hyderabad) as a part of qualification. Paint manufacturer shall provide the paint samples to laboratory for testing of the parameters for each category of paint as mentioned in Clause 8.0 (Paint Materials Characteristics) and testing of Coating System properties as per Table given below. The testing laboratory will confirm the compliance of the paint material with respect to the acceptance criteria mentioned in this specification. Contractor shall furnish these test certificates along with all necessary supporting documents/information to EIL site for approval/acceptance. The paint manufacturer will be qualified and approved by EIL site for supply of paints after review/assessment of the submissions made by the contractor. Test certificates which are more than 3 years old will not be considered. Paint manufacturers are advised to carryout pre-qualification testing accordingly for paints supply to EIL projects.

TABLE: PRE-QUALIFICATION TESTING

System No.	Coating System	Reference Clause	Total DFT, μ (Min.)
1.	F-9+P6+F6B+F2	Clause 9.3, Sr. No. 2 of table	345
2.	F12+F12+F12	Clause 9.3, Sr. No. 3 of table	60
3.	F15+F15+F15	Clause 9.5, Sr. No. b (2) of table	240
4.	F16+F16	Clause 9.5, Sr. No. b (3) of table	250
5.	F17	Clause 9.6, Sr. No. j (1) of table	375
6.	F8+F8	Clause 9.6, Sr. No. h (1) of table	200
7.	F7+F7+F7	Clause 9.5, Sr. No. b (1) of table	375
8.	F-20	Clause 9.6, Sr. No. e (1) of table	1100
9.	F6A+F6C+F6C	Clause 9.6, Sr. No. d (1) of table	500
10.	Inert Polymeric Matrix	Clause 9.5,	250

		Sr. No. c (1) of table	
11.	F6A+F6A+F6A	Clause 9.6, Sr. No. c (1) of table	300

Sr. No.	Test	For System Number	Duration	Acceptance Criteria
1.	<u>Cyclic Test</u> Salt Spray: 72 hrs. Drying in air: 16 hrs. UV-A340 nm weather meter: 80 hrs. One cycle: 168 hrs. (25 cycles at 168 hrs. each cycle) (ASTM D5894)	1	4200 hrs.	Shall pass. No chalking, cracking, flaking, blistering or peeling shall be observed.
2.	Chemical Resistance Test (ASTM D543)			
2a.	10% & 40% NaOH	3,5,8 & 11* *H ₂ SO ₄ solution pH = 5.0 to 5.5 for system 11	1000 hrs.	Shall pass.
2b.	5% H ₂ SO ₄		168 hrs.	No cracking, discoloration, blistering, peeling or softening of film shall be observed.
2c.	Xylene		4 weeks	
2d.	Acetone		4 weeks	
2e.	Ethanol		4 weeks	
2f.	Kerosene		4 weeks	
2g.	Sea water		2000 hrs.	
3.	Immersion in DM/DI water @ 90° (ASTM C868)	3,5 & 8	30 days	No softening, blistering or film damage.
4.	Resistance to DM water using water immersion. (ASTM D870)	9	2000 hrs.	Shall pass. No chalking, cracking, flaking, blistering or peeling.
5.	100% Humidity Test (ASTM D2247)	1 to 11 (except system-2)	1440 hrs.	Shall pass

6.	Dry Heat Resistance Test (ASTM D2485 method B at 540 ⁰ C for system 2 and 550 ⁰ C for system 4)	2 & 4	-	Shall pass the test. No peeling, cracking, blistering, abnormal discoloration or loss of adhesion.
7.	Thermal Shock Resistance Test; 5 cycles @ 30 minutes in furnace at 120 ⁰ C and 15 minutes in water after quenching in water for each cycle. (ASTM D2485 method A)	2,3,4 & 10 (For system-2, testing to be done after heating the panels at 175°C for 2 hrs.)	-	Shall pass
8.	Cathodic Disbondment Test (ASTM G8 @ 60°C)	3 & 5	-	Shall pass

Each coating product to be qualified shall be identified by the following:

- 1) Specific gravity of Base and curing agent (Ref. ISO 2811)
- 2) Ash content (ASTM D1650), volatile and non-volatile matters (ISO 3251) of each component

These identification tests of coating materials shall be carried out on the batch, which is used for the Pre-qualification testing and in the same reputed government laboratory.

17.3 Information to be furnished during delivery of paint materials:

CONTRACTOR along with delivery of paint material has to furnish following information from paint manufacturer to EIL for acceptance/approval of products:

a) Batch test certificates

Along with paint products delivery to site from the pre-qualified coating manufacturer, CONTRACTOR has to produce test certificate (from paint manufacturer) for each category of product for the following test items. All test results must mention clearly the batch no. and category of product tested. Tests shall be witnessed by NACE CIP Leve-2 (minimum) inspector. Tests to be conducted for following properties:

- Specific Gravity
- % solids by weight (% zinc content in case of inorganic or organic zinc primer)

b) Product information sheet/ technical data sheet for each category of product

The contractor shall be fully responsible for the quality of the paints products as per prequalification testing. After the paint materials are supplied to site, the supplier shall

organize random sampling and testing in a NABL accredited laboratory as per discretion of the Engineer-in-charge (refer clause 14.2). Failing to meet the specified quality requirements may cause rejection of the paint products.

18.0 METHOD OF SAMPLING & DISPATCH FOR LABORATORY TESTING

(Pre-Qualification tests (sec. 17.2), Batch testing (sec. 17.3) and Inspection testing (sec. 14.0))

18.1 Samples of coating materials should be submitted to the laboratory in sealed containers with batch no. and test certificate on regular format of manufacturer's testing laboratory.

18.2 All test panels should be prepared by testing laboratory. Surface preparation for a system shall be done in accordance with this specification. For individual products testing, minimum surface preparation shall be Sa 2.5. Colour photographs of test panels should be taken before and after the test and should be enclosed along with test report.

Sample batch no. and manufacturer's test certificate should be enclosed along with the report. Test report must contain details of observation and rusting if any, as per the testing code.

18.3 Manufacturers should intimate EIL, details of sample submitted for testing, name of testing agency, date, and contact personnel of the testing agency.

ANNEXURE-I

SPECIFICATION FOR THERMALLY SPRAYED ALUMINIUM COATING (TSAC)

1.0 SCOPE

The following sections outlines the requirement of supply, application and testing of thermally sprayed aluminum coatings (TSAC) for corrosion protection of carbon steel piping and equipments with design temperature not exceeding 540 ° C.

2.0 ITEMS TO BE THERMALLY SPRAYED

Steel Structures/equipments to be protected by TSAC shall be as specified in this specification. Structures, components thermally sprayed shall not have any uncoated area or shall not be in mechanically connected by flanges etc to any uncoated bare steel work. Such adjacent areas to TSA coated areas, if not coated by TSA shall have suitable paint coating system as per the standard specification.

3.0 TSAC REQUIREMENTS

3.1 Surface Preparation

All the parts to be sprayed shall be degreased according to SSPC-SP-1. The absence of oil and grease after degreasing shall be tested by method given elsewhere in the specification (Refer Sec. 6.7). Thereafter the surface to be abrasive blasted to white metal finish as per NACE 1/SSPC-SP-5 for marine and immersion service. Using SSPC VIS 1, it is to be visually assessed that the blast cleaned surface meets requirement of SSPC-SP-5. Thereafter clear cellophane tape test as per ISO 8502-3 shall be used to confirm absence of dust on the blasted surface. Finally blasted surface shall be tested for presence of soluble salts as per method ISO 8502-9. Maximum allowable salt content shall be considered 50mg/m². (5 micrograms/cm²) .In case salt content exceeds specified limit. The contaminated surface shall be cleaned by method as per Annex C of IS 12944-4 (Water Cleaning). After cleaning the surface shall be retested for salt content after drying. Testing shall be carried out at least on each component, once per 200 m² and a min of 3 times per shift during progress of work.

The blasting media shall be either chilled iron or angular steel grit as per SSPC-AB-3 of mesh size G-16 to G-40. Copper, Nickel slag, Garnet or Aluminum Oxide as abrasives will also be suitable having mesh size in the range of G16 to G24 (10-30 mesh), conforming to SSPC-AB-1. Mesh size shall be required as appropriate to the anchor tooth depth profile requirement and blasting equipment used. The blasted surface should be having angular profile depth not less than 65 microns with sharp angular shape but shall not exceed 85 microns. The profile depth shall be measured according to NACE standard RP 0287 (Replica Tape) or ASTM D 4417 method B (Profile depth gauge).

For manual blasting one profile depth measurement shall be taken every 10-20 m² of blasted surface. Surface preparation shall be completed in one abrasive blast cleaning operation wherever possible. If rust bloom (visual appearance of rust) appears on the blast cleaned surface before thermal spraying, the affected area shall be re-blasted to achieve specified degree of cleanliness after which only thermal spraying shall commence.

Air blasting pressure at nozzle shall be normally maintained at 100 psi. Air pressure and media size should be reduced and adjusted to preclude damage/distortion to thin gauge materials. Blasting time on work piece should be adjusted to only clean the surface and cut required anchor tooth with minimum loss of metal. Blast angle should be as close to perpendicular as possible but in no case greater than $\pm 30^\circ$ from perpendicular to work surface. Blasting media must be free of debris, excessive fines, and contaminants such as NaCl and sulfur salts (Ref. SEC 6.0 of this Spec). Blast cleaning shall not be performed when the surfaces to be blasted are wet or less than 5°C above dew point temperature or when the relative humidity in the vicinity of the work is greater than 90%.

3.1.1 Blasting Equipment

The TSAC applicator shall use mechanical (centrifugal wheel) or pressure pot blast cleaning equipment and procedures. Suction blasting equipment shall not be used. Sec 6.6.2 shall be used to validate clean and dry air.

3.1.2 Feed Stock

The feed stock shall be in the form of wire. The feed stock shall be 99.5% aluminum of commercial purity grade, its composition shall be in accordance with requirement of BS 1475 or ASTM B833 or ISO 209-1 type A1 (wrought aluminum and aluminum alloys, wire). Wire shall be supplied in protective wrapping indicating batch number and other details.

3.1.3 Thickness Requirement

The nominal thickness of finished TSAC shall be 250 microns having minimum value of 225 microns at low thickness areas (valleys) and not more than 275 microns at peak areas.

The finished thickness shall be measured using SSPC-PA 2 type 2 fixed probe gauge (Magnetic Gauge).

3.1.4 Coating Bond Strength Requirement

The TSAC coating shall have a minimum individual tensile-bond strength value of 1000 psi for flame sprayed and 1500 psi for arc sprayed coating with an average of 2000 psi for arc sprayed coatings. Minimum tensile bond strength should be achieved by proper anchor tooth profile of blasted surface, laying down the TSA thickness in multiple passes and carrying out TSA application under controlled environment

3.1.5 Porosity

All thermally sprayed metallic coatings will have porosity. For thermally sprayed aluminum coatings porosity shall not exceed 15% of total surface area for flame sprayed coating and 8% for arc spray coating.

4.0 THERMAL SPRAY APPLICATION PROCEDURE

Items in the atmospheric zone to be coated by TSA shall be applied by either Flame spray or Arc spray method only. For coating under insulation, application shall be by arc wire method.

4.1 Equipment Set Up

4.1.1 Thermal spray equipment shall be set up calibrated, operated (1) according to manufacturer instructions/technical manuals and also TSAC applicators refinement thereto and (2) as validated by Procedure Qualification (Sec 7.0 of this specification).

4.1.2 Spray Parameters

Spray parameters (see 4.1.3 below) and thickness of each crossing pass shall be set and shall be validated with bend test (See 6.5 of this Spec).

4.1.3 Spray Parameters

Spray Parameters	Method of Application	
Arc voltage	Arc wire Spray	Flame Wire Spray
	27 V	-
Air pressure	80 psi	80 psi
Steel surface cleanliness	NACE-1 white metal	NACE-1 white metal / or Near white metal
Steel surface profile	75 microns (minimum)	75 microns (min.)
Arc current	250-280A	-
Coating thickness	225 microns (nominal)	225 microns(Nominal)
Coating adhesion	> 1500 psi (Total coating),see 3.1.4	>1000 psi
Coating porosity	Less than 8%	Less than 15%.
Spray distance (spray Gun work piece)	6-8"	5-7"
Spray Pass width	40mm	20 mm

The above parameters to be validated with a bend test by the contractor before start of work (for details of bend test see Sec 6.5 of this Spec).

4.2 Post Blasting Substrate Condition and Thermal Spraying Period.

4.2.1 The steel surface temperature shall be at least 5°C above dew point of ambient air temperature.

Steel substrate surface temperature shall be recorded by with a contact pyrometer. Thermal spraying should commence within 15 minutes from the time of completion of blasting

4.2.2 Holding Period

Time between the completion of final anchor tooth blasting and completion of thermal spraying of blasted surface should be no more than four hours. If within this period rust bloom appears Sec 4.4.1 of this specification will apply.

4.3 Pre-Heating

For flame spraying, the initial starting area of 1-2 square feet to be preheated to approx.120°C to prevent condensation of moisture in the flame on the substrate. For arc spraying the preheating is not required.

4.4 Thermal Spraying

Spraying should commence only after validation of equipment set up by procedure qualification test and spray parameter validation tests described in Sec 7.0 and 6.5 respectively. Thermal spraying must commence within 15 minutes from the time of completion of blast cleaning

The specified coating thickness shall be applied in several crossing passes. The coating bond strength is greater when the spray passes are kept thin. Laying down an excessively thick spray pass increases the internal stresses in TSAC and decreases the bond strength of total TSAC. The suitable thickness for crossing passes shall be determined by procedure qualification test described in Sec 7.0 of this specification.

For manual spraying, spraying to be done in perpendicular crossing passes to minimize thin spots in coating. Approx. 75-100 microns of TSAC shall be laid down in each pass.

The surface geometry of the item or area to be sprayed should be inspected before application. The spraying pass and sequence shall be planned according to following.

- Maintain Gun as close to perpendicular as possible and within $\pm 30^\circ$ from perpendicular to the substrate.
- Maintain nominal standoff distance and spray pass width as given below:

Spray method	Standoff (Inches)	Spray pass width (Inches)
Arc Wire	6-8	1 1/2(40mm)
Flame wire	5-7	3/4(20mm)

4.4.1 Rust Bloom (Visual appearance of rust or Discoloration):

If Rust bloom appears on the blasted surface before thermal spraying, the affected area shall be re-blasted to achieve the specified level of cleanliness.

If Rust bloom in form of discoloration, or any blistering or a degraded coating appears at any time during application of TSAC, then spraying shall be stopped and acceptable sprayed area shall be marked off. The unsatisfactory areas shall be repaired to the required degree of surface cleanliness and profile.

Blast the edges of the TSAC to provide for 2-3" feathered area overlap of the new work into existing TSAC.

Then apply TSAC to the newly prepared surfaces and overlap the existing TSAC to the extent of feathered edge so that overlap is a consistent thickness.

4.4.2 Masking

Masking all those parts and surfaces which are not required to be thermally sprayed as instructed by purchaser should be inspected by applicator to ensure that they are properly marked and covered by purchaser.

Complex geometries (flanges, valve manifolds, intersections) shall be masked by applicator to minimize overspray i.e. TSAC applied outside spray parameters (primarily gun to substrate distance and spray angle).

4.4.3 TSAC Finish

The deposited TSAC shall be uniform without blisters, cracks, loose particles, or exposed steel as examined with 10 X magnification.

5.0 SEALER

Sealant shall be applied after satisfactory application of TSAC and completion of all testing and measurements of the finished TSAC as per Sec 6.0 of this specification.

For shop work Sealer shall be applied immediately after thermal spraying and for field work sealer shall be applied within 8 hours. The sealcoat shall be thin enough to penetrate into the body of TSAC.

The sealant shall be Silicone Alkyd Aluminium paint having DFT not more than 35-40 micron. Typically seal coat shall be applied at a spreading rate resulting in theoretical 38 microns DFT. The seal coat shall be applied in accordance with SSPC-PA 1 and the paint manufacturer instruction for sealing.

6.0 TESTING AND MEASUREMENT SCHEDULE

6.1 Surface Finish

That the blasted cleaned surface meets the required criteria (NACE 1/SSPC-SP 5) shall be visually inspected using SSPC-VIS 1. The clear cellophane-tape test as per ISO 8502-3 shall be used to confirm absence of dust or foreign debris on the cleaned surface. Checks shall be done on each component at least once per 200 m² of blasted surface and minimum of 3 checks per shift.

6.2 Blast Profile Measurement: (In-Process testing during actual production before application of TSA coating)

The angular profile depth measurement shall be done by profile tape as per method NACE Standard RP 0287 or ASTM D 4417 method B (Profile depth gauge micrometer). Spot measurement shall be carried out every 15m² of blasted surface. At each spot three measurements shall be taken over an area of 10 cm² and average of measurements to be recorded and reported.

If profile is <65 microns blasting shall continue till greater than 65 microns depth profile is achieved.

6.3 TSAC Thickness (In-Process Testing For finished coating during regular production)

6.3.1 TSAC finished thickness shall be measured using SSPC-PA 2 type 2 fixed probe gauge.

- 6.3.2 For flat surfaces, measurements shall be taken along a straight measurement line, one measurement line for every 15 m² of applied TSAC shall be selected along which 5 measurements to be taken at 25 mm interval and average to be reported.
- 6.3.3 For curved surface or complex geometry, 5 measurements shall be taken at a spot measuring 10 cm² in area. One spot to be taken for every 15 m² of applied TSAC area.
- 6.3.4 The TSAC thickness in surface changes or contour changes, welds and attachments shall be also measured and reported.
- 6.3.5 If TSAC is less than specified minimum thickness, apply additional TSAC until specified thickness range is achieved.
- 6.3.6 All locations and values of TSAC thickness measurements shall be recorded in Job Record (JR).

6.4 Tensile Bond Testing (In-Process testing for finished coating during regular production)

- Tensile Bond strength of the TSAC finish coat shall be determined according to ASTM D 4541 using a self-aligning adhesion tester.
- One measurement shall be made every 50 m². If tensile bond at any individual spot is less than 1000 psi for flame sprayed coating and 1500 psi for arc sprayed coating the degraded TSAC shall be completely removed and reapplied.
- The tensile bond portable test instrument to be calibrated according to ASTM C 633

6.5 Bend Tests

Bend test shall be carried out at beginning of each work shift. Bend tests shall also be conducted on sample coupons before start of thermal spraying work to qualify the following as mentioned earlier in this specification.

- To qualify spray parameters and thickness of each crossing pass.

6.5.1 Test Procedure

- a) Five corrosion control steel coupons each of dimension 50 mm x 150 mm x 1.3 mm thick to be prepared.
- b) Surface shall be prepared by dry abrasive blast cleaning as per this specification.
- c) TSAC shall be applied as per specified thickness range. TSAC should be sprayed in crossing passes laying down approx. 75-100 microns in each pass.
- d) TSAC applied coupons shall be bent 180° around a 13 mm diameter mandrel.
- e) Bend test shall be considered passed if on bend radius there is
 - No cracking or spalling or lifting by a knife blade from the substrate
 - Only minor cracking that cannot be lifted from substrate with a knife blade.

- f) Bend test fails if coating cracks with lifting from substrate.

6.6 Tests for blasting media, blasting air

6.6.1 Blasting Media (For every fresh batch of media and one random test during blasting)

Blasting Media shall be visually inspected for absence of contamination and debris using 10 X magnification.

- a) Inspection for the absence of oil contamination shall be conducted using following procedure :
- Fill a small clean 200 ml bottle half full of abrasive.
 - Fill the bottle with potable water, cap and shake the bottle.
 - Inspect water for oil film/slick. If present, the blasting media is not to be used.
- b) Soluble salt contamination if suspected shall be verified by method ASTM D 4940. If present, media to be replaced.
- c) Clean blasting equipment, especially pot and hoses, and then replace blasting media and retest.

6.6.2 Test for Blasting Air (Once Daily before start of blasting and once at random during blasting)

The air for blasting shall be free from moisture and oil. The compressor air shall be checked for oil and water contamination per ASTM D 4285.

6.7 Test for presence of oil/grease and contamination

The steel substrate after degreasing as per SSPC-SP 1 shall be tested as per following procedure to validate absence of oil and grease contamination.

- a) Visual inspection - Continue degreasing until all visible signs of contamination are removed.
- b) Conduct a solvent evaporation test by applying several drops or a small splash of residue-free tri-chloromethane on the suspect area especially pitting, crevice corrosion areas or depressed areas. An evaporation ring formation is indicative of oil and grease contamination.

Continue degreasing and inspection till test is passed.

7.0 TSAC APPLICATOR QUALIFICATION

Following tests to be carried out as part of procedure qualification test for the applicator.

- Thickness measurement
- Coating bond strength
- Porosity test
- Bend strength

TSAC applicator's surface finishing and application process and equipment set up, calibration and operation shall be qualified by application of TSA on a reference sample which shall be used as a comparator to evaluate the suitability of application process. Only that applicator will be permitted to carry out the work when test specimens coated by the applicator meets the desired requirements as cited below. The sample shall be made of a steel plate measuring approx. 18"x 18" x 1/4" thick. If the actual work is less than 1/4" thick then the sample to be made from material of representative thickness.

The surface preparation, TSAC application shall be made with actual field equipments and process/spray parameters and procedures as per the specification. The depth profile of blasted surface, TSAC coating thickness for each cross pass and total thickness range shall be as per specification.

The surface preparation and thermal spraying shall be carried out in representative environmental conditions spraying with makeshift enclosure.

7.1 After application of coating, thickness and tensile bond measurements shall be made in following manner.

- Divide the sample piece into four quadrants.
- Measure thickness along the diagonal line of each quadrant.
- Four each quadrant five in-line thickness measurements at 1" interval shall be done using SSPC-PA 2 type 2 fixed probe gauge. Thus a total of four "five in line" thickness measurements to be done for the whole sample.
- One tensile bond measurement using ASTM D 4541 type III or IV portable self-aligning test instrument to be done at centre of each quadrant. Total of 4 measurements for the sample.
- One porosity evaluation test by Metallographic examination shall be conducted to demonstrate the achievement of porosity within the limits specified. Sample shall be prepared for Metallographic examination as per ASTM E-3.
- The procedure shall be considered qualified if thickness and tensile-bond strength and porosity values meet the specification requirement.

7.2 Bend test: Bend test shall be carried out as detailed at sec. 6.5 of this specification.

Applicators thermal spray equipment set-up, operation and procedure of application including in-process QC checkpoints adopted during procedure qualification as described above should be always subsequently followed during entire duration of work.

8.0 DOCUMENTATION

The following information shall be provided by TSAC applicator before award of work.

- TSAC application process consisting of equipment capabilities and their technical parameters, feed stock material and source of procurement.
- Detailed application procedure and in-process quality control check points for (a) surface preparation (b) thermal spraying (c) seal coats.

- Type and specification of instruments to be deployed for measurement of blast profile depth, TSAC thickness and tensile bond.

- Paint manufacturer data sheet for the selected sealing coat to be applied.

9.0 RECORDS

- The TSAC applicator shall maintain job record to record production and QC information. All the results of the tests and quality control checks shall be entered in the record for each component/part thermally sprayed. All the result of tests (thickness, tensile bond, bend tests) and other validation tests (e.g. procedure qualification test, test for surface cleanliness after abrasive blasting, test for cleanliness of abrasives and air) shall also be recorded and duly signed by the Owner/ Owner's Representative.
- All the information mentioned in Sec 8.0 above should also form part of the Job record.
- Any modification affected after procedure qualification in the procedure, QC, spray parameter, equipment spec to the original information (submitted before award of the work) must also form part of Job record.

10.0 WARRANTY

The TSAC applicator shall warrant the quality of material used by providing the purchaser with a certificate of materials used to include

- Spray feed stock: Alloy type/designation, Lot Number, wire diameter, chemical analysis, name of supplier, manufacturer.
- Sealant: Name of manufacturer, application data sheet.

11.0 SAFETY

The TSAC applicator shall follow all safety procedures required by the purchaser/owner. Owner shall also give compliance requirement to be followed by applicator. The applicator shall follow all appropriate regulatory requirements.

12.0 CODES AND STANDARDS

This specification shall apply in case of conflict between specification and following applicable standards:

AWS C. 2.17	Recommended Practice for Electric arc Spray.
ASTM C 633	Test Method for Adhesive/Cohesive Strength of Flame Sprayed Coatings.
ASTM D 4285	Method for indicating Oil or Water in Compressed Air.
ASTM D 4417	Test Method for Field Measurement of Surface Profile of Blasted Steel.
BS 2569	Specification for Sprayed Metal Coating.
NACE Standard RP 0287	Field Measurement of Surface Profile of Abrasive Blast Cleaned Steel Surfaces Using a Replica Tape.
ASTM D 4541	Test method for Pull-Off Strength of Coating Using Portable Adhesion Testers.
ANSI/AWS C2.18	Guide for the Protection of Steel with Thermal Spray

	Coatings of Aluminum, Zinc and Their Alloys and Composites.
NACE No. 12/AWS C2.23M/SSPC-CS 23.00	Specification for the application of thermal spray coatings (Metallizing) of aluminum, zinc, and their alloys and composites for the corrosion protection of steel.
SSPC Publication	The inspection of coatings and linings: A Handbook of Basic practice for Inspectors, Owners, and Specifiers.
SSPC-AB 1	Mineral and Slag Abrasives.
SSPC-AB 3	Ferrous Metallic Abrasives.
SSPC-PA 1	Shop, Field, and Maintenance Painting of Steel.
SSPC-PA 2	Measurement of Dry Coating Thickness with Magnetic Gages.
NACE No. 1/SSPC-SP 5	White Metal Blast Cleaning.
NACE No. 2/SSPC-SP 10	Near –White Metal Blast Cleaning.
SSPC-VIS 1	Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.

ANNEXURE-II

EIL Standard Specification No. 6-79-0011

**Standard Specification for Tape Coating for
Underground Steel Pipelines**

भूमिगत स्टील पाइपलाइनों हेतु टेप कोटिंग के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR TAPE COATING FOR UNDERGROUND STEEL PIPELINES

2	09.08.18	REVISED & ISSUED AS STANDARD SPECIFICATION	SM	SS	SG	RKT
1	16.08.12	REVISED & ISSUED AS STANDARD SPECIFICATION	SS	RC	PPL	DM
0	09.06.03	ISSUED AS STANDARD SPEC.	GVS	GS	KKS	SKG
Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convener	Standards Bureau Chairman
Approved by						

Abbreviations:

ASTM	:	American Society for Testing and Materials
AWWA	:	American Water Works Association
DFT	:	Dry Film Thickness
ISO	:	International Organization for Standardization
SSPC	:	Steel Structure Painting Council

For the purpose of this specification, the following definitions shall apply:

OWNER	:	Owner is the party that initiates the project and ultimately pays for its design & construction.
PMC	:	Owner's authorized agent/consultant to act for the owner. PMC is the party, which carries out management of the project.
MANUFACTURER	:	The party which manufactures and/or supplies the tape coating materials and services to perform the duties specified by owner/PMC.

Materials & Coating Standards Committee

Convener : Mr. S.Ghosal

Members : Mr. Deepak Gupta (Projects)
Mr. M. Ismaeel (Piping)
Mr. K.J Harinarayanan (SME)
Mr. D.C. Brahma (Structural)
Mr. R. Muthu Ramalingam (SCM)
Mr. Divyajyot Singh (Construction)
Mr. Naveen Parashar (Projects)
Mr. Satya Sridhar (Process-2)

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1.0 SCOPE

This specification covers the requirement for materials, surface preparation, application, inspection, repairs and handling for external corrosion protection of underground carbon steel pipelines, field joints and coating repair with service temperature upto 60°C using coal tar tape coating.

2.0 REFERENCE DOCUMENTS

The latest edition of the following standards and documents shall apply:

- 2.1 AWWA C-203: Coal tar protective coatings and linings for steel water pipelines
- 2.2 SIS 05-5900: Pictorial surface preparation standard for painting steel surface ISO 8501:1988
- 2.3 SSPC-SP: The Society for Protective Coatings surface preparation specifications :
 - SSPC-SP1: Solvent cleaning
 - SSPC-SP3: Power tool cleaning
 - SSPC-SP10: Near white metal blast cleaning
- 2.4 BS 4164: British Standard Specification for coal tar based hot applied coating materials for protecting iron and steel including a suitable primer

3.0 GENERAL REQUIREMENTS

- 3.1 Equipments and accessories required for tape coating shall be in good operating conditions. Adequacy of equipments and accessories shall be ensured by EPCC Contractor and Certified.
- 3.2 Necessary arrangements for power supply and other utilities shall be made for completion of the job.
- 3.3 Necessary testing and inspection facilities as required by this standard shall be developed at site and shall be approved by the PMC/OWNER.
- 3.4 Protective tapes and other materials brought to site shall be as per the specifications of this standard and should be approved by the PMC/OWNER.

Field and laboratory tests as given in this standard shall be carried out for each batch of primer and tape.

- 3.5 All work shall be carried out in accordance with this specification and shall be phase wise approved by PMC/OWNER. Any working procedure developed from this specification shall be approved in advance by the Engineer-In-Charge (EIC).
- 3.6 Manufacturers recommended/ Trained supervisor and skilled applicator shall be engaged by the contractor for application, inspection and quality assurance.
- 3.7 Applicator shall possess copy of reference documents and test procedure appearing in this standard, which are required for field application.

4.0 DOCUMENTATION

The following documentation is required:

4.1 Before Starting-Up of the Work

A quality plan with procedures for qualification trials and for the actual work shall be made. The quality plan shall include a time table for the various activities, with a description of coating materials to be used, their application, qualification of personnel involved in the work, responsibilities and lines of communications, details of equipment and their calibration, proposed hold points for PMC/OWNER inspection and endorsement and the detailed procedures for the testing and inspection. Documented evidence that the requirements of this specification have been met during production shall be shown.

4.2 During Execution of Coating Job

- Daily progress reports on application of tape coating materials with details on weather conditions
- Results of comparison of surface cleanliness, surface profile on blast cleaned surface, tape coating thickness, holiday detection and adhesion tests
- Particulars of surface preparation, priming and tape application; no. of wraps
- Details of non-compliance, rejects and repairs
- Types of testing equipments and calibration
- Code and batch numbers of coating materials used
- Field tests on primers and tape coat
- Progress of work as per scheduled program.

5.0 MATERIALS

5.1 General Requirements

5.1.1 Manufacturer's test certificates shall be produced and examined by the PMC/OWNER for all materials, proposed to be used for tape coating as per this standard.

5.1.2 All materials brought to site for tape coating shall be suitably marked and identifiable with the following information:

- Manufacturer's name
- Type of material and code
- Batch number
- Date of manufacturing
- Technical datasheet for each type of material
- Shelf life
- Manufacturer's quality control test certificates with actual results of each batch.

5.1.3 Materials without manufacturer's test certificates and identification marks shall not be accepted and used.

5.1.4 Test certificate from competent/recognized Govt. laboratory/in the laboratory of internationally reputed certifying agencies like, Lloyds registrars, DNV (Det Norske Veritas), BV (Bureau Veritas) on the properties of materials quoted by the manufacturer in the technical data sheet shall also be submitted along with the technical data sheet of the products. Any recent past certificate can also be submitted

5.1.5 Each batch of primer and tape shall be tested in the field by the procedure as given in this standard. PMC/OWNER will review the field test data before use of the materials.

5.2 Characteristics and Functional Requirements of Coating Materials

5.2.1 Coal tar tapes

Materials for coal tar tape coating shall conform to the following specifications. The following are the salient features of coal tar tape coating materials.

5.2.1.1 Primer

The primer shall be type B as specified in AWWA C-203. Following are the main characteristics:

Type	Fast drying, synthetic, chlorinated rubber-synthetic plasticizer-solvent based
Drying time (tack free)	15 minutes (approx.) (ASTM D1640)
Flash point	> 23°C (ASTM D93/D3941)
Volatile matter (105-110°C) percent by mass	75 (maximum) (ASTM D2369)
Viscosity, on FORD CUP NO. 4 (4mm nozzle) at 23°C	35-60 seconds (ASTM D1200)
DFT	25 microns/coat (minimum)
Coverage (Theoretical)	10 M ² /Lit/Coat
Coverage (Practical) @ 25 microns DFT coat	6 M ² /Lit/Coat (minimum) (ASTM D344)
Application properties	By brush/ spray should produce an effective bond between metal and subsequent coaltar tape
Adhesion test (after 72 hours)	The primer shall be tested after applying tape coating as per AWWA C-203.

5.2.1.2 Coal tar tape

The tape shall be coal-tar component supported on fabric of inorganic fibres.

a) Raw coal tar pitch

The coal tar (hard pitch) which shall have the following salient properties:

Characterization	Values		Standard
Softening point °C	65	121	ASTM D36
Specific gravity	1.30±0.05		ASTM D71
Ash content, %	0.5 Max.		ASTM D2415
Physical state	Solid at ambient temperature		

b) Fabric

Type: The fabric shall be a thin, flexible, uniform mat or tissue composed of glass fibers in an open structure bonded with a suitable resinous inert material compatible with coal tar.

Weight (min) g/m² 40
 Thickness (min.) mm 0.3
 Breaking load in the longitudinal direction: 2.28KN/m (min.)

Porosity	When related to pressure difference across the sample, the glass fibre fabric shall have porosity of not less than 0.6mm and not more than 1.9mm of water at an average air velocity of 61m/minute (1m/sec.)
Temperature resistance	The fabric shall be unaffected under load in hot coal tar at 288°C for one minute. It shall not shrink length wise or width wise.
Pliability test	No cracking shall take place when bent over a mandrel of 3mm radius through 90° arc at a uniform speed of approximately 2 seconds after immersing in water for 10 to 15 minutes.

Note (1) : Manufacturer's test data in the laboratory are required for the above properties on the materials supplied.

c) Physical properties of coal tar tape

Property	Requirement		Test method
	Min.	Max.	
Service temperature (°C)	-	60	
Tape thickness mm	2.0	2.5	AWWA C-203
Weight average (kg/sq.m/mm)	1.25	-	ASTM D146
Breaking strength in longitudinal direction kN/m	0.7		AWWA C-203
Adhesion	AWWA C-203.		
Insoluble content % by wt in petrol	93 minimum (procedure given in ANNEXURE-I)		

d) Physical properties of coal tar component in the finish tape

Property	Requirement		Test method
	Min.	Max.	
Softening point (°C)	65	121	ASTM D36
Penetration at 25°C/100g/ 10 ⁻¹ mm/5 sec	1	9	ASTM D5/BS-4164
Filler %	20	35	ASTM D 2415 or AWWA C-203

e) Filler

Characteristics	Requirement	Test Method
Fineness: % w/w, minimum	Shall pass through mesh size of 75 microns	ASTM D1366
Loss on ignition at 800° C, w/w max.	10	ASTM D1208

f) Field Tests

Few test methods given in ANNEXURE-I are mainly applicable during field application.

6.0 SURFACE PREPARATION

- 6.1** All oil, grease on the pipe metal surface shall be thoroughly removed by flushing with a suitable solvent (such as xylene or 1,1,1 trichloroethylene) and wiping with clean rags. The solvent cleaning shall be as per SSPC-SP-1. If required detergent cleaning shall be done before or after solvent cleaning.
- 6.2** The degreased pipe metal surface shall be blast cleaned to Sa2½ of SIS -05-5900 or SSPC-SP-10 with a surface profile of 30-50 microns trough to peak. Blasted surface that rusts before priming shall be cleaned by wire brushing or shall be re-blasted. Priming shall be done within 4 hours of completion of blast cleaning. Otherwise total re-blasting may be necessary.

7.0 APPLICATION OF PRIMER

One coat of primer shall be applied on blast cleaned surface by brush or spray to achieve complete wetting of the surface as recommended by the manufacturer. In case the surface is wet during application of primer, the surface should be made dry. The primer shall be allowed to become touch dry prior to tape application. Primer and tape shall be supplied by the same manufacturer.

8.0 TAPE COATING SYSTEM AND APPLICATION

8.1 Tape Coating System

- (a) One coat of fast drying synthetic primer by brush or spray after surface preparation to provide complete wettability of the surface.
- (b) One layer of coal tar tape coating with 2 mm thickness on the surface of primed pipe after touch dry.
- (c) Second coat of fast drying synthetic primer by brush or spray on 1st layer of tape coating to provide complete wettability of the surface for application of 2nd layer of tape.
- (d) 2nd layer of coal tar tape coating with 2 mm thickness on the surface of primed pipe after touch dry.

8.2 Application Method

Tape application should follow primer application as soon as the primed pipe surface is touch dry. The primer and tape application should not be done in case of dusty/windy weather or during rain. Primed surface should not be kept exposed to atmosphere for very long duration.

The tape shall be wrapped in accordance with the manufacturer's recommendations in a manner that shall meet the adhesion and holiday detection requirement of this standard. In any event, there shall be a minimum of 12.5 mm overlap per single wrap.

The applied coating system shall be as follows:

- (a) In application, care shall be taken that there are no air pockets or bubbles beneath tape and the tape shall be in intimate contact with the primed steel.
- (b) Manufacturer recommended/trained supervisor and skilled applicator shall be engaged for tape application.

9.0 FIELD JOINT COATING AND REPAIR OF DAMAGED COATING

9.1 Field Joint Coating on Exterior Welds

The exterior joints shall be cleaned and surface preparation by blast cleaning to Sa2½ finish of SIS-05-5900/SSPC-SP-10 as given in clause 6.0. The coating materials shall be same as applied on as main pipeline. The tape coating material applied on field weld joints shall overlap at least 75 mm the main pipe coating on each side of the field joint to form a continuous external coating free of defects. The coating inspection for quality assurance shall be as given in clause 10.0.

9.2 Repair of Damaged Tape Coating

- 9.2.1 Damages, flawed areas and holidays: Areas that are damaged, flawed or contain holidays shall be repaired using the tape coating materials applied on main pipeline and made by the same manufacturer. In no case, shall damaged areas be repaired by applying additional tape over loose damaged tape where the damage goes down to the metal or where the bond of the tape has been destroyed.
- 9.2.2 Repair of tape: Repair shall be made by removing the applied tape coating from the area around the holiday. The surface preparation shall be done as per clause 6.0 of this specification and then repair the area by using the same system of primer and hot applied tape as was used for the original wrapping as given in clause 8.0. When completed, the area shall be re-tested following the method of electrical inspection described in clause 10.8.

10.0 INSPECTION AND TESTING FOR QUALITY ASSURANCE

The following stage wise inspection and testing shall be carried out at manufacturers end/at site by the OWNER or by OWNER's representative third party inspection agency. Petrol test as per Clause No. 5.2.1.2 c) and Section 2.3 of ANNEXURE-I shall be conducted at site under the supervision of EIC.

10.1 Fast Drying Synthetic Primer Materials

The physical properties of primer are given in clause 5.2.1.1. The test procedure given is in Annexure-1

10.2 Tape Coating

As per 5.2.1.2 (b), (c), & (d), the procedure is given in ANNEXURE-I.

10.3 Measurement of Pipe thickness (in case of coating refurbishment)

10.4 Surface Preparation

- Blast cleaning equipment for nozzle type, size, safety gauges, working condition, and pressure at the tip of the gun.
- Abrasive type, hardness to provide required profile size and cleanliness.
- Measurement of surface profile and comparing cleanliness with visual standards of ISO 8501.

10.5 Measurement of pitting depth area of pitted portion, inspection of weld filling and grinding and patch plate welding, welding of replaced pipe if any.

10.6 Checking of condition of concrete saddles, rubber padding and end seals wherever required.

10.7 Inspection of Primer after Application

- Checking for drying time to be touch dry, tack free drying and hard drying of primer.
- Dry film thickness (DFT) shall be checked on metal panel separately.

10.8 Inspection of Tape Coating after Application

- Visual inspection for uniformity without any wrinkles and irregularities and overlapping width as per specifications
- Adhesion test as per AWWA C-203
- High voltage holiday detection test for pinholes as per AWWA C-203.

10.8.1 Visual

The coated pipes including field joint coating shall be visually inspected for cracks, trapped air, uniformity, damage etc. Any repair arising out of visual inspection will be decided by PMC/OWNER.

10.8.2 Thickness

Thickness has to be measured with a caliper with caliper surfaces of at least 20mm diameter, on 5 tape pieces with an edge length of at least 50mm taken from 5 different coils. The measuring pressure should be 0.5 N/m². The measuring accuracy should be within 0.1 mm.

10.8.3 Adhesion Test

- a) Adhesion tests shall be made to determine the proper bond between the tape and the primed pipe. One test per section (of upto 10 meter length) shall be carried out initially afterwards adhesion test is to be done as per the advice of PMC/OWNER. Repair required due to adhesion testing shall be decided by the PMC/OWNER.
- b) Temperature of the tape and pipe to be tested shall be between 10°C and 27°C. If required cold water shall be poured over the test area to bring down the temperature to within the above range. The coating shall be allowed to set at ambient temperature for 72 hrs.
 - A test area shall be selected where the tape is smooth for 150 mm in the longitudinal direction of the tape.
 - Two knife cuts of 150 mm long and 50 mm apart shall be made through the tape.
 - A flat blade shall be used to pry up 50 mm of the fabric.
 - The 50 mm flap of fabric shall be grasped firmly in one hand and shall be pulled with a quick motion in the direction of the remaining 100 mm of the 150 mm knife cut.
 - The adhesion is satisfactory if (i) the tape tears at the point of stripping or (ii) the fabric strips from the underlying tape component, leaving no more than 10% or less of the primer or bare metal exposed.
- c) Adhesion between tape to tape can be tested following similar procedure as in (b). This should preferably be done on a test panel.

10.8.4 High voltage holiday detection test

- All tape coated pipes and joints shall be tested with an approved high voltage holiday detector preferably equipped with an audio visual signaling device to indicate any faults, holes, breaks or conductive particles in the protective coating.

- The applied output voltage of the holiday detector shall have a spark discharge of thickness equal to at least twice the thickness of the coating to assure adequate inspection voltage and compensate for any variation in coating thickness. The electrode shall be passed over the coated surface at approximately half the spark discharge distance from the coated surface only one time at the rate of approximately 10 to 20 meters per minutes. The edge effects shall be ignored. Excessive voltage shall be avoided as it tends to induce holidays in the coated surface thereby giving erroneous readings.
- While selecting test voltages, consideration shall be given to the tolerance on coating thickness and the voltage should be selected on the basis of maximum coating thickness likely to be encountered during testing of a particular pipe.

Thickness of Coating (mm)	Test Voltage (Max.) (kV)
2	10
3	12
4	15

- The electrical equipment used to test tape coating shall be a portable, low amperage, adjustable-voltage, pulse type holiday detector. It shall be furnished with a coil spring electrode or a suitable brush type electrode. The primary input wattage shall not be higher than 20 W, and the minimum pulse at crest voltage shall be 20 per second.

11.0 PROTECTION OF COATED PIPES AGAINST UV DEGRADATION

When the coated pipes are required to be left out exposed to sun light for more than a week before back filling the trench, the coated pipe shall be protected with white coloured water emulsion latex paint. The water emulsion latex paint to be used must be stabilized, pigmented dispersion of water-insoluble film forming, high molecular wt. Synthetic polymeric materials in water. After application and drying the paint must be able to produce a film that adheres to the coal tar tape coating is white in colour, water resistant and able to withstand exterior exposure without degradation for a minimum of 90 days.

12.0 COAL TAR TAPE WIDTH

The width of coal tar tape coating for various pipe sizes shall be as follows:

Pipe Size (Nominal Bore)	Tape Width (mm)
80	100/125
100	100/125/166
150	125/166/200
200	125/166/200/250
250	166/200/250/333
300	166/200/250/333
>300	333

ANNEXURE-I

TEST METHODS

1.0 PRIMER (fast drying chlorinated rubber based synthetic primer)

1.1 Test method for volatile content (refer ASTM D2369 for full details)

Procedure:

A specimen sample of primer 0.50 ± 0.10 gms is weighed into a tared aluminum foil dish into which add 3 ml of solvent toluene technical grade and disperse completely. Heat the above sample in the forced draft oven for 60 mins. at $110^{\circ}\text{C} \pm 5^{\circ}\text{C}$. Remove the dishes from the oven place immediately in desicator, cool to room temperature and weigh. Calculate % volatile matter (V) by using the following formula:

$$V = \frac{(W_2 - W_1) \times 100}{S}$$

Where, W_2 - Weight of dish + Specimen
 W_1 - Weight of dish + Specimen after heating
 S - Specimen wt.

1.2 Test method for viscosity by ford cup no. 4 (refer ASTM D1200 for full details)

The efflux time of primer is determined by ford cup no.4. The cup is cleaned thoroughly by solvent toluene and a soft brush. Fill the cup with the primer to full level by holding the orifice with a rubber stopper or finger pull the stopper away and simultaneously start the timer and measure the time until the first break of primer in the orifice. Measure the temperature of the fluid in the efflux stream. It shall be reported the efflux time in seconds at a measured temperature.

1.3 Test method for drying time (refer ASTM D1640 for full details)

Apply the primer by brush on clean glass/clean mild steel panels of suitable sizes and measure the drying time at a normal room temperature and 50% relative humidity with the coated panels on horizontal position:

- Set-to-touch time:** Lightly touch the test film with the tip of clean finger and immediately place the finger tip against a piece of clean clear glass. Observe if any coating is transferred to the glass. The film is set- to- touch where it still shows a tacky condition, but none of it adheres to the finger.
- Dust free time:** The coating film is considered to have dried dust free when the cotton fibres can be removed by blowing lightly over the surface of film.
- Tack free time:** The film is considered free from after tack when the test paper drops of the test film within 10 seconds.

2.0 COAL TAR TAPE

2.1 Test Method for Relative Density of Tape (refer ASTM D71 for full details)

The test sample is suspended from a thin wire and weighed first in air, then in water at 25°C in a glass beaker. The relative density is calculated from these weights.

$$\text{Relative density of tape sample at 25°C} = \frac{A}{(A-B)}$$

Where, A = Weight of specimen in air in mg.
B = Weight of specimen in water at 25°C in mg.

2.2 Test Method for Adhesion of Tape Coating in Laboratory (AWWA C-203)

Clean a section of 2 inch dia steel pipe of 2 ft length or a flat steel panel of 2 inch x 6 inch prime the cleaned metal and apply a 2 inch width of tape as per manufacturer's recommendations. The coating shall be allowed to set at room temperature for 72 hrs. after the test sample has completely set, grasp one end of the tape and pull it off by hand. The coating is considered to have satisfactory adhesion if [1] the fabric tears at the point of stripping or (2) the fabric strips from the under lying coating material leaving no more than approximately 10% or less of the primer or bare metal exposed.

2.3 Test Method for % Wt Loss in 24 hrs Immersion of Tape in Petrol

Samples as described below for this test shall be drawn at random in presence of EIC at site from the lot delivered to site.

Test Method: Cut 2 tape samples from the same batch weighing accurately 100gms each with same dimensions (wt. A) and put this sample in a clean and dry 600 ml capacity glass beaker. Pour 550 ml of standard quality petrol (gasoline) into the glass beaker in v-shape form so that the tape sample gets totally immersed in petrol. The level of petrol shall be about 5 cm above the tape sample.

Cover the mouth of the beaker with two layers of thick polyethene sheets and tie these polyethene sheets with a rubber band around the mouth of the glass beaker. Allow the beaker to stand at room temperature for 24 hrs without any disturbance. No stirring is to be done. Take the tape sample out of the beaker after 24 hrs and spread it on blotting papers on a table. Allow it to dry in the air for 4 hrs weigh the tape accurately again (wt. B)

$$\% \text{ Loss in wt.} = \frac{(A-B) \times 100}{A}$$

$$\% \text{ Insoluble} = 100 - \% \text{ Loss in wt.}$$

The above test shall simultaneously be carried out with 3 more tape samples selected at random and the average result shall be taken.

The indicative loss for coal tar tape in petrol shall be 7% maximum.

2.4 Standard Test Method for Relative Density of Solid Hard Pitch of Coal (refer ASTM D71 for full details).

This test is applicable for testing at manufacturer's end.

2.4.1 Summary of Test Method

The sample is suspended from a thin wire and weighed, first in air, then submerged in water at 25°C. The relative density is calculated from these weights.

$$\text{Relative density of sample at } 25^{\circ}\text{C} = \frac{A}{A - B}$$

Where A = Weight of specimens in air in mg.
B = Weight of the specimen in water at 25°C in mg.

2.4.2 Procedure

Tare the balance with a piece of 0.127, (5 ml) nichrome wire or mono-filament nylon line sufficiently long to reach from the hook on the pan. Support to the saddle when the latter is in position across the pan. Attach the test specimen to the wire or line so that it is suspended 20 to 30 mm above the straddle when the other end of the wire is attached to the hook.

Weigh the suspended specimen to the nearest 1 mg and record this weight as "A". Fill a 400 or 600ml beaker two thirds full with freshly boiled distilled water containing a small amount of detergent. About 100 mgs of Alconox detergent to 200 ml of water has been found satisfactory. Adjust the temperature of water to $25 \pm 2^{\circ}\text{C}$ and maintain this temperature during the remainder of the test. Place the beaker with water on the saddle with the specimen, still suspended, and fully submerged. Weight the immersed specimen to the nearest 1 mg and record this weight as "B".

Repeat the determination with the second test specimen.

2.4.3 Report

Report the average of two determinations to the third place, unless the individual values differ by more than 0.005. In this case, repeat the determinations.