CENTRIFUGAL EXHAUST FAN WITH ELECTRIC MOTOR

1.0 **Scope:**

This standard specifies the requirements of the radial centrifugal exhaust fan with electric motor (flange mounted) used in lube oil system of high speed Industrial Turbo Generator sets

2.0 **Technical Requirements:**

2.1 General:

The general arrangement of the fan and the dimensions should be as per sketch in sheet no.4 The exhaust fan is direct type. The impeller shall be dynamically balanced and mounted on carbon steel shaft of a mole size running in ball bearings with a provision for lubrication. The whole unit shall be of rugged design and in spark proof construction. The casing shall be fabricated from mild steel sheets of ample thickness.

The motor shall be preferably of flange mounted type, however if the motor is of foot mounted type proper sealing of motor shaft at fan casing shall be provided to prevent any leakage of oil vapor fumes from casing. 8

2.2 SPECIFICATIONS:

2.21	Quantity of oil vapour mixed with air to be handled.	:	0.11 Cu. Mtr / Sec
2.2.2	Head	:	100 mm of water column
2.2.3	Specific weight of vapour	:	1.2 Kg/m^2
2.2.4	Temperature of oil vapour	:	Approx. 60^0C
2.2.5	Suction branch	:	As per dimensional sketch
2.2.6	Delivery branch	:	As per dimensional sketch
2.2.7	Material of fan	:	Non sparking(Aluminum preferably)
2.2.8	Suction/Discharge flanges	:	Dia. 3” ANSI 150 class RF
2.2.9	**MOTOR DETAILS:**		
	- Power	:	To be recommended by supplier should not be more than 0.5 HP
	- Speed	:	3000 rpm (Synchronous speed)
	- Voltage	:	V ±10% , V shall be as per variant table (sheet 4)
	- Frequency	:	50 Hz ±5%

- Combined voltage and frequency variation : ±10%

- Enclosure : Flame proof(As per gas group I, II A, IIB

- Ambient Temperature : 50^0C (or mentioned in the enquiry)

2.3 **OTHER DETAILS:**

Location of assembly is out door and shall be suitable for continuous service in tropical humid climate. Motor should be supplied as per IS: 2148(Latest) Insulation class "B", Enclosure: IP55 with canopy. CMRS certificate required for motor. The performance certificate of motor should be as per IS: 325(Latest). Motor should be suitable for an ambient specified in the indent.
Refer BHEL spec TC54368 for IE2 efficiency class efficiency and TC54173 for IE3 efficiency class**.(R07)**

3.0 **SCOPE OF SUPPLY**:

Motor fan unit with suitable cable glands and Foundation bolts.

4.0 **INSPECTION**:

Fan is to be tested at supplier's work for its satisfactory performance in presence of BHEL representative, if not otherwise indicated.

5.0 **TEST AND GUARANTEE CERTIFICATE**:

5.1 **TEST CERTIFICATE**:

3-Copies of performance test certificate of motor fan unit and CMRS certificate for Flame proof motor shall be supplied for each item of the consignment quoting BHEL standard number, Purchase order number & Manufacturer's identification serial number.

5.2 **GUARANTEE CERTIFICATE**:

A guarantee certificate for 24 months of trouble free performance from the date of shipment or 18 months(including motor) from the date of commissioning whichever is earlier shall be supplied.

6.0 **DOCUMENTS**:

6.1 The supplier shall supply the following documents along with offer.

a) Dimensional drawing of the fan in triplicate
b) Performance curve
c) Complete technical literature
d) Cross sectional drawing of the fan showing details
e) List of previous customers
f) Motor Data sheets(Preliminary)

6.2 The supplier shall supply the following documents within 2-weeks after placement of order.

a) Operating and maintenance instructions 20-copies and reproducible
b) Final dimensional drawing of the fan in triplicate
c) Cross sectional drawing of the fan in triplicate
d) Performance curve(as tested)
e) Final Motor Data sheets

7.0 **PACKING**:

The material should be properly packed against mechanical damage and rust during transits

8.0 NAME PLATE DETAILS:

8.1 The name plate details of motor fan unit shall contain the following information.

a) Manufacturer's identification serial number.
b) Type / Model number
c) Quantity of oil vapour
d) Head
e) Input power
f) Motor HP
g) Speed
h) Voltage and Frequency

8.2 A tag bearing 12 digit material codes shall be attached for each consignment.

8.3 The following details shall be marked on the packing case.

a) Manufacturer's name
b) BHEL purchase order number
c) BHEL standard number: TC54301
d) BHEL material code number

9.0 **VARIANT TABLE:**

Sl.No.	Description	Voltage	Material code	Variant No.
1	Oil vapour fan assy	415 V AC	TC9754301018	01
2	Oil vapour fan assy	440 V AC	TC9754301026	02
4	Oil vapour fan assy	400 V AC	TC9754301042	04
5	Spare motor	415 V AC	TC9754301050	05
6	Spare bearing for oil vapour Ext. Fan		TC9754301069	06
7	CN EXH FAN+ACMTR,0.11M3/S,380V AC,2900RPM	380V	TC9754301077	07
9	SET OF IMPELLERS FOR CEN EXH FAN		TC9754301093	09
10	CEF-EX-'D'AC MTR,0.11M3/S,415V,2900RPM	415 A AC	TC9754301107	10
11	Oil vapour fan with IE2 motor Motor spec TC54368-R01 to be referred along with TC54301	415 V	TC9754301115	11
12	IE3 MOTOR FOR EXHAUST FAN		TC9754301123	12
13	BEARNG IE3 MOTR OF EXHAUST FAN		TC9754301131	13
14	SPACE HEATER IE3 MOTR OF EXHAUST FAN		TC9754301140	14
15	COOLING FAN IE3 MOTR EXHAUST FAN		TC9754301158	15
16	CENT EXHAUST FAN WITH IE3 MOTOR		TC9754301166	16
17	SPARE FOR .37 KW IE2 MTR AS PER TABLE 1		TC9754301174	17
18	SPARE IE2 .37KW MTR FOR EXHAUST FAN		TC9754301182	18
19	SPARE IMPELLER FOR OIL VAPOR EXH. FAN		TC9754301190	19
20	SPARES EXH FAN MOTOR AS PER TABLE 2		TC9754301204	20
21	SPARE EXHAUST FAN 0.11 M3/S		TC9754301212	21
22	SP.COOLING FAN FOR EXHAUST FAN		TC9754301220	22
23	CEN EXH FAN AC0.11M3/S,415V-15%,2900RPM (Voltage variation -15% to +10%)		TC9754301239	23
24	BEARINGS DE & NDE EXHAUST FAN MTR		TC9754301247	24
25	COOLING FAN FOR EXHAUST FAN MTR		TC9754301255	25
26	TERMINAL BLOCK FOR EXHAUST FAN MOTOR		TC9754301263	26

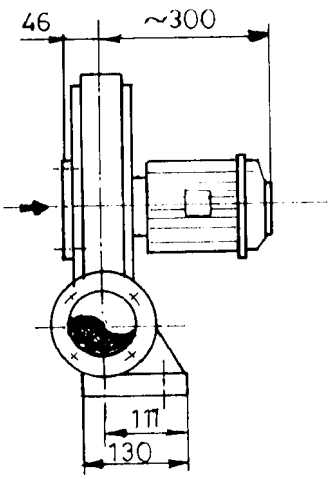
27	DE & NDE BEARING EXHAUST FAN IE3 MOTOR		TC9754301280	28
28	COOLING FAN FOR EXHAUST FAN IE3 MOTOR		TC9754301298	29
29	TERMINAL BLOCK EXHAUST FAN IE3 MOTOR		TC9754301301	30

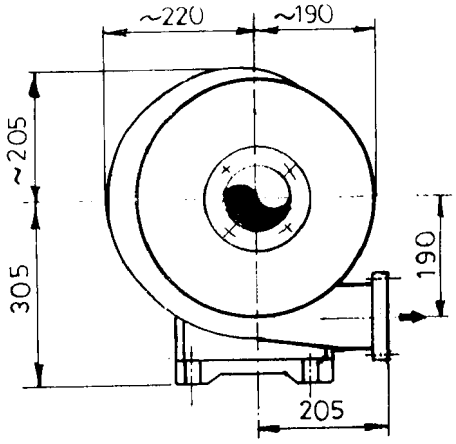
Table No 1

S.No	Material description	Quantity
1	Bearings	1
2	Cooling fan	1
3	Motor terminal block plates	1
4	Complete set of couplings	1

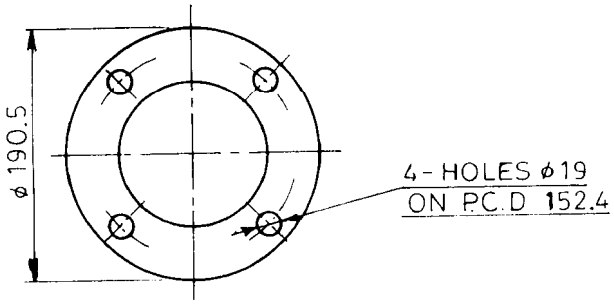
Table No 2

S.No	Material description	Quantity
1	Bearings	4
2	Motor terminal block plates	10

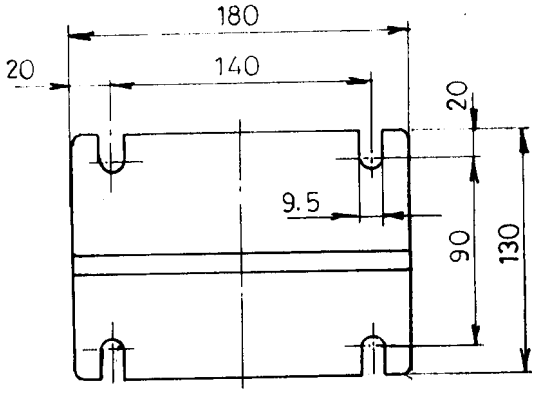




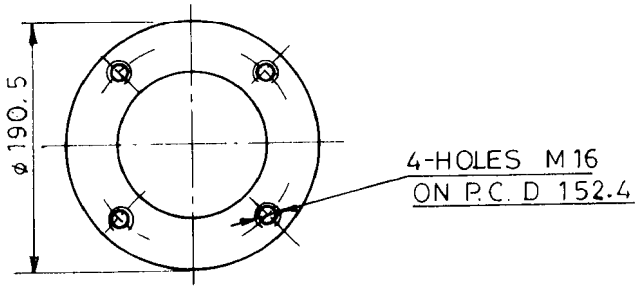
DELIVERY FLANGE DETAIL



BASE PLATE HOLE DETAIL



SUCTION FLANGE DETAIL



RECORD OF REVISIONS.

Rev.No	Date	Revision Details	*Revised*	Approved
00	04.07.84	First issue.	-	-
01	08.03.07	Variant 06 added	*M.V.S.Raju*	*K.K.Rao*
02	29.05.13	Variant 07 added	*Anshul*	M.V.S.Raju
03	12.06.14	Variant upto 10 added	*Anshul*	M.V.S.Raju
04	06.09.14	Variant upto 11 added	*K.Bharath*	M.V.S.Raju
05	25.02.15	Variant upto 18 added	*Anshul*	M.V.S.Raju
06	07.07.12	Variant upto 23 added	*K.Bharath*	M.V.S.Raju
07	15.02.16	Variant upto 30 added and motor clause added	*Anshul*	M.V.S.Raju
08	06.04.17	Clause 2.1 modified - sealing of motor shaft details updated. Warranty clause updated.	*K.Bharath*	Sunil B

CENTRIFUGAL EXHAUST FAN WITH A.C MOTOR

1.0.0 **SCOPE:**

This standard specifies the requirements of design, manufacture, assembly, testing and supply of radial centrifugal exhaust fan with A.C electric motor used in the lubrication oil system of Utility Turbo Generator sets.

2.0.0 **FUNCTION:**

2.1.0 The centrifugal exhaust fan comes in operation in conjunction with the running of any one of the lube oil pumps. The exhaust fan is to handle oil fumes generated during running of the Turbine. It shall also maintain a partial vacuum in the lube oil tank and bearing pedestals. The oil fumes to be handled by the fan shall contain free droplets of oil The fan is mounted on the lube oil tank.

3.0.0 **SPECIFICATIONS:**

3.1.0	Centrifugal Fan:	
3.1.1	Medium	: Oil Vapour
3.1.2	Continuous discharge capacity	: 0.18 M^3/Sec.
3.1.3	Normal discharge pressure	: 200 mm of water column
3.1.4	Specific weight of vapour	: 1.2 Kg/M^3
3.1.5	Temperature	
3.1.5.1	Working temperature of oil vapour	: 65ºC
3.1.5.2	Design Temperature	: 100ºC
3.1.6	Suction branch size & bolt hole drilling	: As per attached document TCEG-120MW-OVEF
3.1.7	Delivery branch size & bolt hole drilling	: As per attached document TCEG-120MW-OVEF
3.1.8	Overall dimensions execution	: As per attached document TCEG-120MW-OVEF
3.1.9	Absorbed power by fan	: To be indicated by supplier.
3.1.10	Speed	: 2900 RPM
3.1.11	MATERIALS:	
3.1.11.1	Material of construction	: Non-sparking
3.1.11.2	Casing with suction & discharge flanges	: Grey Iron Casting
3.1.11.3	Running wheel (Impeller)	: As per Manufacturer's standard.

3.2 **ELECTRICAL MOTOR:**

3.2.1	Type	: Squirrel cage Induction.
3.2.2	General requirements	: As per BHEL spec TC54175 or TC54370, IS:325
3.2.3	Type of starting	: Direct online
3.2.4	Enclosure & execution	: IP 55, TEFC, Flame proof as per IS:2148 suitable for gas groups IIA & IIB.
3.2.5	Insulation class	: Class "F" temperature rise limited to class "B"

Revisions	Prepared	Approved	Date
Refer to record of revisions	M.V. S.RAJU	K.K.RAO	13.06.08

3.2.6	Cable glands	: Cable glands shall be supplied along With motor.
3.2.7	Out put	: To be furnished by vendor.

Note: It shall have at least 25% reserve power rating over required power to Drive the exhaust fan, when discharging maximum quantity of oil vapour.

3.2.8	Speed of motor	: 2900 RPM
3.2.9	Voltage	: 415 V ± 10%
3.2.10	Frequency	: 50 HZ ± 5%
3.2.11	combined voltage & frequency Variation	: ± 10%
3.2.12	Ambient temperature	: 50º C (or as mentioned in the enquiry)
3.2.13	Performance	: As per IS: 325 or IEC60034
3.2.14	Certification	: CMRS
3.2.15	Acceptable make of motors	: Siemens, BBL, CGL, KEC, ABB, LHP

4.0.0 **DESIGN & CONSTRUCTION FEATURES**:

4.1.0 The overall dimensions and execution of the fan shall be as shown in the attached drawing TCEG-120MW-OVEF.

4.2.0 The material of construction shall be Non-sparking type. The materials used shall be such as to resist corrosion and erosion and shall give a long trouble free service.

4.3.0 The design shall be such as to keep the friction less and wear caused by thrust, wear in seals and bearings to minimum. The rotor of the fan should be dynamically balanced, so that the vibration of the fan is not greater than 10 microns peak to peak. The noise level should not be greater than 85 Dba to a reference of 0.0002 microbar, when measured at a distance of 1.2 meters above floor level and one meter horizontally from the base of the equipment.

4.4.0 The fan bearings shall be designed, so as to assure 50000 hours continuous service for friction bearings and 25000 hours for ball roller bearings.

4.5.0 Location of assembly is out door and shall be suitable for continuous service in tropical humid climate.

5.0.0 **Documentation**:

5.1.0 Documentation to be submitted along with offer (2 Hard Copies):

5.1.1 General arrangement drawing of the oil vapour exhaust fan giving all dimensions, fixing details, mating flange details & weight of the total unit.

5.1.2 Performance curve showing discharging capacity Vs discharge pressure and power consumption.

5.1.3 Complete technical literature.

5.1.4 Centrifugal pump data sheet.

5.1.5 Motor data sheet as per BHEL specification TC54175 or TC54370.

5.1.6 Cross-sectional drawing showing 2 year recommended normal operational spares.

5.1.7 Cleaning & painting procedure adopted by vendor. The final painting shade is to be indicated.

5.1.8 Vendor's standard quality plan

5.2.0 Documentation to be submitted after placement of order (3 Hard Copies+1 soft copy):

5.2.1 General arrangement drawing of the oil vapour exhaust fan giving all dimensions, fixing details, mating flange details & weight of the total unit.

5.2.2 Performance curve showing discharging capacity Vs discharge pressure and power consumption.
5.2.3 Centrifugal pump data sheet.
5.2.4 Motor data sheet as per BHEL specification TC54175 or TC54370.
5.2.5 Vendor's standard quality plan

5.3.0 Documentation to be submitted along with consignment (3 hard copies & 1 soft copy):

5.3.1 Material certificates.
5.3.2 Test certificates.
5.3.3 Guarantee certificate
5.3.4 O& M Manuals

6.0.0 **SCOPE OF SUPPLY:**
6.1.0 Motor fan unit as shown in the attached drawing TCEG-120MW-OVEF.
6.2.0 Mating flanges for suction and discharge to suit pipe OD 114.3x6.02.
6.3.0 Fixing bots & nuts.
6.4.0 Cable glands for motor.

7.0.0 **INSPECTION AND TESTING**
Inspection and testing shall be as per quality plan as specified in this specification.

7.1.0 **SCHEDULE OF QUALITY CHECKS FOR CENTRIFUGAL EXHAUST FAN**

S.No	Type of check & Test	Certificate designation	Type of Inspection
1	Material tests (Chemical analysis and mechanical test)	Test reported by manufacturer's Q.C dept.	Verification of test report
2	Dynamic balancing of rotor	Test reported by manufacturer's Q.C dept.	Verification of test report
3	Performance test		
3.1	Discharge capacity Vs discharge pressure and power consumption	Test reported by manufacturer's Q.C dept.	Witness
3.2	Vibration Levels	Test reported by manufacturer's Q.C dept.	Witness
3.3	Noise levels	Test reported by manufacturer's Q.C dept.	Witness
4	Dimensional check of all critical dimensions	Test reported by manufacturer's Q.C dept.	Witness
5	Routine test of motor	Test reported by motor manufacturer's Q.C dept.	Verification of test report
6	Enclosure of motor as per IS:2148	CMRS Certificate	Verification of test report

8.0.0 **TEST AND GUARANTEE CERTIFICATES:**
8.1.0 6-copies of inspection and test certificates shall be supplied for each item of the consignment quoting BHEL Std. No., Purchase Order No. & manufacturer's identification serial number.

8.2.0 **GUARANTEE CERTIFICATE**

8.2.1 A guarantee certificate for 24 months of trouble free performance from date of shipment or 18 months from the date of commissioning whichever is earlier shall be supplied.

8.2.2 If any mal-performance or defects occur during the guarantee Period, the vendor shall make all necessary alteration, repairs and replacement free of charge.

9.0.0 **CLEANING, PAINTING, CONSTRUCTION & PACKING :**

9.1.0 The surface shall be cleaned and prepared for the application of the coatings of blasting with non-silicate abrasive agents. The protective coating shall be oil resistant to prevent contamination of oil specified (ISC VG 46) and to prevent the deterioration of coating itself. The supplier shall give exact and precise details about measures envisaged by him for surface protection. After testing the fan, its internals shall be thoroughly cleaned, dried and conserved before packing it. The fan shall be suitably packed for transportation. It should be packed such that it is safe at least for 2 years in a very damp atmosphere. The equipment shall be properly packed to withstand mechanical damage and rust during transit. The packing for shipment shall be as per seaworthy packing.

10.0.0 **MARKING :**

10.1.0 Name plate identification marking should be as follows:

- Manufacturer's serial number & year of manufacturing.
- Type/model number
- Volumetric flow in M^3/Sec.
- Discharge pressure in mm of water column.
- Flow medium
- Operating temperature
- Absorbed power in KW
- Motor rating in KW
- Speed in RPM
- Voltage & frequency

11.0.0 **SPECIAL NOTE :**

11.1.0 Vendor to submit the signed & stamped copy of Annexure-I & II

VARIANT TABLE

Var No.	*Description*	*Material Code*
01	Oil vapour exhaust fan with motor 415V AC	TC9754329010
02	Spare drive end bearing for Oil vapour exhaust fan motor	TC975432902*
03	Spare non drive end bearing for Oil vapour exhaust fan motor	TC975432903*
04	Spare Cooling fan for Oil vapour exhaust fan motor	TC975432904*
05	Spare end shield cover for DE & NDE brg for OVEF motor	TC975432905*
06	Spare terminal box for OVEF motor	TC975432906*
07	SPARE MOTOR FOR OVEF 0.75KW- IE-3 MOTOR	TC9754329079
08	Oil vapour exhaust fan with motor 415V AC (IE-2 as per TC54370/TC54368)	TC9754329087
09	Oil Vapor exhaust fan with IE3 motor	TC9754329095
10	BARE FAN CAP 0.18M3/HR, 200MM WC	TC9754329109
11	DE BEARING IE3 MOTOR OF EX FAN	TC9754329117
12	NDE BEARING IE3 MOTOR OF EX FAN	TC9754329125
13	TERMINAL BLOCK IE3 MOTOR OF EX FAN	TC9754329133

PRODUCT STANDARD
INDUSTRIAL TURBINES & COMPRESSORS

RECORD OF REVISIONS

Rev. No.	Date	Revision Details	Revised By	Approved By
00	13.06.08	First Issue		
01	03.09.09	Variants 02 to 06 are added	MVS Raju	R A Krishnan
02	11.09.15	Variants 07, 08 & 09 are added with IE-2 Motor specification reference.	Sunil Jiwtode	MVS Raju
03	08.08.18	Variant upto 13 added	Anshul	Sunil

SQUIRREL CAGE INDUCTION MOTORS IE-3 (Premium Efficiency Class)

(For BFP Drive Turbine)

1. SCOPE:

This standard specifies the requirements of the 3-phase medium voltage squirrel cage Induction motors used for driving Centrifugal / Screw / Gear pumps of lube oil systems of Industrial Turbo sets and BFP drives.

2. TECHNICAL REQUIREMENTS:

2.1 General:

The squirrel cage induction motors shall be of horizontal foot mounted (B3) type or Vertical flange mounted (V1) type construction as per enquiry suitable for bi-directional rotation. Unless otherwise specified the motors are of type IP55 enclosure (as per IS: 4691 & IEC60034-05) with class 'B' insulation and continuous duty (S1). Class 'F' insulation is also accepted with temperature rise limited to class 'B'. The motors shall be suitable for 100% humid (at 40 deg C), salty tropical conditions and highly polluted environment.

2.2 Design Standards:

The motors shall conform to relevant latest amendments of National and International Codes and standards, especially the Indian Statutory Regulations.

- Performance : IS 325 & IS 8789 & IEC:60034
- Dimensions : IS 1231 / IS 2223
- Enclosure and protection : IS 4691 / IEC:60034-05
- Tropicalizing treatment : IS 3202
- Energy Efficient motors : IS 12615 / IEC:60034-30
- Method of Cooling : IS 6362 / (Equivalent IEC: 60034 Std.)

2.3 Design and Constructional Features:

2.3.1 Motors shall work satisfactorily for following supply conditions:

Variation of supply voltage from rated voltage : ± 10%
Variation of supply frequency from rated frequency : + 3% to - 5%
Combined voltage and frequency variation : ± 10%

2.3.2 The Voltage level of motors shall be as follows: (unless otherwise specified)
Up to 200 kW: 3 Phase 415V AC

2.3.3 Rated frequency: 50 Hz

2.3.4 The ambient temperature is 50°C and an altitude not exceeding 1000 meters above mean sea level shall be taken into consideration unless otherwise specified.

2.3.5 TEMPERATURE RISE 70°C by resistance method for both thermal class 130(B) & 155(F) insulation.

2.3.6 Continuous duty LT motors up to 160 KW Output rating (at 50°C ambient temperatures), shall be Energy Efficient motors, Efficiency class of Premium efficiency (IE3) as per IEC: 60034-30 unless otherwise specified.

2.3.7 Winding and Insulation shall be Non-hygroscopic, oil resistant, and flame resistant.

2.3.8 Motor body shall have two earthing points on opposite sides.

2.3.9 All motors shall be so designed that maximum inrush currents and locked rotor and pullout torque developed by them at extreme voltage and frequency variations do not endanger the motor and driven equipment.

2.3.10 The motors shall be suitable for bus transfer schemes provided on the 11kV, 3.3 kV /415V systems without any injurious effect on its life.

2.3.11 The starting time of the motor shall be less than 3 secs.

2.312 The motor shall be totally enclosed fan cooled (TEFC) unless otherwise specified.

2.4 Performance:

2.4.1 Motor shall be suitable for DOL starting.

2.4.2 The motor shall be capable of start & operating satisfactorily at full load for 5 minutes without injurious heating with 75% rated voltage at motor terminal.

2.4.3 Accelerating torque at any speed with the lowest permissible starting voltage shall be at least 10% motor full load torque. Starting torque should not be less than 120% of FLT. The pullout torque at the rated voltage shall be not less than 205% of the full load torque with no negative tolerance. Unless otherwise agreed, the pullout torque shall not exceed 300% of the rated load torque.

2.4.4 Fault capacity of the system to which motor is connected is about 45 kA RMS 1 second.

2.4.5 Noise level for all the motors shall be limited to 85dB (A) at distance of 1 m as per IS12065 (latest) /IEC60034.

2.4.6 Vibration shall be limited within the limits prescribed in IS: 12075 / IEC 60034-14. Motors shall withstand vibrations produced by driven equipment.

2.4.7 The spacing between gland plate & center of terminal stud shall be as per Table-1.

2.4.8 For motors with starting time up to 20 secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 2.5 secs. more than starting time.

2.4.9 The ratio of locked rotor KVA at rated voltage to rated KW shall not exceed the following (without any further tolerance)

a) Below 110 kW: 10.0

(b) From 110 kW & up to 200 kW: 9.0

2.4.10 Motors and EPB located in hazardous areas shall have flame proof enclosures conforming to IS: 2148 as detailed below

(a) Fuel oil area: Group - IIB

2.4.11 The starting voltage requirement shall be 85% for motors below 110KW rating and 80% from 110KW to 200KW.

2.5 ACCESSORIES:

Terminals and Terminal box:

2.5.1 All the six terminals should be brought out on the terminal block, which shall be provided with connecting strips and shall amply be rated.

2.5.2 The terminal box shall be capable of being turned through 360 degrees in steps of 90 degrees and location is to be midway on right hand side when viewed from coupling end.

2.5.3 The terminals shall be clearly marked R.Y.B.

2.5.4 The terminal box shall be furnished completely with nickel coated brass double compression glands for termination.

2.5.5 Grounding pads shall be as per relevant standards.

2.5.6 The degree of protection shall be IP55 as per IS4601 & IEC60034-05

2.6 Suitable single phase AC (240 V) space heaters shall be provided on motors rated 30KW and above to maintain windings in dry condition when motor is standstill. Space heaters shall be wired up to separate terminal box complete with removable gland plate and suitable terminals & glands for connections of cable & temperature detectors, bearing temperature indicators and moisture detectors terminals, Neutral CT terminals shall also be provided.

2.7 Lower capacity motors (less than 30kW) where separate Anti condensation heaters are not provided, two phases of the winding will be subjected to 240V AC, 50HZ supply continuously whenever the motor is switched off to avoid any ingress of moisture. The supplier in the offer in this regard shall bring out any limitations. For LV Motors: Two point five (2.5) mm2, two (2) core copper conductor PVC insulated, armoured & FRLS PVC sheathed heavy duty 650/1100 V grade cable to IS: 1554 Part-I).

2.8 RATING PLATES

A rating plate of non-corrosive material upon which shall be engraved Manufacturer's name, Motor type, Motor model, Serial no. of motor, Rating, Voltage, Speed in RPM, Type of duty, Full load current in Amps, type of protection and efficiency class (IE3 / IE4).

These rating plates shall be of White non-hygroscopic material with engraved black lettering.

Stainless steel name plate as per IS 325 (Latest) /IEC 60034 (latest).

2.9 PROTECTION AND PRESERVATIVE COATING REQUIREMENTS:

2.9.1 All coated surfaces shall be protected against abrasion impact, discoloration any other damages. All exposed threaded portions shall be suitably protected with either metallic or a nonmetallic protection device. The shaft ends of motor shall be properly sealed with suitable devices to protect them from damage. The parts which are likely to get rusted due to exposure to whether, should also be properly treated and protected in a suitable manner. All primers / paints / coatings shall take into account the hot humid, corrosive & alkaline, subsoil or over ground environment as the case may be.

2.9.2 Preservative shop coating:

All exposed metallic surfaces subject to corrosion shall be protected by shop application of suitable coatings. All surfaces that will not be easily accessible after the shop assembly shall be treated before-hand and protected for the life of the equipment. All surfaces shall be thoroughly cleaned of all mill scales, oxides and other coatings and pre heated in the shop. The surfaces that are to be finish painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer.

All other steel surfaces which are not to be painted shall be coated with suitable dust preventive compound subject to the approval of Customer / BHEL.

2.10 PAINT AND FINISH

Motor external parts shall be finished and painted to produce a neat and durable surface, which would prevent rusting, and corrosion. The equipment shall be thoroughly degreased, all rust, sharp edges and scale removed and treated with one coat of primer and finished with two coats of RAL 5012 blue paint unless otherwise specified.

Material shall be properly packed to withstand mechanical damage and rust during transit.

2.11 The motor winding shall be tropicalized. The windings shall preferably be vacuum impregnated. Alternately the winding shall be suitably varnished, baked and treated with epoxy gel for operating satisfactorily in humid and corrosive atmospheres.

2.12 Cooling fan hub shall be threaded for withdrawing.

2.13 Drain plug shall be provided at the bottom of the starter frame.

2.14 The following **cable sizes** shall be considered for selecting suitable cable glands, unless otherwise specified.

Up to 3.7 KW - 3C x 2.5 mm^2 multi stand cu. conductor armored cable.

Above 3.7 KW up to 11KW - 3C x 10 mm^2 Multi stand Al. conductor, Armored cable

Above 11 KW up to 26KW - 3C x 25 mm^2 Multi stand Al. conductor, Armored cable.

Above 26 KW up to 37KW - 3Cx50 mm^2 Multi stand Al. conductor, Armored cable.

Above 37 KW up to 55KW - 3Cx95 mm^2 Multi stand Al. conductor, Armored cable.

Above 55 KW up to 75KW - 3Cx150 mm^2 Multi stand Al. conductor, Armored cable.

Above 75 KW up to 150KW -2x 3Cx185 mm^2 Multi stand Al. conductor, Armored cable.

Three (3) core cables .....Stranded aluminium conductor, XLPE insulated, colour coded, laid up, FRLS PVC type ST2 sheathed, GI wire /strip armoured, FRLS PVC type-ST2 jacketed overall, 650 / 1100V grade, heavy-duty cable as per IS:1554 Part-I).

For space heater 2Cx6 mm^2 Aluminum conductor, Armored cable

Special sizes if any will be as per our enquiry.

- For NTPC:

90 kW AC motor: 1x3C x 150sq mm

2.15 Bearing & Lubrication:

Motors shall have greased lubricated ball or roller bearings. In all cases, the bearings shall be chosen to provide a minimum life of 5 Years (40000 hours) at rated operating conditions. Unless otherwise specified the bearings shall be adequate to absorb axial thrust produced by the motor itself or due to shaft expansion. Vertical motors shall be provided with thrust bearings suitable for the load imposed by the driven equipment. In cases such as pumps for hot liquids where the driven machine operates at high temperatures, a shaft-mounted fan shall cool bearings. This shall ensure efficient ventilation of the bearing and disperse the heat transmitted from the driven object by conduction or convection. For motors operating in hazardous areas fans shall be of an anti-static non-sparking material.

Bearings shall be capable of grease injection from outside without removal of covers with motors in the running conditions. The bearing boxes shall be provided with necessary features to prevent loss of grease or entry of dust or moisture e.g. labyrinth seal. Where grease nipples are provided, these shall be associated, where necessary with appropriately located relief devices, which ensure passage of grease through the bearing. Pre-lubricated sealed bearings may be considered provided full guarantee is given for 4 to 5 years of trouble free service without the necessity of re-lubrication.

2.16 Cooling system:

All motors shall be self-ventilated, fan cooled (TEFC). Fans shall be corrosion resistant or appropriately protected. They shall be suitable for motor rotation in either direction without affecting the performance of the motor. If this is not possible for large outputs, it shall be possible to reserve the fan without effecting the balancing of the motor.

Motor shall be capable of 5 equal spaced cold starts per hour under normal conditions, 3 starts in quick succession from cold condition and two hot start in succession with motor initially at normal running condition.

2.17 **ROTOR:**

The rotor shall be of squirrel cage type, dynamically balanced to provide a low vibration level and long service life of the bearings. The accepted values of peak-to-peak vibration amplitudes for a motor at rated voltage and speed on a machined surface bedplate with the motor leveled and with a half-key or coupling fitted shall not exceed those given in IS-12075 (latest).

2.18 Grounding

General- Two (2) grounding terminals one (1) on either side at the bottom suitable for connecting mild steel/GI flat/GI wire grounding conductor, size of grounding conductor shall be decided during detailed engineering.

LV Motors-At each earthing point, two (2) drilled and tapped holes with hexagonal head bolts, plain washers, spring washers and tinned lugs (for motors upto 5.5 KW) for size of conductor specified shall be provided.

3. TESTS CERTIFICATE:

3 copies of performance test certificate of motor shall be supplied for each item of the consignment quoting BHEL Standard number, purchase order number and manufacturer's identification serial number.

4. GUARANTEE CERTIFICATE:

4.1 A guarantee certificate for 24 months of trouble free performance from the date of shipment or 18 months from the date of commissioning whichever is earlier shall be supplied.

4.2 If any mal-performance or defects occur during the guarantee period, the vendor shall make all necessary alteration, repairs and replacement free of charge.

5. SCOPE OF SUPPLY:

5.1 Main Supply

5.1.1 Motor with suitable double compression cable glands, lugs and along with shaft keys.

5.1.2 Space heater & RTD for motors with separate terminal box of rating 30 KW and above.

5.2 1 Set of commissioning spares (DE &NDE Bearings) items- Separate Purchase Requisitions is raised if required.

5.3 3 years Normal Operational spares (optional price shall be quoted for validity of 2 years) - Separate Purchase Requisitions will be raised as and when required.

5.3.1 Terminal Box.

5.3.2 Cooling Fan with End shield Cover

5.3.3 DE and NDE side Bearings

6. TESTS:

6.1 Each motor shall be Routine tested in accordance with IEC 60034-2 latest in presence of purchaser's representative.

Type test of similar frame size motor to be produced at the time of inspection. Tests on completely assembled motor shall be carried out in the presence of BHEL / Customer representative. The results shall be tabulated and signed by both vendor and BHEL / Customer representatives. **Though the motors shall be accepted on the basis of the satisfactory result of the tests at the vendor's works, it shall not absolve the vendor from liability regarding the proper functioning of motor coupled to the driven equipment at BHEL works or at sites.**

6.2 LT Motors supplied shall be of type tested design. During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests as listed in this specification and carried out within last eight (8) years.

6.3 These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. However if the contractor is not able to submit report of the type test(s) conducted within last eight (8) years from the date of ordering, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.

1. <u>Type tests</u>

i. No load saturation and loss curves up to approximately 115% of rated voltage.
ii. Momentary overload test.
iii. Temperature rise test at rated conditions. During heat run test, bearing temp., winding temp., core temp., coolant flow and its temperature shall also be measured. In case the temperature rise test is carried at load other than rated load, specific approval for the test method and procedure is required to be obtained. Wherever ETD's are provided, the temperature shall be measured by ETD's also for the record purpose.iv. Surge withstand test on the sample coil after placing it in stator core at (4U + 5 KV) and with at least five impulse of 1.2/50 micro sec. wave, for HV motors only,where U is the line to line voltage in kV.

v. Surge-withstand test with 0.3/3 micro sec. wave on each type of 6.6/11 kV motor coils with at least five such impulses, followed by one minute power frequency high voltage test on turn to turn insulation, after cutting the coil and bringing out the turns suitably. The power frequency test voltage shall be decided during detailed engineering.
vi. Dimensions (for motors covered by IS 1231:1974 and IS 2223:1983 only).
vii. Measurement of resistance of windings of stator and wound rotor.
viii. Reduced voltage running up test at no load (for squirrel cage motors up to 37kw

only).

ix. Full load test to determine efficiency, power factor and slip.

x. Insulation resistance test.

xi. Test for vibration severity of motor.

xii. Test for noise levels of motor.

xiii. Test for degree of protection by enclosure.

xiv. Temperature rise test at limiting values of voltage and frequency variations.

xv. Over speed test.

2. Routine Tests

The following shall constitute the routine tests.

i. Insulation resistance test

ii. Measurement of resistance of windings of stator and wound rotor.

iii. No load test

iv. Locked rotor readings of voltage, current and power input at a suitable reduced voltage

v. Reduced voltage running up test (for squirrel cage motor) vi. Open circuit voltage ratio of stator and rotor windings (for slip ring motors);rotor;

vii. High voltage test

7. DOCUMENTATION:

7.1 All the drawings/ documents submitted by the vendor during detailed engineering stage shall be stamped “For Approval” or For Information” prior to submission. After the approval of the drawing, further work by the vendor shall be in strict accordance with these approved drawings and no deviations shall be permitted without the written approval of customer.

7.2 All manufacturing, fabrication and execution of work in connection with the equipment prior to the approval shall be at the vendor’s risk. The vendor is expected not to make any changes in the design of the approval of the drawings equipment, once they are approved by customer. However, if some changes are necessitated in the design of equipment at a later date, the vendor may do so, but such changes shall promptly be brought to the notice of customer indicating the reasons for the change and get the revised drawing approved again in strict conformance to the provisions of the technical specification.

7.3 LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED

- All the motors shall be tested in accordance of IEC 60034-2
- The following type test reports shall be submitted for each type and rating of

LT motor of above 50 KW only

1. Measurement of resistance of windings of stator and wound rotor.
2. No load test at rated voltage to determine input current power and speed
3. Open circuit voltage ratio of wound rotor motors (in case of Slip ring motors)
4. Full load test to determine efficiency power factor and slip.
5. Temperature rise test.
6. Momentary excess torque test.
7. High voltage test.
8. Test for vibration severity of motor.
9. Test for noise levels of motor (Shall be limited to 85 dB (A) until otherwise specified)
10. Test for degree of protection
11. Over - speed test.
12. Type test reports for motors located in fuel oil area having flame proof enclosures as per IS 2148 / IEC 60079-1.

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment basic price.

The type test reports once approved for any projects shall be treated as reference. For subsequent projects of NTPC, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.

7.4 NUMBER OF DOCUMENTS TO BE SUBMITTED:-

- Drawings, Data sheets, Curves for Information /approval .....3 prints (1 soft copy).
- Final Drawings, Data sheets, Curves for Information / approval .... 3 Prints.
- Performance and functional guarantee test reports .... 3 prints
- O&M manual with project drawings, data sheets, performance and functional guarantee test reports ..... 10 Prints & 1 CD

8. DRAWINGS, DATA TO BE FURNISHED

8.1 Documents to be sent along with offer (2 copies)

(Without following data, offers will not be considered)

8.1.1 The descriptive leaflets / catalogues giving full sectional details of the item.
8.1.2 Motor Overall dimensional drawing along with terminal box details.
8.1.3 Motor cross-sectional drawing showing spare part details.
8.1.4 Filled in motor data sheets as per NTPC format (Page 12 to 15)
8.1.5 Characteristics curve of motor.
8.1.6 Speed torque characteristic curve of motor along with GD^2 Value.
8.1.7 Quality plan
8.1.8 Type test Certificates of similar frame size

8.2 DOCUMENTS TO BE SENT AFTER PLACEMENT OF ORDER FOR APPROVAL
(3 Hard Copies + 1 Soft copy)

8.2.1 Motor Overall dimensional drawing along with terminal box details.
8.2.2 Motor cross-sectional drawing showing spare part details.
8.2.3 Filled in motor data sheets as per NTPC format (Page 12 to 15)
8.2.4 Characteristics curve of motor
8.2.5 Speed torque characteristic curve of motor along with GD^2 value
8.2.6 Quality plan
8.2.7 Type test Certificates of similar frame size

8.3 DOCUMENT TO BE SUBMITTED AFTER FINAL APPROVAL

8.3.1 Material test certificates.
8.3.2 Guarantee certificates
8.3.3 Motor Overall dimensional drawing.
8.3.4 Filled in motor data sheets.
8.3.4 Quality plan.
8.3.7 Type test report

8.4 DOCUMENT TO BE SUBMITTED ALONG WITH CONSIGNMENT

8.3.1 Material test certificates.
8.3.2 Performance test certificates & Performance curve.
8.3.3 Guarantee certificates
8.3.4 Motor Overall dimensional drawing.
8.3.5 Filled in motor data sheets.
8.3.6 Quality plan.
8.3.7 Type test reports
8.3.8 O&M Manual

9. SPECIAL NOTES:

9.1 Final documents shall be furnished in CD for using in MS – word, AutoCAD & PDF.
9.2 Before forwarding the drawings and documents, vendor shall ensure that the following information is properly entered in each drawing.
9.2.1 Name of the equipment
9.2.2 Equipment tag number
9.2.3 Name of the project
9.2.4 Client / Customer
9.2.5 Drawing / Document title
9.2.6 Drawing / Document number.
9.2.7 Revision and date.
9.2.8 The manufacturer's serial no. shall be marked at suitable location.
9.2.9 A tag number bearing the relevant 12 digit material code shall be attached for each item.

10. **REFERENCE**

- IS 325: THREE-PHASE INDUCTION MOTORS
- IS 8789: Values of performance characteristics for three-phase induction motors(up to 37 kw)
- IEC:60034: Rotating electrical machines
- IS 1231: Dimensions of Three-phase Foot-mounted Induction Motors
- IS 2223: Dimensions of flange mounted ac induction motors
- IS 4691: Degrees of protection provided by enclosure for rotating electrical machinery
- IS 3202: Code of practice for climate proofing of electrical equipment
- IS 12615, Energy Efficient Induction Motors - Three Phase Squirrel Cage
- IEC:60034-30: Rotating electrical machines - Part 30: Efficiency classes of single-speed, three-phase, cage-induction motors (IE-code)
- IS 6362: Designation of methods of cooling of rotating electrical machines

11. **TABLE 1:**

DIMENSIONS OF TERMINAL BOXES FOR LV MOTORS:

S.N.	Motor MCR in KW	Minimum distance between centre of stud and gland plate in mm
1	UP to 3 KW	As per manufacturer's practice.
2	Above 3 KW - up to 7 KW	85
3	Above 7 KW - up to 13 KW	115
4	Above 13 KW - up to 24 KW	167
5	Above 24 KW - up to 37 KW	196
6	Above 37 KW - up to 55 KW	249
7	Above 55 KW - up to 90 KW	277
8	Above 90 KW - up to 125 KW	331
9	Above 125 KW-up to 200 KW	203

PHASE TO PHASE/ PHASE TO EARTH AIR CLEARANCE:

NOTE: Minimum inter-phase and phase-earth air clearances for LT motors with lugs installed shall be as follows:

S.N.	Motor MCR in KW	Clearance
1	UP to 110 KW	10mm
2	Above 110 KW and up to 150 KW	12.5mm
3	Above 150 KW	19mm

12. **DATA SHEET** (NTPC FORMAT)**:**

DE-1	LT MOTORS	

A.	**GENERAL**	
1.	Manufacturer & Country of origin.	
2.	Equipment driven by motor	
3.	Motor type	
4.	Quantity	
B.	**DESIGN AND PERFORMANCE DATA**	
1.	Frame size	
2.	Type of duty	S1
3.	Type of enclosure /Method of cooling/ Degree of protection	
4.	Applicable standard to which motor generally conforms	
5.	Efficiency class as per IS 12615 (latest) / IEC 60034-30 (latest)	IE3 (default)
6.	(a)Whether motor is flame proof	Yes/No
	(b)If yes, the gas group to which it conforms as per IS:2148	
7.	Type of mounting	
8.	Direction of rotation as viewed from DE END	Bi-directional
9.	Standard continuous rating at 40 deg. C ambient temperature as per Indian Standard (KW)	
10.	Deaerated rating for specified normal condition i.e. 50 deg. C ambient temperature (KW)	
11.	Maximum continuous load demand of driven equipment in KW	
12.	Rated Voltage (volts)	415
13.	Permissible variation of :	
	a. Voltage (Volts)	±10
	b. Frequency (Hz)	±5
	c. Combined voltage and frequency	±10
14.	Rated speed at rated voltage and frequency(RPM)	
15.	At rated Voltage and frequency:	
	a. Full load current	
	b. No load current	
16.	Power Factor at	
	a. 100% load	
	b. NO load	
	c. Starting.	
17.	Efficiency at rated voltage and frequency,	
	a.100% load	
	b. 75% load	

	c. 50% load	
18.	Starting current (amps) at	
	a. 100 % voltage	
	b. 85% voltage	
	c. 80% voltage	
19.	Minimum permissible starting Voltage (Volts)	
20.	Starting time with minimum permissible voltage	
	a. Without driven equipment coupled	
	b. With driven equipment coupled	
21.	Safe stall time with 100% and 110% of rated voltage	
	a. From hot condition	
	b. From cold condition	
22.	Torques :	
	a. Starting torque at min. permissible voltage (kg-mtr.)	
	b. Pull up torque at rated voltage.	
	c. Pull out torque	
	d. Min accelerating torque (kg-m) available at lowest permissible starting voltage	
	e. Rated torque (kg-m)	
23.	Stator winding resistance per phase (ohms at 20 Deg.C.)	
24.	GD^2 value of motors	
25.	No of permissible successive starts when motor is in hot	
26.	Locked Rotor KVA Input	
27.	Locked Rotor KVA/KW	
28.	Vibration limit :Velocity (mm/s)	
29.	Noise level limit (dBA)	
C.	**CONSTRUCTIONAL FEATURES**	
1.	Stator winding insulation	
	a. Class & Type	

	b. Winding Insulation Process	
	c. Tropicalised (Yes/No)	Yes
	d. Temperature rise over specified maximum ambient temperature of 50 deg C	
	e. Method of temperature measurement	
	f. Stator winding connection	
2.	Main Terminal Box	
	a. Type	
	b. Location(viewed from NDE side)	
	c. Entry of cables(bottom/side)	
	d. Recommended cable size (To be matched with cable size envisaged by owner)	
	e. Fault level (MVA),Fault level duration(sec)	50kA RMS for 0.25 sec
	f. Cable glands & lugs details (shall be suitable for power cable)	
3.	Type of DE/NDE Bearing	
4.	Motor Paint shade	RAL5012(Blue)
5.	Weight of	
	a. Motor stator (KG)	
	b. Motor Rotor (KG)	
	c. Total weight (KG)	
D.	**List of accessories.**	
1.	Space Heaters (Nos./Power in watts/supply voltage)	
2.	Terminal Box for Space Heater (Yes/No)	yes
3.	Speed switch (Yes/No) No of contacts and contact ratings of speed switch	
4.	Insulation of bearing (Yes/No)	
5.	Noise reducer(Yes/No)	
6.	Grounding pads	
	i) No and size on motor body	
	ii) Nos on terminal Box	
7.	Any other fitments	

E.	List of curves.	
1.	Torque speed characteristic of the motor	
2.	Thermal withstand characteristic	
3.	Starting. current Vs. Time	
4.	Starting. current Vs speed	
5.	P.F. and Effi. Vs Load	

13. **VARIANT TABLE:**

Var. No.	Description	Material code
01	TEFC SQ. CAGE HOR FOOT MOUNTED (B3) A.C IND. MOTOR FOR L.O.P. RATING: 90 KW, 415 VAC, 1450 RPM EFFICENCY AS PER IE3 IEC60034-30, SCOPE AS PER CLAUSE 5.1, NTPC Project	**TC9754373019**
02	SPARE SET OF BEARINGS (DE+NDE) FOR 90 KW A.C MOTOR- COMMISSIONING SPARE	**TC9754373027**
03	SPARE COOLING FAN FOR 90 KW A.C.MOTOR	**TC9754373035**
04	TERMINAL PLATE FOR IE3 90KW MOTOR	**TC9754373043**
05	SPACE HEATER FOR 90KW IE3 MOTOR	**TC9754373051**
06	TEFC SQ. CAGE HOR FOOT MOUNTED (B3) A.C IND. MOTOR FOR L.O.P. RATING: 110 KW, 415 VAC, 2900 RPM EFFICENCY AS PER IE3 IEC60034-30, SCOPE AS PER CLAUSE 5.1	**TC9754373060**
07	IE3 TEFC(B3)AC IND MTR,90KW,415VAC,2900	**TC9754373078**
08	IE3 TEFC(B3)AC IND MTR,75KW,415VAC,1450	**TC9754373086**

RECORD OF REVISIONS

Rev. No.	Date	Revision Details	Revised By	Approved By
00	01.07.14	First Issue		
01	20.06.16	First revision	Anshul	M.V.S.Raju
02	19.05.17	Second revision	Anshul	Sunil Jiwtode
03	16.12.17	Third revision , Var 08 added	Anshul	Sunil Jiwtode

PRODUCT STANDARD
INDUSTRIAL TURBINES & COMPRESSORS

THIS QUALITY PLAN DESCRIBES TYPICAL STANDARD TEST REQUIREMENTS OF Centrifugal Exhaust Fan. VENDOR MAY BE REQUIRED TO PREPARE & SUBMIT QUALITY PLAN SPECIFIC TO ENQUIRY WITH ADDITIONAL REQUIREMENTS AS PER APPROVED ENGINEERING DOCUMENTS (DRAWING / DATA SHEET).

BHEL	**BHARAT HEAVY ELECTRICALS LIMITED R.C.PURAM, HYDERABAD**	**STANDARD QUALITY PLAN FOR VENDOR ITEMS** **ITEM: CENTRIFUGAL EXHAUST FAN WITH ELECTRIC MOTOR** **BHEL SPEC: TC54301, TC54329 Rev. No. – as per PO**	**QP. NO:** HYQA/SQP/TC/1415/15 **Rev. No. :** 03 **DATE:** 07.07.2020 **VALID UPTO:** 06.07.2022 **PAGE 1 OF 3**

Sl No	Component & Operations	Characteristics	Class	Type Of Check	Quantum Of Check	Ref Document	Acceptance Norms	Format Of Record	* D	Agency P	Agency W	Agency V	Remarks
1.0	**RAW MATERIALS & BOUGHT OUT ITEMS**												
1.1	Sheet/Plates for casing & impellers, Base Plate & Flanges	Chemical Composition & Mechanical Properties	Major	Review	One Sample/ Heat	As per BHEL SPEC. / Approved Drawing./ Datasheet	As per BHEL SPEC. / Approved Drawing./ Datasheet	MTC	√	2		1	
		Visual & Dimensional		Visual / Measrt.	100%								
1.2	AC Motor (Brought out item)	Performance	Major	Routine Test & Type Test	100%	As per BHEL SPEC. / Approved Drawing./ Datasheet	As per BHEL SPEC. / Approved Drawing./ Datasheet	TC	√	2		1	Flame Proof Certificate for motor shall be reviewed by BHEL TPI.
2.0	**INPROCESS INSPECTION**												
2.1	Casing Welding & Impeller welding	Availability of WPS, PQR & WQR	Major	Review	100%	-	-	WPS, PQR, WQR		2		1	
		Weld Soundness	Major	Visual & LPI	100%	ASTM E-165	NO DEFECT	IR	√	2		1	
		Dimensional Conformity	Major	Measrt.	100%	Approved Drawing.	Approved Drawing.	IR	√	2		1	
2.2	Static & Dynamic Balancing of impeller	unbalance	Critical	Balancing	100%	Approved Drawing./ Datasheet	Approved Drawing./ Datasheet	TC	√	2		1	

LEGEND:
P: - PERFORM, W: - WITNESS , V: - VERFICATION,
INDICATING 1: - BHEL / BHEL NOMMNATED INSPECTION AGENCY, 2: - VENDOR / SUB VENDOR AS APPROPRIATE AGAINST EACH COMPONENT / CHARACTERISTICS UNDER THE COLUMNS P, W & V.
* D: RECORDS IDENTIFIED WITH TICK (✓) SHALL BE ESSENTIALLY INCLUDED IN QA DOCUMENTATION.

PREPARED BY	REVIEWED BY	APPROVED BY
Sachin Katiyar Sr. Engineer / QA	B. Ashok Kumar AGM/QA	B. Ashok Kumar AGM/QA

Sl No	Component & Operations	Characteristics	Class	Type Of Check	Quantum Of Check	Ref Document	Acceptance Norms	Format Of Record	* D	Agency P	Agency W	Agency V	Remarks
3.0	**FINAL INSPECTION & TESTING**												
3.1	Assembly	Dimensional Check, Completeness wrt Drg./ BOM	Major	Measurement & Visual	100%	Approved Drawing.	Approved Drawing.	IR	√	2	1		
		Performance Test with Job motor (Capacity, Static Pressure, Power Consumption, speed, efficiency & Noise level)	Critical	Performance check	100%	Approved Drawing./ Datasheet	Approved Drawing./ Datasheet	TC	√	2	1		100% by Supplier. **10% (minimum 1No) of each type/size witness by BHEL / TPI.**
		Mechanical run test with job motor	Critical	Measurement	100%	Approved Drawing./ Datasheet	Approved Drawing./ Datasheet	TC	√	2	1		
4.0	**PAINTING, PRESERVATION AND PACKING**												
4.1	Final Assembly	Cleaning & Painting	Major	Visual	100%	Manufacturer's Standard Procedure/	Manufacturer's Standard Procedure	IR	√	2		1	
4.2	Final Stage	Marking & Packing	Major	Visual	100%	As per BHEL SPEC.	As per BHEL SPEC.	IR	√	2		1	

ABBREVIATIONS:		
MTC – MILL TEST CERTIFICATE	MPI - MAGENTIC PARTICLE INSPECTION	TC – TEST CERTIFICATE
HT – HEAT TREATMENT	UT - ULTRASONIC TEST	TPIA - THIRD PARTY INSPECTION AGENCY APPOINTED BY BHEL.
IR - INSPECTION REPORT	RT – RADIOGRAPHY TEST	COC – CERTIFICATE OF CONFORMITY
MEASRT - MEASUREMENT	WPS – WELDING PROCEDURE SPECIFICATION	PQR – WELDING PROCESS QUALIFICATION RECORD
WQR – WELDER QUALIFICATION RECORDS	PO – PURCHASE ORDER	LPI – LIQUID PENETRANT INSPECTION
PMI – POSITIVE MATERIAL IDENTIFICATION	SS – STAINLESS STEEL	AS – ALLOY STEEL

Refer Annexure-I for Notes.

LEGEND:
P: - PERFORM, W: - WITNESS , V: - VERFICATION,
INDICATING 1: - BHEL / BHEL NOMMNATED INSPECTION AGENCY, 2: - VENDOR / SUB VENDOR AS APPROPRIATE AGAINST EACH COMPONENT / CHARACTERISTICS UNDER THE COLUMNS P, W & V.
* D: RECORDS IDENTIFIED WITH TICK (✓) SHALL BE ESSENTIALLY INCLUDED IN QA DOCUMENTATION.

PREPARED BY	REVIEWED BY	APPROVED BY
Sachin Katiyar Sr. Engineer / QA	B. Ashok Kumar AGM/QA	B. Ashok Kumar AGM/QA

Sl No	Component & Operations	Characteristics	Class	Type Of Check	Quantum Of Check	Ref Document	Acceptance Norms	Format Of Record	* D	Agency P	Agency W	Agency V	Remarks

Annexure – I

Notes:

1. Pre-despatch inspection photographs of the equipment/item shall be included in Quality documentation.
2. LATEST VERSION OF STANDARDS/DRAWINGS /TOLERANCES ETC TO BE MENTIONED IN QUALITY PLAN/DRAWING. THIS QP SHOULD BE READ ALONG WITH BHEL SPEC, BHEL DRAWINGS / APPROVED DRAWINGS, DATA SHEET, BOM AND PO.
3. DRAWING / DATA SHEET/ SPECIFICATION SHALL PREVAIL OVER QUALITY PLAN IN CASE OF ANY CONTRADICTION.
4. BHEL RESERVES THE RIGHT FOR CONDUCTING REPEAT TEST, IF REQUIRED.
5. BHEL APPROVED INSPECTION ENGINEERS TO BE DEPLOYED FOR INSPECTION.
6. ONLY LEVEL II & ABOVE QUALIFIED PERSON IN RESPECTIVE NDE TO VERIFY OR WITNESS THE NDT TEST REPORT/RESULTS.
7. INSPECTION TO BE OFFERED ONLY AFTER ENSURING THAT ALL DOCUMENTS (QUALITY PLAN, DRAWINGS, DATA SHEET, PURCHASE SPECIFICATIONS, ETC) ARE AVAILABLE AS PER PURCHASE ORDER.
8. VENDOR TO OFFER ORIGINAL TEST CERTIFICATES ISSUED BY THIRD PARTY LABORATORIES OR SUPPLIERS.
9. VENDOR TO ENSURE WITH TPIA THAT A NOTE 'COMPARED WITH ORIGINAL TEST CERTIFICATE. REVIEWED, VERIFIED AND FOUND IN ORDER' SHALL CONTAIN WITH EVERY INSPECTION REPORT.
10. ONLY VALID AND CALIBRATED MEASURING INSTRUMENTS AND EQUIPMENT SHALL BE USED – TPIA TO VERIFY.
11. VENDOR TO ENSURE WITH TPIA THAT MATERIAL TEST CERTIFICTAE & TRACEABILITY RECORDS ARE AVAILABLE FOR USE OF CORRECT MATERIAL.
12. QUALIFICATION OF EQUIPMENT, PROCESS & PERSONNEL FOR SPECIAL PROCESSES LIKE WELDING, BRAZING, PAINTING & METAL COATING ETC. (AS APPLICABLE AS PER PO) SHALL BE ENSURED.
13. VENDOR TO ENSURE THAT ALL CERTIFICATES ARE ENDORSED BY TPIA WITH COMMENTS (WITNESSED OR VERIFIED) AS PER QUALITY PLAN.
14. VENDOR SHALL OFFER LOG SHEETS CONTAINING ACTUAL MEASURED VALUES INSTEAD OF SAYING OK/NOT OK TO TPIA.
15. VENDOR SHALL SUBMIT COMPLETE INSPECTION AND TEST DOCUMENTATION WHICHEVER IS IDENTIFIED WITH (√) UNDER COLUMN 'D' OF APPROVED QULAITY PLAN SHALL BE ENCLOSED WITH THE INSPECTION REPORT.
16. VENDOR SHALL SUBMIT ORIGINAL COPIES OF ALL INSPECTION AND TEST DOCUMENTS AUTHENTICATED BY TPIA.

SPECIFICATION FOR SURFACE PREPARATION AND PROTECTIVE COATING SYSTEM - NEW CONSTRUCTION

PROJECT : 500 KTA PDH PP PROJECT, USAR

OWNER : GAIL (INDIA) LTD.

JOB NO. : B378

Rev. No.	Date	Purpose	Prepared by	Reviewed by	Approved by
2	12.2.2021	Table 9.6 Sr No. c revised and Reissued For Tender	S S Pandey	P Chowdhary	A Roy
1	4.12.2020	Revised and Reissued For Tender	S S Pandey	P Chowdhary	A Roy
0	1.12.2020	Issued For Tender	S S Pandey	P Chowdhary	A Roy

Contents

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 Coating 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 Complete coating (i.e., primer, intermediate and top coats) of shop fabricated equipment and piping, may be carried out at shop. Any coating damage during transportation of equipment/piping to site shall be repaired by the fabricator/manufacturer in accordance with this specification.

2.5 In case of conflict between coating systems given in this document and any other system specified elsewhere in the applicable contractual documents like SOR, MR, and PR etc, Contractor shall approach the Client/Client's authorized representative for confirming the suitable coating systems.

2.6 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.

International Organization for Standardization (ISO):

ISO 12944: Corrosion Protection of steel Structures by Protective Paint System

ISO 14713-2: Zinc Coatings - Guidelines and Recommendations for the Protections against Corrosion of Iron and Steel in Structures, Part-2: Hot Dip Galvanizing

ISO 8502-3: Preparation of steel substrates before application of paints and related products -Tests for the assessment of surface cleanliness - Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)

ISO 8502-9: Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness - Part 9: Field method for the conductometric determination of water-soluble salts.

ISO 2808: Paints and varnishes - Determination of film thickness

National Association for Corrosion Engineer (NACE):

NACE SP 0198: Control of Corrosion under Thermal Insulation and Fireproofing Materials

NACE SP 0188: Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates

Steel Structures Painting Council (SSPC)

SSPC VIS 1: Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

SSPC PA 2: Measurement of Dry Paint Thickness with Magnetic Gauges

American Society for Testing and Materials (ASTM):

ASTM D6677-18: Standard Test Method for Evaluating Adhesion by Knife

ASTM D1475-13: Standard Test Method for Density of Liquid Coatings, Inks, and Related Products

ASTM D5894–16: Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)

ASTM D823–18: Standard Practices for Producing Films of Uniform Thickness of Paint, Coatings and Related Products on Test Panels

ASTM D2369-10 (2015): Standard Test Method for Volatile Content of Coatings

ASTM D1640/D1640M-14(2018): Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings

ASTM D522/D522M–17: Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings

ASTM D3363 - 05(2011): Standard Test Method for Film Hardness by Pencil Test

ASTM D2197–16: Standard Test Method for Adhesion of Organic Coatings by Scrape Adhesion

ASTM D968–17: Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive

ASTM D1044–13: Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion

ASTM D1849-95 (2019): Standard Test Method for Package Stability of Paint

ASTM D2247–15: Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity

ASTM D543–14: Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents

ASTM D870–15: Standard Practice for Testing Water Resistance of Coatings Using Water Immersion

ASTM D5146-10(2019): Standard Guide to Testing Solvent-Borne Architectural Coatings

ASTM D2485–18: Standard Test Methods for Evaluating Coatings for High Temperature Service

Other Applicable Standards:

RAL DUTCH: International Standard for colour shade (Dutch Standard)

ANSI A 13.1: Scheme for identification of piping systems: American National Standards Institution

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 The contractor shall arrange, at his own cost, to keep a set of latest edition of above standards and codes at site.

3.3 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 3^0C 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, $A1_2O_3$ 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 ¾". 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 sued 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, doubers, or sheepkin.

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	Manual or hand tool cleaning 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	Mechanical or power tool cleaning 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	Dry abrasive blast cleaning There are four common grades of blast cleaning				
3.1	White metal 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	Near white metal 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	Commercial Blast 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	Brush-off Blast 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
Theoritical covering capacity in m^2/coat/ litre	8-10	8-10	8-10	4m²/kg
Weight per litre in Kg/litre	1.3±0.05	1.2±0.05	1.4±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 isocynate 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
Theoritical 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±0.03	1.15±0.03	1.42±0.03	1.40±0.03	1.40±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.	Ambient Temperature Curing, 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 (Note-13)
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±0.03	2.3±0.03	0.95±0.03	1.00±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
Theoritical 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±0.03	1.65±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/mm2 (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 applicable for "Table: Paint Materials Characteristics"

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. Where F12 is used as primer, anchor profile height shall be as per F12 paint manufacturer recommendation.
14. F-14 shall be suitable for under insulation service up to 125 deg C.
15. F-15 shall be suitable for high temperature immersion & under insulation services.
16. 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 selected for a high durability (beyond 15 years) period.

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 Painting (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 or equivalent make.

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 of 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 allow steel surfaces

(Structural steel, pipings, 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 @ 65-75µ DFT/Coat	None	None	65-75	**a)** No over-coating to be done on F-9 as it will lead to mud cracking.
2	-14 to 80	SSPC-SP-10; 1 coat of F-9 @ 65-75µ DFT/Coat	1 coat of P-6 @ 40 µ DFT/coat (Tie/ Mist Coat)	2 coats of F-6A/ F-6B @ 100 µ DFT/Coat + 1 coat of F-2 @ 40µ DFT/Coat	345-355	
3	81 to 400	SSPC-SP-10; 1 coat of F-9 @ 65-75µ DFT/Coat	None	2 coats of F-12 @ 20µ DFT/Coat	105-115	
4	401 to 540	SSPC-SP-10; 2 coat of F-12 @ 20µ DFT/Coat	None	2 coats of F-12 @ 20µ DFT/Coat	80	

Notes:

1. 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.

2. 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.

3. Flare line within unit or offsite areas shall be coated as per Sr. No. 3 of above table

4. 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.

5. For external surface of RCC Chimney, 2 coats of F-6B @ 100µ DFT/coat to obtain total DFT of 200 µ shall be applied after proper surface preparation as per clause no. 5.1.6.

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.

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.					
	-45 to 80	SSPS-SP-10	1 coat of F-9 @ 65-75µ DFT/coat + 1 Coat of P-6 @ 40 µ	2 coats of F-6A/ F-6B @100µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat; (2x100+40=240)	345-355	-
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					
	-45 to 80	SSPS-SP-10	1 coat of F-9 @ 65-75µ DFT/coat + 1 coat of epoxy based mist 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.					
	-45 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 or equivalent International standards)		4.5mm	Natural Rubber lining shall be applied as per specific manufacturer and Engineer-in-Charge instructions

Notes:

1. 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 floating roof, outside surfaces (other than oil side surface) of external floating roof pontoons and associated external structural works.					
1	-45 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/ F-6B @ 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 120	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	121 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	-45 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 400	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)					
1	-180 to 650	For CS, SSPC SP 10 For SS, SSPC-SP-7 (15-25µ surface profile)	1 coat of inert polymeric matrix coating @ 125 µ	1 coats of inert polymeric matrix coating @ 125 µ	250	Note 2(c)

Notes

1. All paint coating application including primer for tankage shall be carried out at field after erection and completion of all welding.

2. For underside of bottom plate :

   a) Painting shall be carried out before laying of bottom plate for tanks with Non-Post Weld Heat Treatment (PWHT).

   b) For tanks with PWHT, painting shall be carried out after PWHT.

   c) In case tank is not lifted during PWHT then painting shall be applied before laying of bottom plate.

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 external floating roof, top side & underside of internal 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 surface of pontoon of external floating roof, all outside surfaces of pontoon of internal floating roof, roof structures, structural steel, ladders and other CS internals					
1	-45 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 external floating roof, top side & underside of internal floating roof, 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 surface of pontoon of external floating roof, all outside surfaces of pontoon of internal floating roof , support structures, ladders and other CS internals					
1	-45 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 Water, Raw Water & Fire Water** All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-45 to 65	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	-45 to 60	SSPC-SP-10	1 Coats of F-6B @ 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	-45 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	-45 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	-45 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	-45 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;	280-300	-

Notes

1. For Potable water tank lining, F-6 A shall be suitable for drinking water service and should have certification from competent authority like NSF International Standard NSF/ANSI-61 2004 or Water Regulations Advisory Scheme (WRAS), UK or Central food research Institute Mysore, India.

2. Coatings recommended in above table, shall be suitable for immersion in targeted service upto the mentioned design temperatures.

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 @ 25µ DFT/ coat	1 layer of coal tar tape coating @ 2mm +1 coat of synthetic fast drying primer @ 25µ DFT/ coat + 1 layer of coal tar tape coating @ 2mm /layer as per EIL Std. Spec. 6-79-0011	-	Note 1
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	-45 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

Notes:

1. Alternatively, 3LPE shop coated pipes conforming to DIN 30670 Type S-n up to maximum design temperature of 75°C is also acceptable. Fittings for 3LPE coated pipes, shall be coated with 1500 microns of Liquid Epoxy as per DIN EN 10289, Class C and type 3. Heat Shrink Sleeves shall be used for field joint coating of 3LPE coated pipes (Refer EIL Std. Spec. 6-71-0044 for details of specified field joint coating).

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

(Insulated Structures, 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. (Note-1)**					
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; 2 coats of F-12@20µ DFT/coat	-	2 coat of F-12 @ 20µ DFT/coat;	80	Note-2
b	**Stainless Steel and Alloy-20 Piping, Vessels & Equipments (Note-1, 3)**					
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 (Note 4)**					
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-5

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

Notes

1. Coating system for design temperature range not covered in Sr. No. a & Sr. No. b, shall be as per the Sr.No.c2.
2. Alternatively, for Tanks, Vessels & Equipments, thermally sprayed aluminium coating (TSAC) @ 300µ as per ANNEXURE-I is also acceptable.
3. The blast cleaning abrasives for SS and Alloy steel surfaces shall be Aluminium oxide grits/shots or garnet.
4. “Cyclic Service” is characterized by rapid temperature fluctuation.
5. Alternatively, for this temperature range, 1 coat of F-17 @ 300 µ is also acceptable.
6. No painting is required for insulated Monel, Incoloy and Nickel lines.

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	-45 to 80	SSPC-SP-10	1 coat of F-15 @ 80 microns	2 coats of F-15 @ 80µ 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	-45 to 80	Sweep Blasting	1 coat of F-15 @ 80µ DFT/coat;	1 coat of F-15 @ 80µ 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 INFLAMABLE" 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.

In absence of any existing color coding scheme of the OWNER, Color Code scheme given in ANNEXURE-II shall be followed.

12.0 IDENTIFICATION OF COLUMNS, TANKS, 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:

a. All Columns
b. All Tanks in Offsites
c. Large Vessels
d. 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 30º to 60º 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 16.0).

14.2 The contractor must produce Test Certificate from Pre-Qualified Paint Manufacturer for various tests as detailed out in section 17.0 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.) / Owner/ 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 m^2 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/m^2. Checks shall be done on each component atleast once per 200 m^2 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 15m^2 of blasted surface. At each spot three measurements shall be taken over an area of 10 cm^2 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 m^2 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 mush 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 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 manufacturer for at least past 5 years.
- Manufacturer should posses 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 posses 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 Site-in-charge for approval/ acceptance. The paint manufacturer will be qualified and approved by Site-in-charge 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 prior to paints supply at site.

TABLE: PRE-QUALIFICATION TESTING

System No.	Coating System	Reference Clause	Total DFT, µ (Min.)
1.	F-9+P6+F6A/B+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,	240

		Sr. No. b (2) of table	
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.	F6B+F6C+F6C	Clause 9.6, Sr. No. d (1) of table	500
10.	Inert Polymeric Matrix	Clause 9.5, Sr. No. c (1) of table	250
11.	F6A+F6A+F6A	Clause 9.6, Sr. No. c (1) of table	300

Sr. No.	Test	For System Number	Duration	Acceptance Criteria
1.	Cyclic Test 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_2SO_4 solution pH = 5.0 to 5.5 for system 11	1000 hrs.	Shall pass.
2b.	5% H_2SO_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 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 ^{0} 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/m^2. (5 micrograms/cm^2) .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 m^2 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 m^2 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 $\pm 30^{0}$ 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 300 microns having minimum value of 275 microns at low thickness areas (valleys) and not more than 325 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^{0}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 ± 30° 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 ½(40mm)
Flame wire	5-7	¾(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 m^2 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 15m^2 of blasted surface. At each spot three measurements shall be taken over an area of 10 cm^2 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 m^2 of applied TSAC shall be selected along which 5 measurements to be taken at 25 mm internal and average to be reported.

6.3.3 For curved surface or complex geometry, 5 measurements shall be taken at a spot measuring 10 cm^2 in area. One spot to be taken for every 15 m^2 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 m^2. 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 ¼" thick. If the actual work is less than ¼" 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	Specification for the application of thermal spray coatings (Metallizing) of aluminum, zinc, and their alloys and composites for the corrosion protection of steel.

23.00	
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

COLOR CODE

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. Colour code is applicable for both unit and offsite pipes.

SR. No.	SERVICE	RECOMMNDED COLOUR FOR PAINT SYSTEM	RAL COLOUR CODE	
			BASE COLOUR	BAND COLOUR
HYDROCARBON LINES (UNINSULATED)				
1	CRUDE SOUR	Dark Admiralty grey with 1 orange band	7012	2011
2	CRUDE SWEET	Dark Admiralty grey with 1 red band	7012	3001
3	LUBE OILS	Dark Admiralty grey with 1 green band	7012	6010
4	FLARE LINES	Heat Resistant Aluminium	9006	
5	LPG	Orange with 1 oxide red band	2011	3009
6	PROPYLENE	Orange with 2 blue bands	2011	5013
7	NAPTHA	Orange with 1 green band	2011	6010
8	M.S.	Orange with 1 dark admiralty grey band	2011	7012
9	AV.GASOLINE (96 RON)	Orange with 1 band each of green, white and red bands	2011 / 6010	9010 / 3001
10	GASOLINE (regular, leaded)	Orange with 1 black band	2011	9005
11	GASOLINE (premium, leaded)	Orange with 1 blue band	2011	5013
12	GASOLINE (white)	Orange with 1 white band	2011	9010
13	GASOLINE (Aviation 100/130)	Orange with 1 red band	2011	3001
14	GASOLINE (Aviation 115/145)	Orange with 1 purple band	2011	4006
15	N-PENTANE	Orange with 2 blue bands	2011	5013
16	DIESEL OIL (White)	Oxide red with 1 white band	3009	9010
17	DIESEL OIL (Black)	Oxide red with 1 yellow band	3009	1023
18	KEROSENE	Oxide red with 1 green band	3009	6010
19	HY.KEROSENE	Oxide red with 2 green bands	3009	6010
20	DISUFIDE OIL (EX-MEROX)	Oxide red with 1 black band	3009	9005
21	M.T.O	Oxide red with 3 green bands	3009	6010
22	DHPPA	Oxide red with 2 white bands	3009	9010
23	FLUSHING OIL	Oxide red with 2 black bands	3009	9005
24	LAB FS	Oxide red with 2 dark admiralty grey bands	3009	7012
25	LAB RS	Oxide red with 3 dark admiralty grey bands	3009	7012
26	LAB (Off. Spec)	Oxide red with 1 light grey band	3009	7035
27	N-PARAFFIN	Oxide red with 1-blue band	3009	5013
28	HEAVY ALKYLATE	Oxide red with red band	3009	3001
29	BLOW DOWN, VAPOR LINE	Off white / Aluminum with 1-Brown band	9006	8004
30	BLOWDOWN	Off white / Aluminum with 2 brown bands	9006	8004
31	A.T.F.	Leaf brown with 1 white band	8003	9010
32	TOULENE	Leaf brown with 1 yellow band	8003	1023

33	BENZENE	Leaf brown with 1 green band	8003	6010
34	LAB PRODUCT	Leaf brown with 1 blue band	8003	5013
35	FUEL OIL	Black with 1 yellow band	9005	1023
36	FULE OIL (Aromatic rich)	Black with 2 yellow bands	9005	1023
37	ASPHALT	Black with 1 white band	9005	9010
38	SLOP AND WASTE OILS	Black with 1 orange band	9005	2011
39	SLOP AROMATICS	Black with 2 orange bands	9005	2011
	CHEMICAL LINES			
40	TRI-SODIUM PHOSPHATE	Canary yellow with 1 violet band	1012	5000
41	CAUSTIC SODA	Canary yellow with 1 black band	1012	9005
42	SODIUM CHLORIDE	Canary yellow with 1 white band	1012	9010
43	AMMONIA	Canary yellow with 1 blue band	1012	5013
44	CORROSION INHIBITOR	Canary yellow with 1 Aluminum band	1012	9006
45	HEXAMETA PHOSPHATE	Canary yellow with 2 black bands	1012	9005
46	ACID LINES	Golden Yellow with 1 red band	1004	3001
47	RICH AMINE	Canary yellow with 2 blue bands	1012	5013
48	LEAN AMINE	Canary yellow with 3 blue bands	1012	5013
49	SOLVENT	Canary yellow with 1 green band	1012	6010
50	LCS	Canary yellow with 1 smoke grey	1012	7031
	WATER LINES			
51	RAW WATER	Sky blue with 1 black band	5015	9005
52	INDUSTRIAL WATER	Sky blue with 2 signal red band	5015	3001
53	TREATED WATER	Sky blue with 1 oxide red band	5015	3009
54	DRINKING WATER	Sky blue with 1 green band	5015	6010
55	COOLING WATER	Sky blue with 1 light brown band	5015	1011
56	SERVICE WATER	Sky blue with 1 signal red brown	5015	3001
57	TEMPERED WATER	Sky blue with 2 green bands	5015	6010
58	DM WATER	Sky blue with 1 aluminum band	5015	9006
59	DM WATER ABOVE 150°F	Sky blue with 2 black bands	5015	9005
60	SOUR WATER	Sky blue with 2 yellow bands	5015	1013
61	STRIPPED WATER	Sky blue with 2 blue bands	5015	5013
62	ETP TREATED WATER	Sky blue with 2 oxide red bands	5015	3009
	FIRE PROTECTION SYSTEM (ABOVE GROUND)			
63	FIRE WATER FOAM & EXTINGUISHERS	Post office red	3002	
	AIR & OTHER GAS LINES (UNINSULATED)			
64	SERVICE AIR	Sea green with 1 signal red band	6018	3001
65	INSTRUMENT AIR	Sea green with 1 black band	6018	9005
66	NITROGEN	Sea green with 1 orange band	6018	2011
67	FREON	Sea green with 1 yellow band	6018	1023
68	CHLORINE	Canary yellow with 1 oxide band	1012	3009
69	SO_2	Canary yellow with 2 white bands	1012	9010
70	H_2S	Orange with 2 red oxide bands	2011	3009
71	GAS (Fuel)	Orange with 1 aluminum band	2011	9006
72	GAS (Sour)	Orange with 2 aluminum bands	2011	9006
73	GAS (Sweet)	Orange with 2 signal red band	2011	3001

74	HYDROGEN	Orange with 1 light green band	2011	6021
STEAM AND CONDENSATE LINES (UNINSULATED)				
75	HP STEAM	Off white / Aluminum with 1 yellow band	9006	1023
76	MP STEAM	Off white / Aluminum with 1 red band	9006	3001
77	MLP STEAM	Off white / Aluminum with 1 orange band	9006	2011
78	LP STEAM	Off white / Aluminum with 1 light green band	9006	6021
79	CONDENSATE	Sky blue with 1 white band	5015	9010
80	CONDENSATE ABOVE 150°F	Sky blue with 3 oxide red band	5015	3009
81	BFW	Sky blue with 2 red bands	5015	3001
Note: For all insulated steam lines, the colour coding shall be follow as given for un-insulated lines with the specified length of color bands.				
INSULATED HYDROCARBON PIPING				
82	IFO SUPPLY	1Black ground colour with 1 yellow band in centre	9005	1023
83	IFO RETURN	Black ground colour with 1 green band in centre	9005	6010
84	HPS	Black ground colour with 1 red band in centre	9005	3001
85	BITUMEN	Black ground colour with 2 red bands in centre	9005	3001
86	CLO	Black ground colour with 1 brown band in centre	9005	8004
87	VB TAR	Black ground colour with 2 brown bands in centre	9005	8004
88	VR AM (BITUMEN / VBU FEED)	1 Black ground colour with 1 blue band in centre	9005	5013
89	VR BH	1 Black ground colour with 2 blue bands in centre	9005	5013
90	VAC. SLOP	1 Black ground colour with 1 white band in centre	9005	9010
91	SLOP	1 Black ground colour with 1 orange band in centre	9005	2011
92	CRUDE SWEET	1 Dark admiralty grey ground colour with 1 red band in centre	7012	3001
93	CRUDE OUR	1 Dark admiralty grey ground colour with 1 orange band in centre	7012	2011
94	VGO / HCU	1 Oxide red ground colour with 2 steel grey bands in centre	3009	7011
95	OHCU BOTOM / FCCU FEED	1 Oxide red ground colour with 2 steel grey bands in centre	3009	7011
UNINSULATED EQUIPMENTS, TANKS AND STRUCTURES				
96	HEATER STRUCTURE	Steel grey	7011	
97	HEATER CASING	Heat resistant aluminium	9006	
98	VESSELS & COLUMNS	Aluminium	9006	
99	HYDROGEN BULLETS	Pink	3014	
100	LPG VESSELS	Oxide red	3009	
101	SO_2 VESSEL	Canary yellow	1012	
102	HEAT EXCHANGER	Heat resistant aluminium	9006	
103	FO TANK AND HOT TANKS	Black	9005	

104	ALL OTHER TANKS	Aluminum / Off white	9006
105	CAUSTIC / AMINE / ACID TANKS	Golden yellow	1004
106	SOUR WATER	Sky Blue	5015
107	OUTER SURFACE IN BOILER HOUSE	Heat resistant aluminum	9006
108	COMPRESSORS AND BLOWERS	Dark admiralty grey	7012
109	PUMPS	Navy blue	5014
110	MOTORS & SWITCH GEAR	Bluish green	5024
111	HAND RAILING, MIDDLE RAIL, TOE PLATE, LADDER VERITAL POSTS, OVER HEAD MONORAIL, MONORAIL STOPPER PLATES, COKE CUTTING SYSTEM	Signal red	3001
112	STAIRCASE, LADDER, WALKWAYS, LADDER RUNGS, RAILING VERTICAL POSTS, CHEQUERED PLATE (BOTH FACES), GRATINGS	Black	9005
113	LOAD LIFTING EQUIPMENT	Leaf brown	8003
114	GANTRY GIRDER & MONORAIL	Dark Green	6009
115	EOT / HOT CRANES	Canary Yellow	1012
116	PIPE RACK STRUCTURALS, BUILDING STRUCTURALS, STEEL COLUMNS, BRACKETS, BEAMS, BRACINGS, ROOF TRUSSES, PURLINGS, SIDE GIRTS, LOUVERS, STRINGERS	Dark admiralty grey	7012
117	TRANSFORMERS & BATTERY ROOM STRUCTURALS	Dark admiralty grey	7012
118	ELECTRICAL MOTORS	Dark Blue (see Note)	5013
119	GENERAL STRUCTURE	Black	9005
	PIPES AND FITTINGS OF ALLOY STEEL AND SS MATERIAL IN STORE		
120	IBR	Signal red	3001
121	9Cr-1Mo	Verdigris green	6021
122	5Cr-0.5Mo	Satin blue	5012
123	$2_{1/4}$Cr-1 Mo	Aircraft yellow	1026
124	$1_{1/4}$Cr-½ Mo	Traffic Yellow	1023
125	SS-304	Dark blue grey	5008
126	SS-316	Dark violet	4005
127	SS-321	Navy blue	5014

SAFETY COLOUR SCHEMES				
128	DANGEROUS OBSTRUCTION	Black and alert orange band	9005	2008
129	DANGEROUS OR EXPOSED PARTS OF MACHINERY	Alert orange	2008	

Notes:

- All LPG service PSVs shall be painted in Deep Blue (RAL 5014).
- 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.
- Color code of electrical items shall be in-line with electrical deptt. specification.

Ground Colour

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

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 or any other equivalent international standard.

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.

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)

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