PROCESS FOR PAINTING OF METAL COMPONENTS AND STEEL SURFACES

1.0 GENERAL:

This standard details the process to be followed to provide a coating on metal components and technical information regarding generic of paint medium and application related information. The paint shall be applied by spray/brush/airless spray and dried by stoving/air drying. The painted surface shall be protecting the components in their environment of exposure. This specification supersedes other AA 0674111 and 0674122.

SPECIFIC DEFINITIONS:

DFT : Dry Film Thickness; the thickness of the dried or cured paint coating film.

Operating Temp. : Temperature at which painting is to be performed.

TDFT : Total Dry Film Thickness, the thickness of the total number of coatings specified after curing.

VS% : Volume Solids Percent

1.1 METHODS OF PAINT APPLICATION

The paint shall be applied in accordance with the paint manufacturer's product data sheet, which shall include the mixing ratio, the maturation time, the method of application, the use of thinners and coating intervals. The dry film thickness of individual coatings shall be as specified. Areas with inadequate coating thickness shall be thoroughly cleaned, if necessary, abraded and additional compatible coats shall be applied until they meet the required film thickness.

Painting shall not be performed when the temperature is less than 3°C above the dew point of the surrounding air or when the relative humidity of the air is greater than 85% unless local conditions dictate otherwise and the Principal is in agreement. Guidance on the estimation of the probability of condensation can be found from the Table referred in Annexure-I.

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CORPORATE STANDARD

In addition, paints shall not be applied under the following conditions:

- when the surface temperature is greater than 40°C (unless a higher temperature is recommended by the paint manufacturer).
- when the air temperature is less than 10°C (depending on local conditions).
- when there is the likelihood of an unfavorable change in the weather conditions within two hours after painting.
- when there is deposition of moisture in the form of rain, condensation, frost etc. on the surface.
- when the available light, ventilation is not adequate for painting.

If condensation, rain, dust or other foreign materials contaminate the surface of a paint coating which is not dry to the touch, the paint shall be removed, the surface re-cleaned and fresh paint is applied in accordance with this specification.

Paints shall not be applied within 50mm of edges which will later have to be welded. Such weld areas should be taped for a distance of 50mm on either side of the weld line.

Extra coats of paint shall be applied on the areas where the shape and/or plane of application result in thinly applied coatings etc., at edges, welds, corners etc. To compensate for these effects, stripes coats of paints shall be applied (normally applied first so that they will be covered by the full coat).

When zinc rich primers are used, care shall be taken to avoid any possibility of over spraying onto duplex or austenitic stainless steels, nickel alloys or 9% nickel steel components.

Note : Zinc rich primers shall not be applied on equipment made from the above mentioned materials unless such equipment is located in a shielded position which will minimise the risk of molten zinc falling onto the equipment in the event of a fire.

Proper application of protective coatings is an important criterion in giving the paint system its required life. To achieve good finish out of paint systems recommended paint putty mastic compound may be used after primer / under coat compatible with system and recommended by manufacturer.

Given below are the four main application procedures along with the advantages and disadvantages of each.

1.1.1 Brush application :

Used frequently for decorative paints, in protective coatings this is in vogue in painting complex areas where the use of spray methods would increase the loss factor. However, a word of caution about brush application, it is difficult to achieve higher thickness with a high build coating by brush application in one coat. The process is relatively slow and may result in a poor finish for thixotropic or high viscosity top coats.

1.1.2 Conventional spray:

A widely accepted method of paint application where liquid paint is atomised by an air stream. A correct combination of air pressure, air volume and fluid flow has to be selected to achieve full atomisation and a paint film free of defect. One may also face problems like sagging, pin holing and poor paint flow if the control parameters are not monitored properly.

The major disadvantage of conventional spray is that high build coatings cannot be applied by this method, as most paints have to be thinned to a suitable viscosity for satisfactory atomisation.

1.1.4 Airless spray

This is by far the fastest and most versatile method because it enables application at variable thicknesses. The equipment utilises an electric or air driven motor and a high pressure fluid pump to compress the coating to extreme pressures. The paint is then made to pass through a special tip which atomises it, and thus controls the application properties.

The main advantages of this method are :

a) High build coatings can be applied without thinning.
b) Fast rate of application achievable.
c) Reduce pollution and environmental friendly.
d) Reduced wastage of material.
e) Less air consumption and saving of power.

As already indicated, the special tips used in the spray gun and the pressure control enables one to monitor application of very low to very high viscosity products. Similarly, different slot angles produce spray fans of different widths. The selection of a particular fan width is dependent on the shape and size of the structure to be painted. The choice of fan width is also related to orifice size. For the same orifice size the paint applied per unit area will be less, wider the spray fan. The general indication of orifice sizes is given below to help in choosing the proper orifice size for a paint.

Wet film thickness	Orifice size(mm)
Upto 50 microns	0.02 – 0.03
100-200 microns	0.03 – 0.04
>200 microns	0.04 – 0.07
Mastics	0.10 – 0.15

There are several designs of tips available, the choice of which depends upon the finish required, the ease of application and ease of cleaning blockages from tips.

Table-1.

Mode of Application	FORD CUP: 4 Viscosity in secs.
Brushing	40-60
Spraying	30±2

Note: Viscosity measurement of high build epoxy paint may be done by viscometer.

Above table gives general guideline about consistency to be maintained for brush/spray/airless spray painting unless otherwise specified by paint manufacturer.

1.2 PREPARATION OF PAINT :

All industrial paints generally consist of a binder medium, pigment, thinner and accelerator. The composition of constituents varies based on performance requirements.

The primer which form first coat on a surface has higher concentration of pigments and extenders than the finish paint which has higher concentration of medium. The concentration and type of accelerator depends on drying cycle requirements. Air drying paints are generally single pack systems except aluminum paints, epoxy, polyurethane etc. Some of the stoving compositions are also available in single pack. The binder mediums generally used in paints are oil based Alkyd phenolics, epoxy, silicone, vinyl ester and urethane resins. Generic information is provided in Cl.3 of this specification. All the paint manufacturers mostly provide processing conditions to be followed before application. However, a few are given below :

(a) When the containers of air drying paints are opened, the material is observed for skin formation. The skin formed should be carefully removed and settled pigment has to be broken up and loosened by vigorous stirring preferably mechanically to ensure homogenous dispersion. Care should be taken to avoid air entrapment while stirring. The paint, if required may be strained through muslin cloth or 60mesh sieve.

(b) **Maturation process** :

Maturation is an important criterion for two pack products where curing takes place through chemical reaction when the components are mixed before application. The mixed paint is normally matured for about 30 minutes to initiate the reaction process which ensures thickness build up and proper drying of the paint film unless otherwise specified.

Maturation time is, however, to be adjusted depending on pot life and ambient temperature. Products having a short pot life should be allowed less maturation time as recommended by supplier to provide the adequate effect during film formation.

1.3 APPLICATION LOSSES AND SPREADING RATE ESTIMATION

It is extremely complicated to estimate accurately the quantity of paint required for a particular job since the theoretical spreading rate does not take into account the various “losses” involved during application.

In the following paragraphs general guidelines are described taking into account major areas of losses and to arrive at appropriate requirement. Usually two types of losses are considered : **“Apparent Losses”** where the paint-though on the surface-does not contribute to the required thickness, and **“Actual Losses”** where the paint is wasted.

Apparent Losses

Effect of blast profile: On a blasted surface the film thickness over the peaks is less than the thickness over the troughs. However, it is the thickness over the peaks which is most important in relation to performance of the paint coating and hence it can be considered that the paint which does not contribute to this thickness is “lost in the steel profile”. The extent of paint “loss” is proportional to the surface roughness produced by blasting or in other words, the dimension and type of abrasive used.

Typical “losses” in dry paint film thickness for given blast profiles are given below:

Surface	Blast profile	DFT loss
- Steel blasted using round - Shot And shop primed	0-50 microns	10 microns
- Fine open blasting	50-100 microns	35 microns
- Coarse open blasting	100-150 microns	60 microns
- Old pitted steel-reblasted	150-300 microns (or more)	125 microns (or more)

Paint distribution loss : This is loss of paint resulting from over-application when an attempt is made to achieve the minimum specified paint thickness with reasonable certainty.

The extra paint consumed over and above that calculated from the theoretical spreading rate is dependent on the method of application as well as on the type of structure being painted. A simple structure with a high proportion of flat surfaces should not incur heavy losses, but for complex structure losses will be high. Typical details given below:

Application	Type of structures	Loss(%)
Brush + Roller	Simple structures	5%
-do-	Complex structures	10-15%
Spray Air / Airless	Simple structures	20%
Spray Air / Airless	Complex structures	60% for single coat 40% for two coats 30% for three coats

When an open complex structure is sprayed, no realistic estimate can be made of paint distribution loss. In case the specification calls for a minimum thickness at all measured points, the distribution losses would be higher than those indicated above.

Actual losses: These include the paint loss during application and wastage

Application Loss: The paint which drips from a brush or roller during transfer from the container to the surface being painted can be termed as application loss. With care, this can be discounted as a significant contribution to overall “loss”.

When application is done by spraying, losses are inevitable and their extent is dependent largely on the shape of the structure being painted together with atmospheric conditions.

The following spray losses are common:

Well ventilated but confined space	5%
Outdoors in almost static air	5 – 10%
Outdoors in windy conditions	Over 20% (This figure can be abnormally high if painting is done in unsuitable windy conditions).

Paint wastage: Some wastage is inevitable like paint spill, certain amount remaining in discarded containers and in case of two pack materials mixed paint left beyond its pot life.

The following losses are common:

Single pack materials	Not more than 5%
Two pack materials	5-10%

Spreading rate estimation:

Having given by the paint supplier the theoretical spreading rate and with the preceding loss factors, it is possible to calculate the practical spreading rate, as is illustrated by the following example for guidance.

Example :

Two coats of two pack paint are to be applied by spray in a confined space to a blasted surface of complete structure to yield a DFT of 100 microns per coat. The theoretical spreading rate is 6.0 sq. mtr/ltr. What is the practical spreading rate?

	First coat
Required DFT	100 microns
Loss due to surface roughness	10 microns
Loss due to distribution 40% i.e. 100x0.4	40 microns

	150.0 microns
Loss due to application 5% i.e. 150x0.05	7.5 microns

	157.5 microns
Loss due to wastage 10% ie. 157.5x0.1	15.75 microns

	173.25 microns

Extra paint used (173.25-100) $= \frac{73.25 \times 100}{100} = 73.3\%$

		Second coat
Required DFT		100 microns
Loss due to surface roughness		Nil
Loss due to distribution 40% i.e. 100 x 0.4		40 microns
		140 microns
Loss due to application 5% i.e. 140x0.05		7 microns
		147 microns
Loss due to wastage 10% i.e. 147 x 0.1		14.7 microns
		161.7 microns
Extra paint used (161.7 – 100)	$= \frac{61.7 \times 100}{100} = 61.7\%$	
Total loss for two coats	$= \frac{73.3 + 61.7}{2}$	67.5%

In other words, for the two coat of two pack system, 67.5% more paint is required than would be calculated from the theoretical spreading rate.

Loss factors : In the above example the theoretical spreading rate is 6 sq.mtr/ltr. In practice 1.68 ltr. Of paint can be expected to cover 6 sq.mtr.
Therefore, the practical spreading rate is $\frac{6}{1.68}$ = 3.6 sq.mtr. /ltr.

The loss factor is usually expressed as the difference between the theoretical and practical spreading rates expressed as a percentage of the theoretical spreading rate. In the above example the loss factor is:

$$\frac{6 - 3.6}{6} = 40\%$$

Calculation of Volume Solids :

The volume solid of a paint can be calculated as follows :

$$\% \text{ volume solid} = \frac{\text{DFT(microns)} \times \text{Theoretical coverage(sq.mtr./ltr)}}{10}$$

The volume solids of a paint is an indicator of the mileage it will give at a specified thickness. A service life data published on life of paint with various polymeric medium in different environments is given in Table-II.

1.4 THINNER CONSUMPTION:

This is another important parameter and has to be closely monitored to obtain the desired performance from the paint film. In each Data Sheet a special section is devoted to thinner consumption which should be strictly adhered to. However, it should be noted that the mentioned quantity is only for adding to the paint. The consumption for an optimum environment depends on prevailing temperature, application methods, nature of surface, weather conditions and may require adjustment in thinner volume. The thinner used should be compatible with the paint and corresponds to the same batch of paint.

Adding a small percentage of extra thinner does not necessarily impair the film properties, but excess thinning increases the quantity of liquid paint without contributing to the solid content. The volume solid, after thinning, should be calculated and the resultant coverage worked out to achieve the recommended film thickness.

$$\text{Volume solid percentage after thinning} = \frac{\%\ \text{Volume solid} \times 100}{\%\ \text{thinner added} + 100}$$

2.0 SURFACE PREPARATION :

Surface preparation may be carried out as per BHEL STANDARD AA 0674101. However following instructions in general should be adhered to unless otherwise agreed upon

- Surfaces not to be painted shall be properly masked.
- Surfaces shall be cleaned by solvent cleaning method to remove oil, grease, dirt, cutting fluids and other contaminants.
- Surfaces to be coated shall be blast cleaned with suitable abrasive to the required surface finish for operating temperatures above 120° C and a minimum of a commercial blast cleaning for operating temperatures below 120° C.
- The average maximum blast profile shall be between 3.5 to 6.0 mils. For sand castings, average maximum surface profiles after blasting to be specified.
- All traces of abrasive and other debris shall be removed by brushing, sweeping, blowing with clean compressed air, and vacuuming before the application of any coating.

3.0 GENERIC PAINT CHARACTERISTICS:

Paint have polymeric resigns as binder mediums. These mediums are selected depending on the environment in which it has to operate.

For ease of reference, a generic description of the paint mediums are indicated below together with a specific characterisation of some of their properties.

- High solids, amine-cured epoxies:
  Polyamine-cured epoxies generally have a good resistance to chemicals and solvents.
- High build, polyamide-cured epoxies :
  Polyamide-cured epoxies exhibit a longer pot life, superior flexibility and durability compared with amine-cured epoxies. They possess adequate chemical resistance.
- High build, aliphatic polyurethanes :
  Two component isocyanate-free urethanes produce extremely hard, resistant and durable coatings. Aliphatic urethanes are preferred over aromatic urethanes because of their excellent durability and gloss retention.

- Phenolic epoxies :
  Two component, high build, amine-cured phenolic epoxy coatings have excellent resistance to a wide range of solvents and (organic) acids.

- (Alkyl) zinc silicate :
  Two component, moisture curing, zinc (alkyl) silicate coating, containing a minimum of 75% metallic zinc, is a hard, abrasion resistant coating that can withstand temperatures up to 400°C.

- Aluminium pigmented silicate :
  One component, (alkyl) silicate, zinc-free coating is suitable for temperatures up to 600°C.

- Aluminium silicones :
  Aluminium pigmented, silicone resin-based paint. Heat resistant up to 600°C. A minimum temperature of 200°C is required for 2 hours to obtain a sufficient cure.

- Silicone acrylics :
  One component, aluminium (or colour) pigmented acrylic-modified silicone resin. Heat resistant up to 350°C. Full cure can be achieved at ambient temperature.

- Zinc-rich epoxy primer :
  Two component, epoxy based primer. Developed to provide sacrificial protection to steel surfaces.

- Solvent free epoxies :
  Two component, amine cured, modified epoxies without solvent. They can be applied as a heavy duty coating up to 28 mil thick.

- Polysiloxane :
  Two component, inorganic polysiloxane. Used for heat resistance (continuous and cyclic) up to. 1110°C Current experience with this coating is good but still very limited.

- Thermally sprayed metal coatings :
  Thermally sprayed metal coatings may be used in applications where organic coatings are ineffective or cause product contamination.

- Black coal tar epoxy :
  Generally, Thixotropic amine cured two pack system. Conventional epoxy blended with high purity coal tar to impart flexibility, is mostly recommended for inner sides of water tanks.

The estimated life of the resin systems for various environments is given in Table-2.

Lead containing paints, should not be used because of the associated health and environmental restrictions that apply unless otherwise insisted upon.

Paints specifically intended for use on austenitic stainless steels or high nickel-chromium alloys shall not contain free chlorides or other halides after curing, although trace amounts in the raw materials is accepted. Chlorides or other halides tied up within the cured resin's chemical molecule are acceptable, unless they are subject to release through ageing within the temperature range specified. Such paint formulations shall also not contain metallic zinc, because of the possibility of inducing liquid metal embrittlement.

Note: It has been shown that zinc oxide or zinc phosphate, which are the more recent non-lead, non-chromate, corrosion inhibitive pigment developments, do not cause embrittlement even at 850°C.

3.1.0 <u>PREPARATION OF THE PAINT AIR DRYING ENAMEL:</u>

3.1.1 Removal of skin from the paint:

Before application, any skin formed on the paint in the container shall be carefully removed, any settled pigment broken up and loosened and the paint thoroughly stirred to ensure complete and uniform mixing of the constituents. Care shall be taken to avoid entering air into the paint while stirring. The paint shall be strained through a muslin cloth or 60 mesh sieve.

3.1.2 Consistency of the paint:

The paint shall be used at an appropriate consistency depending on the mode of application. Table 1 provides the general guidance.
The above consistency shall be adjusted using white spirit or recommended thinner to AA 56701depending on mode of application.

3.2.0 PREPARATION OF THE PAINT (ETCH PRIMER AND EPOXIDE PAINTS):

3.2.1 Etch primer:

Etch primer, as supplied, consists of two separate ingredients viz., primer base and accelerator. Shortly before use, mix together the primer base and accelerator in the proportions as per the recommendation of the supplier. The paint prepared as above does not require any thinning.

IMPORTANT NOTE:
After mixing, the paint shall be allowed to mature for 30 minutes unless otherwise specified. The mixed paint shall be used within 8 hours.

3.2.2 COMPOSITION:

The paint shall consist of a two pack system viz., base and accelerator, as per AA 56103.

Generally the base, shall consist of zinc tetroxy chromate pigment dispersed in Polyvinyl butyl resin solution while accelerator shall consists of orthophosphoric acid in suitable solutions like butanol, industrial methylated spirit, etc.

The base shall be in such a condition that uniform and smooth dispersion material is obtained by stirring. There shall not be any tendency for viscosity build up, gelling and pigment settlement throughout the shelf life of the paint.

Etch primer may be applied prior to epoxy paint wherever recommended.

3.2.3 Mixing of the constituents of epoxide paints:

a) These paints, as supplied, consist of two separate ingredients, namely base and accelerator. Shortly before mixing and use, these shall be thoroughly stirred. The base and the accelerator shall be accurately mixed together in the proportions as per the recommendations of the supplier.

   Accelerator should be added to the base but not the base to the accelerator. The paints shall be mixed with continuous stirring until a uniform consistency is obtained.

b) Consistencies of the paints :
   The paints mixed shall be used at an appropriate consistency depending on mode of application. Table 1 provides general guidance.

   Important Note:
   After mixing, the paint shall be allowed to mature for 30 minutes and the mixed paint shall be used within 8 hours, unless otherwise specified in, by the paint supplier. All other properties should be as per individual specification.

3.2.4 Safety precautions:

Etch primer and epoxy paints are liable to cause irritation to the skin. This may transpire into inflammation, swelling, rash or pustules on the hands, arms and occasionally on the whole body.

Following precautions should be observed while handling these materials:

i) Work place and storage rooms shall be adequately ventilated.
ii) Before starting the work, hands should be washed with soap and water and good barrier cream applied.
iii) Maximum care should be taken to avoid splashes on the skin
iv) Splashing on the skin should be immediately washed with soap and water.
v) After the work, hands, arms and face should be washed with soap and water followed by thorough drying with a clean towel.

3.3.0 PREPARATION OF THE PAINTS (ALUMINUM SILICON):

3.3.1 Mixing of paint material shall be in strict accordance with manufacturer’s instructions

3.3.2 Thinning shall only be done if necessary for the workability of the paint and in accordance with manufacturer’s instructions. Petroleum or mineral spirits shall be used for thinning and shall not exceed 5% by volume.

3.3.3 Application over ethyl silicate zinc-rich primer:

(a) Underlying inorganic zinc primer shall be completely cured before application of aluminum silicone topcoat.

(b) Apply one coat of aluminum silicone paint to achieve a dry film thickness of 15 - 30 µm. A thin mist coat may be necessary before full coat application to avoid top coat bubbling.

Allow to air dry for 16 hours before direct exposure to operating conditions of the heat or before curing.

All other properties should be as per relevant corporate supplier's standard.

3.4.0 PAINT APPLICATION :

3.4.1 Paint application shall comply with the requirements of individual specification and with the paint manufacturer’s printed instruction.

3.4.2 Paint shall be applied at ambient temperatures preferably not below 10^{o} C.

3.4.3 Conventional air spray or airless spray application is acceptable. Brush application is also acceptable for surfaces inaccessible to spray and for touch up coats.

3.4.4 After thorough mixing of the product of two component systems, the maturation time as indicated in the manufacturer’s product data sheet is to be allowed before applying the paint.

3.4.5 Short shelf life / two component paint mixture thickens as the time progresses and at the end of the pot life period, the mixture becomes highly viscous and unusable. It is best to consume mixed paint at least one hour before the end of the pot life.

3.4.6 Avoid using excess solvent than the recommended volumes since this leads to reduced dry film thickness, sagging and longer curing time.

3.4.7 Apply Epoxy Primer paint to achieve a dry film thickness of 35-50 microns and a coat of etch primer wherever recommended.

3.4.8 Allow the painted substrate to dry for 16 hrs before direct exposure to outside weather conditions or heat. In case of stoving paints, it is to be stoved at temperature and time specified in a suitable oven.

3.4.9 Apply a coat of finish paint after ensuring removal of dust, dirt and other contaminants from the primed surface. Intermediate coats of paints may be applied wherever recommended.

3.4.10 All measurements and instrument calibration shall be in accordance with the specification AA 067 41 05 and the data to be recorded in accordance with AA 067 41 06 for each job.

3.5.0 QUALITY CHECKS & INSPECTION:

3.5.1 Following points shall be ensured to achieve overall quality of the job:

(a) Compressed air used for spray application shall be free from oil, moisture and other contaminants.

(b) Steel surfaces to be painted shall be free from burrs, sharp edges, lamination, surface imperfections and any other contamination detrimental to paint adhesion finish or appearance.

(c) All surfaces to be coated have been cleaned in accordance with the requirements of BHEL STANDARD AA 067 4101.

(d) All surfaces to be coated shall be completely dry before paint application.

(e) Paint components shall be mixed as prescribed / recommended and mixed paint shall be consumed with in specified pot life.

(f) Drying / curing requirements shall be fully satisfied.

(g) Damaged paint coating shall be properly touched up before another coating application.

(h) All paint coating measurements like thickness gloss, finishing and adhesion shall be usable as per AA 067 41 05.

3.5.2 INSPECTION:

a) VISUAL:
The painted surfaces shall be free from spacks of iron, salt or dust. It shall be smooth and uniform and there will be no visible porosity, pot holes, or any other paint coating defects. If runs and sags dry spray and over spray are present these defects shall not be more than 5% in any given area (sq. feet) and cumulatively not more than 2% of total surface area unless otherwise specified.

b) Dry film thickness DFT: Dry film thickness should be measured with an appropriate measurement gauge calibrated as per AA 067 41 05. Unless otherwise specified.

c) ADHESION:
The adhesion of the primer to the steel substrate and the intercoat adhesion of the subsequent coat(s) after curing shall be determined by the application of a cross-cut test in accordance with BHEL Standard AA 067 41 05.

d) Gloss level: As per AA 067 41 05.

e) Finish: as per AA 067 41 05.

f) Shade: As per IS : 5 unless otherwise specified.

g) Coated surfaces are smooth and uniform in coverage.

h) There is no visible porosity or pot holes.

i) Unacceptable defects such as peeling, blistering cracking and damage caused by external sources are clearly marked with a mark-free chalk and with in thespecification requirements.

j) Runs and sags, dry spray and over spray are not present in excess of 5% in any given square foot and cumulatively not in excess of 2% of any surface. Unless otherwise specified

k) Drying time/curing time requirements have been satisfied.

l) Holiday / pinhole detection shall be conducted on all conventional thin film thickness, having total DFT 0.5mm or less, by low voltage wet sponge method as per ASTM D5162. This is carried out after top coat applied & fully cured / dried. For tank & vessel internals 100% of the surface shall be tested. Special attention shall be paid to welds, edges & irregular surfaces for holiday / pinhole testing. For external surfaces, random inspection, which shall be representation of entire surface shall be tested. No pinhole is acceptable.

3.6.0 PAINTING SCHEMES:

Selection of painting scheme has to be made on specific operational and environmental requirements. Similarly, selection of colours have to be made suitably unless both are specified by the customer. – BHEL painting scheme for various power equipment and related components is given in annexure - II. However, any deviation from number of coats and thickness specified by customer shall be followed.

Typical painting schedules for various industrial components and painting systems are also given in Annexure III and IV respectively. For general reference.

The list of BHEL Corporate Standards on Paints is enclosed in Annexure-V.

ANNEXURE-I.

RELATIONSHIP BETWEEN `DEW POINT', AIR TEMPERATURE AND RELATIVE HUMIDITY.

Air Temp. °C	`Dew Point' in °C at Relative Humidity of								
	50%	55%	60%	65%	70%	75%	80%	85%	90%
5	-5	-3	-2	-1	0	1	2	3	4
6	-3	-3	-1	0	1	2	3	4	4
7	-3	-1	0	1	2	3	4	5	5
8	-2	-1	1	2	3	4	5	6	6
9	-1	0	1	3	4	5	6	7	7
10	0	1	3	4	5	6	7	8	9
11	1	2	4	5	6	7	8	9	9
12	2	3	5	5	7	8	9	9	10
13	3	4	5	6	8	9	10	10	11
14	4	5	6	7	8	10	11	12	12
15	5	6	7	8	9	11	12	12	13
16	5	7	8	9	10	12	12	13	14
17	7	8	9	10	12	12	14	14	15
18	7	9	10	11	12	13	14	15	16
19	8	10	11	12	13	14	15	16	17
20	9	11	12	13	14	15	16	17	18
21	10	12	13	14	15	16	17	18	19
22	11	13	14	15	16	17	18	19	20
23	12	14	15	16	17	18	19	20	21
24	13	14	16	17	18	19	20	21	22
25	14	15	17	18	19	20	21	22	23
26	15	16	18	19	20	21	22	23	24
27	16	17	18	20	21	22	23	24	25
28	17	18	19	21	22	23	24	25	26
29	18	19	20	22	23	24	25	26	27
30	18	20	21	23	24	25	26	27	28

BHEL PAINTING SCHEME FOR PRODUCT Annexure II

Sl. No.	System	Environment (See note 1)	General description	** Painting Scheme reference	Total Dry film Thickness, In µm TDFT	Remarks
1	Power Boiler	Rural	Epoxy Two pack (organic) Zinc rich and Two pack Polyurethane.	1	80	
		Industrial	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane.	2	180	
		Coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	3	180	
		Industrial and coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	8	180	
2	HRSG /Industrial Boilers	Rural	Chlorinated Rubber Based, chemical resistant	4	120	
		Industrial	Epoxy Two pack (Organic) Zinc rich and Epoxy Two pack chemical resistant and Two pack Polyurethane	5	155	
		Coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	3	180	
		Industrial and Coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	8	180	
3	Column, Pressure Vessel, Heat Exchanger	Rural	Epoxy Two pack (organic) Zinc rich and Two pack Polyurethane	1	80	
		Industrial	Epoxy Two pack (organic) Zinc rich, Epoxy Two pack chemical resistant and Two pack Polyurethane	5	155	

** **Refer Annexure - II (a)**

Note -1 : The painting scheme specified provides life to first maintenance of 5 years, under specified environment.

II Continued..

Sl. No.	System	Environment (See note 1)	General description	** Painting Scheme reference	Total Dry film Thickness, in µm TDFT	Remarks
		Coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	3	180	
		Industrial and Coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane.	8	180	
4	Tankage	Rural	Chlorinated Rubber Based, chemical resistant	4	120	
		Industrial	Epoxy Two pack chemical resistant and Two pack Polyurethane	7	175	
		Coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	3	180	
		Industrial and coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	8	180	
5	Rotating Equipment, Pumps, Compressors	Rural	Epoxy Two pack (organic) zinc rich and Epoxy Two pack chemical resistant and Two pack Polyurethane	5	155	
		Industrial	Epoxy Two pack chemical resistant and Two pack Polyurethane	7	175	
		Coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	3	180	
		Industrial and coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	8	180	

**** Refer Annexure - II (a)**

II Continued..

Sl. No.	System	Environment (See note 1)	General description	** Painting Scheme reference	Total Dry film Thickness, in µm TDFT	Remarks
6	Piping Valve Fittings	Rural	Chlorinated Rubber based, chemical resistant	4	120	
		Industrial	Epoxy Two pack chemical resistant and Two pack Polyurethane.	7	175	
		Coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	3	180	
		Industrial and coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	8	180	
7	Transformers Tank conservation Bushing Turact Header, Piping work support structure	Rural	Epoxy Two pack (organic) Zinc rich and Two pack Polyurethane.	1	80	
		Industrial	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	2	180	
		Coastal	Epoxy Two pack chemical resistant and Two pack Polyurethane	7	175	
		Industrial and Coastal	Inorganic alkyl Zinc silicate, Epoxy Two pack chemical resistant and Two pack Polyurethane	8	180	
8	Control Cubicles	For indoor installation	Epoxy Two pack chemical resistant and Two pack Polyurethane	10	170	appln. Only by spray

**** Refer Annexure -I I (a)**

Note 1: Rural = Exterior, Exposed non-polluted inland atmosphere, operating temperature upto 90° C
Industrial = Exterior, Exposed polluted inland atmosphere, operating temperature upto 90° C
Coastal = Exterior, Exposed non-polluted inland atmosphere, operating temperature upto 90° C
Industrial & Coastal = Exterior, Exposed polluted inland atmosphere, operating temperature upto 90° C

Note 2: For operating temperature 91 - 400 ° C and 401 to 600 ° C, the painting scheme reference no: 6 and no: 9 respectively shall be followed

BHEL Painting Schemes Details ANNEXURE - II (a)

Paint reference Scheme	Surface Prepn. Grade/ Surface profile	Primer Coat			Intermediate coat			Finish coat			Total DFT, in µm
		Primer paint	No. of coats	DFT in µm	Intermediate paint	No. of coats	DFT in µm	Finish paint (See note)	No. of coats	DFT in µm	
1	Shot Blasting to Sa 2 1/2 35 to 50 µm	Epoxy zinc rich primer (Two pack) AA 561 14	1	50	- -	--	--	Full gloss polyurethane finishing paint AA 561 42	1	30	80
2	Shot Blasting to Sa 2 1/2 35 to 50 µm	Inorganic Ethyl zinc silicate primer AA 561 13	1	75	High build intermediate Epoxy paint AA 561 12	1	75	Full gloss Polyurethane finishing paint AA 561 42	1	30	180

CORPORATE STANDARD

II (a) Continued….

Note: The shade of finish paint shall be decided based on the option of concerned unit / customer's requirement.

Paint reference Scheme	Surface Prepn. Grade/ Surface profile	Primer Coat			Intermediate coat			Finish coat			Total DFT, in µm
		Primer paint	No. of coats	DFT in µm	Intermediate paint	No. of coats	DFT in µm	Finish paint (See note)	No. of coats	DFT in µm	
3	Shot Blasting to Sa 2 1/2 35 to 50 µm	Inorganic Ethyl zinc silicate primer t AA 561 13	1	75	High build intermediate epoxy paint AA 561 12	1	75	Full gloss Polyurethane finishing paint t AA 561 42	1	30	180
4	Shot Blasting to Sa 2 1/2 35 to 50 µm	Chemical resistant Chlorinated Rubber base priming paint AA 561 07	2	70				Chemical resistant chlorinated rubber based finishing paint AA 561 36	2	50	120

II (a) Continued….

Paint reference Scheme	Surface Prepn. Grade/ Surface profile	Primer Coat			Intermediate coat			Finish coat			Total DFT, in µm
		Primer paint	No. of coats	DFT in µm	Intermediate paint	No. of coats	DFT in µm	Finish paint (See note)	No. of coats	DFT in µm	
5	Shot Blasting to Sa 2 1/2 35 to 50 µm	Epoxy based zinc rich primer (Two pack) AA 561 14	1	50	High build intermediate Epoxy paint AA 561 12	1	75	Full gloss Polyurethane finishing paint AA 561 42	1	30	155
6	Shot Blasting to Sa 2 1/2 35 to 50 µm	Inorganic Ethyl zinc silicate primer AA 561 13	1	75				Heat resistant air dry Aluminium paint Gr - I AA 561 49	2	40	115
7	Shot Blasting to Sa 2 1/2 35 to 50 µm	Chemical resistant epoxide redoxide zinc phosphate priming paint AA 561 05	2	70	High build intermediate epoxy paint AA 561 12	1	75	Full gloss Polyurethane finishing paint AA 561 42	1	30	175

CORPORATE STANDARD

II (a) Continued….

Paint reference Scheme	Surface Prepn. Grade/ Surface profile	Primer Coat			Intermediate coat			Finish coat			Total DFT, in µm
		Primer paint	No. of coats	DFT in µm	Intermediate paint	No. of coats	DFT in µm	Finish paint (note See)	No. of coats	DFT in µm	
8	Shot Blasting to Sa 2 1/2 35 to 50 µm	Inorganic Ethyl zinc silicate primer t AA 561 13	1	75	High build intermediate epoxy paint AA 561 12	1	75	Full gloss Polyurethane finishing paint AA 561 42	1	30	180
9	Shot Blasting to Sa 2 1/2 35 to 50 µm	Two pack, air drying heat resistant Polysilaxone paint AA 561 43	1	100	--	--	--	--	--	--	100

II (a) Continued….

Paint reference Scheme	Surface Prepn. Grade/ Surface profile	Primer Coat			Intermediate coat			Finish coat			Total DFT, in µm
		Primer paint	No. of coats	DFT in µm	Intermediate paint	No. of coats	DFT in µm	Finish paint (See note)	No. of coats	DFT in µm	
10	Shot Blasting to Sa 2 1/2 35 to 50 µm or Phospha-ting to coating weight of 16.15 gm per sq.m	Chemical resistant epoxide redoxide zinc phosphate priming paint AA 561 05	1	35	High build intermediate epoxy paint AA 561 12	1	75	Full gloss Polyurethane finishing paint AA 561 42	2	60	170

ANNEXURE-III

TYPICAL PAINTING SCHEDULE

PIPING, VESSELS, COLUMNS, EXCHANGERS, REACTORS, STRUCTURAL STEEL AND FIRE-FIGHTING SYSTEMS.

ITEM	OPERATING TEMPERATURE (°C)	SUBSTRATE	PAINT SYSTEM No.(Annexure-V)
PIPING, VESSELS, COLUMNS, EXCHANGERS, REACTORS etc.	<120	Carbon steel, low alloy steel	1
	<120	9% Ni steel	2
	120-200	Carbon steel, low alloy steel	3
	200-450	Carbon steel low alloy steel	4
	Ambient – 200	Stainless steel	5
	200-450	Stainless steel	6
	Ambient – 1100	Carbon steel, stainless steel	7*
STRUCTURAL STEEL, LADDERS, GRATINGS etc.	-	Carbon steel, low alloy steel	1
	-	Hot dip galvanized carbon steel	8**
FIRE FIGHTING SYSTEMS(above ground)	<120	Carbon steel	9

* Current experience with this polysiloxane coating is good but still very limited.

** This duplex system shall only be applied to hot dip galvanized steel in cases where access for future maintenance is difficult.

ANNEXURE-III (continued..)

ITEM		OPERAT-ING TEMPERA-TURE (°C)	SUBSTRATE	PAINT SYSTEM NUMBER (Annexure-V)
CRUDE OIL TANKS BOTTOM and LOWEST SHELL COURSE	INTERNAL Non-corrosive	<80	Carbon steel, low alloy steel	10*
	INTERNAL Corrosive	<80	Carbon steel, low alloy steel	11
CRUDE OIL TANKS ROOF and SHELL	INTERNAL	<80	Carbon steel, low alloy steel	10*
	EXTERNAL	<80	Carbon steel, low alloy steel	1
STORAGE TANKS	INTERNAL	<120	Carbon steel, low alloy steel	10*
	EXTERNAL	<120	Carbon steel Low alloy steel	1
		50-200	Stainless steel	5
	INTERNAL, Chemical Resistant	<60	Carbon steel, Low alloy steel	12
	INTERNAL Industrial water **	<80	Carbon steel, low alloy steel	11
LPG SPHERES and BULLETS	INTERNAL	<120	Carbon steel, low alloy steel	10
	EXTERNAL	<120	Carbon steel, low alloy steel	1
MOUNDED LPG STORAGE ***	EXTERNAL	Ambient	Carbon steel	13

* This treatment is a shop-applied temporary protection only. No further painting is required after construction.

** Primer is optional for use in industrial water tanks

*** For full details about this system, manufacturer's instructions may be followed.

Annexure-III (Continued…)

ITEM	OPERATING TEMPERATURE (° C)	SUBSTRATE	PAINT SYSTEM NUMBER (Annexure-V)
FURNACES, STACKS, FLARE STACKS And FLUE DUCTS	<120	Carbon steel, low alloy steel	1
	120-200	Carbon steel, Low alloy steel	3
	200-550	Carbon steel, Low alloy steel	14
	<400	Carbon steel, hot-dip galvanised*	15
	<200	Stainless	5
	200-450	Stainless	6
	Ambient-1100	Carbon steel, stainless steel	7**
OFF SHORE STRUCTURES, TIDAL ZONES	<120	Carbon steel, Low alloy steel	11
TOP SIDDE FACILITIES, EQUIPMENT and PIPING	<120	Carbon steel, Low alloy steel	9
	120-200	Carbon steel, Low alloy steel	3

* For long life time service (>20 years) a hot dip galvanised duplex system is preferred.

** Current experience with this polysiloxane coating is good but still very limited.

ANNEXURE-IV

TYPICAL PAINT SYSTEMS.

SYS. No.	SURFACE PREPARATION	PAINT SYSTEM		
		Primer	Inter-coat	Top-coat
1	Sa 2 ½	Alkyl zinc silicate DFT 75 microns	High build, epoxy sealer DFT 75 microns	High build, aliphatic polyurethane DFT 75 microns
2	Sa 2 ½	High build, polyamide cured, (zinc free) epoxy DFT 100 microns	-	High build, high solids, polyamide-cured epoxy DFT 100 microns
3	Sa 2 ½	Alkyl zinc silicate DFT 75 microns	-	2 coats silicone acrylic TDFT 60 microns
4	Sa 2 ½	Alkyl zinc silicate	-	2coats heat resistant, aluminium silicone TDFT 50 microns
5	Light sweep blast (steam clean if not possible)	Silicone Acrylic DFT 25 mic.	-	Silicone acrylic DFT 25 microns
6	Light sweep blast (steam clean if not possible)	Heat-resistant, Aluminium silicone DFT 25 micrones	-	Heat resistant, aluminium silicone DFT 25 microns
7	Carbon steel SA 2 ½ Stainless steel- sweep blast to surface profile of 40 microns		Polysiloxane DFT 125 microns	Polysiloxane DFT 125 microns
8.	Hot dip galvanized after light sweep blast	Zinc-rich epoxy primer DFT 40 mic.	-	High build, aliphatic polyurethane DFT 100 microns
9	Sa 2 ½	Alkyl zinc silicate DFT 75 microns	Polyamide cured, MIO pigmented, Epoxy tie coat DFT 40 mic.	2coats high solids Aluminium-pigmented epoxy TDFT 200 microns

Annexure-IV (Continued…)

SYS. No.	SURFACE PREPARATION	PAINT SYSTEM		
		Primer	Inter-coat	Top-coat
10	Sa 2 ½	Zinc-rich epoxy DFT 25 microns	-	-
11	Sa 2 ½	Polyamide-cured epoxy primer DFT 75 microns	-	Solvent-free high solids, amine-cured epoxy DFT 500 microns
12	Sa 2 ½	Amine cured, phenolic epoxy primer DFT 100 microns	Amine adduct-cured, Phenolic epoxy DFT 100 microns	High build, amine adduct-cured epoxy DFT 100 microns
13	Sa 2 ½	-	-	Solvent-free, high solids epoxy (hot applied) DFT 800 microns
14	SA 2 ½	Zinc silicate DFT 75 microns	-	Alkyl silicate Aluminium-pigmented DFT 40 microns
15	Hot dip galvanized (slightly sweep blast if aged)	Zinc-rich epoxy primer DFT 75 microns	Polyamide-cured, MIO pigmented, Epoxy tie coat DFT 40 mic.	High solids, Aluminum-pigmented epoxy DFT 100 microns

ANNEXURE-V.

LIST OF CORPORATE PAINT SPECIFICATION.

AA 561 01	ANTI-CORROSIVE PRIMING PAINT
AA 561 03	ETCH PRIMER
AA 561 05	CHEMICAL RESISTANT EPOXIDE RED OXIDE ZINC PHOSPHATE PRIMING PAINT
AA 561 07	CHEMICAL RESISTANT CHLORINATED RUBBER BASED PRIMING PAINT.
AA 561 11	ALKYD BASE RED OXIDE ZINC PHOSPHATE ANTI CORROSIVE PRIMING PAINT
AA 561 12	HIGH BUILD INTRMEDIATE EPOXY PAINT
AA 561 13	INORGANIC ETHYL ZINC SILICATE PRIMER
AA 561 14	EPOXY BASED ZINC RICH PRIMER -TWO PACK
AA 561 26	HIGH QUALITY FULL GLOSSY OUTDOOR FINISHING PAINT
AA 561 27	NON-YELLOWING FULL GLOSSY WHITE PAINT
AA 561 28	ALUMINIUM PAINT FOR GENERAL PURPOSES
AA 561 31	CHEMICAL RESISTANT EPOXIDE FINISHING PAINT
AA 561 32	OIL RESISTANT, AIR DRYING, SYNTHETIC ENAMEL
AA 561 34	HEAT RESISTANT AIR DRY ALUMINIUM PAINT - Gr. 2 (TEMPERATURE UPTO 400^0 C)
AA 561 35	HIGH BUILD BLACK COAL TAR EPOXIDE PAINT
AA 561 36	CHEMICAL RESISTANT CHLORINATED RUBBER BASED FINISHING PAINT .
AA 561 40	EXTRA HIGH BUILD BLACK COAL TAR EPOXIDE PAINT
AA 561 42	POLY URETHANE FINISHING PAINT
AA 561 43	TWO PACK, AIR DRYING, HEAT RESISTANT POLYSILOXANE PAINT.
AA 561 49	HEAT RESISTANT AIR DRY ALUMINIUM PAINT - Gr.1 (TEMPERATURE UPTO 600^0 C)
AA 561 59	EPOXY POLYESTER POWDER COATING MATERIAL
AA 561 60	EPOXY POWDER COATING MATERIAL

CORPORATE STANDARD

TABLE - II
Estimated Service Life Years, Before First Maintenance Painting) of Paint Protective Coating, Galvanizing and Zinc-Rich Systems.

Sl. No.	Number of coats	Coating system	Surf. Prep SSPC *	Minimum DFT mill or microns.	Maint.sched	Sea coast Maint.	Sea coast Heavy Industrial	Caustic	Acid	Fresh water Immersion	Salt water / Brine immersion	Ammonia	Chlorine	Solvents / Gasoline	Mild	Moderate	severe	Dry heat resistance °C
1	2	Alkyd primer/top	2/3	4.0 100	I	1	1	0.5	0.5	N	N	0.5	0.5	0.5	3	2	1	66-94
2	3	Alkyd primer/top	2/3	6.0 150	I	2	2	1	1	N	N	1	1	1	6	4	2	66-94
3	2	Alkyd primer/ silicone alkyd	6	4.0 100	I	2.5	2.5	1	1	N	N	1	1	1	7	5	2.5	149-177
4	2	Universal primer /HB epoxy	2/3	6.0 150	I	4	3	3	2	N	N	3	2	3	7	5	3	121-149
5	3	Universal primer/ HB epoxy/ Acrylic polyurethane	2/3	7.5 180	I	5	3	3	3	N	N	3	3	3	9	6	4	149
6	2	Epoxy primer / HB epoxy	2.3	6.0 150	I	4	3	3	2	N	N	3	2	3	7	5	3	121-149
7	2	Epoxy zinc/ HB epoxy/ Acrylic polyurethane	6	7.0 175	I P	6 9	3 4.5	3 4.5	4 6	N N	N N	3 4.5	4 6	5 7.5	11 16.5	8 12	5 7.5	149
8	3	Epoxy zinc/HB Epoxy / Acr. Ure	10	9.0 225	I P	8 12	6 9	6 9	7 10.5	N N	N N	6 9	7 10.5	6 9	15 19.5	10 15	7 10.5	149

* Rust grades as per SSPC Vis-2 or SSPC D- 610: