

**CONSTRUCTION STANDARD
FOR
PAINTING**

CONTENTS :	PAGE No.
1. SCOPE	3
2. REFERENCES	3
3. UNITS	4
4. DEFINITIONS & TERMINOLOGY.....	4
5. GENERAL REQUIREMENTS.....	11
6. PAINT MATERIALS	14
7. PAINT APPLICATION COLOR CODING.....	14
8. COMPONENTS OR WORK PIECES	17
9. INSPECTION AND TESTING.....	18
10. QUALITY SYSTEMS.....	18
11. PROCEDURE QUALIFICATION.....	19
12. METAL SURFACE TREATMENTS (CONVERSION COATINGS).....	19
13. PREPARATION OF PAINT FOR USE.....	20
14. APPLICATION METHODS OF PAINT.....	22
15. APPLICATION PROCEDURES FOR GENERIC GROUP OF PAINT	27
16. PAINTING OF FERROUS METALS.....	29
17. PAINTING OF NON-FERROUS METALS INCLUDING METAL COATED SURFACES	34
18. PAINTING OF PLASTER, CONCRETE, BRICK, BLOCK AND STONE.....	37
19. PAINTING OF WOOD	39
20. DRYING AND HANDLING	41
21. CLEAN-UP	41
22. INSPECTION PROCEDURE.....	42
23. SAFETY.....	51
 APPENDICES:	
 APPENDIX A PAINT SCHEDULES FOR NON METALLIC SURFACES	54

TABLES :

TABLE A.1	PAIN T SYSTEMS FOR PLASTER, CONCRETE, BRICK, BLOCK AND STONE (INTERNAL)	55
TABLE A.2	PAIN T SYSTEMS FOR PLASTER, CONCRETE, BRICK, BLOCK AND STONE (EXTERNAL)	56
TABLE A.3	MISCELLANEOUS PRIMERS FOR BUILDING.....	57
TABLE A.4	UNDERCOATS FOR BUILDING.....	57
TABLE A.5	PIGMENTED FINISHES FOR BUILDING.....	58
TABLE A.6	PAIN T SYSTEMS FOR WOOD, INTERNAL AND EXTERNAL	61
TABLE A.7	PRIMERS FOR WOOD.....	62
TABLE A.8	NATURAL FINISH SYSTEMS FOR WOOD, EXTERNAL AND INTERNAL.....	63
TABLE A.9	NATURAL FINISHES FOR WOOD.....	65
ATTACHMENT	66

1. SCOPE

This construction Standard gives the minimum requirements for initial construction and maintenance painting of surfaces.

This Standard also gives minimum requirements for painting of ferrous metals, non ferrous metals, which will be exposed to different corrosive environments. Painting of non-metallic surfaces (e.g. plaster concrete, brick, stone, block and wood) is included in Appendix A.

This Standard is intended for corrosion protection of structures in oil, gas and petrochemical industries mainly for refineries, chemical and petrochemical plants, gas plants, above ground facilities of gas transmission and distribution systems, marine and off shore facilities and ships, building, and where applicable in exploration, production and new ventures.

This construction standard is limited to the liquid applied (usually by brush, or spray) of paint and coating materials, that are commonly used for corrosion protection in atmospheric or immersion service.

Definitions, and test methods for quality control are also specified here in this Standard.

The paint schedule for non metallic surfaces is discussed in the Appendix, while selection of paint systems for metallic structures surfaces, specially steel, reference shall be made to IPS-E-TP-100 "Paints". Metal surface treatments (conversion coatings) are given as Attachment to this Standard.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor.

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

B-117	"Method of Salt Spray (Fog) Testing"
B-201	"Method of Abortion Testing"
B-449	"Method of Adhesion Testing"
D-714	"Method for Evaluating Degree of Blistering of Paints"
D-822	"Weatherometer Testing"
D-2092	"Practices for Preparation of Zinc Coated Galvanized Steel Surfaces for Painting"
D-2792	"Solvent Resistance Testing"
F-941-85	"Inspection of Marine Surface Preparation and Coating Application"
F-1133-88	"Inspecting the Coating System of Ship"

AWWA (AMERICAN WATER WORKS ASSOCIATION)

C-203	"Standard Specification for Coal Tar Protective Coating and Lining for Steel Water Pipelines"
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BSI (BRITISH STANDARDS INSTITUTION)

BS 1133	"Temporary Protection of Metal Surfaces Against Corrosion"
BS 2015	"Glossary of Paint Terms"
BS 2562	"Protection of Iron and Steel Against Corrosion and Oxidation at Elevated Temperature"
Part 2	

BS 2992	"Specification for Painters' and Decorators' Brushes for Local Authorities and Public Institutions"
BS 3189	"Phosphate Treatment of Iron and Steel"
BS 3900 part C5-(75)	"Determination of Film Thickness"
BS 4310	"Specification for Permissible Limit of Lead in Low Lead Paint and Similar Material Specification for Ready Mixed Aluminum Priming"
BS 4756	"Paint for Wood Work"
BS 4764	"Specification for Powder Cement Paint"
BS 4842	"Specification for Organic Coating for Aluminum Alloy"
BS 5082	"Specification for Water-Borne Priming Paints for Wood Work"
BS 5358	"Specification for Solvent Borne Priming Paints for Wood Work"
BS 5493	"Protective Coating of Iron and Steel Structure Against Corrosion"
BS 6150	"Painting of Building"

IPS (IRANIAN PETROLEUM STANDARDS)

C-TP-101	"Surface Preparation"
E-GN-100	"Units"
E-SF-100	"Classification of Fire and Fire Hazard Properties"
E-SF-420	"Safety for Scaffolds"
E-SF-900	"Noise and Vibration"
E-TP-100	"Paints"

ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

9004	"Quality Management and Quality System Elements Guide Lines"
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SSPC (STEEL STRUCTURE PAINTING COUNCIL)

SSPC-Vol. 1	"Good Painting Practice"
SSPE-Vol. 2	"Systems and Specification"

3. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

4. DEFINITIONS & TERMINOLOGY (see also IPS-E-TP-100, IPS-C-TP-101 and BS 2015)

Acrylic latex

Aqueous dispersion, thermoplastic or thermosetting, of polymers or copolymers of acrylic acid, methacrylic acid, esters of these acids, or acrylonitrile.

Acrylic resin

A synthetic resin made from derivatives of acrylic acid.

Additive

Any substance added in small quantities to another substance, usually to improve properties.

Adhesion

State in which two surfaces are held together by interfacial forces which may consist of valence forces or interlocking action, or both.

Aging

Storage of paints, varnishes, etc. (under defined conditions of temperature, relative humidity, etc.) in suitable containers, or as dry films of these materials, for the purpose of subsequent tests.

Airless spraying

Process of atomization of paint by forcing it through an orifice at high pressure. This effect is often aided by the flashing (Vaporization) of the solvents, especially if the paint has been previously heated.

Aliphatic solvents

Hydrocarbon solvents compounded primarily of paraffinic and cycloparaffinic (Naphthenic) hydrocarbon compounds. Aromatic hydrocarbon content may range from less than 1% to about 35%.

Alkyd resins

Synthetic resins formed by the condensation of polyhydric alcohols with polybasic acids. They may be regarded as complex esters. The most common polyhydric alcohol used is glycerol, and the most common polybasic acid is phthalic anhydride. Modified alkyds are those in which the polybasic acid is substituted in part by monobasic acid, of which the vegetable oil fatty acids are typical.

Aluminum paint

Coating consisting of a mixture of metallic aluminum pigment in powder or paste form dispersed in a suitable vehicle.

Aluminum paste

Metallic aluminum flake pigment in paste form, consisting of aluminum, solvent, and various additives. The metallic aluminum pigment can be in the form of very small, coated leaves or amorphous powder, known under the respective designations of "leafing" and "nonleafing".

Anchor pattern

See surface profile.

Anti-corrosion paint or composition

Coating used for preventing the corrosion of metals and, more particularly, specially formulated to prevent the rusting of iron and steel.

Anti fouling paint

Paint used to prevent the growth of barnacles and other organisms on ships' bottoms, usually containing substances poisonous to organisms.

Aromatic solvents

Hydrocarbon solvents comprised wholly or primarily of aromatic hydrocarbon compounds. Aromatic solvents containing less than 80% aromatic compounds are frequently designated as partial aromatic solvents.

Binder

Nonvolatile portion of the liquid vehicle of a coating. It binds or cements the pigment particles together and the paint film as a whole to the material to which it is applied. The amount of binder needed to completely wet a pigment is determined primarily by the particle size, shape, chemical composition, and density of the pigment; and the particle size, degree of polymerization and wetting properties of the binder.

Bituminous coating

Asphalt or tar compound used to provide a protective finish.

Blistering

Formation of dome-shaped projections in paints or varnish films resulting from local loss of adhesion and lifting of the film from an underlying paint film (intercoat blistering) or the base substrate.

Brushing

Application of a coating by means of a brush.

Cathodic protection

A technique to reduce the corrosion rate of a metal surface by making it a cathode of an electrochemical cell.

Cement paint

Paint supplied in dry powder form, based essentially on Portland cement, to which pigments are sometimes added for decorative purposes. This dry powder paint is mixed with water immediately before use.

Chemical conversion coating

A treatment, either chemical or electrochemical, of the metal surface to convert it to another chemical form which provides an insulating barrier of exceedingly low solubility between the metal and its environment, but which is an integral part of the metallic substrate. It provides greater corrosion resistance to the metal and increased adhesion of coatings applied to the metal examples are phosphate coatings on steel.

Chlorinated rubber

Resin formed by the reaction of rubber with chlorine. Unlike rubber, the resulting product is readily soluble and yields solutions of low viscosity. It is sold as white powder, fibers, or as blocks. Commercial products generally contain about 65% chlorine. It has good chemical resistance properties. Mostly chlorinated polymers are now used, i.e., 1-butane, polyethylene, etc.

Coal tar epoxy coating

Coating in which binder or vehicle is a combination of coal tar with epoxy resin.

Coal tar urethane coating

Coating in which binder or vehicle is a combination of coal tar with a polyurethane resin.

Coating

Generic term for paints, lacquer, enamels, etc. A liquid, liquifiable or mastic composition that has been converted to a solid protective, decorative, or functional adherent film after application as a thin layer.

Coating system

A number of coats separately applied in a predetermined order at suitable intervals to allow for drying or curing.

Contractor

The contractor is the party which carries out all or part of the design, engineering, procurement, construction and commissioning for the project.

The company may sometimes undertake all or part of the duties of the contractor.

Conversion coatings

See chemical conversion coating.

Cure

To change the properties of a polymer system into a final, more stable, usable condition by the use of heat, radiation, or reaction with chemical additives.

Dew point

The temperature at which moisture will condense.

Drying time

Time required for an applied film of coating to reach the desired stage of cure, hardness, or nontackiness.

Dry-to-handle time

Time interval between the application of the coating and its ability to receive the next coat satisfactorily.

Dry-to-recoat time

Time interval between the application of the coating and its ability to receive the next coat satisfactory.

Dry-to-touch time

Interval between application and tack-free condition.

Emulsifier

Substance that intimately mixes, modifies the surface tension of colloidal droplets, and disperses dissimilar materials ordinarily immiscible, such as oil and water, to produce a stable emulsion.

The emulsifier has the double task of promoting the emulsification and of stabilizing the finished product.

Emulsion paint

A paint, the vehicle of which is an emulsion of binder in water. The binder may be oil, oleoresinous varnish, resin or other emulsifiable binder. Not to be confused with a latex paint in which the vehicle is a latex.

Engineer

The person, firm, or employee representing the purchaser for adequacy of design and quality assurance.

Epoxy resin

Cross-linking resins based on the reactivity of the epoxide group. One common type is the resin made from epichlorhydrin and bisphenol A. Aliphatic polyols such as glycerol may be used instead of the aromatic bisphenol A or bisphenol F.

Etch

To roughen a surface by a chemical agent prior to painting in order to increase adhesion (see IPS-C-TP 101).

Etching primer

A priming paint usually supplied as two separate components which require to be mixed immediately prior to use and thereafter are usable for a limited period only. These materials are also known as "Pretreatment Primers, Wash Primers" and Self Etch Primers" (see IPS-E-TP-100).

External rendering

The application of coat of mortar over external of framework.

Finish coat (Top coat)

Final coat in a painting system.

Field painting

Surface preparation and painting operation of structural steel or other materials conducted at the project site.

Fungicide

Paint additive that discourages the growth of fungi.

Hand cleaning

Surface preparation using hand tools such as wire brushes, scrapers, and chipping hammers (see IPS-C-TP-101).

Hazard

The likelihood that injury will result when a substance or object is used in a particular quantity or manner. Note that, properly speaking, there are no hazardous substances or objects, only hazardous ways of using them.

High-solids coatings

Generally, a coating that contains at least 70% solids by volume. The term "higher solids" is more appropriate for coatings which have a higher percentage of solids than previous (conventional) formulations but still contain less than 70% solids by volume.

Inhibitor

General term for compounds or materials that slow down or stop an undesired chemical change such as corrosion, oxidation or polymerization, drying, skinning, mildew growth, etc.

Inhibitive pigment

Pigment that assists in the prevention of corrosion or some other undesirable effect.

Inorganic coatings

Coating based on silicates or phosphates and usually used pigmented with metallic zinc. Also see cement paint and zinc-rich primer.

Inspector

The inspector or engineer employed by the purchaser and acting as the purchaser's representative, the inspector's respective assistants properly authorized and limited to the particular duties assigned to them, or the purchaser acting as the inspector.

Lacquer

Coating composition that is based on synthetic thermoplastic film-forming material dissolved in organic solvent and that dries primarily by solvent evaporation. Typical lacquers include coatings based on vinyl resins, acrylic resins, chlorinated rubber resins, etc.

Lining

Any sheet or layer of material attached directly to the inside face of form work to improve or alter quality and surface texture.

Manufacturer

The person, firm, or corporation that manufactures and provides the primer and cold-applied tape under the provisions of this Standard.

May

Is used where a provision is completely discretionary.

Paint

Any pigmented liquid, liquifiable, or mastic composition designed for application to a substrate in a thin layer that is converted to an opaque solid film after application. Used for protection, decoration or identification, or to serve some functional purpose.

Pigment

Finely ground, natural or synthetic, inorganic or organic, insoluble dispersed particles (powder) that, when dispersed in a liquid vehicle to make paint, may provide in addition to color many of the essential properties of paint: opacity, hardness, durability, and corrosion resistance.

Pinhole

Film defect characterized by small pore-like flaws in a coating which extend entirely through the applied film and have the general appearance of pin pricks when viewed by reflecting light. The term is rather generally applied to holes caused by solvent bubbling, moisture, other volatile products, or the presence of extraneous particles in the applied film.

Plaster

A cementitious material, when mixed with a suitable amount of water, forms a plastic mass or paste which when applied to surface, adheres to it and subsequently hardens.

Precast concrete

A concrete member that is cast and cured in other than its final position.

Prefabrication primer

Quick-drying material applied as a thin film to a metal surface after cleaning, e.g., by a blast cleaning process, to give protection for the period before and during fabrication. Prefabrication primers shall not interfere seriously with conventional welding or cutting operations or give off toxic fumes during such operations (see IPS-E-TP-100).

Pretreatment

Usually restricted to mean the chemical treatment of unpainted metal surface before painting (see Section 12).

Pretreatment primer

See etching primer.

Profile

See surface profile.

Rust

The reddish, brittle coating formed on iron or ferrous metals resulting from exposure to humid atmosphere or chemical attack.

Salt spray test

Test applied to metal finishes to determine their anti-corrosive properties, involving the spraying of common salt (sodium chloride) solution on the surface of a coating steel panel.

Spraying

Method of application in which the coating material is broken up into fine mist that is directed onto the surface to be coated. This atomization process is usual, but not necessarily, effected by a compressed air jet.

Threshold limit value (LTD)

A concentration of air-borne material that experts agree can be inhaled for a working lifetime by almost all workers without any injury. The few workers who will be affected will develop their symptoms so slowly that periodic medical examination can be expected to detect them while the effects are still reversible (see Table 7).

Wash primer

See etch primer.

Wood preservation

Treatment of wood with chemical substances which reduces its susceptibility to deterioration by fungi, insects, marine borers.

Zinc-rich primer

Anti-Corrosive primer for iron and steel incorporating zinc dust in a concentration sufficient to give electrical conductivity in the dried film, thus enabling the zinc metal to corrode preferentially to the substrate, i.e., to give galvanic protection (see IPS-E-TP-100).

5. GENERAL REQUIREMENTS

5.1 All surfaces shall receive an appropriate paint system as specified by the company with reference to IPS-E-TP-100 with the following exceptions:

- any equipment furnished completely painted by the manufacturer unless it is specially required to match a color scheme or to repair damage to the paint film;
- hot-dip galvanized steel, weathering steel, stainless steel and non-ferrous metals, monel, brass, copper, aluminum jacketing, unless it is specially required;
- nonmetallic surface;
- nameplates, code stampings and push-buttons;
- surfaces to be fireproofed;
- concrete, brickwork, tile, glass and plastics, unless specially required;
- machined surfaces;
- insulation weatherproofing material or sheeting;
- rubber, hoses, belts, flexible braided connectors, stainless steel tubing and fittings, gages, valves, and motor shafts;
- and any surface particularly indicated as not to be painted.

5.2 Paint systems are generally specified by dry film thickness of coat(s) and total dry film thickness of primer, intermediate and top coat rather than by the number of coats.

5.3 Unless otherwise stated in IPS-E-TP-100 and/or specified by the contract, the total dry film thickness of paint system shall be 100 microns minimum. All paints and paint materials used shall comply with the specification given in IPS Material Standards and they shall be obtained from approved manufacturers only.

5.4 All materials shall be supplied in the manufacturer's original containers, durably and legibly marked according to relevant IPS-M-TP Standards.

5.5 The characteristics of paint systems are described in Appendix B of IPS-E-TP-100.

5.6 Paint life depends primarily on surface preparation. Surface preparation shall be in accordance with IPS-C-TP-101.

5.7 Fabrication should preferably be complete before surface preparation begins.

5.8 All painting shall be carried out in full conformity with this Standard. Particular attention shall be paid to instructions on storage, mixing, thinning, pot life, application conditions, application technique and recommended time intervals between coats. Coatings shall not be applied to wet or damp surfaces.

5.9 No paint shall be used in which the vehicle has set hard and which can not readily be reincorporated by correct mixing. Similarly, no paint shall be used which has jellified or which has thickened to such an extent that too much thinner is required to brushing consistency.

5.10 Unless in special cases paint shall not be applied under the following conditions:

- When the temperature of the surface is less than 3°C above the dew point of the surrounding air, and/or the relative humidity is higher than 80%;
- when the temperature is below 4°C;
- when the surface temperature is higher than 35°C;
- when there is the likelihood of an unfavorable change in weather conditions within two hours after coating;
- when there is a deposition of moisture in the form of rain, condensation, frost, etc., on the surface. This is likely to occur when the relative humidity is over 80% and the temperature is below 15°C.

Each layer of paint shall be allowed to dry for a period of time within the limits prescribed by the paint manufacturer, before the next layer is applied.

5.11 Subsequent layers of a paint system shall have a difference in tint or color.

5.12 Particular attention shall be paid to the painting of corners, edges, welds, etc. especially with respect to the specified minimum dry-film thickness (see also 16.6).

5.13 During both application and drying, adequate ventilation shall be provided if the work area is enclosed.

5.14 All steel constructions or plates shall be provided with a priming or coating system to protect the steel surfaces during the transport, storage, construction and joining stages, e.g. welding of the project.

5.15 All surface inaccessible after assembly shall be fully painted before assembly.

5.16 It shall be the responsibility of the contractor to coordinate work so that shop primed items are primed and painted with compatible coating, as specified in the contract and/or according to IPS-E-TP-100.

5.17 Coatings shall be applied by conventional and/or airless spray in exact accordance with this Standard and/or the manufacturer's instructions.

5.18 Two pack paints shall be carefully mixed in strict accordance with this Standard and/or manufacturers instructions. The pot life of such paints, shall be carefully noted and any mixed paint which has exceeded its pot life must be discarded irrespective of its apparent condition (see 13.2.1.14).

5.19 The application shall leave no sags, runs, marks or other defects.

- 5.20** Drying and application time between coats shall adhere to the coating manufacturer’s recommendations with temperature and humidity conditions taken into account, and shall generally be kept to the minimum in order to prevent contamination between coats. Where contamination occurs between coats, this must be completely removed, generally be washed per manufacturers recommendation or otherwise with suitable detergent solution and rinsed with clean water. The paint surface shall be dry before over-coated application.
- 5.21** The greatest precaution shall be taken in the spraying of inorganic zinc primers to ensure proper cohesion and adhesion permitted care shall be taken not to exceed the maximum film thickness (see 15.6.1).
- 5.22** Any and all holes and surface imperfections shall be cleaned and filled in an approved manner before painting.
- 5.23** Number of coats when specified shall be a minimum number of coats to achieve the specified film thickness. Maximum dry film thicknesses should not exceed those specified by the company.
- 5.24** All equipment shall be maintained in good working order. Equipment shall be thoroughly cleaned daily. Worn parts shall be replaced. Effective oil and water separators shall be used and serviced regularly.
- 5.25** All points of damage to paintwork incurred at any stage of the work including site welding operations, shall be re-prepared (see IPS-C-TP-101 Section 13) to the original standard and recoating with the specified priming coat and finish coat to restore the film thickness. In all such instances preparation shall extend 25 mm into the sound paintwork and a further 25 mm of sound paintwork shall be lightly blasted to etch the surface. Repainting shall then cover the prepared surface and the etched paintwork (see 16.5).
- 5.26** When painting insulating flanges with paints containing metallic pigments insulating materials will be covered with protective striping to prevent breaking or "electrically shorting" the insulating barrier.
- 5.27** Unless otherwise specified the minimum allowable time before application of intermediate or finish coat shall be three hours.
- 5.28** Maximum allowable time between application of intermediate and finish coat shall be as recommended by the paint manufacturer but shall not be less than eight hours.
- 5.29** Any surfaces to be coated shall be rendered dust-free prior to the application of the prime coat. This shall be accomplished by blowing of the surface with clean dry air or by using an industrial vacuum cleaner

TABLE 1 - DEW POINT DETERMINATION

DEW POINTS (°C) AT VARIOUS RELATIVE HUMIDITIES								
AIR TEMP.	30%	40%	50%	60%	70%	80%	90%	100%
-1	—	—	—	—	-6.5	-4	-2	-1
4	—	-6.5	-4	-2	0.5	1.5	3.5	4.5
10	-6.5	-3.5	0.5	2	3.5	5.5	8.5	10
15.5	0	2	4	8	10	11.5	14	15.5
21	3	6.5	10	13	15	18	19.5	21
26.6	7	12	15.5	19	21	23.5	25	26.5
32	13	16.5	20.5	24	25.5	28.5	30.5	32
38	18	22	25.5	29	31	33.5	36	38

Note:

It is essential to ensure that no condensation occurs on blasted steel or between coats during painting.

Air at a given temperature can only contain a certain (maximum) amount of water vapor. This proportion is lower at lower temperatures.

The dew point is the temperature of a given air-water vapor mixture at which condensation starts, since at that temperature its maximum water content (saturation) is reached.

In practice, a safety margin must be kept, whereby the substrate temperature is at least 3°C above dew point.

6. PAINT MATERIALS

6.1 Selection of Paint Materials

6.1.1 Before painting is permitted, the paint system and the application process shall be defined and qualified in accordance with the painting procedure approval specified in the appropriate section.

6.1.2 Only paint system which comply with IPS-E-TP-100 shall be used. For paint systems for buildings and wood see Appendix A.

6.1.3 The paint materials supplied shall be certified by the manufacturer in accordance with the requirements relevant IPS-M-TP Standards for paint. The contractor shall obtain and retain all certificates and manufacturers' data sheets.

6.2 Identification of Paint Materials

The Contractor shall ensure that all materials supplied for painting operations are clearly marked according to IPS-M-TP Standards for paints.

6.3 Storage of Paint Materials

All paint materials consigned to the coating site shall be properly stored in accordance with the manufacturer instructions at all times to prevent damage and deterioration prior to use. Materials shall be used in the order in which they are delivered.

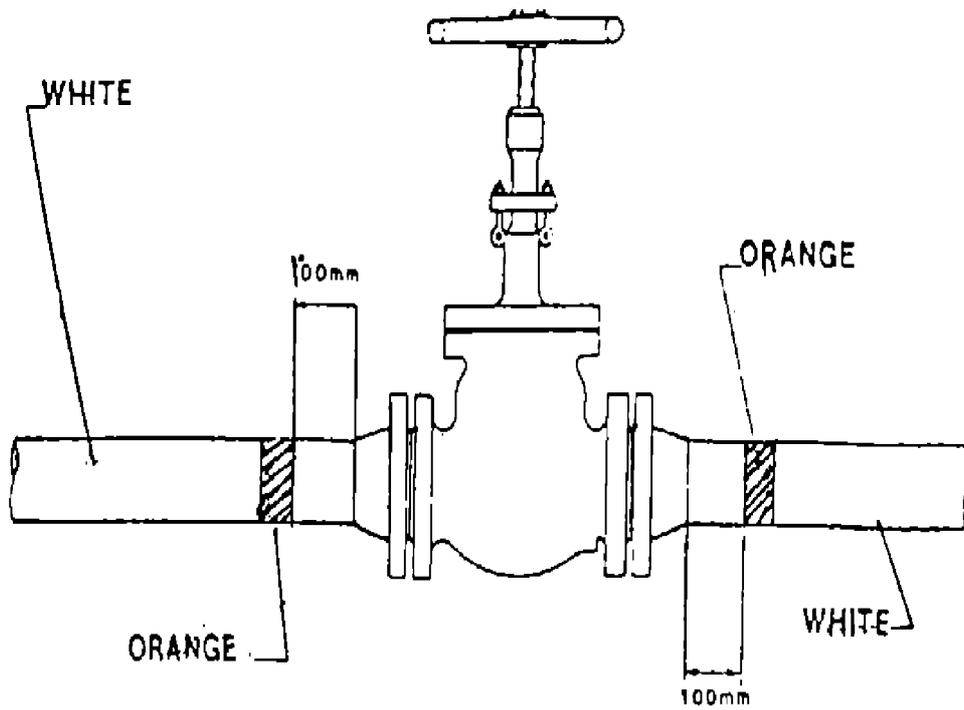
7. PAINT APPLICATION COLOR CODING

7.1 The manufacturer and product color codes are given to identify the shade of color to be applied.

7.2 Unless otherwise specified on drawings, all equipment shall be color coded using the color code listed in IPS-E-TP-100 Table 3.

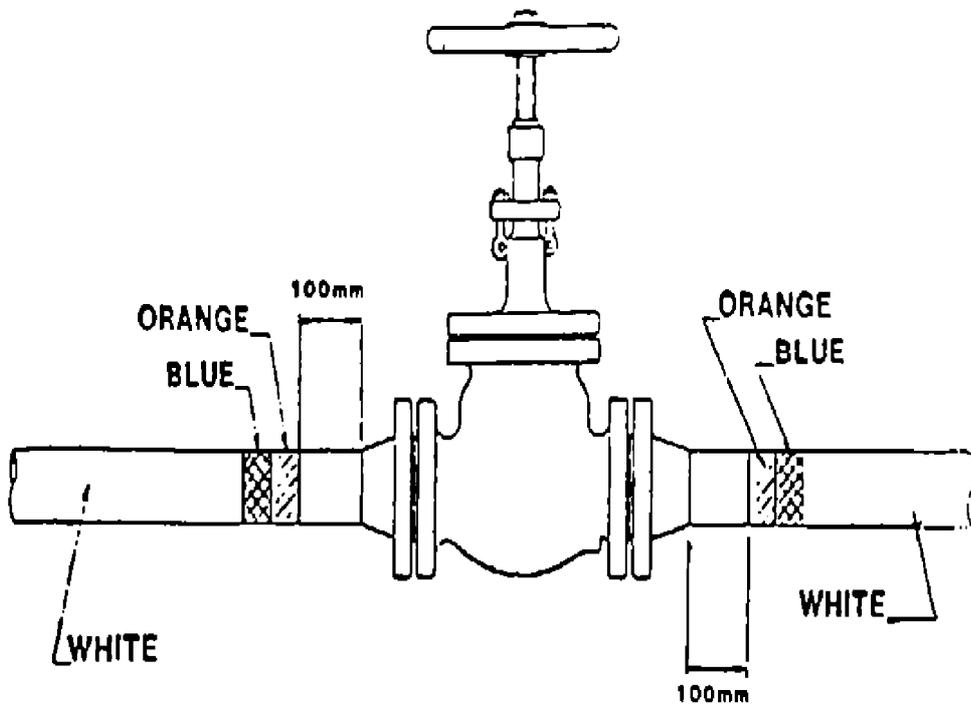
7.3 All painted color coding bands shall be 50 mm wide.

7.4 Painted color coding bands will be placed on both sides of every valve and flange along the line where space permits. For small facilities where line space is limited between valves and flanges, the lines shall be adequately marked with painted color coded bands so that the bands shall be visible from each valve and flange (see Figures 1, 2, 3 and 4).



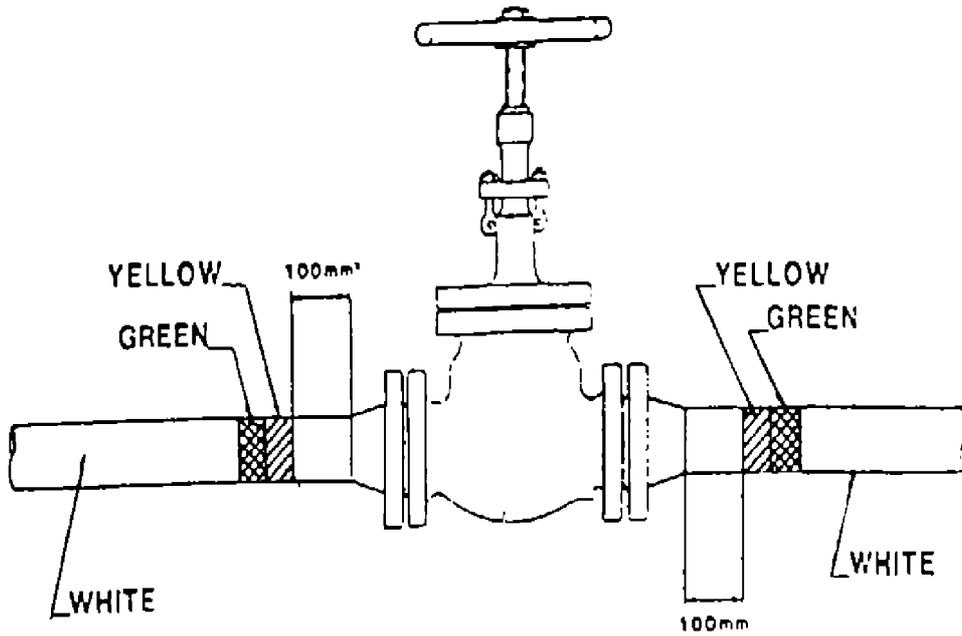
PAINTED COLOR CODING BANDS FOR VALVE AND FLANGE IN SOUR HYDROCARBON LIQUID PIPELINE

Fig. 1



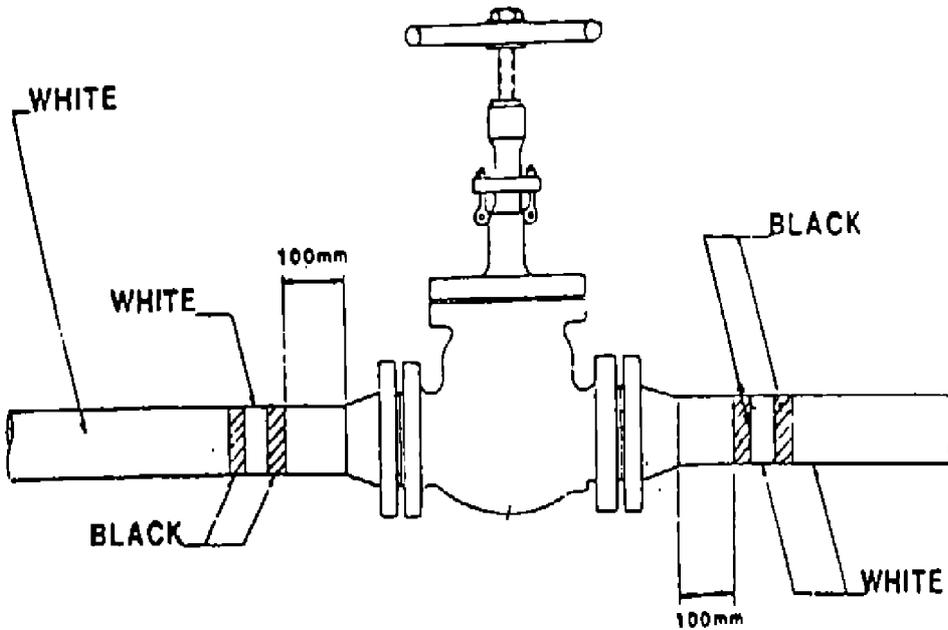
PAINTED COLOR CODING BANDS FOR VALVE AND FLANGE IN SOUR PRODUCED WATER PIPELINE

Fig. 2



PAINTED COLOR CODING BANDS FOR VALVE AND FLANGE IN SWEET HYDROCARBON LIQUID PIPELINES

Fig. 3



PAINTED COLOR CODING BANDS FOR VALVE AND FLANGE IN LIQUID SULFUR PIPELINE

Fig. 4

8. COMPONENTS OR WORK PIECES

8.1 Component Identification

All identification markings, whether internal or external to the component, shall be carefully recorded before surface preparations begin.

When applicable, identification plates shall be carefully removed and, after the painting has been accepted, replaced using an adhesive compatible with the paint. Special care shall be taken to ensure that the original data is re-affixed to the correct component.

The Contractor shall provide for company a documentary procedure for compliance with these requirements.

8.2 Protection of Weld and Preparations

8.2.1 Weld end preparations shall be protected from mechanical damage during handling, storage, surface preparation and the coating processes.

The methods used shall also ensure that no damage occurs to the internal surface of the component.

8.2.2 Protection during handling and storage shall be in accordance with Section 20.

8.2.3 Weld end preparations shall be protected from paint during paint application process by a method agreed with company.

8.2.4 The paint shall not be applied within 150 ± 15 mm of the component ends before welding.

8.3 Surface Preparation

Unless otherwise specified by the company the method of surface preparation shall be specified by the Contractor as part of the painting procedure qualification and shall take into account the requirements specified in IPS-C-TP-101, plus any special requirements specified by the company.

All surfaces shall be inspected immediately after preparation for compliance with the requirements specified in IPS-C-TP-101. Any components or parts found to have defects which exceed the levels permitted in the relevant component or part specification shall be set aside for examination by the company.

8.4 Surface Treatments

The surface treatments of the substrate when required by the job or by the company shall be performed in accordance with Section 12.

8.5 Painting Process

The painting process shall be carried out using a procedures specified in this Standard.

8.6 Painting Procedure Tests

The painting application process shall comply with the procedure established in the relevant coating procedure qualification. Any changes in coating materials, component dimensions or the coating process may, at the discretion of the company, necessitate a new coating procedure test.

Additionally, approved procedure tests shall be confirmed at intervals of not more than 1 year for each type of paint used by the Contractor and for each size of component as requested by the company (see Table 2).

9. INSPECTION AND TESTING

9.1 The quality control system shall include as a minimum the requirements listed in Table 2.

9.2 If, in the opinion of company after examination or test, any component has not been cleaned or painted in accordance with this construction standard, the Contractor shall be required to remove the paints which are considered defective or inadequate and to reclean and recoat the component to the satisfaction of the company.

TABLE 2 - MINIMUM QUALITY CONTROL REQUIREMENTS

REQUIREMENTS	REFERENCE STANDARD
a) Check cleanliness of components immediately prior to cleaning	IPS-C-TP-101
b) Monitor size, shape and cleanliness of the blast cleaning material and process	IPS-C-TP-102
c) Check visually in good light, the surface of the components for metal defects, dust and entrapped grit	IPS-C-TP-101
d) Check component surface blast profile	IPS-C-TP-101
e) Check for residual contamination of component surfaces	IPS-C-TP-101
f) Check temperature control of the component surface by an agreed method	IPS-C-TP-101
g) Check the weather condition	Section 22 of this Standard
h) Check the paint thickness	"
i) Check the cure of paint	"
j) Check the paint adhesion	"
k) Supervision to ensure the adequate and proper repair of all defects	"
l) Check on paint color and appearance, e.g. uniformity and flow	"
m) Check for damage to weld and preparations	"

10. QUALITY SYSTEMS

10.1 The Contractor shall set up and maintain such quality assurance and inspection systems as are necessary to ensure that the goods or services supplied comply in all respects with the requirements of this construction standard.

10.2 The company will assess such systems against the recommendations of the applicable parts of ISO 9004 and shall have the right to undertake such surveys as are necessary to ensure that the quality assurance and inspection systems are satisfactory.

10.3 The company shall have the right to undertake inspection or testing of the goods or services during any stage of work at which the quality of the finished goods may be affected and to undertake inspection or testing or raw material or purchased components.

11. PROCEDURE QUALIFICATION

11.1 General

Before bulk painting components commences the requirements of 11.2 shall be met and a detailed sequence of operations to be followed on the painting of components shall be submitted to company for checking the compliance with this Standard and approval.

The company shall also specify which painted components are to be subjected to the tests specified in 11.3 and 11.4 for formal approval of the coating procedure. No painted components shall be dispatched to the company or no painting shall be done until the painting procedure has been approved and approval confirmed in writing by the company.

11.2 Painting Procedure Specification

The painting procedure specification shall incorporate full details of the following but not limited to them:

- a) The paint system (s) to be used together with appropriate data sheets as defined in 6.1.
- b) Cleaning of component and method of cleaning
- c) Cleaning medium and technique.
- d) Blast cleaning finish, surface profile, type of abrasive and surface cleaning in the case of blast cleaning.
- e) Dust removal.
- f) Painting method (brush or spray)
- g) Preheat time and temperature, if any
- h) Powder spray, if any, including use of recycled material.
- i) Curing and quenching time and temperature.
- j) Post cure time and temperature.
- k) Surface treatment medium and technique.
- l) Repair technique.
- m) Painting stripping technique.

11.3 Coating Procedure Approval Tests

A batch of 15 to 20 components (representing a normal production run) or in case of painting structure 3 to 5 different sections with the minimum of 2 m² for each section shall be painted in accordance with the approved painting procedure (see 11.2), the painting operations being witnessed by the company.

Three components from the batch and 3 sections shall be selected by the company for painting procedure approval tests and shall be subjected to the complete set of tests specified in Section 22.

Testing shall be witnessed by the company and a full set of records shall be submitted to the company for consideration. No painted component shall be dispatched or no painting performed until the procedure has been certified in writing as being acceptable to the company.

11.4 Long Term Proving Tests

Long term proving tests shall be carried out on painted components specified in 11.3.

12. METAL SURFACE TREATMENTS (CONVERSION COATINGS)

12.1 Metal surface treatment or prepaint treatments when required by job and/or by the company will be applied by chemical means, where by the chemically active metal surface, subject to oxidation, is converted to one which is less active and more resistant to corrosion. the conversion coating serves as a substrate for the subsequent bonding of metal

to paint or other organic finishes. The corrosion resistance of the painted article can be measured by humidity (ASTM D-822), salt-spray (ASTM B-117) and other standardized corrosion tests.

12.2 Metal treatment do not replace anti-corrosion primers which shall be applied as soon as the conversion painting is dry.

Wash primer, phosphate coating and chromate coating are the types of conversion coatings which are applied over ferrous and non-ferrous metals.

12.3 Generally wash primer uses for treatment of ferrous and non ferrous metals, phosphate treatment uses for steel and zinc coated steel and chromate treatment is only used for non-ferrous metallic surfaces.

12.4 For metal surface treatment details see Attachment B of this Standard.

13. PREPARATION OF PAINT BEFORE USE

13.1 Storage and Appearance

13.1.1 Paint shall be stored in a well ventilated room, free from excessive heat or direct rays of the sun and maintained at a temperature between 4°C and 27°C. Open air storage shall be avoided particularly of heavy paints such as primers and undercoats.

13.1.2 The maximum storage time for paints shall be as recommended by relevant IPS-M-TP Standards. Paints shall not be stored in open containers, even for a short time.

13.1.3 All containers of paint shall remain unopened until required for use. Those containers which have been previously opened shall be used first. The label information shall be legible and shall be checked at the time of use.

13.1.4 The settlement of heavy paints such as red lead oxide primers, enamel undercoats, and wood priming paints shall be lessened by rolling the drums in which they are stored every six weeks. Touring the drums on their ends is not allowed. The normal finishing paints and drum paints do not require rolling during the storage period.

13.1.5 If paint has thickened to such an extent that more than 5% by volume (10% by volume for priming paints) of the correct thinners is required to bring it to brushing consistency.

13.1.6 Paint which has levered, gelled, or otherwise deteriorated during storage shall not be used; however thixotropic materials which can be stirred to attain normal consistency may be used.

13.1.7 The oldest paint of each kind shall be used first.

13.1.8 Temperature of paint may be excessively high or low depending on storage or shipping conditions. If so, warm or cool the paint to a temperature of 10-32°C before mixing and use.

13.2 Preparation of Paint for Application

13.2.1 Mixing

13.2.1.1 Paints shall preferably be mixed by powered mixers and/or shakers. Only small quantities are suitable for hand mixing, and then shall only be mixed by an efficient method such as boxing*. Avoid shaking partly full cans of latex paint, it cause foaming.

13.2.1.2 The paint shall be mixed in a manner which will insure the break-up of all lumps, complete dispersion of pigment and a uniform composition.

* **Boxing is the process of mixing paint by pouring from one container to another. The maximum container size shall be 20 litres.**

13.2.1.3 The lumpy or stiff paste shall be broken up with a mechanical agitator. In some cases with a wide strong paddle made of wood or iron, stirred with a motion from container (see 13.2.1.15).

13.2.1.4 Where a skin has formed in the container, the skin shall be cut loose from the sides of the container, removed and discarded. If the volume of such skins are more than 2% of the remaining paint, the paint shall not be used.

13.2.1.5 Mixing in open containers shall be done in a well ventilated area away from sparks or flames.

Paint shall not be mixed or kept in suspension by means of an air stream bubbling under the paint surface.

13.2.1.6 Dry pigments which are separately packaged shall be mixed into paints in such a manner that they are uniformly blended and all particles of the dry powder are wetted by the vehicle.

13.2.1.7 Pastes shall be made into paints in such a manner that the paste shall be uniformly blended and all lumps and particles broken up to form a homogeneous paint.

13.2.1.8 Tinting pastes or colors shall be wetted with a small amount of thinner, vehicle, or paint and thoroughly mixed. Next, the thinned mixture shall be strained. Finally, it shall be added to the large container of paint and mixed until the color is uniform.

13.2.1.9 Paint which does not have a limited pot life (time interval) or does not deteriorate on standing may be mixed at any time before using, but if settling has occurred it must be remixed immediately before using.

13.2.1.10 Paint shall not remain in spray pots, painter's buckets, etc. Overnight, but shall be stored in a covered container and remixed before use.

13.2.1.11 Catalysts, curing agents, or hardeners which are separately packaged shall be added to the base paint only after the latter has been thoroughly mixed. The proper volume of the catalyst shall then be slowly poured into the required volume of base with constant agitation. Do not pour off the liquid which has separated from the pigment and then add the catalyst to the settled pigment to aid mixing. The mixture shall be used within the pot life specified by the manufacturer. (For example, more than 20 minutes and less than eight hours after mixing are the pot life limits for some chemically cured paints.) Therefore only enough paint shall be catalyzed for prompt use. Most mixed, catalyzed paints cannot be stored, and un-used portions of these shall be discarded at the end of each working day at the expense of the contractor. When specified, special continuous mixing equipment shall be used according to the manufacturer's directions.

13.2.1.12 The drum paints shall be rolled on its side for some minutes before opening. The entire paint content shall be poured into an empty clean drum or can, ensure that no heavy paste remains in the original container. If paste remains, some of paint shall be poured back and the mixture again stirred thoroughly and returned to the bulk.

13.2.1.13 All pigmented paint shall be strained after mixing except where application equipment is provide with strainers. Strainers shall be of a type to remove only skins and undesirable matter but not to remove the pigment. Cheese-cloth of a fine metal gauze, approximately 0.15 mm (80 mesh) is recommended as strainer.

13.2.1.14 When mixing two-component paints, check and remix each component individually. Then blend the two components at low speed until the mixture is completely uniform in color. Often, the two components are supplied in different colors so that a good mix can be readily determined. Do not mix more than a few liters at a time since the exotherm caused by the mixture may be so high as to make the paint solidify in the container.

13.2.1.15 Hand mixing of paints shall only be permitted for containers up to 5 liters. All larger containers shall be mixed by mechanical agitators and brought to a uniform consistency. Where pigment separation readily occurs such as heavy or metallic pigments, prevention shall be made for continuous mixing during application.

13.2.2 Thinning

13.2.2.1 Do not thin the paint unless recommended by supplier or needed for spray application or in case of thickening of paint as in 13.2.2.2.

13.2.2.2 If thickening of paint prevents proper application by brush, not more than 5% by volume of the correct thinner may be added; for oil-based primers containing red lead, up to 10% by volume is acceptable. For enamels which are applied by spraying, special enamel thinners shall be used. For drum paints and for priming paints, white spirit (mineral turpentine) shall be used as thinner. Emulsion paints normally require thinning up to 12% by volume of clean fresh water. The addition of more water than is necessary to obtain a satisfactory brushing consistency is not allowed.

13.2.2.3 When thinning the paint, first be sure that it is well mixed before adding the thinner. Then thinner shall be added slowly to paint during the mixing process.

13.2.2.4 If the paint is cold, do not add thinner to make application easier. Instead, bring the paint to 10-32°C. Paint heaters can be used to reduce viscosity for spray application, thus avoiding the addition of thinners. Do not apply warm paint to cold steel. Results are best if both are similar in temperature.

14. APPLICATION METHODS OF PAINT

14.1 General

14.1.1 The accepted methods of applying coating on site are by brush, and spray; applying paint by paint pad and paint glove, are also tolerated in same cases (see 14.4).

Choice of method is usually determined by the nature of the work or the type of material to be applied (see Section 15).

Manufacturer's recommendations regarding the suitability of coatings for application by particular methods should also be considered.

14.1.2 Whatever method is employed, operators shall be skilled and experienced in the techniques of application, as well as in the care and maintenance of tools and equipment and, where relevant, in the setting up and adjustment of equipment to obtain optimum results. The qualification of the operators shall be approved by the company.

14.1.3 This Section describes the general characteristics of the methods referred to the above and the types of tools and equipment employed. On the assumption that operator will be skilled and experienced, techniques of application are not described in more detail than is necessary for an appreciation of the basic principles by users of this Standard not directly involved with application.

14.1.4 In all methods of application the aim is to produce a uniform coating of the film thickness specified, free from pinholes, missed area, runs, sags or curtains, and wrinkling or other blemished which may impair durability.

14.2 Brush Application

14.2.1 Brush application may be used under the following circumstances:

- a) When area can not be properly coated by spray application for any reason.
- b) For repair to localized damaged paint.
- c) Where manufacturer considers the coating material suitable for brush application.
- d) For applying the initial coat of paint (primer) to corners, crevices or other irregular surfaces prior to spray application.

14.2.2 The brush shall not be dipped more than one-third of bristle length into the paint to avoid overloading the bristles and filling the "heel" with paint. The brush shall be held at an angle of about 75° to the work.

14.2.3 The paint shall be spread to hide the surface and provide a uniform coating. Work from dry to wet surface.

14.2.4 Excessive pressure shall not be applied to the brush. When the surface has been completely covered with paint, the wet area shall be brushed cross-wise to ensure uniformity, and finally brushed lightly to smooth out brush marks and laps. On large areas this final light brushing shall be in vertical direction.

14.2.5 The film produced by brushing shall be free from brush marks, consistent with good practice for the type of paint used.

14.2.6 Brushes shall be made from a good quality hog bristle for solvent based paints and synthetic filament (Nylons and polyester) for water-thinned paints and caustic material such as cement paint.

Avoid brushes with filament that are not flagged. Round or oval brushes are suitable for irregular surfaces and wide, flat brushes are suitable for large flat areas.

14.2.7 The construction and dimensions of brushes shall comply with requirements of BS 2992.

14.3 Spray Application

14.3.1 Uses

14.3.1.1 Spray application is preferred especially for application to large area.

14.3.1.2 There are several types of spray equipment as follows: Air, airless, hot and electrostatic spray.

14.3.1.3 Spray equipment shall be kept sufficiently clean so that dirt, dried paint, and other foreign materials are not deposited in the paint film. Any solvents left in the equipment shall be completely removed before using.

14.3.1.4 Paint shall be applied in a uniform layer with overlapping at the edges of the spray pattern. During application, the gun shall be held perpendicular to the surface and at a distance which will ensure that a wet layer of paint is deposited on the surface. The trigger of the gun should be released at the end of each stroke.

14.3.1.5 All runs and sags shall be brushed out immediately or the coating shall be removed and the surface repainted.

14.3.1.6 Before spraying each coat, all corners, edges, welds cracks, crevices, blind areas of all rivets and bolts, nuts and all other inaccessible areas shall be prepainted by brush, daubers or sheepskins, to ensure that these areas have at least the minimum specified dry-film thickness.

14.3.1.7 Paint shall be suitable for the particular spray application method use.

14.3.1.8 Particular care shall be observed with respect to type of thinner, amount of thinner, paint temperature, and operating techniques in order to avoid deposition of paint which is too viscous, too dry, or too thin. In some cases, the paint may have to be reformulated to suit the application method.

14.3.1.9 Caution must be exercised so that hot coatings are not applied to cold surfaces and, conversely, that cold coatings are not applied to hot surfaces.

14.3.1.10 The skills required for spray application (see 14.1.3 for qualification).

14.3.1.11 Possible limitations to spray application include the following:

- a) Possible hazards to health or safety (see Section 23).
- b) Spray application on exterior work in windy weather shall cause difficulties.
- c) The conventional primers for buildings surfaces shall not be applied by spray. Exceptions to the include zinc-rich epoxy primers which shall be applied by spray.

14.3.2 Air spray

14.3.2.1 The original method of spray application was by air atomization. A compressor supplies air under pressure via an air hose to a spray gun that atomizes the paint to produce a fine spray which is projected on to the surfaces. According to the design of the equipment, working air pressures shall be from 2 to 4.7 bars (see Fig. 5).

14.3.2.2 The air caps, nozzles, and needles shall be those recommended by the manufacturers of the material being sprayed and the equipment being used.

14.3.2.3 Traps or separators shall be provided to remove oil and condensed water from the air. The traps or separators must be of adequate size and must be drained periodically during operations. The air from the spray gun impinging against a clean surface shall show no condensed water or oil.

14.3.2.4 The pressure on the material in the pot and of the air at the gun shall be adjusted for optimum spraying effectiveness. The pressure on the material in the pot shall be adjusted when necessary for changes in elevation of the gun above the pot. The atomizing air pressure at the gun shall be high enough to properly atomize the paint, but not so high as to cause excessive fogging of paint, excessive evaporation of solvent or loss by overspray.

14.3.2.5 If compressor units for air spray equipment are powered by a petrol or diesel engine, they shall be located outside the building. If this is not practical, exhaust fumes shall be conveyed directly to the open air.

14.3.2.6 For normal use gravity-fed or suction fed guns fitted with a paint cup of required size shall be used. If the work requires the continuous use of more than 0.5 liter of paint, the installation of the pressure pot having a capacity up to 4.5 liters may be provided.

This pot shall have a filter and water trap inserted in the line. Where several guns are being employed, the air line couplings shall be interchangeable.

14.3.2.7 Spraying shall be done in such a manner as to produce a full uniform film of paint without runs, rays, uneven surface ('orange peel'), pin holes to the satisfaction of the company.

14.3.2.8 At the end of each day or upon completion of the job, the gun shall be cleaned thoroughly by spraying the thinner through the gun and forcing it into the container by holding the cloth over the air cap.

The air cap shall be removed and the fluid tip washed with thinner. The cap shall be immersed in thinner and the holes cleaned with a matchstick but not with a nail or wire. The spray gun shall never be immersed in the thinner.

14.3.2.9 The gun shall be lubricated at regular intervals.

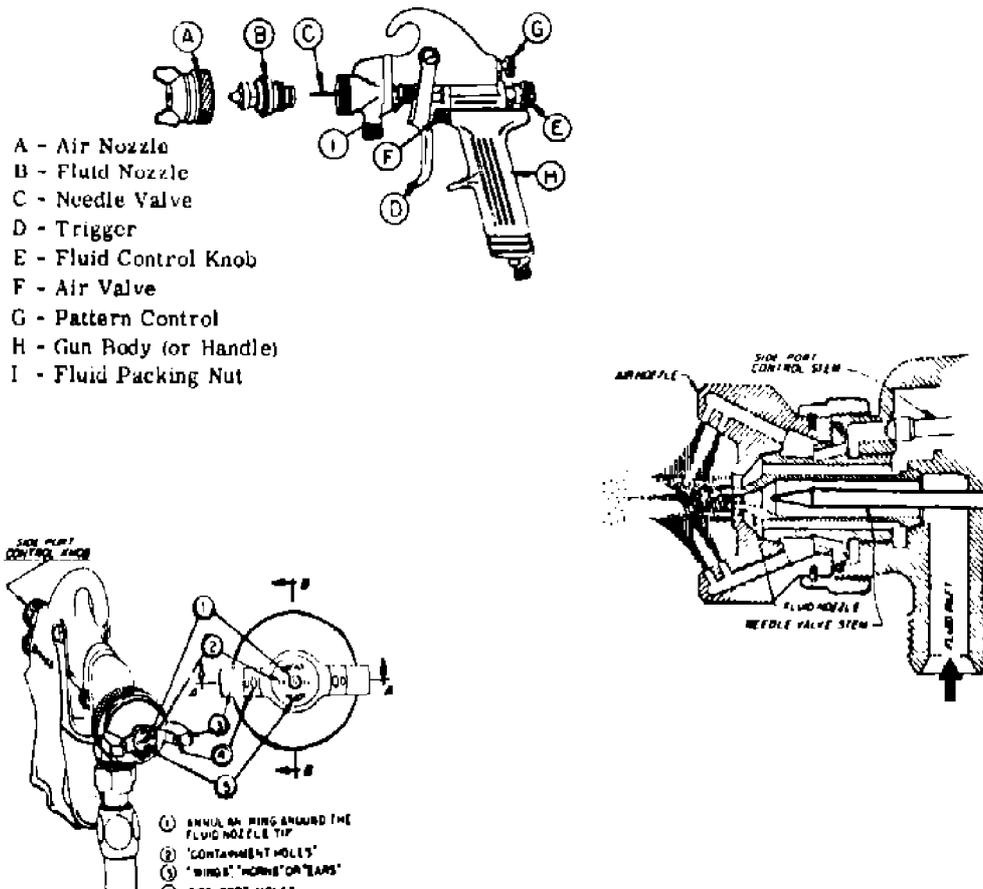
14.3.3 Airless spray application

14.3.3.1 Airless spray relies on hydraulic pressure rather than air atomization to produce the desired spray. An air compressor electric motor or gas engine is used to operate a pump to produce pressures of 71 to 430 bars. 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 very small orifice resulting in atomization of paint without the use of air. This results in more rapid coverage with less overspray (Fig. 6).

14.3.3.2 Caps of capacities from approximately 0.25 liters per minute to 5 liters per minute are available and care shall be taken to select the correct cap for the particular application. For best results, specially formulated paints are necessary. Heavier coatings are usual and because of the lower degree of control given by the airless spray gun, and the high paint flow rate, greater resistance to sagging and tearing is required from the paint.

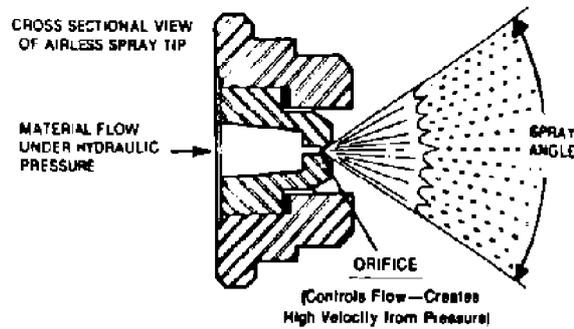
14.3.3.3 For good results, the gun is held at right angles to the work and about 300 mm away and the operator shall start at the bottom and work upwards. The speed of the operating strokes shall be much faster than for normal spraying. Trigger movement must be abrupt and the spray started and stopped just after commencing the stroke, and just before completion. Successive passes of the gun shall overlap only slightly since the spray pattern is of uniform thickness throughout its width.

14.3.3.4 Paint must never be allowed to dry in the gun. Cleaning instructions must be strictly followed.



CONSTRUCTION OF AIR SPRAY GUN

Fig. 5



AIRLESS SPRAY ACTION

Fig. 6

14.3.3.5 Airless spray usually is faster, cleaner, more economical and easier to use than conventional air spray and gives thicker film.

14.3.3.6 Most types of coatings can be applied, possible exceptions being those containing coarse aggregates or fibers, e.g. some masonry paints (cement paint).

14.3.3.7 Because of the very high pressures involved, caution shall be exercised in the handling of airless spray equipment; in particular, the spray gun shall never be pointed towards any part of the body whilst the equipment is in operation.

14.3.3.8 Fluid tips shall be of proper orifice size and fan angle, and the fluid control gun of proper construction, as recommended by the manufacturer of the material being sprayed and the equipment being used. Fluid tips shall be of the safety type with shields to prevent penetration of the skins by the high pressure stream of paint.

14.3.3.9 The air pressure to the paint pump shall be adjusted so that the paint pressure to the gun is proper for optimum spraying effectiveness. This pressure shall be sufficiently high to properly atomize the paint. Pressures considerably higher than those necessary to properly atomize the paint shall not be used.

14.3.3.10 Spraying equipment shall be kept clean and shall utilize proper filters in the high pressure line so that dirt, dry paint, and other foreign materials are not deposited in the paint film. Any solvents left in the equipment shall be completely removed before applying paint. Because of very high pressures, paint must be thoroughly screened to prevent clogging of the nozzles.

14.3.3.11 The trigger of the gun shall be pulled fully open and held fully open during all spraying to insure proper application of paint.

14.3.3.12 Airless paint spray equipment shall always be provided with an electric ground wire in the high pressure line between the gun and the pumping equipment. Further, the pumping equipment shall be suitably grounded to avoid the build-up of any electrostatic charge on the gun. The manufacturer's instructions are to be followed regarding the proper use of the equipment.

14.3.4 Hot spray

14.3.4.1 In this method, the material is passed through a heater unit before delivery to the spray gun.

Heating enables the solvent content of the material to be reduced, so allowing a thicker film to be applied. Coatings require to be specially formulated for hot spray application; water-thinned coatings are not suitable.

The hot spray method can be used in conjunction with either air spray or airless spray equipment but is rarely used for site application.

14.3.4.2 Avoid applying heated paint on cold steel. Heated spray units have a number of advantages over unheated units as follows:

- a) Faster application and dry.
- b) Lower pressure (under 69 bars or 1000 psi) and less power and air required.
- c) Increased thickness per coat if solids are increased.

14.3.5 Electrostatic spray

Electrostatic spraying method shall not be used for site work. This method is ideal for painting of wire fence, angles, channels, cables and pipes.

This involves imparting to the material and electrical charge (up to 60,000 volts) of opposite potential to the surface to be painted, causing the charged particles to be attracted to the surface. This reduces wastage of material and also creates a "wrap round" effect so that components such as pipes and railing may be coated all round from one direction.

Electrostatic spray has expensive equipment in servicing and slower operation than other spray application and also unsuitable for large steel structures.

14.4 Paint Pad and Gloves

Paint pad and gloves shall only be used for coating pipes, railings and surfaces which are inaccessible to other methods. It is not possible to obtain a high standard of finish by this method.

15. APPLICATION PROCEDURES FOR GENERIC GROUP OF PAINT

15.1 General

The materials covered herein are to be applied as specified. In case of conflict with any other portion of this Standard, these special provisions shall govern. Minimum dry film thicknesses are indicated, but thicker coatings shall be applied when specified by the company and/or recommended by the manufacturer's instructions. Materials which are not specifically covered in this Standard shall be applied in accordance with the directions of the manufacturer.

15.2 Conventional Paints

Conventional paints (i.e., oils, alkyds, or a combination thereof) shall be applied in accordance with Section 14.

15.3 Vinyls and Chlorinated Rubber Paints

Vinyl and chlorinated rubber finish paints shall be applied by spray, with application by brush limited to small areas and touch-up. Primers may be brushed or sprayed. These paints shall be thinned as recommended by the manufacturer. They shall be applied at a coverage that will result in the dry film thickness as specified by the company with reference to IPS-E-TP-100 or, if not specified, the dry film thickness recommended by the manufacturer. When vinyl or chlorinated rubber paints are applied by brush, paints shall be applied to the surface with a minimum of brushing so that there is little or no lifting or softening of the undercoats.

15.4 Bituminous Coatings

15.4.1 Bituminous paint (thin film)

The term "bituminous paint (thin film)" refers to low consistency solutions of coal tar or asphalt without filler or with only a slight amount of filler.

They shall be applied according to Section 14 and shall be applied at a coverage that will result in the dry film thickness specified by the company or, if not specified, the dry film thickness as recommended by the manufacturer.

15.4.2 Cold-applied bituminous coating (medium film)

The term "cold-applied bituminous coating (medium film)" refers to high consistency filled solutions of coal tar or asphalt. They shall be applied by brushing or spraying. If spray applied, special heavy-duty pump type spray equipment shall be used. This material shall be stirred without thinning until it attains proper consistency for application. It shall be applied at a coverage that will result in the dry film thickness specified by the company, if not specified, the dry film thickness as recommended by the manufacturer.

15.4.3 Cold-applied bituminous coating (thick film)

The term "cold-applied bituminous coating (thick film)" refers to very high consistency filled solutions of coal tar or asphalt. They shall be applied by brushing or spraying. If spray applied, special heavy-duty pump type spray equipment

shall be used. These materials must be stirred without thinning until they attain the proper consistency for application. They shall be applied at a coverage that will result in the dry film thickness specified by the company or, if not specified, the dry film thickness as recommended by the manufacturer. The expected range of dry film thickness for the cold-applied bituminous coating (thick film) is from 375-450 microns, per coat and unless otherwise specified the necessary number of coats shall be applied to provide a minimum dry film thickness of 625 microns.

15.4.4 Cold-applied bituminous mastic (extra-thick film)

The term "cold-applied bituminous mastic (extra-thick film)" refers to very thickly applied filled solutions of coal tar or asphalt applied by brushing, troweling, or spraying. If spray applied, special heavy-duty pump type spray equipment shall be used.

Thinning should not be necessary and shall not take the place of adequate stirring. They shall be applied at a coverage that will result in the dry film thickness specified by the company with reference to IPS-E-TP-100 or, if not specified, the dry film thickness as recommended by the manufacturer.

The expected range of dry film thickness for the cold-applied bituminous mastic (extra-thick film) is about 1000-1700 microns per coat and it is preferable that it be applied in two coats.

15.4.5 Coal tar and bitumen primer and enamels (Hot applied)

Coal tar and bitumen primer and enamels for underground steel pipes shall be applied in accordance with IPS-C-TP-274.

15.5 Chemically Cured Coatings (Catalized Epoxies, Coal Tar Epoxies)

15.5.1 Two-pack chemically cured coatings (examples: catalized epoxies, and coal tar epoxies) shall be stored, mixed, thinned, applied, and cured in accordance with the manufacturer's instructions and with the provisions of 13.2.1.11. Also, any special precautions and instructions by the manufacturer shall be followed. As an example, the time between coats for a coal tar epoxy should not exceed that indicated by the manufacturer's data; otherwise, it may become necessary to roughen the previous coat to obtain proper intercoat adhesion. Chemically cured coatings shall not be applied when the surface, paint, or air is below 13°C. Low temperatures greatly reduce the curing rate of chemically cured coating.

15.5.2 A reaction time shall be required after introduction and mixing of the catalyst with the pigmented component. Allow a reaction time of one hour unless otherwise specified by the manufacturer.

15.5.3 Epoxy coatings may be thinned, but shall not be reduced by adding more than 0.50 liter epoxy thinner to 3.7 liters of epoxy enamel.

15.5.4 Precaution shall be taken to protect surfaces other than that being covered from splatter, drip, overlap, etc.

15.5.5 Each coat shall be flowed on (do not spread out thin) in a deep wet film of 150 microns thickness.

15.5.6 Epoxy coatings may be applied over base coats after a minimum cure time of eight (8) hours.

15.6 Zinc Rich

15.6.1 Inorganic zinc-rich

Inorganic zinc-rich paints shall be applied by airless spray. If the zinc powder is packaged separately, mix with the vehicle just before use. They shall be applied at a coverage rate recommended by IPS-E-TP-100. Unless otherwise specified by IPS-E-TP-100 the dry film thickness shall not be less than 50 microns. Prior to top coating, a barrier or tie coat may be required for overcoating with certain generic coatings. The manufacturer's recommendations shall be followed.

Complete curing of the zinc-rich primer is necessary before top coating. Overspray of the zinc-rich primer will result in improper adhesion of the topcoat. Overspray shall be removed with a stiff bristle brush or wire screen. Popping will be eliminated by scraping the painted surfaces with a soft sand paper before overcoating.

15.6.2 Organic zinc-rich

The provisions of 15.6.1 are also applicable for the application of organic zinc-rich paints except that they may also be applied by brush.

15.7 Urethane Coatings

15.7.1 Single component (one pack) moisture cured urethane coatings which meet ASTM D-16, "Definition of Terms Relating to Paint, Varnish, Lacquer, and Related Products", urethane coating, type II may be applied by brush, conventional spray, and airless spray.

Special care shall be taken to insure that all spray equipment is moisture free. Since these coatings cure by reaction with moisture in the air, it should be noted that application on days when the humidity is low will result in slow cure. The manufacturer's directions shall be followed concerning thinning and application parameters. One-package moisture-cured urethane coatings shall be mixed by a mechanical mixer prior to application. This shall be done slowly so as not to create a vortex and introduce moisture into the coating which could reduce the potlife. One-Package moisture-cured urethane coatings are extremely susceptible to moisture contamination and shall not be applied unless temperatures both during and up to two hours after application will be at least 3°C above the dew point.

15.7.2 Two component polyisocyanate polyol-cured urethane coatings may be applied by brush, conventional spray, or airless spray. Special care shall be taken to ensure that all spray equipment is moisture free. The manufacturer's directions shall be followed concerning thinning and application parameters. During the mixing operation, the catalyst shall be poured slowly into the base component and both components shall then be mixed by a mechanical mixer. Mixing shall be done slowly so as not to create a vortex and introduce moisture into the coating which could reduce the potlife. These urethane coatings are extremely susceptible to moisture contamination and shall not be applied unless temperatures both during application and up to three hours after application will be at least 3°C above the dew point.

15.8 Latex Paints for Steel

15.8.1 Latex paints may be applied by brush or preferably by spray.

Cross brushing or cross spraying application is highly desirable. Application by spray tends to provide the best leveling. Conventional or airless spray can be used with most latex coatings. Since one-coat systems have very limited protective properties, multiple-coat systems shall always be applied. For structural steel the preferred system is two coats of primer and one coat of topcoat for a total thickness of 190 microns.

15.8.2 The atmospheric conditions at the time the latex paint, especially the primer, is applied are extremely important. A latex primer shall not be applied at a temperature below 10°C or above 49°C.

15.8.3 The best conditions for storage of latex paints are at temperatures between 4°C and 27°C. Latex paints shall never be allowed to attain temperatures over 49°C or subjected to repeated freezing and thawing.

16. PAINTING OF FERROUS METALS

16.1 General

16.1.1 Paints shall be applied in accordance with this Standard and good industrial practice. Manufacturer instruction shall also be considered.

16.1.2 For preparation method(s) of iron and steel and also stainless steel see IPS-C-TP-101.

16.1.3 Paint shall not be applied under the conditions described in 5.10. The paint film shall not be exposed to moisture and contamination before it has dried. Priming and painting under controlled condition in the shop is preferred.

16.1.4 The degree of cleanliness of surface will be determined by the requirements in respect of paint system (see IPS-E-T-100 paint schedule).

16.1.5 The number of coats applied after priming and the total dry film thickness of paint will be determined by the requirement in respect to paint system and conditions with reference to IPS-E-TP-100. By no means the total dry film thickness of paint shall not be less than 125 microns for moderate exterior environments, severe environment needs higher film thickness.

16.1.6 For quality control of painting after each coat or finished product see Section 22.

16.2 Priming of Ferrous Metals

16.2.1 General

16.2.1.1 Prepared surfaces should be primed generally within four hours or before visible re-rusting occurs.

16.2.1.2 Blast cleaned surfaces may be protected for short periods by thin coat of pre-treatment primer (see Section 12). Such primers shall be applied as a continuous coating in an even manner to achieve a minimum film thickness of 20 microns. Such primers do not replace the full thickness of permanent primer.

16.2.1.3 The priming coat or coats on steel shall be as specified by IPS-E-TP-100 but in no case shall have a total dry film thickness less than 50 microns. When applied in two coats, a shade contrast between coats is recommended.

16.2.1.4 In order to minimize contamination between successive coats of paint, overcoating of the preceding coat shall be done within the period of time recommended by the manufacturer and shall not be delayed beyond the period specified. When delays are unavoidable, the painted surface shall be thoroughly cleaned and dried to the satisfaction of the company before overcoating may take place.

16.2.1.5 The primer is applied by spray, except when the company prefers another method of application or required by the job and/or material.

16.2.1.6 Primed steelwork, especially if it has been exposed for a lengthy period, shall be examined carefully before further coats of paint are applied. If the primer has been deteriorated, e.g. is perished, eroded or poorly adhering, or has been damaged, so allowing corrosion to develop, the affected areas shall be re-prepared and primed. If there is evidence of widespread corrosion beneath the primer, it shall be removed and the surface again prepared and primed.

16.2.1.7 Removal of salt deposits by washing from surfaces primed with zinc-rich primers is especially important as the corrosion products formed by reaction between the salts and the zinc can affect the performance of subsequent coats.

16.2.1.8 With a single coat of primer, it is difficult to obtain films of uniform thickness and free from pinholes, the points at which corrosion starts. In all but 'mild' interior environments, application of two coats of primer is suitable. If application of two coats cannot extend to the whole of the surface, a second coat shall be applied to vulnerable points, e.g. along external angles and to bolts and rivet heads.

16.2.1.9 When a factory-applied prefabrication primer has been used and a paint system of conventional type (see 15.2 and IPS-E-TP-100 paint schedule) is to be applied, the second coat can be a drying-oil chromate or zinc phosphate type (see 12.3.2).

16.2.1.10 Surface primed with red-lead primer shall not be exposed to the weather for more than one month.

16.2.2 Priming of steel prepared by blasting

16.2.2.1 Blast cleaned steel prepared to SIS Grade Sa 3 or Sa 2½ (see IPS-C-TP-101) shall frequently be coated either in the shop or on site with a pre-treatment (see Section 12) or pre-fabrication primer or with original primer. For pre-fabrication and blast primers (see IPS-E-TP-100 Appendix B).

16.2.2.2 For further priming over the pre-fabrication primers or for direct application to blast cleaned steel, the priming paint shall be in accordance with relevant IPS-M-TP Standards for paints.

16.2.2.3 Unless otherwise specified by the company with reference to IPS-E-TP-100, it is essential that the total film thickness of the priming coats (blast or pre-fabrication primer plus second primer) shall meet the prescribed thickness of 75 micron minimum in all area.

16.2.3 Priming of steel prepared by pickling

16.2.3.1 Steelwork prepared by acid pickling shall be treated by phosphating process (see Section 12). This method is not generally used outside the pipe industry, but large plates for storage tank: have been treated in this way.

16.2.3.2 Zinc rich primers, both organic and inorganic, are not suitable for application to phosphate treated surfaces.

16.2.3.3 Zinc chromate primers are not recommended and their use would generally be confined to aluminum surfaces.

16.2.3.4 Irrespective of the type of primer used on pickled steel it is essential that the total film thickness of the priming coats meet the specified film thickness but not less than 50 microns and this would normally be achieved by the site application of a further coat of primer on pre-fabrication primer.

16.2.4 Priming of steel prepared by wire brushing (Tool cleaning)

16.2.4.1 Priming paints for steelwork prepared by wire brushing if any, must have good wetting properties and must be applied by brush in order to ensure a high standard of adhesion to the prepared steel surface.

16.2.4.2 The red lead alkyd priming paint when applied as a two coat system to a minimum dry film thickness of 50 microns, is recommended for wire brushed surface.

16.3 Shop Painting of Steel

16.3.1 Full protection applied in the shop immediately after fabrication normally results in a longer life of the protective system. However, damage during transportation and erection may subsequently necessitate widespread repair or touch-up of coating, so the structural steelwork, surface pipework, towers, vessels, heat-exchanger shells and similar containers which will not be lagged can be treated in the shop, subject to mutual agreement.

16.3.2 The shop treatments will be determined by requirements in respect to paint system and conditions such as type of environment transportation, economic, etc.

16.3.3 Handling and storage of shop treated items shall be so that to prevent damage to the treated surfaces.

16.3.4 Damage resulting from handling in the shop following painting, such as during storage or loading, is to be repaired as a part of the field painting operations. If the shop coat is damaged in fabrication, it shall be repaired before leaving the shop.

16.3.5 Contact surfaces shall be painted or left unpainted as specified in the procurement documents. When painted, at least the first coat shall be applied in the shop, with subsequent coats being applied in the field while the surfaces are still accessible, unless otherwise specified (see 16.6.1).

16.3.6 If the paint specified is harmful to the welding operator or is detrimental to the welding operation or the finished welds, the steel shall not be painted within 100 mm of the areas to be welded (see 16.6.3).

16.3.7 Shop painting in cold climates

The paint shop shall be enclosed and heated at least enough to keep the temperature above 4°C (40°F). If practical, the temperature shall be kept up to 18-21°C.

Note:

Temperature and humidity have considerable effect on the quality of the paint job. Most cases of paint failure due to mill scale lifting occur on steel that was fabricated, cleaned, and painted during the winter.

16.4 Field and Touch-Up Painting of Steel

16.4.1 Previously applied shop coatings must be dry and free of dirt, oil, or other contaminants. The manufacturer's instructions shall be followed if special surface preparation procedures are required before application of the field coats (see also IPS-E-TP-101 Sub-Section 10.5).

16.4.2 All shop primed items which have deteriorated as a result of transshipment to the extent that either crumbling or white staining of the coating is evident shall receive. A superficial sweep blast cleaning sufficient to remove the degradation and to reprepare exposed degraded metal substrate and dust.

16.4.3 Shop coated steel members shall preferably be field painted after erection of such members is completed. Steel members may be field painted on the ground before erection, provided such painting is touched-up where damaged with the same number of coats and kinds of paints after erection. However, the last complete coat of paint shall be applied after erection.

16.4.4 The first field coat of paint shall be applied within a reasonable period after the shop coat(s), and in any event before the weathering (and required touch-up) of the shopcoat becomes excessive.

16.4.5 When the type of paint for field coats is not specified, it shall be determined that the paint to be used is compatible with the shop applied coats(s). Paint used in the first field coat over shop painted surfaces shall not cause wrinkling, lifting, or other damage to the underlying paint.

16.4.6 Contact surfaces shall be painted or left unpainted as specified in the the procurement documents or required by the job (see also 16.6).

16.4.7 Surfaces (other than contact surfaces) of fabricated assemblies that are accessible before erection but which will not be accessible after erection shall receive all field coats of paint before erection.

16.4.8 All cracks and crevices shall be filled with paint if practical.

16.4.9 The final coat of steel structures paint shall not be applied until all concrete work is finished. In addition to the cleaning specified in IPS-C-TP-101, all cement or concrete spatter and drippings shall be removed before any application of paint.

If any paint is damaged, the damaged surface shall be cleaned and repainted before the final coat is applied.

16.4.10 Wet paint shall be protected against damage from dust or other detrimental foreign matter as much as is practical.

16.4.11 Steel stored pending erection shall be kept free from contact with the ground and so positioned as to minimize water-holding pockets, soiling, contamination, and deterioration of the paint film. Such steel shall be cleaned and repainted or touched-up with the specified paint whenever it becomes necessary to maintain the integrity of the film.

16.4.12 All field welds and all areas within 100 mm of welds shall be cleaned before painting, using surface preparation methods at least as effective as those specified for the structure itself; all welds shall either be blast cleaned, thoroughly power wire brushed, chemically scrubbed, or water scrubbed of all detrimental welding deposits as required (see IPS-C-TP-101 surface preparation).

16.5 Maintenance Painting of Steel

16.5.1 Surface preparation for maintenance work shall be as specified in IPS-C-TP-101 Section 13.

16.5.2 Paint that curls or lifts after application of the spot or priming paint shall be removed and the area shall be repainted.

16.5.3 On structures that are known to have been originally pre-treated with basic zinc chromate wash primer, or other methods, the cleaned areas shall, unless otherwise specified, be similarly pre-treated (see Section 12) before applying the prime coat of paint.

16.5.4 All prepared surfaces shall be primed (see 16.2) before any deterioration of the preparation occurs or within 4 hours whichever is the sooner. Where patch priming is being carried out this shall extend 50 mm on to the adjacent sound paintwork.

16.5.5 The minimum dry film thickness of individual coatings and the total dry film thickness of complete paint system and also wet film thickness, (specially where existing paint surfaces are over coated) shall be determined at the discretion of the company with reference to IPS-E-TP-100.

16.5.6 On repair work, epoxy coatings and inorganic zinc coating shall only be applied on newly blasted surfaces.

16.5.7 If pinholes are present, they shall, depending on the extent, be treated as follows:

- If pinholes are few and local: the areas shall be rubbed down and (an) additional coat(s) shall be applied by brush.
- If the areas are extensive: the area shall be made paint-free and be repainted at the contractor's expense.

The word "pinhole" is synonymous with "holiday" and "pore" (see pinhole and holiday detection in 22.2.3).

16.6 Painting of Specific Surfaces

16.6.1 Contact surfaces

Unless otherwise specified by the company, the following practice shall be followed regarding painting of contact surfaces:

16.6.1.1 The areas of steel surfaces to be encased or embedded in concrete shall not be painted.

16.6.1.2 Steel to be completely enclosed in brick or other masonry shall be given at least one coat of shop paint.

16.6.1.3 The areas of steel surfaces to be in contact with wood shall be painted as indicated in 16.6.1.5.

16.6.1.4 Surfaces to be in contact only after field erection shall be painted as provided in 16.6.1.5, except where the paint interferes with assembly or where indicated in 16.6.1.7.

16.6.1.5 Steel surfaces not in direct bonded contact, but inaccessible after assembly shall receive the full specified paint system before assembly.

16.6.1.6 Bearing-type joints may be painted as required in 16.6.1.5.

16.6.1.7 Contact surfaces of members to be joined by high strength bolts in friction-type joints are a special case. Unless specifically authorized to the contrary, they shall be left unpainted and free of oil, grease, and coatings.

16.6.2 Edges

All sharp edges shall be coated to the same film thickness as the adjacent steelwork to prevent premature breakdown from this area. Corners, services, bolt heads and rivet heads require similar attention. Where there is any doubt that these areas have received adequate film thickness the company may direct that an additional strip coat of paint, be applied to ensure the full film thickness, without any additional cost to the company.

16.6.3 Welds

As rolled steel may be blast-cleaned and protected with blast primer before fabrication and welding (see IPS-E-TP-100 Appendix B). This prevents the serious development of rust, which would be difficult to remove after fabrication. The

use of steel that has rusted heavily during storage should be avoided for the same reason. When welding metal coated or zinc-dust painted steel, it is necessary to remove the coating near the weld area, or mask-off the weld area before coating. Most painted steel can be cut and welded satisfactory provided that the coating thickness is less than 25 microns. After welding, scale and heat-damaged coating shall be removed by local blast-cleaning and the area renovated by re-painting the original coating. For blast cleaning specification see IPS-C-TP-101 Section 8.

16.7 Painting of Stainless Steel

16.7.1 Stainless steel is not normally required to be painted but where insulation is to be applied to stainless steel equipment or piping or such items that are to be stored in the open air for long periods or are to be shipped as deck cargo, protective coating shall be specified by the company. Zinc containing paints are not allowed for this purpose.

16.7.2 For potential fire situations, where hot-dip galvanizing or zinc coating are present, austenitic stainless steel equipment shall be specially protected against the possibility of zinc embrittlement failure which may result in rapid fire escalation. Such equipment shall be located in a shielded position which will reduce the risk of molten zinc falling onto the steel. Any bare stainless steel parts, e.g. flanges, which are within reach of zinc shall be protected with a painted steel shield.

16.7.3 Where adequate shielding is impractical, hot-dip galvanized or zinc-coated components shall not be used in close proximity to and particularly above the stainless steel concerned. Stainless steel plates in store shall be stacked on edge.

16.7.4 The company shall indicate whether austenitic stainless steel surfaces below 50°C or above 200°C are to be painted.

16.7.5 When painting of stainless steel surface is specified, the paint shall be applied on surface prepared in accordance with IPS-C-TP-101 Section 11.

16.7.6 The paint system and the dry film thickness of paint shall be as determined by the company and/or job requirements.

17. PAINTING OF NON-FERROUS METALS INCLUDING METAL COATED SURFACES

17.1 General

17.1.1 Non-ferrous metals are more resistant to corrosion than iron and steel, for this reason, are often used as alternatives.

17.1.2 In most conditions, painting is not necessary except for appearance but shall be applied in some environments, e.g. in acid or marine conditions.

17.1.3 Zinc, aluminum and some other non-ferrous metals shall be pretreated to improve paint adhesion (see Section 12).

17.2 Painting of Aluminum and Its Alloys

17.2.1 Unless when the type of primer specified by company, similar primers are used for aluminum and its alloys. Primers containing zinc or other chromates, but not lead or graphite pigments, are suitable. The chromate pigment should constitute about 20% by mass of the dried paint film, but factory applied red oxide/chromate primers with about 5% chromate can be satisfactory if the alloy is resistant to corrosion and the conditions of exposure are not severe.

17.2.2 Pretreatment primers, especially of the two-pack wash primer (see Attachment) are particularly suitable for aluminum and its alloys, and assist adhesion on smooth surfaces, e.g. sheets, extruded sections and aluminized steel.

17.2.3 Finishing paints for aluminum shall not contain lead or graphite pigments, which stimulate corrosion, as the priming coat may not isolate them from contact with the metal.

17.2.4 Surface preparation of aluminum and its alloys shall be in accordance with IPS-C-TP-101 Section 12.

17.3 Painting of Zinc and Zinc Coated Steel

17.3.1 After preparation of zinc coated surface according to IPS-C-TP-101 Sub-Section 12.2, the surface shall be treated with chemicals, according to (Attachment 4) followed by specified paint system with reference to IPS-E-TP-100 (paint schedule).

17.3.2 Lead-containing primers shall not be used on zinc and aluminum.

17.3.3 Table 3 shows a site treatment procedure for previously metal-coated steel work as a guide line. The case and the paint system shall be defined by the Company.

TABLE 3 - SITE TREATMENT AND PAINTING OF PREVIOUSLY METAL-COATED STEELWORK

INITIAL CONDITION	PRESENT CONDITION	SURFACE PREPARATION (SEE IPS-C-TP-101 SECTION 12)	REPLACEMENT OF METAL WHERE REQUIRED	PAINT TREATMENT OVER (SEE IPS-E-TP-100)	
				SPRAYED METAL	GALVANIZING
Bare metal coating	Areas of corrosion and/or some rusting of substrate	If metal is to be replaced, blast-clean	Sprayed metal to appropriate	Not normally necessary	
		If metal not to be replaced, clean corroded areas by best means available	Not applicable	Build-Up cleaned areas with suitable paint system and, preferably apply chemical-resistant finish overall	Build-Up cleaned areas with suitable paint system and, preferably, apply chemical-resistant finish overall
	Areas with some white corrosion products	If decoration is required wash to remove salts, using stiff brush if necessary, remove loose material with non metallic brush	Not applicable	Apply sealing coat and chemical-resistant finish for maximum life	Apply suitable surface pretreatment followed by, preferably, chemical-resistant finish
		If decoration is required, no action is necessary	Not applicable		
	Areas in sound condition	If decoration is required, wash to remove salts, using a non metallic brush	Not applicable	Apply suitable paint which shall be chemical-resistant for maximum life	Apply suitable surface pretreatment; followed by suitable paint which should be chemical-resistant
		If decoration is not required, no action is necessary	Not applicable		
Sealed or painted metal coating	Areas of corrosion or some rusting of substrate	If metal is to be replaced, blast-clean	Sprayed metal to appropriate	Consider one or two coat overall, preferably chemical-resistant	Consider one or two coat overall, preferably chemical-resistant
		If metal not to be replaced, remove corrosion product by best method available	Not applicable	Build-Up cleaned areas with suitable paint apply one or two coats overall, preferably chemical-resistant	Build-Up cleaned areas with suitable paint. apply one or two coats overall, preferably chemical-resistant
	Areas with some degradation of paint, dissipation of sealer, or loss of adhesion of either	Remove loose material with non metallic brush	Not applicable	Apply further coats of paint or sealer, preferably chemical-resistant	Apply further coats of paint or sealer, preferably chemical-resistant
	Areas in sound condition	If decoration is required, dust-down	Not applicable	As above	As above
		If decoration is not required, no action is necessary	Not applicable		

17.4 Painting of Copper and Its Alloys (e.g. Brass and Bronze)

These are rarely painted except for appearance. Adhesion of paint may be assisted by surface preparation (see IPS-C-TP-101 Section 12) and application of pretreatment primer (see Section 12).

In doors, direct application of alkyd gloss finish after preparation and treatment is suitable.

Finishing system for copper are similar to iron and steel (see Section 16).

17.5 Painting of Lead

Surface preparation (see IPS-C-TP-101 Section 12) and treatment with phosphating solution (Section 12) are satisfactory as are many conventional metal primers (see IPS-E-TP-100 Appendix B) provided they do not contain graphite.

Finishing system for lead are similar to iron and steel (see Section 16).

17.6 Painting of Chromium, Nickel, Tin and Cadmium

New chromium and nickel coatings rarely require painting, but it may be necessary if they become corroded. The surfaces shall be prepared to remove corrosion products (see IPS-C-TP-101 Section 12) before application of pretreatment primer (see Section 12). Tin plate presents few difficulties in painting; most paints will adhere satisfactorily after surface preparation (see IPS-C-TP-101 Section 12).

Cadmium shall not be weathered prior to painting (see IPS-C-TP-101 Section 12).

Phosphate treatment (see Attachment) or abrasion followed by pretreatment primer will provide a key for subsequent coats.

18. PAINTING OF PLASTER, CONCRETE, BRICK, BLOCK AND STONE

18.1 General

18.1.1 For surface preparation see IPS-C-TP-101 Appendix D.

18.1.2 Recommendations for paint systems and materials are given in Appendix A Tables A1 to A5.

18.1.3 The paint materials and systems, finish type, primer, finish systems (Tables A1 to A5) and colors shall be as specified by the company.

18.1.4 The finished materials shall be manufactured from the best quality of materials which are defined by tables A and shall meet the requirements of Institute of Standard and Industrial Research of Iran (ISIRI). Specifications as a minimum.

18.2 Treatment of Stains

Brown stains with no appreciable surface deposit sometimes appear on emulsion paints but do not normally affect oil-based paints. They are usually derived from substrates, notably certain types of brick, plaster, hollow clay pot or clinker block, containing soluble salt or coloring material, or from sands containing organic matter which react with alkali.

If it is suspected that this type of staining is likely to occur, a coat of alkali-resisting primer will usually prevent it and may also be used over stained emulsion paint to prevent staining of succeeding coats.

18.3 Plaster

18.3.1 For surface preparation of plaster (see IPS-C-TP-101 Appendix D).

18.3.2 Recommendations for priming and finishing given in (Appendix A Table A1).

18.3.3 Priming is required when oil-base paint systems are applied to plaster, it is not usually necessary with emulsion paints. When emulsion paints are applied to plaster of high or variable porosity, differential absorption can cause difficulties in application or variations in color or sheen which may persist through several coats. A well-thinned first coat of emulsion paints, sometimes referred to as a "Sealing" or "Mist" coat, often overcomes the trouble but is likely to have relatively poor opacity and, if it is required, should be regarded or specified as an additional coat in the system.

Where this proves inadequate it is usually necessary to apply a coat of alkali-resisting primer (A3/1) or primer sealer (A3/3), but this shall be done only if the substrate is substantially dry. The primer or primer-sealer may require thinning to ensure that it does not provide a glossy surface to which emulsion paint may not adhere properly.

18.4 Concrete

18.4.1 For surface preparation of concrete (see IPS-C-TP-101 Section 15). Recommendations for priming and finishing are given in tables A1 and A2.

18.4.2 If concrete surfaces are to be protected the first paint layer shall be applied by brush after having filled any surface, imperfections with an appropriate putty (see IPS-C-TP-101).

18.4.3 Priming is required when oil-based systems are applied, it is not usually necessary with emulsion paints.

18.5 Brick and Stone

18.5.1 For surface preparation of brick and stone see IPS-C-TP-101 Appendix D.

18.5.2 Recommendation for priming and finishing are given in table A1 and A2.

18.5.3 Priming is necessary with oil-based systems and, because mortar joints are likely to be alkaline, an alkali resisting primer shall be used.

18.5.4 Priming is not usually necessary with emulsion paints to accommodate variations in surface porosity and facilitate application, primers of first coats may require thinning in accordance with the manufacturer's instructions.

18.6 Precast Concrete Blocks and External Rendering

18.6.1 For surface preparation of precast concrete blocks and external see IPS-C-TP-101 Appendix D.

18.6.2 Priming and finishing of precast concrete blocks and external rendering are similar as brick and stone (18.5).

18.7 Method of Measuring Moisture Content (see note 1 of Appendix A Table A1)

18.7.1 The general guidance to the selection of paint systems for non-metallic surfaces (see Appendix A) is in relation to dryness or humidity percentage of substrate.

The following methods are used to measuring moisture content of building surfaces.

18.7.2 Weighing

Weighing of the moisture lost during oven drying of samples, e.g. obtained by drilling, is the most accurate method. This may require access to laboratory facilities although a calcium carbide meter can be used with drilled samples for on-site determination of the moisture content of walls and this avoids the need for oven-drying. However, any method of test involving drilling may be impracticable for general use.

18.7.3 Hygrometer

The equilibrium humidity produced in an airspace in contact with the substrate can be measured by using an accurate hygrometer. The space may be formed by a sealed and insulated box in which the hygrometer is mounted; less reliably, a sheet of polyethylene may be taped to the substrate with the hygrometer inside. In either case, several hours should be allowed for equilibrium to be reached.

18.7.4 Electrical moisture meters

Two types in general use are conductivity meters and capacitance meters. Conductivity meters measure the electrical resistance between two steel probes forced into the substrate; the higher the moisture content, the lower is the resistance to the flow of current. With hard, dense substrates it may be necessary to drill holes in order to obtain readings. Resistance is reduced by the presence of soluble salts so the readings may be higher than is justified by the moisture actually present. Capacitance types have two flat electrodes which are pressed against the surface, thus avoiding damage. These meters register moisture present only in the upper 1 mm to 2 mm of the substrate and are inaccurate on rough surfaces; as with the conductivity types, soluble salts may affect the accuracy of readings.

Electrical moisture meters, although less accurate than the other methods described, are easy and convenient to use and enable a number of readings to be taken quickly. Their use is preferable to reliance on surface appearance or rule-of-thumb methods.

If a wall is believed to be damp but meter readings at a shallow depth indicate low moisture content, the area should be covered with a sheet of polyethylene and rechecked 24 hr. later. If there is adjacent woodwork, it is useful to check its moisture content; as there is less likelihood of soluble salts being present in wood, readings will be more reliable, especially if they are significantly lower for the wood (see Section 19).

19. PAINTING OF WOOD

19.1 General

19.1.1 For surface preparation of wood see IPS-C-TP-101 Appendix D. Coating for wood are usually grouped as paints (opaque coatings) and natural finishes (transparent coats) systems. The natural finishes are also grouped as varnishes(1) and stain(2). Like paints natural finishes may not prevent the entry of moisture. Accordingly, their use, even of those wood coating having preservative or water-repellent(3) properties, does not obviate the need for preservative treatment of timber as described in IPS-C-TP-101 Appendix D.

Exterior wood coating (paint, varnish and stain) are conveniently grouped into two major types, water-borne (emulsion) and solvent-borne(oil-based) coating.

Water-borne coating shall not be used over linseed oil putty.

Notes:

1) Varnishes do not completely obscure the grain of wood and give a film build with little or no hiding power. They give one of the most attractive finishes to wood, but used out of doors suffer failure by flaking which is primarily due to embrittlement of the film by solar radiation combined with photodegradation of wood surface.

2) The stains are defined as solutions of coloring matter that color wood by penetration without hiding it and without leaving any perceptible surface film.

3) Water-repellency is the ability of a coating to resist wetting by water, i.e. if wetted the water on the surface forms discrete droplets. Water repellency can be increased by the addition of certain compounds e.g. silicones, waxes).

19.1.2 Recommendations for paint systems and materials are given in Appendix A tables A6, A7, A8 and A9.

19.1.3 The paint materials and systems and colors shall be as specified by the company.

19.1.4 The finished materials shall be manufactured from the best quality of materials which are defined by table A and shall meet the requirements of Institute of Standard and Industrial Research of Iran (ISIRI) standard as a minimum.

19.2 Paint Systems (Opaque Coating) for Wood (See Table A6)

19.2.1 Paint systems in varying type and ranges from matt through semi-glass to glass are used extensively for external and internal wood work, (see table A6) and offer good resistance to the weather including solar "radiation". Glass finishes are suitable for external use and in severe internal environments, and shall be applied as four-coat system including primer. Mid-sheen and matt finishes shall be used in "moderate mild" internal environments, and shall be applied as three-coat system including primer.

19.2.2 Moisture can be very damaging to wood both through its effects on dimensions and by providing conditions under which attack by micro-organisms may commence.

The moisture content at the time of painting shall not exceed about 18%. The moisture content shall be measured as in 18.7.

19.2.3 If timber has received preservative treatment (see IPS-C-TP-101 Appendix D) time shall be allowed for drying out or evaporation of solvent before priming.

19.2.4 Primers for wood are listed in table A7. If site priming is necessary, it shall be carried out immediately after delivery of the joinery, provided that its moisture content is at a satisfactory level.

Joinery is usually factory primed. Primed joinery, if not fixed or erected immediately, shall be properly stored. Both transparent and pigmented primers (BS 5082, BS 5358) are suitable for paint system.

19.2.5 If primed woodwork has been exposed for a lengthy period the condition of the primer shall be checked before continuing application of the paint system.

It is important that areas of defective or poorly-adhering primer be removed and the exposed areas reprimed. If the primer is firmly adhering but is chalking or powdery, it shall be rubbed down with abrasive paper and a further coat applied.

19.2.6 The color of the coating will influence the surface temperature when exposed to sunlight, with black and dark colors reaching a much higher temperature than white or pale colors.

19.3 Natural Finish System (Transparent Coating) for Wood (See Table A8)

19.3.1 Natural finishes for wood are those which unlike paint, do not completely obscure the grain of wood although they may modify its color in varying degree.

19.3.2 The use of varnishes for exterior wood work is best avoided. In special case when exterior wood work is to be varnished, shall first be treated with a preservative effective against blue-stain⁽¹⁾. With adequate maintenance, the fungicide in exterior wood stains will usually inhibit the development of blue-stain.

19.3.3 With most natural finishes, putty glazing is not suitable (see also IPS-C-TP-101 Appendix D). Varnishes are usually applied to unprimed wood.

Note (1):

Blue-Stain fungi, often contribute to the darkening of weathered wood.

19.3.4 The stains can be used in exterior and interior surface, and shall be contained water-repellent preservative and fungicides in exterior uses.

Many stains, especially the low-solids (A9/7 of table 9) are suitable for use on plywood.

19.3.5 For initial treatment of new external wood a minimum of two and preferably three coats of exterior wood stain shall be applied.

19.3.6 Decorative wood stains (A9/5 of table 9) have no protective or preservative properties and serve essentially to impart color to wood prior to the application of varnish or other clear finish.

19.3.7 Transparent and pigmented primer can be used for stain.

20. DRYING AND HANDLING

20.1 Drying of Painted Surfaces (see also IPS-C-TP-101 Appendix C)

20.1.1 No coat of paint shall be applied until the preceding coat has been dried. The paint shall be considered dry for recoating when first, another coat can be applied without the development of any film irregularities such as lifting or loss of adhesion of undercoats, and second, the drying time of the applied coat does not exceed the maximum specified for it as a first coat. The minimum drying time between coats shall be in compliance with the manufacturer's instructions.

20.1.2 The maximum practical time shall be allowed for paint to dry before recoating. Some paints may dry too hard for good adhesion of subsequent coats; these shall be recoated within the time period in accordance with the manufacturer's instructions. If not recoated within the specified time then the previously applied coatings shall be roughened prior to recoating.

20.1.3 No paint shall be force dried under conditions which will cause checking, wrinkling, blistering, formation of pores, or detrimentally affect the protective properties of the paint.

20.1.4 No drier shall be added to paint on the job unless specifically called for in the manufacturer's instructions.

20.1.5 Paint shall be protected from rain, condensation, contamination, snow, and freezing until dry to the fullest extent practical.

20.1.6 No paint shall be subjected to immersion before it is thoroughly dried or cured.

20.2 Handling of Painted Surfaces

20.2.1 Painted surfaces shall not be handled, loaded for shipment, or shipped until the paint has been dried except as necessary in turning for painting or stacking for drying.

20.2.2 Paint which is damaged in handling shall be scraped off and touched up with the same number of coats and kinds of paints as were previously applied to the surface or as specified by the procurement documents.

21. CLEAN-UP

21.1 All paint application tools and equipment must be carefully cleaned. Dried paint in the equipment will ruin it.

21.2 Remove as much paint as possible. With solvent paints, clean thoroughly with a compatible solvent. Use a detergent solution with latex paint. Clean two or three times with fresh solvent (or warm mild detergent solution), then wipe clean and dry. Well cleaned tools and equipment will last longer and always be in prime condition.

21.3 Be sure to clean brushes down to the heel, since paint tends to dry in this less visible area. This can make the bristles shorter and less flexible. After washing, twirl to remove excess water and comb to straighten the bristles. Finally, wrap in paper or place in a brush keeper and lay flat until dry. Never allow a brush to rest on its bristles. This can cause permanent damage.

21.4 Using a large container, wash the paint mitt used for solvent paints in three changes of solvent or warm mild detergent depending on the type of paint. the solvent cleaned mitts should then be washed in mild detergent solution. Rinse in clear warm water, then hang up to dry.

21.5 Place clean solvent (or detergent solution) in pots and pass through hoses and spray guns. Be sure to remove the tip from airless spray guns and wash separately. Never immerse the gun in solvent because this can ruin the packing.

21.6 Clean with three changes of solvent (or detergent). Then dry. When cleaning after spraying water-based paint, be sure to finish rinsing with a water miscible solvent, such as alcohol. Otherwise, some parts of the spray equipment may rust. Make sure that all hoses are flushed thoroughly. Completely non-rusting spray equipment should be used with water-base paints to prevent rusting. Try to leave the solvent in the system when possible to avoid build-up of paint in the hose.

22. INSPECTION PROCEDURE

22.1 Inspection Guide

The contractor shall meet the requirement of sections 5 to 11 before paintwork including surface preparation commences. The company shall have the right to inspect the paint work at all stages and to reject any and all tools, instruments, materials, and qualifications, staging or equipment or workmanship which do not conform to the specification.

Finished paintwork shall have the correct shade, degree of gloss and evenness and be free from tackyness after drying/curing and from cracks, holidays, runs, sage, wrinkles, patchyness, brush marks, or other defects that may be deleterious to the quality of the coating (see table 6).

Prior to final acceptance of the paintwork an inspection shall be made. The contractor and the company shall both be represented and they shall sign an agreed inspection report.

TABLE 4 - INSPECTION GUIDE

WORK STAGE AND CODE	POTENTIAL DEFECTS	HOW DETERMINED	LIKELY CAUSE	SUGGESTIONS FOR ACTION	NOTES
Environment during application					
1	Too cold (Below 4°C)	Air and contact thermometers	Poor air conditioning in works or externally inclement weather	Improve temperature to acceptable level, but little or no license shall be allowed with limit specified. Open-flame heaters shall not be used.	
2	Too hot	Contact thermometer	Heated surfaces	Reduce temperature below 35°C or to whatever higher temperature is allowed with special paints	If necessary, re-arrange program to avoid hot conditions
3	Too damp	Hygrometer or visual	Poor air conditioning in works or externally inclement weather	Improve air conditioning to acceptable level	Try to Avoid Depositions of Dew Before Paint is 'set'
4	Too wet	Visual and/or Moisture	A) Rain, Sleet or Snow B) Condensation	Protect operations with suitable sheeting, but avoid causing condensation provide suitable ventilation	Where cleaning and painting in adjacent areas additional Covers are required to prevent contamination of the paint
5	Too dark	Visual	Insufficient lighting and/or dirt on glass cladding	Improve lighting; clean glass	Where appropriate confirm with luxmeter
6	Too dusty	Visual	(A) Too much wind (B) Poor dust extraction	Shield work or delay it till wind abates Protect work from blasting dust improve extraction	—
7	Air too foul	Smell and/or instruments	Poor ventilation	Improve ventilation to point where tlvs. of solvents, etc. are not exceeded and/or provide fresh air supply to operators	—

TABLE 4 - (continued)

WORK STAGE AND CODE	POTENTIAL DEFECTS	HOW DETERMINED	LIKELY CAUSE	SUGGESTIONS FOR ACTION	NOTES	
Paint mixing and storage*	1	Wrong weight of container paint	Spring balance	Poor filling of containers or wrong paint	Reject all full under weight containers. A check on other containers with the same batch number will probably indicate if material is at fault	
	2	Wrong specific gravity	SG cup and balance (see ASTM D 1963-85)	(A) Poor mixing of paint (B) Thinning or over-thinning	Reconstitute if possible Reject all paintwork where such paint has been used and either remove by stripping or, if agreed by the company apply an extra coat of the correct paint	
	3	Thin consistency	Visual and/or flow cup (See ASTM D 1200-88)	(A) Defective or wrong paint (B) Poor mixing (C) Thinning or over-thinning		
	4	Thick consistency	Visual and/or flow cup	(A) Defective of wrong paint (B) Poor mixing (C) Thinning not as specified (D) Outside the pot life		 Control the correct use of thinners. adjust viscosity Discard all paints affected
	5	Wrong color in container	Visual comparison with wet standard	(A) Wrong paint supplied (B) Poor color matching or variation in raw materials (C) Not thoroughly mixed	Obtain supplies of correct paint Set aside until manufacturer certifies supply as satisfactory Re-mix and check as for 2 or 3	
	6	Wrong color and other characteristics when thoroughly mixed	Visual, instrumental	Wrong proportions of multi-pack materials	Discard unless proportions used are known and can be corrected	
	7	Paint contaminated with moisture	Visual	Dirty paint store, inadequately heated and/or ventilated	Clean up paint store, provide adequate heating and ventilation	
	8	Deterioration of paint in tins, setting, separation, gelling, etc.	Visual	(A) Old stocks outside the stipulated storage period (B) Use of stocks out delivery order, leading to cause (A) above (C) Storage conditions too hot or too cold		

***Whenever there is anything unusual about the paint other than the potential. Defects listed in paint mixing and storage (1 to 4) refer to the paint manufacturer.**

(to be continued)

TABLE 4 - (continued)

WORK STAGE AND CODE	POTENTIAL DEFECTS	HOW DETERMINED	LIKELY CAUSE	SUGGESTIONS FOR ACTION	NOTES
PRIMING					
1	Over-thick areas, sagging, curtaining	Visual and/or instrumental comparison	Failure to brush out properly or too heavy spray application	Scrape off excess, wipe off while still wet, or otherwise remove. Re-prime to give the correct thickness	Particular attention is required to ensure that each primer is not applied too thickly. Loss of adhesion to subsequent coats may occur
2	Thin areas, grinning through	Visual and/or instrumental	Not enough paint	Further application	
3	Dry Spray	Visual or Touch	Incorrect spraying technique or high winds especially with zinc epoxide and zinc silicate paints	If noticed at time of application, brush surface with hard bristle brush and re-apply. If noticed at a later stage, re-blast and re-prime.	
4	Corrosion products	Visual	Too long storage in primed state	(A) If rusting or rust spotting, re-blast and re-prime (B) If zinc corrosion products show on a metallic zinc primer, especially in a sheltered situation, scrub with fresh water and dry	
5	Color change or soft paint near welds	Visual or touch	Non-removal of welding flux, residues have saponified the paint	Remove all the affected paint, by most appropriate method, to bare metal. scrub affected areas with water and mild detergent, rinse thoroughly and allow to dry. Re-prepare surfaces as specified and prime immediately	

(to be continued)

TABLE 4 - (continued)

WORK STAGE AND CODE	POTENTIAL DEFECTS	HOW DETERMINED	LIKELY CAUSE	SUGGESTIONS FOR ACTION	NOTES
Painting					
1	Sagging, curtaining	Visual	Over-application of paint	Remove paint by scraping or other effective method and re-paint	
2	Areas of low thickness, grinning through	Visual, Instrumental	Under-application of paint, poor spray pattern	Apply extra coat or coats, as appropriate, within the recommended limits of the recoating period	
3	"Orange-peel" effect	Visual	Poor spraying techniques	Correct all adjustment to spraying equipment and operator technique	May be difficult to avoid with heavy compositions
4	Lifting, Wrinkling etc.		(A) Incompatibility of solvents with the state of the previous coat. (B) Wrong interval between coats (C) Drying conditions too fast (D) Surface contaminated (E) Over-thick coat	} Reduce all affected paint by most suitable means to a firm sound substrate and replace all coats as necessary	
5	Poor Inter-coat Adhesion	Visual	(A) Surface contaminated, see 'Notes' column (B) For epoxy or urethane types, too long interval between coats (C) Incompatibility of the components of the painting system, see 'Notes' column		} Remove and abrade surface, recoat
6	Loss of gloss, rough surface	Visual or touch	(A) Airborne dust and dirt. and overspray (B) Condensation during drying	Rub down surface with suitable abrasive paper before further coating. If the affected coat was the final coat it shall be repeated Refer to paint manufacturer before proceeding with further coats. if the affected coat was the final coat, re-apply	
7	Slow drying	Touch	(A) Unsuitable, ambient conditions, or too heavy coating (B) Mixing error for two-pack material	Defer further coats until paint is completely dry Remove the coating and re-apply using correct two-pack mix	There are several other causes, but these are the commonest in practice
8	Pinholing	Visual	(A) Contamination of paint or spray airlines, see 'Notes, column (B) Mixing error for two-pack material	}  Remove and re-paint affected area	Particularly with silicones, oils or water

(to be continued)

TABLE 4 - (continued)

WORK STAGE AND CODES	POTENTIAL DEFECTS	HOW DETERMINED	LIKELY CAUSE	SUGGESTIONS FOR ACTION	NOTES
9	Cissing	Visual	Contamination of surfaces, mainly with oils and greases	Remove and re-paint affected area	Particularly with airless spray
10	No color difference between paints for successive coats	Visual	Wrong paint or poor specification	Supply in stock may be tinted to give intercoat color contrast but consult paint manufacturer	

TABLE 4 - (continued)

WORK STAGE AND CODES	POTENTIAL DEFECTS	HOW DETERMINED	LIKELY CAUSE	SUGGESTIONS FOR ACTION	NOTES
Handling and transport					
1	Contamination of cleaned surface by dirt or sweat	Visual	Bare hands or dirty lifting tackle on cleaned surface	Re-cleanse area with clean water	
2	Easily damaged coating	Visual or touch	Insufficient drying period before hardening	Repair damage to coating, allow longer drying and hardening times	
3	Damage by lifting tackle and other handling gear	Visual	Lifting point not included in design, no purpose-made gear provided	Repair damage, agree improved methods of handling	
4	Chafing in transit	Visual	No special support packings or lashings provided on wagons. poor storage.	Repair damage, no further loading without adequate measures to prevent damage	
5	Components adhering together	Visual	(A) No special packaging provided (B) Stacked before paint is thoroughly dry	Repair damage or return for recoating, agree packaging methods	This happens especially with chlorinated rubber coatings

22.2 Test Methods

22.2.1 Wet film thickness (WFT) measurement

22.2.1.1 Wet film thickness readings are used to aid the painter and inspector in determining how much material to apply in order to achieve the specified dry film thickness. Wet film thicknesses on steel and most other metallic substrates are considered guideline thicknesses, with the dry film thickness being the thickness of record. However, when coating concrete or non-metallic substrates, the wet film thickness is often the accepted value because dry film thickness can be determined only by destructive means.

22.2.1.2 WFT Measurement by instrumental method

The wet film thickness gage is generally a standard notch gage (Fig. 7) although circular dial gages (Interchemical thickness gage) are also used. The instrument is pressed firmly into the wet film perpendicular to the substrate and withdrawn.

22.2.1.3 WFT Measurement by calculation method

The wet film thickness/dry film thickness ratio is based on the percent solids by volume of the specific material being applied.

The solids by volume of the coating material is information readily available from the manufacturer and is commonly included in their product data sheets:

- a) For unthinned coating materials

$$\text{WFT} = \frac{\text{Desired Dry Film Thickness}}{\% \text{ Solids by Volume}}$$

- b) For thinned coating materials

$$\text{WFT} = \frac{\text{Desired Dry Film Thickness}}{\frac{\% \text{ Solids by Volume}}{(100\% + \% \text{ thinner added})}}$$

22.2.1.4 Example

Assume a material contains 78% solids by volume and is to be applied in one coat to a dry film thickness of 200 ζm (0.2 mm). Without thinner added, the required wet film thickness is determined as follows:

$$\text{WFT} = \frac{200}{0.78} = 256 \zeta\text{m} (0.26 \text{ mm})$$

If the coating in the same example is thinned 20% the new required wet film is calculated as follows:

$$\text{WFT} = \frac{200}{\frac{0.78}{1.2}} = \frac{200}{(0.65)} = 308 \zeta\text{m} (0.308 \text{ mm})$$

Thus, without thinning, 256 ζm wet film is required to obtain 200 ζm dry. After thinning, however, the solids by volume drops from 78% to 65% and the required wet film thickness increases nearly 50 ζm .



**WET FILM THICKNESS GAGE-MEASURES COATING THICKNESS DURING APPLICATION
BY PROGRESSIVELY DEEPER STEPS MARKED IN MILS**

Fig. 7

22.2.2 Dry film thickness (DFT) measurement

DFT measurement instruments consist of magnetic gages, which measure the thickness of a dry film of a non-magnetic coating applied on a magnetic substrate. Magnetic stages are grouped as two types:

Type 1 - Pull-off-gages (such as Mikrotest, Inspector, Tinsley Thickness gages, and the Elcometer pull of gage).

Type 2 - Fixed probe gages (such as Elcometer thickness gage, Minitector, General Electric type B, thickness Gage, verimeter, permascope, and Dermitron).

For calibration and measurement procedures see SSPC PA₂ and BS 3900 part C5.

22.2.3 Pinhole and holiday detections

22.2.3.1 After all the coats of paint have been applied, the inspector shall verify that the appropriate clean-up is done, and that any abrasions, nicks, or scrapes are repaired as required.

22.2.3.2 Holiday, pinhole, or spark testing is to be used to find the nicks, scrapes, and pinholes in the coating film, particularly if the coating is intended for immersion service. Holiday testing shall be required after application of either the next to last, or last coat of paint. Usually when such testing is done before final cure of the coating has occurred so that any repair material applied will successfully bond to the underlying coat.

22.2.3.3 Pinhole and holiday detectors are in three general types: low voltage wet sponge, DC high voltage and AC electrostatic types.

When testing conductive lining applied over steel substrate (i.e. conductive rubber lining), the AC electro-static type shall be used.

22.2.3.4 If the continuity of the coating, e.g. for tank linings, is checked with a high-voltage spark test, the pinhole detection device shall be set as high as is practicable with a minimum of 5 watts per ζm of average coating thickness. The test apparatus shall be a low-pulse direct-current detector of a type approved by the company.

22.2.3.5 For detect holidays such as pinholes and voids in thin film paints and coatings from 0.0254 to 0.254 mm (1 to 10 mls) in thickness, low voltage holiday detector shall be used.

This Method may be considered to be a non-destructive test because of an applied voltage of less than 100 V DC.

It is effective on films up to 0.508 mm (20 mils) and is not satisfactory for the thickness over 0.508 mm (see ASTM G 62-87).

The voltage between the electrode (sponge) and the metal surface upon which the coating lies shall not exceed 100 V DC and is according to the manufacturer's instructions.

22.2.4 Field adhesion testing

22.2.4.1 Usually, there is a need to test the adhesion of the coatings after application. There are different types of adhesion testing methods used from the simple penknife to more elaborate testing units. The use of a penknife generally requires a subjective evaluation of the coating adhesion based on some previous experience. Generally, one cuts through the coating and probes at it with the knife blade, trying to lift it from the surface to ascertain whether or not the adhesion is adequate.

22.2.4.2 A modified version of this type of testing is the cross-cut test. The cross-cut test consists of cutting an "X", or a number of small "squares or diamonds" through the coating done to the substrate. Tape is rubbed vigorously onto the scribes and removed firmly and quickly. The cross-hatch pattern is evaluated according to the percentage of squares delaminated or remaining intact. The "X" and "cross-cut" tape adhesion tests are described in ASTM D-3359, "Measuring Adhesion by Tape Test".

22.2.4.3 There are also instruments available for testing the tensile adhesion strength of coatings. They apply a value to the adhesion strength in grams per square millimeter (pounds per square inch), thus eliminating some of the subjectivity of the above tests. An instrument for tensile testing is the pull-of Adhesion Tester (Fig. 8). The pull-off Adhesion Tester consists of the test unit itself and aluminum test dollies or lugs, each with a surface contact area 12.7 mm ($\frac{1}{2}$ square inch). The dollies are cemented to the coating surface using an adhesive. After the adhesive has cured, the coating around the periphery of the dolly is cut through down to the substrate. The claw of the test instrument is placed under the lip of the dolly and the unit tightened by hand, using as uniform a turning speed and motion as possible.

The test unit applies a pulling force on the head of the dolly, ultimately breaking it from the surface. The point of the break is read from the scale on the instrument in grams per square millimeter (pounds per square inch). Not only is the numerical value of importance when using this instrument, but also the type of break. For example, there is a significant difference in the test results if one finds a clean break to the substrate or between coats, compared to finding a cohesive break within a coat. Many times one may experience a failure of the adhesive. If this occurs, it establishes that the coating tensile adhesion strength is at least as good as that pressure that broke the adhesive.

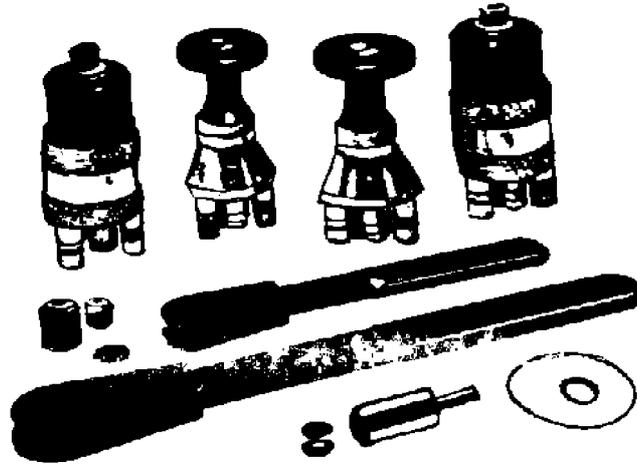
22.2.4.4 It is generally recommended that the two-component type epoxy adhesives be used in preference to the single component fast drying cyano-acrylate types. When testing zinc-rich coating, for example it has been found that the thin cyano-acrylates have a tendency to penetrate and bond the zinc particles together, resulting in a much higher tensile pull than should be expected. In other cases, the adhesive appears to soften and cause premature failure of the coating systems.

22.2.5 Evaluating Cure

22.2.5.1 When a coating is to be used in immersion service, the applied coating film must be allowed to dry cure for a given length of time prior to being placed into service. This dry cure time is generally shown on the manufacturer's product information. Alternately, forced-heat curing may be used to reduce the time between curing and service.

22.2.5.2 Determining the cure of coatings is generally difficult. ASTM D1640 outlines one method, but there are no universally reliable field tests for such purposes. Solvent rub tests can be used, as well as sandpaper tests. When most coatings are suitably cured, rubbing them with sandpaper will produce a fine dust. If the sandpaper gums up, depending upon the coating, it may not be cured properly. Certain phenol-containing coatings may discolor upon heating--and the cure of phenolic tank lining coatings is often determined by comparison of their color with color reference coupons supplied by the coating manufacturer.

22.2.5.3 Because a coating is "dry" or hard does not necessarily mean it is cured. In fact, for most coatings, hardness is not synonymous with cure. The only coating types for which this is true are the solvent deposited coatings such as the chlorinated rubbers and vinyls. Even then, residual retained solvents (and moisture in water emulsion coatings), under certain atmospheric conditions of temperature and/or humidity may take a long time to escape from the paint film. Final attainment of film properties will be acquired only upon satisfactory loss of these entrapped solvents. In some cases this evaporation process may take as long as two or three weeks or more.



PULL-OFF ADHESION TESTERS

Fig. 8

23. SAFETY

23.1 General

23.1.1 This Section describes typical hazard to health and safety that may be encountered in the painting process, and makes general recommendations for dealing with them. Potential hazard include the following: (see also IPS-E-SF-100 classification of fire and fire hazard properties)

- a)** Fire and explosion (see 23.2).
- b)** Toxic hazard (see 23.3).
- c)** Health hazard (see 23.4).

23.1.2 Information in noise levels, e.g. from compressors and mechanical tools, and code of practice for reducing the exposure of employed persons to noise are described in IPS-E-SF-900 (Noise and vibration control).

23.1.3 Hazard may also be created by the use of unsuitable or defective scaffolding. Details are described in IPS-E-SF-420 (Safety for scaffolds).

23.2 Prevention of Fire and Explosion

23.2.1 Flammable, volatile solvents in paints constitute a major hazard with regard to fire and explosions wherever flame or spark exposure is possible. No painting shall be done within 45 meter of steel welding or torch cutting activity.

23.2.2 When painting is required in a confined area, all flame sources (pilots, lights, etc.) shall be extinguished and no smoking permitted. Painting shall cease whenever this condition may be reached, or when solvent vapor concentration reaches hazard level (see Threshold limit value (TLV) in Table 5).

23.2.3 Vapor exhaust equipment shall be used to maintain minimum level of solvent concentration.

23.2.4 The superintendents shall acquaint themselves and their foremen with the fire hazards inherent in the job and job site.

23.2.5 The use and storage of flammable materials are to be kept in restricted areas, and these areas are to be well marked with appropriate signs.

23.2.6 Fire extinguishers and fire hoses shall be placed at location which are agreed upon or designated by the safety manager.

23.2.7 Provide adequate ventilation in all working areas to prevent a build-up of explosive concentrations of solvent vapor. Check regularly in confined areas or closed spaces to be sure vapor concentrations are below explosive limits.

23.2.8 Do not use metal ladders in confined areas or within 3 meters of exposed electric wiring.

23.2.9 Clean up before, during and immediately after painting operations. Wet down sweeping, rags and waste with water and store in closed metal containers. Dispose them daily.

TABLE 5 - THRESHOLD LIMIT VALUES (TLV) FOR SOLVENTS

Substance	Adopted Values TWA-TLV ¹		Adopted Values STEL-TLV ²	
	ppm	mg/m	ppm	mg/m
Acetone	750	1780	1000	2375
Benzene (Benzol) - Skin	10	30	25	75
Butylcellosolve - Skin	25	120	75	360
Carbon Tetrachloride - Skin	5	30	20	125
Cyclohexane	300	1050	375	1300
Epichlorohydrin - Skin	2	10	5	20
Ethyl Acetate	400	1400	—	—
Ethanol (Ethyl Alcohol)	1000	1900	—	—
Ethylene Dichloride (1, 2-Dichloroethane)	10	40	15	60
Ethylenediamine	10	25	—	—
Furfuryl Alcohol - Skin	10	40	15	60
Methanol (Methyl Alcohol) - Skin	200	260	250	310
Methylene Chloride (Dichloromethane)	100	350	500	1740
Naphtha, Coal Tar ³	—	—	—	—
Naphtha, Petroleum ³	—	—	—	—
Perchloroethylene - Skin	50	335	200	1340
Isopropyl Alcohol - Skin	400	980	500	1225
Stoddard Solvent	100	525	200	1050
Toluene	100	375	150	560
Trichloroethylene	50	270	200	1080
Turpentine	100	560	150	840
Xylene (Xylol)	100	435	150	655

1) TWA-TLV (Threshold Limit Value - Time Weight Average): The time weighted average concentration for a normal 8 hour workday or a 40 hour work week.

2) STEL-TLV (Threshold Limit Value - Short Term Exposure Limit): The maximum concentration to which workers can be exposed for a period up to 15 minutes.

3) In general, the aromatic hydrocarbon content will determine what TLV applies.

23.2.10 Threshold limit value (TLV), expressed as parts per million (ppm) of solvent to air, that an operator may be exposed to during an 8 hours working day with no ill effects.

23.3 Prevention of Toxic Hazard

The following components used in organic coating materials are toxic.

23.3.1 Some pigments are toxic. The most common contain lead compound and chromate. Precaution shall be taken when applying or removing paints containing these pigments.

Lead and chromate paints shall not be used on surfaces which may be licked or chewed by animals.

23.3.2 Some paint additives such as the mercurial compounds used to impart fungicidal properties, may be toxic if ingested.

23.3.3 A few binders are toxic to some degree if exposure is excessive. Typical of these are epoxies, acrylics (not latex) polyurethane and polyesters.

23.3.4 Most solvents are toxic to some degree, depending upon exposure. The degree of toxicity can be measured by the Threshold limit value (TLV) (see table 7).

If permissible exposure limits, as determined by an industrial hygienist, are exceeded, the respiratory protection becomes necessary.

23.4 Prevention of Health Hazard

23.4.1 Identify and seal all toxic and dermatitic material when not in use.

23.4.2 Adequately ventilate all painting areas. Air used to fulfill the requirements of coating will require monitoring prior to, during, and following use to assure proper quality. Effluent treatment is required for the removal of fumes, vapors, and particulates where monitoring analyses indicate that levels exceed the acceptable discharge limits.

23.4.3 Wear goggles and the proper respirator when spraying or performing any operation where an abnormal vapor or dust is formed.

23.4.4 Eye protection shall be worn during paint spraying or when painting over head with other applicators.

23.4.5 Cleaning the hands with paint solvents or "thinners" may cause serious chronic skin complaints.

23.4.6 Wear appropriate gloves and clothing when handling dermatitic material, change and clean work clothing daily.

23.4.7 Avoid touching any part of the body when handling dermatitic materials. Wash hands face and arms thoroughly before eating and at the end of the day. Try to take shower at or near the job site.

23.4.8 All alkaline cleaners shall be handled with care. Rubber gloves and face or eye shields shall be worn when these materials are added to cleaning tanks. Should these materials contact the skin, it shall be flushed with water as soon as possible.

These precautions apply also to the handling of acids used in phosphating and chromating.

23.4.9 Liquid acid shall never be drawn from a carboy by using air pressure to force it out, even when using the so-called air pressure reducers. Danger is always present that the carboy will break and spray or splash acid on the operator. This also holds true for drums.

APPENDICES**APPENDIX A
PAINT SCHEDULES FOR NON-METALLIC SURFACES**

(Materials specification shall be in accordance with relevant standards of Institute of Standards and Industrial Research of Iran (ISIRI) as a minimum.)

(to be continued)

TABLE A.1 - PAINT SYSTEMS FOR PLASTER, CONCRETE, BRICK, BLOCK AND STONE (INTERNAL)

SUBSTRATE CONDITION	FINISH TYPES AND REFERENCE IN TABLE A.5	PRIMER AND REFERENCE IN TABLE A.3	FINISH SYSTEM AND REFERENCES IN TABLE A4 OR A5	TYPICAL LIFE TO FIRST MAINTENANCE (NOTE 2)
Dry R. H. below 75%	Alkyd gloss, mid-sheen or matt. (A5/1), (A5/2, A5/3)	Alkali - resisting primer (A3/1) or, plaster only, water - thinned primer (A3/2)	(a) Gloss finish. 1 coat oil-based (A4/1) or emulsion (A4/2) undercoat; 1 coat alkyd gloss finish (A5/1)	5 Years or more
			(b) Mid - sheen finish. 2 coats alkyd mid - sheen finish (A5/2)	5 Years or more
			(c) Matt - finish. 2 coats alkyd matt finish (A5/3)	Up to 5 years
	Emulsion paint (A5/4, A5/5)	Primer not usually required A well - thinned first coat of emulsion paint may be required on surfaces of high or variable porosity	(d) Matt or mid - sheen finish. 2 or 3 coats general purpose emulsion paint, matt or mid-sheen (A5/4) (e) Matt, high - opacity finish. 2 coats 'contract' emulsion paint A5/5 1 coat, spray - applied, may suffice in some situations	5 Years or more Up to 5 years
	Multi - color (A5/13)	Primer or basecoat as recommended by manufacturer	(f) Usually 1 coat multi - color finish (A5/13) spray - applied but refer to manufacturer's instructions	10 Years or more
Drying some damp patches R.H. 75% to 90%	Textured (A5/13)	Primer not usually required but refer to manufacturer's instructions	(g) 'Plastic' texture paint (A5/14). normally 1 coat but may require over - painting (h) Emulsion - based masonry paint, heavy - texture (A5/9). normally 1 coat but refer to manufacturer's instructions	Indefinite in environments in which normally used but likely to require periodic over - painting to maintain appearance
	Cement paint (A5/12) (not on gypsum plaster)	Primer not required	(i) 1 or 2 coats cement paint (A5/12)	5 Years or more in situations for which cement paint is generally used
Damp obvious damp patches R.H. 90% to 100%	Emulsion paint (A5/4, A5/5)	As for 'dry' substrates	As (d) and (e) above	Generally as for similar systems on 'dry' as substrates but some risk of failure at higher moisture levels
	Multi - color finishes (A5/13) possible but consult manufacturer	As for 'dry' substrates	As (f) above	
	Textured paints (A5/14) possible but consult manufacturer	As for 'dry' substrates	As (g) and (h) above. if overcoating is necessary, emulsion paint shall be used	
	cement paints (A5/12) (not on gypsum plaster)	Primer not required	As (i) above	As for 'dry' substrates
Wet moisture visible on surface R.H. 100%	Emulsion paint A5/4, A5/5) possible	Primer not recommended	As (d) and (e) above 'contract' types (A5/5) are usually more permeable than general purpose (A5/4) types and less prone to failure on damp substrates	High risk of early failure
	Cement paint (A5/12) (not on gypsum plaster)	Primer not required	As (i) above	As for 'dry' substrates
	Cement paint (A5/12) (not on gypsum plaster)	Primer not required	As (i) above	Generally as for 'dry' substrates but some risk of failure

Notes:

- 1) 'R.H.' refers to the relative humidity in equilibrium with the surface. See 18.7 for methods of measuring moisture content.
- 2) Life expectancies shown assume application to dry, sound substrates, qualified as indicated for other substrate conditions, and based on performance in 'moderate internal environments.'

(to be continued)

TABLE A.2 - PAINT SYSTEMS FOR RENDERINGS, CONCRETE, BRICK, BLOCK AND STONE (EXTERNAL)

SUBSTRATE CONDITION	FINISH TYPE AND REFERENCE IN TABLE A.5	PRIMER AND REFERENCE IN TABLE A.3	FINISH SYSTEM AND REFERENCES IN TABLE A.4 OR A.5	TYPICAL LIFE TO FIRST MAINTENANCE (NOTE 2)
Dry R. H. below 75% (Note 1)	Alkyd gloss (A 5/1)	Alkali - resisting primer	(a) 1 Coat oil - based undercoat (A4/1); 1 or 2 coats alkyd gloss finish (A5/1)	3 Years to 5 years or more
	Emulsion paint general purpose (A.5/4) if suitable for external use	Primer not usually required	(b) 2 Coats general purpose emulsion paint (A5/4)	Up to 5 years
	Masonry paints, solvent - thinned A5/10 or A5/11	Alkali - resisting primer (A3/1) or as recommended by manufacturer	(c) Smooth or fine - textured (A5/10) types, solvent - thinned. 2 coats	5 Years or more
			(d) Thick, textured (A5/11) types, solvent - thinned. usually 1 or 2 coats applied by spray, often by specialist applications	10 Years or more
	Masonry paints, emulsion - based (A5/8 or A5/9)	Primer not usually required with A5/8 types	(e) Smooth or fine - textured (A5/8) types, emulsion - based. 2 coats	5 Years or more
		Primer not usually required with A5/9 types but refer to manufacturer's instructions	(f) Heavy - textured (A5/9) types, emulsion - based. usually 1 coat applied by roller	10 Years or more
	Cement paint (A5/12)	Primer not required	(g) 2 Coats cement paint (A5/12)	UP to 5 years
Drying some damp patches may be visible R.H. 75% to 90%	Emulsion paint, general purpose (A5/4)	As for 'dry' substrates	As (b) above	Potentially, as for "dry" substrates but some risk of earlier failure at higher moisture levels
	Masonry paints, emulsion - based (A5/8 or A5/9)	As for 'dry' substrates	As (e) or (f) above	
	Possibly solvent-thinned masonry paints (A5/10, A5/11) but refer to manufacturer's recommendations	As for 'dry' substrates	As (c) or (d) above	
Damp obvious damp patches R.H. 90 % to 100 %	Cement paint (A5/12)	Primer not required	2 Coats cement paint (A5/12)	As for "dry" substrates
	Possibly emulsion-based masonry paints (A5/8, A5/9) but refer to manufacturer's recommendations	Primer not recommended	As (e) or (f) above	Potentially as for "dry" substrates but high risk of earlier failure
Wet moisture visible on surface R.H. 100 %	Cement paint (A5/12)	Primer not required	2 Coats cement paint (A5/12)	As for "dry" substrates but some risk of earlier failure

Notes:

- 1) 'R.H.' refers to the relative humidity in equilibrium with the surface. See 18.7 for methods of measuring moisture content.
- 2) Life expectancies shown assume application to dry, sound substrates, qualified as indicated for other substrate conditions, and are based on performance in 'moderate' external conditions. (to be continued)

TABLE A.3 - MISCELLANEOUS PRIMERS FOR BUILDING

REF.	DESCRIPTION	GENERAL COMPOSITION	CHARACTERISTICS AND USAGE
A 3/1	Alkali - resisting	Typically, alkali - resistant drying - oil / resin type binder, lightly pigmented	Although described as 'alkali - resisting', primers of this type are intended for use on substantially dry, possibly alkali - containing, surfaces mainly beneath drying - oil type finishes; they will not necessarily prevent attack by alkalis on subsequent coats if the structure is very damp. Color : typically low - opacity white or of white
A 3/2	Water - thinned primer or primer- undercoat	Emulsion - type binder (typically based on an acrylic polymer). may be identical in composition to A4/2	These primers are for use on dry plaster and similar surfaces. they may also be suitable for priming wood and building boards and as undercoats; see A4/2. Color : typically white or off - white
A 3/3	Primer - sealer. other descriptions include 'stabilizing primer or solution' 'penetrating primer' or 'masonry sealer'	Variable TUT typically drying - oil / resin type binder, lightly pigmented, or semi - transparent with a 'marker' pigment to assist even application	The essential function of a primer - sealer is to 'bind down' powdery or friable residues of previous coatings which can not be removed completely. too much reliance should not be placed on the ability of this type of material to penetrate unsound coatings of substantial thickness, and as much as possible of the old material shall be removed. primer sealers may also be used to reduce absorption on surfaces of high or uneven porosity. 'masonry sealers' are usually formulated specifically for use on exterior surfaces and may not be suitable for interior work; with other types, the reverse may apply. reference should be made to the manufacturer's recommendations. Color : variable.
A 3/4	Universal primer	Typically, drying - oil / resin type binder with white or light - colored pigments, usually including rust-inhibitive types, e.g., zinc phosphate	Primers of this type are convenient for small scale maintenance work involving patch - priming of a variety of substrates, e.g., wood, metal and dry plaster. for new and large - scale work, primers formulated for specific substrates are generally to be preferred. Color : typically white or light grey

TABLE A.4 - UNDERCOATS FOR BUILDING

REF.	DESCRIPTION	GENERAL COMPOSITION	CHARACTERISTICS AND USAGE
A 4/1	Oil - based undercoat	Typically, drying - oil / resin type binder, pigmented with titanium dioxide and / or colored pigments	This type of undercoat provides a matt or low - sheen surface for subsequent application of drying - oil type finishes, especially gloss finishes. in normal conditions, overnight drying is usually required before application of further coats. Most undercoats are suitable for interior and exterior use. Color : wide range
A 4/2	Water - thinned undercoat or primer-undercoat	Emulsion - type binder (typically based on an acrylic polymer), pigmented as A4/1 may be identical in composition to A3/2	These undercoats are quicker - drying than A4/1 and, in normal conditions, may permit same - day recoating. general usage as for A4/1 as primers they may be suitable for priming dry plaster and similar surfaces, building boards and wood. Color : may be limited to white and pale tints, especially with "primer - undercoat" types.

(to be continued)

TABLE A.5 - PIGMENTED FINISHES FOR BUILDING

REF.	DESCRIPTION	GENERAL COMPOSITION	CHARACTERISTICS AND USAGE
A 5/1	Alkyd gloss finish	Typically, drying - oil / alkyd resin binder, pigmented with titanium dioxide and / or light - fast, colored pigments. some types contain small amounts of polyurethane or other resins to increase hardness or extend durability	These are high - gloss protective and decorative finishes suitable for interior and exterior use on most building surfaces. they have good durability and wearing properties in most conditions except those of direct chemical attack or very high humidity. drying and recoating times are variable according to composition but, usually, overnight drying between coats is required. Color : wide range available
A 5/2	Alkyd ' mid - sheen ' finish. other descriptions include 'eggshell', 'satin' and ' silk'	Generally as for A5/1 but adjusted to provide a lower level of gloss	The durability and protective properties of this type of finish are of a lower order than those of 5/1, and exterior use, especially on wood and metal, is not usually recommended. internally, this finish is suitable for use on most building surfaces. drying and recoating characteristics are usually similar to those of A5/1 Color : wide range available
A 5/3	Alkyd matt or flat finish	Generally as for A5/1 adjusted to provide a matt finish	Essentially, this is a decorative finish for interior use only and is not generally recommended for 'hard - wear' situations or in humid conditions. drying and recoating characteristics are usually similar to those of A5/1. color : range may be limited
A 5/4	Emulsion paint, general purpose matt or ' mid - sheen '. other descriptions include 'plastic emulsion', 'latex' and 'vinyl', the latter term being used increasingly as a generic description for emulsion paints rather than an indication of composition. descriptive terms for sheen levels may be described at for A5/2. note: 'glossy' emulsion paints are available, but experience with them is limited and they are not in widespread general use at the present time. reference should be made to the manufacturers for information regarding suitability for specific applications.	Emulsion - type binder, typically based on vinyl or acrylic polymers or combinations of these, with titanium dioxide and/or colored pigments	Emulsion paints of this type are essentially 'decorative' rather than 'protective' in function, although their wear - resistance and washability may approach those of A2/2 finishes. they have advantages over the latter in case of application to large areas, speed of drying (same day recoating is usually possible), absence of solvent odor and ease of clean - up. they are widely used for ceilings and walls, mainly internally although some may be suitable for use on exterior walls. choice of sheen level may depend largely on location and aesthetic considerations but, in general terms washability and resistance to soiling increase proportionately to the degree of sheen. emulsion paints are more permeable to moisture than drying - oil type finishes, and some may be unsuitable for use in situations, e.g., in some kitchens and bathrooms, where humidity is high for long periods. color : a wide range is available
A 5/5	Contract' emulsion paint'	Composition, typically, is similar to that of A5/4 but with higher pigment content	Higher pigment gives increased opacity, compared with 5/4 type, but at the expense of some reduction in washability and resistance to soiling. finish is usually matt. emulsion paints of this type are frequently used for new interior walls and ceilings where, apart from economy in use, their permeability allows drying - out of contained moisture. Color : usually limited to white and pale tints
A 5/6	Aluminum paint, general purpose	Typically, drying - oil / alkyd resin binder pigmented with flake aluminum	The laminar nature of the pigment imparts excellent moisture resistance to aluminum paints, and their reflective and heat - resistant properties are useful in many situations. they are suitable for use on most building surfaces, but their widest application is on structural steelwork, storage vessels and heated metal surfaces.

(to be continued)

TABLE - A.5 (continued)

REF.	DESCRIPTION	GENERAL COMPOSITION	CHARACTERISTICS AND USAGE
A 5/7	Micaceous iron oxide paint, general purpose	Typically, drying - oil or drying - oil / resin type binder pigmented with micaceous iron oxide. small amounts of other pigments may be incorporated to modify the natural color (dark grey) of the main pigment	Because of the laminar nature of the pigment and the substantial thickness of the film, micaceous iron oxide paints provide good protection and are widely used extensively on structural steel, bridges, harbor installations and electricity transmission towers. on weathering, the coating develops a metallic "sparkle". the dark color of the pigment restricts the range of colors available, but overcoating with alkyd gloss finish may be possible.
A 5/8	Masonry paint, emulsion - type, smooth or fine - textured	Emulsion - type binder, typically based on acrylic, vinyl and other polymers formulated to have the degree of flexibility required for exterior used and pigmented with titanium dioxide and/or lime - resistant colored pigments. some types are smooth, others contain fibre, sand or other agent to give a fine texture. most contain an additive to inhibit mould and algal growth.	These are essentially 'decorative' coatings but have the weather resistance and durability required in coatings for exterior walls. they are not generally suitable for application to wood and metal. formulations containing fibre sand, etc., usually provide thicker films than the smooth types. manufacturers should be consulted regarding the use on interior surfaces of masonry paints containing additives to inhibit mould and signal growth because of the possible toxic hazard. Color : a wide range is available.
A 5/9	Masonry paint, emulsion - based heavy - textured. some types may be described as 'organic renderings'	Compositions may vary considerably but consist generally of a heavy - bodied emulsion - type binder, reinforced with coarse 'extenders' and, in some cases, fibrous material and aggregates. pigmentation is similar to that of A5/8 and mould algal inhibitions may be incorporated.	Coatings of this type have been used in Europe for external wall surfaces for many years but have become available in Britain only comparatively recently. they provide thick (1 mm to 2 mm), weather - resistant coatings, and experience in Europe indicates that they are capable of durability in excess of 10 years. their heavy texture is derived partly from their composition specially - designed rollers. in addition to their use externally, coatings of this type may be suitable for internal walls where a hard - wearing textured finish is required. Color: a wide range is available.
A 5/10	Masonry paint, solvent - thinned, smooth or fine - textured. the latter type may be described as 'stone' paints	Composition varies considerably. older types may be based on A0 drying - oil / resin type binder, others on modified or synthetic rubber film - formers. 'stone' paints contain fine sand, stone or mica. pigmentation is generally as for other masonry paints.	The appearance of this type of coating is similar to that of the A5/8 types, and film thickness is of the same order. permeability is usually lower, and they may therefore provide greater resistance to moisture penetration but should be applied to dry substrates. brush application will generally be shower than with A5/8 types. color : may be limited.
A 5/11	Masonry paints, solvent - thinned, thick, textured	Composition variable but typically employs a drying - oil/alkyd resin binder; may be described as 'polyester' (= alkyd). usually contains coarse 'extender' and / or fibrous material. pigmentation as for other masonry paints.	These provide coatings of substantial thickness (0.6 mm to 1.0 mm), of relatively low permeability, and therefore have good resistance to moisture penetration. coatings of this type are usually applied by spray or roller. often by specialist applications. material and application costs are likely to be high. color: may be limited.
A 5/12	Cement paint to BS 4764	Based on white Portland cement with titanium dioxide or colored pigments, and additives to assist application and increase water - repellency. supplied in powder form and mixed with water immediately before application.	Low - cost coatings giving a rough finish and used mainly for exterior wall surfaces, although they may be used inside except on gypsum plaster: not recommended for application over other types of paint. on lengthy outside exposure, pastel shades may tend to lighten and darker colors to become patchy. color : range is fairly limited.

(to be continued)

TABLE - A.5 (continued)

REF.	DESCRIPTION	GENERAL COMPOSITION	CHARACTERISTICS AND USAGE
A 5/13	Multi - col finish	<p>In one type, droplets of pigmented nitrocellulose or vinyl resin solution are dispersed in an aqueous medium so that the coating is water - thinnable. the pigmented droplets remain discrete in the dry film, so providing the multi - color effect. in another type, a pigmented emulsion - type basecoat is followed, when dry, by spray - applied 'spatter' coats of similar material. finally, an emulsion - type clear glazecoat may be applied. in a third type, a pigmented emulsion - type basecoat is followed, when dry, by a clear emulsion glaze in which are suspended multi - colored flakes of solid material.</p>	<p>This is quick - drying, hard - wearing finish for interior wall surfaces, often used in circulating areas, cloakrooms and similar 'hard - wear' locations. application is usually by spray, but materials of the third type may be suitable for brush or roller application. color: a wide range of multi - color effects is available.</p>
A 5/14	'Plastic' texture paint	<p>Typically, based on gypsum and supplied as dry powder for mixing with water before use, but ready - for - use emulsion - based types are available. the term 'plastic' indicates that the material can be 'worked' after application to provide relief texture effects.</p>	<p>This is essentially a 'decorative' coating for interior use only. it may be used as a substitute for plaster skimming on plaster board ceilings or to disguise rough or cracked walls and ceilings. texture is achieved either directly by spraying or by brush or trowel application and subsequent combing, stippling or other treatment. some types are self - colored and require no further treatment; others may require over - painting, e.g., with emulsion paint.</p>

**TABLE A.6 - PAINT SYSTEMS FOR WOOD, INTERNAL AND EXTERNAL
(EXCLUDING HARDWOOD SURFACES NOT USUALLY PAINTED)**

APPLICATION	REQUIREMENTS FOR PRESERVATIVE TREATMENT (NOTE 1)	PRIMERS AND REFERENCES IN TABLE A.7	FINISH SYSTEMS AND PRODUCT REFERENCES IN TABLES A.4 & A.5	TYPICAL LIFE TO FIRST MAINTENANCE (NOTE 2)
Window Joinery, softwood. internal and external	Essential	Low - lead, oil - based (A7/1). Aluminum A7/2 (preferred for resinous woods, e.g. douglas fir, and possibly for timber treated with metallic naphthenate preservatives).water - thinned A7/3 (compatibility with water-repellent organic solvent Preservatives should be checked)	External gloss 1 Coat undercoat (A4/1 or A4/2) 2 coats alkyd gloss finish (A5/1). (or 2 undercoats and 2 coat finish)	3 Years to 5 years
			Internal gloss 1 Coat undercoat (A4/1 or A4/2) 1 Coat alkyd gloss finish	5 Years or more
			Internal mid - sheen 2 coats alkyd mid - sheen finish (A5/2)	Up to 5 years
			Internal matt 2 coats alkyd matt finish (A5/3)	As mid - sheen finish
External sills, hardwood	Optional but necessary if excessive sapwood present	Low - lead, oil - based (A7/1) aluminum (A7/2) filling necessary with open - grain timber	As for external gloss above	Generally as for window joinery but depending on species and nature of timber
Doors and frames internal softwood plywood	Optional	As for window joinery	As for window joinery	As for window joinery
	None	As for window joinery . filling recommended on open-grain veneers		
Doors and frames, external softwood plywood	Desirable	As for window joinery	As for window joinery	As for window joinery
	Optional ; required if it contains non-durable species	low - lead, oil - based (A7/1) aluminum (A7/2) filling recommended on open-grained veneers or if checking occurred		
Skirtings, softwood	Desirable	As for window joinery	As for window joinery	
Cladding, barge - boards, fascias and soffits softwood plywood	Required by building regulations for some species (notwestern red cedar)	As for window joinery		As for window joinery
			Textured coatings finish types A5/9, A5/10 and A5/11 may be suitable for use on timber cladding; consult manufacturers	As for window joinery
	Optional ; required if it contains non-durable species	Low - lead, oil - based (A 7/11) aluminum (A7/2) paper overlay desirable and may allow primer to be omitted		Up to 10 years
Gates and fences softwood hardwood	Essential	Low - lead, oil - based (A7/1) aluminum (A7/2)	Gloss finish as for window joinery	Up to 5 years, depending on design and degree of exposure
	Desirable and maybe essential in some circumstances;see BS 5589	Note: unless painting is necessary for appearance, consideration shall be given to preservative treatment of gates and fences initially and for subsequent maintenance (See Note: 1)		

Notes:

- 1) Preservative treatments are summarized in (IPS-C-TP-101 Sub-Section 17.3). Reference shall also be made to BS 5589.
- 2) Life expectancies shown assume application to dry, sound woodwork which, if necessary, has received appropriate preservative treatment and are based on performance in ‘moderate’ environments.

(to be continued)

TABLE A.7 - PRIMERS FOR WOOD

REF.	DESCRIPTION	GENERAL COMPOSITION	CHARACTERISTICS AND USAGE
A7/1	Low - lead, oil - based primer see BS 5358	Drying - oil / resin type binder with 'low lead' pigmentation.	Primers of this type have a lead content of less than 1% (as determined by the method described in BS 4310) but are equivalent in performance to the traditional 'pink' (white lead / red lead) wood primers. they are suitable for general use on wood not highly resinous and not treated with metallic naphthenate preservatives; also for fibre boards and wood chipboards not fire - retardant treated. Color : typically white or pink.
A 7/2	Aluminum wood primer to BS 4756	Drying - oil / resin type binder with aluminum pigment.	Alternative to A7/1, and more suitable for woods which are resinous or have been treated with metallic naphthenate wood preservatives or creosote. may also be used as primers for fibre boards and wood chipboards (not fire - retardant treated) and as 'sealers' for surfaces that have been coated with bituminous materials. Color: aluminum
A 7/3	Water - thinned primer see to BS 5082	Emulsion - type binder (typically based on acrylic polymer) with lead - free pigmentation.	These primers dry more rapidly than A7/1 & A7/2 types, usually allowing same - day recoating if required. they do not contain flammable solvents and permit tools and equipment to be cleaned with water. their durability without top - coats on exterior exposure is equivalent to that of A7/1 & A7/2 types but, as they are more permeable, they may be less effective in excluding moisture from primed joinery stacked in the open. they are more prone to raise grain than oil - based primers. They may also be used as primers for fibre building boards and woodchip boards not fire - retardant treated. color : typically white, light grey or pink.

(to be continued)

TABLE A.8 - NATURAL FINISH SYSTEMS FOR WOOD, EXTERNAL AND INTERNAL

APPLICATION	PRODUCT TYPE AND REFERENCE IN TABLE A.9	SYSTEM	TYPICAL LIFE TO FIRST MAINTENANCE (NOTE 1)
External window joinery doors and frames			
	Varnish Not recommended		Variable according to product type but unlikely to exceed 3 years on full exposure
	Exterior wood stain Low solids (A 9/7) High solids (A9/8), Opaque (A9/9)	2 to 3 Coats	
Hardwood	varnish Exterior grade, full gloss (A9/2)	4 Coats	Unlikely to exceed 3 years
	Exterior wood stain As for softwood	2 to 3 Coats	As for softwood
Plywood e.g., door panels	Varnish Not recommended	—	—
	Exterior wood stain Low solids (A9/A)	2 to 3 Coats	As for softwood. salt - staining possible
External boarding cladding, bargeboards, soffits fascias			
Softwood	Varnish Not recommended	—	—
	Exterior wood stain As for window joinery Also Madison formula (A9/6)	2 to 3 Coats	As for window joinery
Hardwood	Varnish Exterior grade, full gloss (A9/1)	4 Coats	As for window joinery
	Exterior wood stain As for window joinery As Madison formula (A9/6)	2 to 3 Coats	As for window joinery
Plywood	Varnish Not recommended	—	—
	Exterior wood stain As for window joinery Also Madison formula (A9/6)	2 to 3	As for window joinery. salt - staining possible
Gates, fences, handrails			
Softwood	Varnish Not recommended	—	—
	Exterior wood stain Low solids (A9/A)	2 to 3 Coats	As for window joinery
Hardwood	Varnish Exterior grade, full gloss (A9/1)	4 Coats	As for window joinery
	Exterior wood stain Low solids (A9/7)	2 to 3	As for window joinery

(to be continued)

TABLE A.8 - (continued)

APPLICATION	PRODUCT TYPE AND REFERENCE IN TABLE A.9	SYSTEM	TYPICAL LIFE TO FIRST MAINTENANCE (NOTE 1)
internal general joinery surfaces, linings and fitment			
	Varnish Interior grade full gloss (A.9/2) Or mid - sheen (A.9/3) Polyurethane, two - pack or Moisture - curing (A.9/4) for Exceptional abrasion resistance	2 to 3 Coats	Variable according to type and service conditions but typically up to 5 years in ' average wear ' environments
Softwood, hardwood plywood (note 2)	Wood stain Some exterior wood stains, e.g., A.9/7 & A.5/8, may be Suitable for interior use but Refer to manufacturer's Recommendations	1 to 2 Coats	Variable according to type and service conditions. may give lifetime service in some situations

* Over decorative wood stain (49/5) if required.

Notes:

1) Life expectancies shown assume application to dry, sound timber which, if necessary, has received preservative treatment (see C-TP-101 subsection 17.3).

2) When a high standard of finish is required on internal hardwood surfaces, special-purpose wood finishes, e.g. French polish or lacquer, are generally used.

(to be continued)

TABLE A.9 - NATURAL FINISHES FOR WOOD

	DESCRIPTION	GENERAL COMPOSITION	CHARACTERISTICS AND USAGE
A 9/1	Varnish, exterior grade, full gloss	Typically, drying - oil, phenolic or alkyd resin	This provides a tough, flexible, water - resistant coating, used principally as a clear protective finish for exterior hardwood
A 9/2	Varnish, interior grade, full gloss	Typically, drying - oil / alkyd, urethane or urethane / alkyd resin	Harder than A9/1 type and is more suitable for use on interior hardwood joinery. some types may be sufficiently abrasion-resistant to be suitable for use on hardwood floors, counter tops and similar 'hard wear' locations
A 9/3	Varnish, eggshell, satin or matt finish	Composition generally as for A 9/2 but adjusted to provide a lower level of gloss	Generally as for A9/2 but is likely to be less suitable for use in 'hard wear' locations
A 9/4	Varnish, polyurethane, two - pack or moisture - curing one - pack	Two - pack types are supplied as separate base and 'activator'. which are mixed before use to initiate chemical curing. with one - pack moisture - curing types, the reaction is initiated by absorption of moisture from the atmosphere or from the surface to which the material is applied	These coatings provide extremely hard, strong films with exceptional resistance to abrasion. the stresses set up within the film may lead to peeling and flaking especially on exterior woodwork whose surface through long exposure without protection, has become degraded. in general, the use of this type of coating is best confined to interior woodwork where exceptional resistance to abrasion and possible chemical attack is required.
A 9/5	Decorative wood stain	Drying - oil, spirit or water media, with colored pigments or dyes	Used essentially to modify or enhance the appearance of wood without obscuring its grain and is usually overcoated with clear finishes.
A 9/6	Exterior wood stain, semi - transparent, Madison formula	Drying - oil binder (boiled linseed oil), paraffin wax, fungicide and pigment	Water - repellent penetrating stain that imports an 'oiled' appearance to the wood. suitable for brush application. film remains soft and slightly tacky so will retain dirt and is not suitable for situations where it is likely to be abraded or come in contact with clothing. wax component may cause difficulty if over - painting is subsequently required.
A 9/7	Exterior wood stain, semi - transparent, low solids	Resin solution of low viscosity with fungicide and pigment	Water - repellent penetrating stain suitable for brush application. imports little or no sheen to surface of wood. because of very low film thickness, offers little resistance to passage of water vapor and, in consequence, moisture content of wood may fluctuate considerably. Stains of this type can be used on interior woodwork but before doing so, it should be as certain from the manufacturer that the fungicide contained does not constitute a health hazard.
A 9/8	Exterior wood stain, semi - transparent, high solids	Generally as for A 9/1 but higher resin content	Because of its higher resin content, this type of stain will normally import a noticeable sheen to the surface. it is less penetrative than A 9/7 and offers greater resistance to water vapor movement, so fluctuations in the moisture content of the wood are less pronounced.
A 9/9	Exterior wood stain, opaque	May be a solvent - thinned resin solution or an emulsion - type, with pigment and fungicide	This type may be regarded as intermediate between a stain and a paint. it has low gloss, but the texture of the wood remains evident because of the differences in penetration within the growth rings. Some opaque stains may be used over weathered but sound paintwork.

ATTACHMENT**ATTACHMENT
CONVERSION COATING
(METAL SURFACE TREATMENTS)**

1. Wash primer, phosphate coating and chromate coating are the types of conversion coatings which are applied over ferrous and non-ferrous metals.

2. Wash Primer

2.1 Basic zinc chromate-vinyl butyral wash primers (IPS-M-TP-180) is a pretreatment medium for metals which reacts with the metal and at the same time forms a protective vinyl film which contains an inhibitive pigment to help prevent rusting and improve the adhesion of paint.

2.2 Wash primer shall be mixed with the diluent in quantities which will be applied within six to eight hours after mixing. Primer that cannot be used within a maximum of eight hours after mixing with diluent shall be discarded and not used. Screen wash primer before applying .

2.3 Apply the wash primer by spraying or brushing. Spraying is generally the preferred method, but brushing may be desirable over rough or poorly prepared steel. Roller coating shall not be used.

2.4 Wash primer shall be applied to dried film thickness of 10 to 13 microns dry or approximately 100 to 130 microns wet. Note that at this thickness, which should not be exceeded, the base metal will show through the coating as evidenced by uneven coloring. This is the normal appearance; do not attempt to hide the base metal completely.

2.5 When spot treating, cover only spots free of old paint.

Slight overlap of existing paint is generally not harmful provided adherence of the wash primer to the old paint is satisfactory and the old paint is not lifted.

2.6 The next coat of paint may be applied as soon as the wash primer is dry, usually from one-half hour to four hours later except when otherwise authorized by the inspector.

2.7 Wash primer shall be applied over clean, dry metal; however, a slightly damp surface may be painted over, provided adequate normal butyl alcohol is used in the thinner. If the surface is excessively wet, the vinyl butyral resin will be thrown out of solution and form a gel, or the dried film will turn white, become brittle, and lack adhesion to the metal.

2.8 Wash primer is not intended for use as a shop coat for metal and it should be recoated with the prime coat of paint before exposure, preferably within 24 hours.

2.9 Wash primer is especially effective when applied to galvanized steel or aluminum, but is not effective if applied over another primer or phosphated or chromated surface because the reaction will be impeded and adhesion destroyed. It must be applied directly over a bare metal substrate.

2.10 The wash primer shall not be white in spots; when dry, it shall be tested for adhesion to the substrate by scraping it away with a knife.

2.11 Wash primer permits many types of conventional paint to be used over steel and galvanizing surfaces, specially an emulsion cleaner water blasting is used for preparation of surfaces. It is also used to provide adhesion of paint to stainless steel and aluminum and shall be required by some vinyl paint system.

2.12 Keep wash primer away from heat, sparks, and open flame during storage, mixing, and application. Provide sufficient ventilation to maintain vapor concentration at less than 25% of the lower explosive limit.

3. Phosphate Coating

3.1 Uses

3.1.1 Phosphate coating is the treatment of ferrous metals with a dilute solution of phosphoric acid and other chemicals whereby the surface of the metal, reacting chemically with the phosphoric acid, is converted to an integral, mildly protective layer of insoluble crystalline phosphate.

3.1.2 Phosphate coatings are transformer of metal surface into new surfaces having non-metallic and non-conductive properties. They are used under paint, plastic coating, metallic coating, wax and rust-preventive oil, for protection of surface against corrosion and to improve adhesion. Phosphate coatings are generally used for ferrous metals and applied by immersion and spraying methods.

3.1.3 Two principal type of phosphate coatings are in general use: zinc and Iron. The other types of phosphating include manganese phosphating, solvent phosphating and phosphating in low temperatures are used for special uses.

3.1.4 Phosphate coating is applied in thickness of 2.5 to 50 micron (0.1 to 2 mils). Coating weight (milligrams per square decimeter of coated area), rather than coating thickness has been adopted as the basis for expressing the amount of coating deposited, the types of phosphate coating are given as follow;

Type 1.A. Heavy weight. Coatings that consist essentially of manganese and/or iron phosphate and have coating weights of not less than 7.5 g/m² of treated surface.

Type 1.B. Heavyweight. Coatings that consist essentially of zinc phosphate and have coating weights of not less than 7.5 g/m² of treated surface.

Type 2. Medium weight. Coatings that consist essentially of zinc and/or other phosphates and have coating weights within the range of 4.5 g/m² to 7.5 g/m² of treated surface.

Type 3. Light weight. Coating that consists essentially of zinc and/or other metal phosphates and have coating weight of 0.2 g/m² to 4.5 g/m².

3.1.5 The iron phosphating method has the lower initial capital investment and processing stages than zinc phosphating, but zinc phosphating with higher coating weight than iron phosphating, permits the application of heavier paint finishes with potentially longer life expectancy.

3.2 Zinc phosphate coating

3.2.1 The zinc phosphate coating is formed by crystallization on the surface by chemical reaction.

Zinc phosphating shall be applied by spray or immersion, and can be used for any of the application of phosphating. Spray coating on steel surfaces ranges in weight from 1-11 g/m², immersion coating from 1.6 to 43 g/m².

Zinc phosphate coating 1.6-4.5 g/m² are used for steel prior to painting, and in coating weight 1.6 to 43 g/m² are used for zinc and zinc plated prior to painting (see also table 2).

The type of phosphate coating (see Attachment. 3.1.3) and the coating weight of zinc phosphate coating for specific job shall be approved by the company.

3.2.2 Zinc phosphating process

The zinc phosphate system shall be applied in six stages as follows:

- a) Degreasing with weakly alkaline cleaner (concentration 1%, temperature 50-55°C) according to IPS-C-TP-101 Section 5.5.

- b) Rinsing with water by immersion or spray process.
- c) Zinc phosphating according to Attachment 3.2.3.
- d) Rinse with water.
- e) Passivating rinse according to Attachment 3.2.4.
- f) Drying according to IPS-C-TP-101 Appendix C.

Note:

Usually, only one rinse is required. If the water supply is so high in mineral content that a residue remains on the parts after rinsing, a rinse in deionized water shall be required.

An intermediate stage may be interspersed between stages b and c for the purpose of improving the crystal size of the zinc phosphate by use of a colloidal titanium salt.

3.2.3 Zinc phosphating component-zinc phosphating shall be applied to a surface by either immersion or spray (see Table 1-Attachment). A fine uniform crystal is desirable when gloss is desired for the paint film (coarse crystals promote dullness). When the coating is applied to provide lubricity, a coarse crystal may be preferable.

In this method the surface is treated with a chemical solution prepared by diluting a proprietary concentrate to the 2 to 4% level. Immersion baths are more concentrated than spray baths.

The essential components of a phosphating bath are zinc salt, neutralized phosphoric acid, nitric acid, an oxidant and an accelerator (sodium nitrite).

For chemical control of phosphating solution during the process see Attachment 3.5.

3.2.4 Passivating rinse-Phosphated parts shall be given a chromic acid rinse following the post-phosphating water rinse. The purpose of the chromic acid rinse is to neutralize any phosphating acid that may remain on the parts, and to leave a light chromate coating, which improves the corrosion resistance of the part.

In passivating rinse, the phosphated parts shall be immersed in or sprayed with a chromic acid solution having a concentration of 15-31 ml of acid per 100 liters of water.

When paint sensitive to chromic acid is to be applied subsequently, phosphated parts shall be rinsed with deionized or distilled water to remove excess chromic acid.

For chemical control of solution during chromic and rinsing see Attachment 3.5.5.

3.3 Iron phosphate coating

Most iron phosphate coatings are produced by spray (see Table - 1 Attachment). The iron phosphate system is applied by a four stage process as follows:

- a) Cleaning and phosphating.
- b) Rinse in hot water (70 to 80°C) by immersion or spray process.
- c) Passivating rinse according to Attachment 3.2.4.
- d) Drying according to IPS-C-TP-101 Appendix C.

The components of phosphating solution are salt of phosphoric acid, (ammonium or potassium dihydrogen phosphate 70-80 wt%- solid content), activator (sodium nitrate 8-10 Wt% solid content) and cleaning agent (non-ionic surfactant 10 Wt% solid content). The concentration (volume percent) of these materials normally range from ½ % to 2% iron phosphating solution. Iron phosphate coatings are generally of a very fine structure, amorphous (non-crystalline) in appearance. Because these coatings are used primarily as bases for paint or to assist in the bonding of metal to a non-metallic surface (fabric, wood and others), the fine structure is desirable.

To maintain required specification of iron phosphate coating, chemical control of processes is necessary (see Attachment 3.5.3).

3.4 Other types of phosphate coating

3.4.1 Manganese phosphate coating

Manganese phosphatings are applied only by immersion, requiring times ranging from 5 to 30 min (see table Attachment 1). Because the manganese phosphate crystal is softer and will therefore break down more readily than the fine phosphate crystal, these coatings shall not be used, prior to painting and are used as on oil bases. For chemical control manganese phosphating see Attachment 3.5.4.

3.4.2 Solvent phosphate coating

There is a system using trichloroethylene (or methylen chloride), as the base for cleaning, phosphating, and subsequent finishing.

The method involves 4 stages and requires special equipment:

- a) Vapor degreasing in a boiling bath of trichloroethylene at 86.5°C (see IPS-C-TP-101 Sub-Section 5.2).
- b) Phosphating by either spray or immersion in the organic acid phosphates.
- c) Non-aqueous rinse. The phosphated surface, while in wet condition, is typically immersed or flooded with a chromium containing rinse composition (solvent base).
- d) Coating with an organic finish

Solvent phosphating produce a water resistant coating and is suitable for water-based finishes.

TABLE 1 - (ATTACHMENT) PHOSPHATING SPECIFICATION

PHOSPHATING METHOD	PH	TEMPERATURE °C	PHOSPHATE COATING WEIGHT	
			g/m ²	g/ft ²
Zinc phosphating 1) Immersion 2) Process	1.8-2.4	67-77	6-43	0.16-4.6
Spray process	3-3.4	38-64	1-11	0.12-1.2
Iron phosphating	3-6	50-67	0.2-0.9	0.02-0.92
Manganese phosphating (immersion process)	1.8-2.4	90-99	5-32	0.67-3.4

Note:

Zinc phosphate coating of light to medium (1.6-4.5 g/m²) and light iron phosphate coating (0.2-0.9 g/m²) are used for paint bases.

3.5 Chemical control of phosphating processes

3.5.1 General

To obtain satisfactory phosphate coatings on steel surfaces, phosphating solutions must be chemically controlled within limits. Even the mineral content of plain water rinses need to be controlled, to avoid leaving a residue on parts. The limits vary depending on the specific phosphating concentrate used. Solutions shall be tested on a regular schedule, unless otherwise specified by the company the frequency of tests is determined by the work load of the phosphating line.

General methods of controlling zinc, Iron and manganese phosphating solutions are described bellow:

3.5.2 Zinc phosphating solutions

When zinc phosphating solutions become unbalanced the results are poor coatings, excessive sludge build-up, and insufficient coating weights. Three chemical tests are usually made on a zinc phosphating solution to determine its suitability for coating. These are tests of total acid value, accelerator content, and iron concentration.

3.5.2.1 Total acid value

Zinc phosphate solutions have a total acid value established that should be maintained for satisfactory performance. One commonly used solution is controlled at 25 to 27 points.

To determine the total acid value, a 10 ml sample of the solution is titrated with 0.1 N sodium hydroxide (1 ml of sodium hydroxide used = 1 point), using phenolphthalein as an indicator. The end point is reached when the solution changes from colorless to pink.

3.5.2.2 Accelerator test

Sodium nitrite is used as an accelerator in some zinc phosphate solution. It is usually controlled at 1.0 point. Before the test for sodium nitrite is made, the phosphate solution should be tested for the absence of iron. This is done by dipping a strip of iron-test paper in the phosphate solution. If the paper does not change color, no iron is present in the solution. If the paper changes to pink, however, iron is present, and small additions of sodium nitrite are then made until an iron-test paper shows no change.

The sodium nitrite test is made using a 25 ml sample of the phosphate solution. From 10 to 20 drops of 50% sulfuric acid are added carefully to the solution and it is then titrated with 0.042 N potassium permanganate. The end point is reached when the solution turns from colorless to pink (1 ml = 1 point).

3.5.2.3 Iron concentration

Because iron is constantly being dissolved from parts being zinc phosphated, the concentration of iron may build up until the efficiency of the solution is impaired. Zinc phosphating solutions usually operate best when the iron concentration is maintained between 3 and 4 points. Production experience with a particular solution will indicate whether the iron content can be expanded without affecting the quality of the coating.

To determine the iron content, a 10 ml sample of the solution is first acidulated with a sufficient amount of a 50% mixture of sulfuric and phosphoric acid to assure a low pH while titrating (2 or 3 drops may be sufficient) potassium permanganate until a permanent pink color is obtained (1 ml = 1 point).

This titration is used for immersion zinc phosphating solution. Spray zinc phosphating usually does not involve a build-up of iron in the solution because of the oxidizers that are present.

3.5.3 Iron phosphating solutions

If recommended chemical limits are not maintained in iron phosphating solutions, the results will be low coating weights, powdery coatings or incomplete coatings. To maintain required balance in iron phosphating solutions, titration checks shall be made to determine total acid value and acid consumed value.

3.5.3.1 Total acid value

Total acid value is determined by titration of 10 ml sample of the phosphating solution with 0.1N sodium hydroxide, using thymolphthalein as an indicator. The end point is reached when the solution changes from colorless to blue. The number of milliliters of the 0.1N sodium hydroxide is the total acid value, in points, of the phosphating solution. A normal concentration would be 10.0 points.

3.5.3.2 Acid consumed value

Acid consumed value is determined by titration of a 10 ml sample of the phosphating solution with 0.1 N sulfuric acid, using bromocresol green indicator. The end point is reached when the solution changes from blue to green.

A normal range for the acid consumed value for a solution with a 10 point total acid value would be 0.3 to 0.7 ml of 0.1N sulfuric acid.

3.5.4 Manganese phosphating solutions

The manganese phosphating solutions used to produce wear-resistant and corrosion-protective coatings shall be maintained in balance by control of total acid, free acid, acid ratio, and iron concentration values. Since the phosphate solutions are acid, these values are determined by titration methods using a standard basic solution.

The frequency of control checks on manganese phosphating solutions depends a great deal on the amount of work being processed through the tank and on the volume of the solution. Normally, however, one to two checks per shift would be sufficient.

3.5.4.1 Total acid value

Total acid value is determined by titration of a 2 ml sample of the phosphating solution with 0.1 N sodium hydroxide, using phenolphthalein as an indicator. The end point is reached when the solution changes from colorless to pink. The number of milliliters of 0.1 N sodium hydroxide multiplied by five (because a 2-ml sample is used rather than a 10-ml sample), equals the point value of the total acid. A normal total acid value would be 60 points (12 ml \times 5).

3.5.4.2 Free acid value

Free acid value is determined by titration of a 2 ml sample of the phosphating solution with 0.1 N sodium hydroxide, using methyl orange xylene cyanole indicator. The end point is reached when the solution color changes from purple to greenish grey. The number of milliliters, multiplied by five, is the free acid value in points. A normal free acid value for a 60 point total acid value would be 9.5 to 11.0 ml or points.

3.5.4.3 Acid ratio

In order to obtain satisfactory coatings, the ratio of total acid to free acid contents of manganese phosphating solutions should be maintained within certain limits. For a solution with a 60 to 70 point total acid value, this ratio should be between 5.5 to 1 and 6.5 to 1. Low-ratio solutions produce incomplete coatings, poorly adherent coatings or coatings with a reddish cast. High-ratio solutions also result in poor coatings.

3.5.4.4 Iron concentration

Since iron is continually dissolved from the parts going into the phosphating bath, the concentration of ferrous iron in the bath gradually builds up. Some manganese phosphate coating problems that can be traced to high iron concentrations are: light grey instead of dark grey to black coating, powdery coatings, and incomplete coatings in a normal time cycle.

The concentration limits of iron will depend on the type, hardness and surface condition of the steel being treated. A normal manganese phosphating bath will operate satisfactorily with an iron concentration ranging from 0.2% to 0.4%. Production experience will indicate whether the iron concentration limits can be expanded without affecting the quality of the coating.

To determine iron concentration, a 10-ml sample of the phosphating solution is used. To this sample 1 ml of 50% sulfuric acid is added. The solution is then titrated with 0.18 N potassium permanganate. The end point is reached when the solution changes from colorless to pink. One milliliter of the 0.18 N potassium permanganate is equivalent to 0.1% iron.

3.5.4.5 Iron removal

If iron removal becomes necessary, the ferrous iron in the solution is oxidized with hydrogen peroxide, which causes the iron to precipitate and also liberates free acid in the bath. Since the free acid in the bath will increase and thus lower the acid ratio, it is necessary to neutralize the liberated free acid by adding manganese carbonate.

The approximate amount of hydrogen peroxide needed to lower the concentration of iron by 0.1% is 1.25 ml per 1 liter of manganese carbonate is needed to neutralize the liberated free acid.

Iron removal may be unnecessary if the square meter of steel being processed and the volume of the phosphate bath limit the amount of iron build-up.

3.6 Repair of phosphate coatings

Small parts that did not accept a satisfactory phosphate coating can easily be stripped, cleaned and rephosphated. Large parts with a faulty coating or with a coating that was damaged in processing are less easily handled, and repair of the phosphated surface may therefore be preferable to stripping and rephosphating.

The most simple method is to blast the phosphate film until all defective coating is removed and clean bare metals is exposed. A proprietary phosphating solution compounded for this type of application is brushed or wiped on the area to be rephosphated, and is allowed to remain for a prescribed length of time (usually measured in seconds); the surplus solution is then removed by thoroughly water rinsing and wiping dry with clean rags.

These "wash off" or "wipe off" solutions usually consist of phosphoric acid, butyl celosolve and a suitable wetting agent, plus 50 to 70% water.

If the volume of repairs is considerable, a portable steam spray unit may be used. This will spray, in turn, hot phosphating solution, water, and chromic acid rinsing solution through a hose and nozzle.

3.7 Inspection methods

3.7.1 The majority of phosphate coating quality control methods are based on visual inspections. For zinc and manganese phosphate, the coating must be continuous, adhere well to the surface, and be of uniform crystalline texture suitable for the intended use. Color shall be from grey to black. Loose smut or white powder (due to dried phosphate solution), blotchiness, excessive coarseness, and poor adhesion are causes for rejection. Crystal size may be observed by using micrographs at magnifications of 10x to as much as 250x depending on the type of coating.

Iron phosphate coatings have no apparent crystalline texture; rather they appear to be amorphous. Their color will vary from blue to brown. Loose or patchy coatings are cause for rejection.

3.7.2 Test for the presence of a phosphate coating

a) Reagent

Dissolve 8 g of ammonium molybdate in 80 ml of distilled water add 12 ml concentrated hydrochloric (d=1.14), 20 g ammonium chloride and 10 ml of saturated potassium persulfate solution. The reagent shall be freshly prepared.

b) Procedure

Add one drop of the reagent to the test surface. The appearance of a blue color within 30 s indicates the presence of a phosphate coating.

A plain untreated surface of the same basis metal should be used as a control.

3.7.3 Determination of coating weight

c) Test procedure

The sample shall be weighed on a balance with a precision of 0.1 mg and immersed in a fresh solution of concentrated hydrochloric acid ($d=1.14$) containing 20 g per litre of antimony trioxide at room temperature. When the coating has dissolved off (a period of 5 min. is normally sufficient), the sample shall be removed from the solution and washed for 30 s in running water; any non-adherent matter shall be rubbed off with a wet swab. The sample shall then be thoroughly dried and reweighed and the weight of the phosphate coating calculated as g/m^2 .

d) Alternative stripping solution

A solution containing 50 g/liter of chromic acid. Operated at approximately 75°C. may be used as an alternative to that specified in (c).

3.7.4 Coating voids or spots not covered may be checked as follows:

- a) Use a clean, dry phosphated specimen.
- b) Soak a piece of filter paper, 40 to 50 sq. cm in area, in a solution containing 7.5 g potassium ferricyanide and 20 g sodium chloride per liter. Allow excess solution to drain off.
- c) Apply wet filter paper to phosphate sample 5 min. Remove and observe blue spots, which indicate non-coated areas.
- d) The method of rating may vary with different processes and requirements; one general method is as follows:

Excellent None to three fine spots up to 1 mm.

Good Not more than 10 fine spots.

Satisfactory Not more than 20 fine spots or up to 3 large spots.

4. Chromate Treatment

4.1 Component

Chromate conversion coatings is employed to impart brightness and improve the corrosion resistance of bare metal and as a substrate to provide improved paint adherence on non-ferrous surface includes: aluminum, zinc, tin plate, copper, cadmium, magnesium and zinc-plated surfaces. These coatings are obtained by immersion and electrochemical processes. A variety of chromate treatments are disclosed, using hexavalent chromium (VI) and trivalent chromium (III) as well as resinous coating containing chromate. Table 2 Attachment shows some recommended compositions of chromate solutions.

Chromate treatments are also used as a sealing, anticorrosive or coating or iron or steel pretreated with a phosphate solution (see Attachment 3.2.4), and as an insulating or anticorrosive coating for electrolytic iron plate. Chromate coating will not prevent the growth of metallic filaments, commonly known as "whiskers". The chromic acid or chromium salts such as sodium or potassium chromate or dichromate; together with reducing agent and one or more of certain anions which act as activators, are used as chromating solutions.

Method of applying the chromate treatments on zinc coated steel and aluminum are described in Attachment 6.3 and Attachment 6.6.

TABLE 2 - (ATTACHMENT) RECOMMENDED COMPOSITIONS OF CHROMATE SOLUTIONS

PHOSPHATE COATING AND TYPE OF SEALANT OR ORGANIC COATING	RECOMMENDED COMPOSITIONS IN TERM OF CrO ₃ TRIVALENT Cr	
	MINIMUM	MAXIMUM
Coatings with subsequent demineralized water rinse to be finished with paint, varnish or lacquer	0.2 g/liter	1.0 g/liter
Coatings without subsequent demineralizer water rinse to be finished with paint, varnish or lacquer	0.1 g/liter	0.5 g/liter
Coatings to be finished with oil, grease or wax	0.1 g/liter	2.5 g/liter

4.2 Chemical controlling of chromating process

4.2.1 The concentration of active ingredients (primarily hexavalent chromium) in the bath shall be maintained within ±10% of the initial make up value. Close control of pH of the bath is a useful aid in maintaining uniformity of result.

4.2.2 Chromic acid solutions

The concentration of chromic acid solutions may be determined by two, and sometimes three, titration checks for total acid value, free acid value, and when necessary, for chromate concentration.

4.2.3 Total acid value

Total acid value is determined by titrating a 25 ml sample of the chromic acid solution with 0.1N sodium hydroxide, using phenolphthalein indicator.

The end point is reached when the color change from amber to a reddish shade that lasts at least 15 sec. Each ml of 0.1N NaOH required equals 1 point total acid.

4.2.4 Free acid value

Free acid value is determined by titrating a 25 ml sample of the chromic acid solution with 0.1N sodium hydroxide, using bromocresol green indicator. The end point is reached when the color changes from yellow to green. Each ml of 0.1N NaOH required equals 1 point free acid.

The concentration of free acid in chromic acid solutions is usually maintained between 0.2 to 0.8 ml.

4.2.5 Chromate concentration

Chromate concentration may be determined by placing a 25 ml sample of the solution into a 250 ml beaker, adding 25 ml of a 50% sulfuric acid solution, 2 drops of orthophenanthroline ferrous complex indicator, and titrating with a 0.1N ferrous sulfate solution. Each ml of 0.1N ferrous sulfate solution of the amount required to change to solution from blue to a reddish-brown color is 1 point of chromate concentration.

4.3 Inspection methods

4.3.1 Visual method for colored coating ⁽¹⁾

The appearance of a visible colored film having good continuity and adhesion, (thoroughly dried coating can not be wiped off by gently wiping with clean white cloth), without visible flows or defect in the basis metal and coating may, under many conditions, be a sufficient test of quality.

4.3.2 Test method for colorless ⁽²⁾ coating on aluminum surface

4.3.2.1 The use of a drop of chemical solution that when in contact with the basis metal results in a change in color of the spot test solution, may be used to determine the presence of a protective colorless film when compared to a similar drop of solution on a cleaned but untreated surface.

Notes:

- (1) Colored chromate coatings are preferred for maximum corrosion resistance and for use as a paint base color will be yellow to brown.
- (2) Colorless chromate coating used for decorative purpose and low electrical resistance.

Solution A	Solution Make up
Reagent grade	
Ferric nitrate-	
Fe (NO₃)³. 9 H₂O	2 g
Reagent grade	
Hydrochloric acid-HCl (36.5-38.0 percent)	20 ml
Distilled or deionized water	473 ml
 Solution B	
Reagent grade	
Potassium ferricyanide-K³ Fe(CN)⁶	2 g
Distilled or deionized water	473 ml

4.3.2.2 When stored separately the solutions are stable. When mixed, storage life is limited to a maximum of one week. The mixed solution (equal volumes of solutions A and B) shall be kept in a brown bottle.

4.3.2.3 An untreated surface from which the surface oxide has been removed by acid or alkali shall be used for comparison. The treated surface shall be allowed to dry thoroughly before testing. A drop of test solution is applied by an eye dropper to both the treated and untreated surface. The solution will turn blue-green very quickly on an untreated surface while the time to turn blue-green on the treated surface will vary with the thickness of the chromate film. Aged coatings dried at elevated temperatures (that is, dehydrated coating) develop a colored spot more quickly than fresher ones.

4.3.3 Test method for colorless coating on zinc and zinc coated surface

This test applies only to coatings that are free of secondary supplementary coatings, such as oil, water or solvent-based polymers, or wax.

4.3.3.1 Determine the presence of a colorless (clear) coating by placing a drop of lead acetate testing solution on the surface. Allow the drop to remain on the surface for 5 s. Remove the testing solution by blotting gently, taking care not to disturb any deposit that may have formed. A dark deposit or black stain is indicative of the absence of a coating.

4.3.3.2 Prepare the test solution by dissolving 50 g of lead acetate trihydrate (Pb (C₂H₃O₂)₂ , 3 H₂O) in 1 liter of distilled or deionized water. The pH of the solution shall be between 5.5 and 6.8. Any white precipitate formed during the initial preparation of the solution may be dissolved by small additions of acetic acid; Provided that the pH is not reduced to a value below 5.5. Upon formation of a white precipitate thereafter, the solution shall be discarded.

4.3.3.3 For comparative purposes , treat an untreated surface similarly. On an untreated surface, a black spot forms almost immediately.

4.3.4 Determination of chromate coating weight (colored or colorless coating)

Satisfactory for coatings dried or baked at any temperature up to normal paint baking temperatures.

4.3.4.1 Procedure

Use a 71 by 71 mm (approximately 3 by 3 in.) test panel.

- a) Wipe panel with solvent to remove oil, grease, and other surface soil.
- b) Weigh on analytical balance to ± 0.2 mg.
- c) Immerse for 2 min. in molten salt bath of the following composition:
Reagent grade sodium nitrate (NaNO_2)
Temperature of salt bath -326 to 354°C
- d) Remove from salt bath and rinse thoroughly in cold water.
- e) Immerse for 30 s in 1 part (by volume) of concentrated nitric acid (reagent grade) and 1 part (by volume) water at room temperature.
- f) Rinse thoroughly in cold water and blow dry.
- g) Reweigh on analytical balance
- h) Repeat (a) through (g). The loss in weight on the second stripping should normally be less than 0.6 mg on a 71 by 71 mm panel.

4.3.4.2 Calculation

Weight loss in milligrams = coating weight, g/m^2 .

4.3.5 For adhesion resistance, salt spray resistance and abrasion resistance test methods see ASTM B201, B449 and B117.

5. Surface Treatment of Ferrous Metals

For surface treatment of ferrous metals, phosphating or applying of wash primer shall be used. These include treatment to form oxide and carbide surface layers of improved corrosion resistance, processes for handling rust, for improving subsequent coating, and for special situations in processing steel sheets and the manufacture of steel products.

Cast iron shall be phosphating with zinc and manganese phosphate coating. For protection against corrosion in outdoor storage for one year. The stainless steel and alloy steels shall not be treated by phosphating.

Ferrous metal surfaces shall be prepared according to IPS-C-TP-101 prior to surface treatment and painting.

6. Surface Treatment of Non-Ferrous Surfaces

6.1 Zinc and zinc plated surfaces

The conversion coating improve the paint holding qualities of zinc surface after surface preparation (see IPS-C-TP-101 Section 12), and prevent the formation of "wet storage" stain and paint bonding to zinc-coated steel. Three types of conversion coating can be applied over zinc and zinc coated surface; phosphate coating (see Attachment 6.2) chromate coating (see Attachment 6.3) and wash primer (see Attachment 6.4).

6.2 Phosphating treatments of zinc and zinc plated surfaces

6.2.1 The phosphating treatment of zinc and zinc coated steel convert the surface to a non-reactive zinc phosphate and contains of six stages as follows:

- a) Clean with mild alkaline-type cleaner
- b) Cold-water rinse
- c) Hot-water rinse
- d) Zinc phosphating (applied by brush, spray or immersion, see B.6.2.2).
- e) Warm-water rinse
- f) Chromic acid rinse

6.2.2 A phosphating formulation which can be successfully recommended is as follow:

66 grams	zinc oxide
66 grams	nickel carbonate
170 cm ³	phosphoric acid (75% wt)
2 cm ³	lactic acid
Water to make up 1 liter of solution	

The nickel salt serves as an accelerator. Nitrites, copper, and cobalt salts are used for the same purpose.

6.2.3 The presence of aluminum in quantities of 0.1 to 0.5 percent in hot dip zinc coating necessitates the use of an additional "accelerator" in the phosphating solution. Fluoborated, ammonium salts of fluorine or other soluble metal fluorides are used for this purpose.

6.2.4 Phosphate coating used as a base for painting of zinc and zinc plated surface, in weight from 1.6 to 43 g/m² of surface (see coating weight see Attachment 3.2.1).

6.3 Chromate treatment of zinc and zinc plated surface (see also ASTM D 2092)

6.3.1 Chromate conversion coatings are applied to zinc and galvanized steel for wet storage stain control. The steps involved, typical, chromating process, would include:

- a) Preparation included degreasing and pickling and rinsing remove oil, grease, oxides and heavy metallic impurities (see IPS-C-TP-101).
- b) Chromate treatment by immersion or electrochemical process.
- c) Dye application when desired and rinsing.
- d) Drying according to IPS-C-TP-101 Appendix C.

6.3.2 Care must be taken so that over heating does not occur (above 65°C), as this results in lowering the corrosion resistance of the film owing to its dehydration.

6.3.3 Careful handling of the freshly coated parts is critical, because the films are relatively soft and gelatinous in nature, and may be marred easily until completely dried.

6.3.4 The test methods for evaluating the protective value of chromate treatment are described in B.4.3. For control of chromating process see Attachment 4.2.

6.4 Wash primer for zinc and zinc plated (see also Attachment 2)

6.4.1 While the range of paints that will adhere well to such films is somewhat smaller than for phosphating, a system based upon wash primer shall be used. Their major advantage is that no rinsing is required. The dry film thickness shall not exceed 12.5 micron.

6.4.2 The wash primer shall not be applied to a wet surface nor to a previously chromated or phosphatized surface because the reaction will be impeded and adhesion destroyed.

6.4.3 Wash primer shall be primed and top coated promptly, since inherent resistance of wash primer films to moisture is low.

6.5 Aluminum and aluminum alloys surfaces

The surface treatment of aluminum are processes for improved weathering coating for short-term protection. Unanodized aluminum surfaces shall be treated by chromate treatment after preparation (see IPS-C-TP-101 Clause 12.1.2) and prior to painting.

6.6 Chromate treatment of aluminum surfaces

6.6.1 Aluminum surfaces shall be chromate treated when is to be used in marine and humid environments. The process of chromating of aluminum surface consist of the following stages:

- a)** Alkaline cleaning and rinsing (see IPS-C-TP-101).
- b)** Deoxidizing or desmutting with mineral acid solution (nitric or hydrofluoric acid).
- c)** Rinsing with clean fresh water spray.
- d)** Chromate treatment, with hexavalent chromium, which is applied by immersion or spray.
- e)** Final rinsing with water maximum temperature of 70°C. Use of deionized water is recommended.
- f)** Drying, according to IPS-C-TP-101 Appendix C. The chromated surfaces does not attain a temperature greater than 70°C in the drying process'.

6.6.2 Chromate conversion coating shall be applied to weight from 0.1 to 1.07 g/m² (0.01 to 0.01 g/ft²) for use as a paint base. The weigh of coating shall be approved by company.

6.6.3 The test methods for evaluation the protective value of chromate treatment are described in Attachment 4.3. For control of chromating process see Attachment 4.2.