

CONSTRUCTION STANDARD
FOR
SURFACE PREPARATION

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1. SCOPE

This Construction Standard gives the minimum requirements for surface preparation of substrates prior to protecting against corrosion, both for initial construction and/or maintenance.

The standard includes the minimum requirements for surface preparation of ferrous metals, non ferrous metals and non-metallic surfaces (e.g. masonry materials and wood). Applicable methods of surface preparation such as degreasing, pickling, manual cleaning, flame cleaning and blasting are discussed in this Standard. Recommendations are made regarding the selection of appropriate method(s) of surface preparation with reference to substrate and the Coating (including metallic coating and electroplating) to be applied.

2. REFERENCES

Throughout this Standard the following standard codes are referred to. The edition 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/Consultant.

ACI (AMERICAN CONCRETE INSTITUTE)

"Manual of Concrete Practice 1989"

ANSI (AMERICAN NATIONAL STANDARD INSTITUTE)

8701 "Protection Tools"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

D 610-85	"Method of Evaluation Degree of Rusting on Painted Steel"
D 714-87	"Method of Evaluation Degree of Blistering of Paints"
D 3640-80	"Standard Guide Lines of Emission Control in Vapor Process"
E 161-87	"Precision Electroformed Sieves"
E 323-80	"Perforated-Plate Sieves for Testing Purposes"
F 941-85	"Practice for Inspection of Marine Surface Preparation and Coating Application"

BRE (BUILDING RESEARCH ESTABLISHMENT) Digests. London HMSO

No. 110 "Control and Lichens, Moulds and Similar Growths"

BSI (BRITISH STANDARD INSTITUTE)

187	"Specification for Calcium Silicate Bricks"
427	"Vickers Hardness Test"
524	"Specification for Refined Cresylic Acid"
580	"Specification for Trichloroethylene"
805	"Specification for Toluenes"
1191 Part 1,2	"Specification for Gypsum Building Plasters"
2451	"Chilled Iron Shot and Grit"

2713	"Specification for 2-Ethoxy Ethanol"
3591	"Specification for Industrial Methylated Spirits"
4072	"Wood Preservatives by Means of Copper/Chromium/Arsenic Composition"
4764	"Specification for Powder Cement Paint"
5056	"Specification for Copper Naphthenate Wood Preservatives"
5262	"External Rendered Finishes"
5589	"Code of Practice for Preservation of Timber"
5707 Part 2	"Specification for Pentachlorophenol Wood Preservative"
6073 Part 1	"Specification for Precast Concrete Masonry Units"
CP 3012	"Cleaning and Preparation of Metal Surface"

DIN (DEUTSHES INSTITIUE FUR NORMEN)

18364	"Contact Procedure for Building Works"
53209	"Designation of Degree of Blistering of Paint Coats"
53210	"Designation of Degree of Rusting of Paint Coats"
55928 Part 28	"Corrosion Protection of Steel Structure by Organic, Inorganic and Metallic Coatings"

IPS (IRANIAN PETROLEUM STANDARD)

IPS-C-TP-102	"Painting"
IPS-E-TP-100	"Paint"

ISO (INTERNATIONAL STANDARDIZATION FOR ORGANIZATION)

ISO 3274	"Instruments for the Measurement of Surface Roughness by the Profile Method-Contact (Stylus) Instruments of Consecutive Profile Transformation-Contact Profile meters, System M"
ISO 4288	"Rules and Procedures for the Measurement of Surface Roughness using Stylus Instruments"
ISO 8501	"Preparation of Steel Substrate before Application of Paint and Related Products"
ISO 9004	"Quality Management and Quality System Elements Guidelines"

NACE (NATIONAL ASSOCIATION OF CORROSION ENGINEERS)

RP-01-72	"Surface Preparation of Steel by Water Blasting"
	NACE-Coating and Lining Hand Book

NIOC (NATIONAL IRANIAN OIL COMPANY)

OSCO-22	"Painting"
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NIGC (NATIONAL IRANIAN GAS COMPANY)

1004	"Painting"
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SSPC (STEEL STRUCTURE PAINTING COUNCIL)

Vol. 1	"Good Painting Practice"
Vol. 2	"System and Specification"

SIS (SWEDISH STANDARD)

05 5900	"Rust Levels of Steel Structure and Quality Levels for Preparation of Steel Surface for Rust Protecting Paints"
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3. DEFINITION & TERMINOLOGY**3.1 Acid Pickling**

Is a treatment for removal of rust and mill scale from steel by immersion in an acid solution containing an inhibitor. Pickling should be followed by thorough washing and drying before painting.

3.2 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%.

3.3 Anchor Pattern

See surface profile.

3.4 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.

3.5 Blast Cleaning

cleaning and roughening of a surface (particularly steel) by the use of metallic or non-metallic abrasive, which is projected against a surface by compressed air, centrifugal force, or water.

3.6 Blistering

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

3.7 Calcareous Deposits

Deposits containing calcium or calcium compounds.

3.8 Cathodic Protection

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

3.9 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.

3.10 Centrifugal Blast Cleaning

Use of motor-driven, bladed wheels to hurl abrasive at a surface by centrifugal force.

3.11 Chalking

Formation of a friable powder on the surface of a paint film caused by the disintegration of the binding medium due to disruptive factors during weathering. The chalking of a paint film can be considerably affected by the choice and concentration of the pigment. It can also be affected by the choice of binding medium.

3.12 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.

3.13 Chemical Environment

An exposure in which strong concentration of highly corrosive gases, fumes or chemicals either in solution or as solids or liquids contact the surface. The severity may vary tremendously from mild concentration in yard areas to direct immersion in the chemical.

3.14 Chlorinated Hydrocarbons

Powerful solvents that include such members as chloroform, carbon tetrachloride, ethylene dichloride, methylene chloride, tetrachlorethane, trichlorethylene, etc. Generally, they are toxic and their use is now restricted in some countries. Their main applications include nonflammable paint removers, cleaning solutions and special finishes where presence of residual solvent in the film is a disadvantage.

3.15 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 thin layer.

3.16 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.

3.17 Company

The company is the party which initiates the project and ultimately pays for its design and construction. The company will generally specify the technical requirements. The company may also include agent or consultant, authorized to act for the principal.

3.18 Compatible

- 1) Two or more paints or varnishes which can be mixed without producing any undesirable effects such as precipitation, coagulation, gelling, are said to be compatible.
- 2) Different coats of paint which can be associated in a painting system or other coating systems without producing undesirable effects are said to be compatible.

3.19 Corrosion Protection

Is the separation of the metallic material from the attaching medium by paint or coating.

3.20 Damp

Either moderate absorption or moderate covering of moisture, implies less wetness than that connoted by "wet" and slightly less wet than that connoted by moist.

3.21 Descaling

Removal of mill scale or caked rust from steel by chemical or mechanical means.

3.22 Dew Point

The temperature at which moisture will condense.

3.23 Efflorescence

A deposit of salts, usually white, formed on a surface the substance having emerged in solution from within concrete or masonry and deposited by evaporation.

3.24 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.

3.25 Emulsion

Two-phase liquid system in which small droplets of one liquid (the internal phase) are immiscible in and dispersed uniformly throughout a second continuous liquid phase (the external phase).

3.26 Engineer

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

3.27 Erosion

Phenomenon manifested in paint films by the wearing away of the finish to expose the substrate or undercoat. The degree of failure is dependent on the amount of substrate or undercoat visible. Erosion occurs as the result of chalking or by the abrasive action of windborne particles of grit.

3.28 Etch

To roughen a surface by chemical agent prior to painting in order to increase adhesion.

3.29 Etching Primer

A priming paint usually supplied as two separate components which require to be mixed immediately prior to use and thereafter is usable for a limited period only. On clean light alloy or ferrous surfaces and on many non-ferrous surfaces such paints give excellent adhesion, partly due to chemical reaction with the substrate (hence the term 'etching primer'), and give a corrosion inhibiting film which is a very good bases for the application of subsequent coats of paint. These materials are also known as "pretreatment primers", "wash primers" and "self etch primers".

3.30 External Rendering

The application of a coat of mortar over external of fram work.

3.31 Flame Cleaning

Impingement of an intensely hot flame to the surface of structural steel resulting in the removal of mill scale and the dehydration of any remaining rust, leaving the surface in a condition suitable for wire brushing followed by the immediate application of paint.

3.32 Flint (chert)

A very fine grained siliceous rock.

3.33 Galvanizing

Application of a coating of zinc to steel by a variety of methods.

3.34 Gypsum

A mineral having the composition calcium sulfate dehydrate. ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)

3.35 Hand Cleaning

Surface preparation using hand tools such as wire brushes, scrapers, and chipping hammers.

3.36 Hydro-Blasting

See water blasting.

3.37 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.

3.38 Inorganic Coatings

Coatings based on silicates or phosphates and usually used pigmented with metallic zinc. Also see "Cement Paint" and "Zinc-Rich" primer.

3.39 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. The qualification of Inspector shall be confirmed by Company.

3.40 Laitance

A milky white deposit on new concrete.

3.41 Lime

Specifically, calcium oxide (CaO), also, loosely a general term for various chemical and physical forms of quick lime, hydrated lime, and hydraulic hydrated lime.

3.42 Lining

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

3.43 Manual Cleaning

Includes hand cleaning and power tool cleaning.

3.44 Manufacturer

The person, firm, or corporation that manufactures and provides the coatings under the provisions of this standard.

3.45 Masonry

Construction composed by shaped or molded units, usually small enough to be handled by one man and composed of stone, ceramic, brick or tile, concrete, glass, or the like.

3.46 Masonry Cement

A hydraulic cement for use in mortars for masonry construction, containing a type of cement plus one or more material such as hydrated lime, limestone chalk, talc, slag or clay.

3.47 Maximum Amplitude

The term "maximum amplitude" as used in this Standard is defined as the greatest vertical distance between the summit of any peak on the blast-cleaned surface and the bottom of an immediately adjacent trough, but without taking into account any exceptionally high "rogue peaks" which are liable to occur on a blast-cleaned surface as a result of embedded particles of abrasive.

Such peaks are very undesirable and their size and number may be the subject of special agreement between the parties to a contract.

3.48 May

Is used where a provision is completely discretionary.

3.49 Metallic Coating

A metallic coating means one or more layer of metal on a steel base (base material).

3.50 Metal Spraying

Application of a spray coat of metal (usually zinc or aluminum) onto a prepared surface. The metal to be sprayed is rendered molten by passing it, in wire or powder form, through a flame pistol that projects the semimolten metal onto the surface by means of a jet of compressed air.

3.51 Mill Scale

Mill scale is the term used for the surface oxides produced during hot rolling of steel. It breaks and flakes when the steel is flexed and paint applied over it may fail prematurely. The extent of such failures is unpredictable but they frequently occur within a few weeks of painting, particularly in aggressive environments.

No protective coating can give long-life protection unless both the scale and rust are removed.

3.52 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.

3.53 Passivation

Act of making inert or unreactive.

3.54 Phosphating

Pretreatment of steel and certain other metal surfaces by chemical solutions containing metal phosphates and phosphoric acid as the main ingredients, to form a thin, inert, adherent, corrosion-inhibiting phosphate layer which serves as a good base for subsequent paint coats (see IPS-C-TP-102 "Painting").

3.55 Plaster

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

3.56 Power Tool Cleaning

Use of pneumatic and electric portable power tools to prepare substrate for painting.

3.57 Precast Concrete

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

3.58 Pretreatment

Usually restricted to mean the chemical treatment of unpainted metal surface before painting.

3.59 Pretreatment Primer

See "etching primer" and "phosphating".

3.60 Profile

See "surface profile".

3.61 Primer

First complete coat of paint of a painting system applied to a surface. Such paints are designed to provide adequate adhesion to new surfaces and are formulated to meet the special requirements of the surfaces. The type of primer varies with the surface, its condition, and the total painting system to be used. Primers for steel work contain special anti-corrosive pigments such as red lead, zinc chromate, zinc powder, etc. (see IPS-E-TP-100).

3.62 Rural Environment

An atmospheric exposure that is virtually unpolluted by smoke and sulfur gases, and which is sufficiently inland to be unaffected by salt contaminations or the high humidities of coastal areas.

3.63 Rust

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

3.64 Sand Blast

To use sand, flint or similar non-metallic abrasive propelled by an air blast, on metal, masonry, concrete, etc., to remove dirt, rust, or paint.

3.65 Sanding

An Abrasive process used to level a coated surface prior to the application of a further coat.

3.66 Scarifying

A method of preparing concrete surfaces for coating. Scarifiers are sharp rotating knives in a self contained unit resembling a plant sweeper.

3.67 Shall

Is used where a provision is mandatory.

3.68 Should

Is used where a provision is advisory only.

3.69 Sieve

A metallic plate or sheet, a woven wire cloth or other similar device, with regularly spaced apertures of uniform size, mounted in a suitable frame or holder for use in separating material according to size.

3.70 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 usually, but not necessarily, effected by a compressed air jet.

3.71 Stain

The coloring matter that colored wood, plaster or other masonry by penetration without hiding it and without leaving any perceptible surface film.

3.72 Stucco

A cement plaster used for coating exterior walls and other exterior surface of building.

3.73 Surface Preparation

Any method of treating a surface in preparation for painting. Swedish standards include photographic depictions of surface appearance of hand and power tool cleaning and various grades of blast cleaning over four initial mill scale and rust conditions of steel.

3.74 Surface Profile

Surface profile is a measurement of the roughness of the surface which results from abrasive blast cleaning. The height of the profile produced on the surface is measured from the bottoms of the lowest valleys to the tops of the highest peaks.

3.75 Threshold Limit Value (TLV)

A concentration of airborne 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.

3.76 Wash Primer

See "etch primer".

3.77 Water Blasting

Blast cleaning of metal using high velocity water with or without addition an abrasive.

3.78 Water Immersion

An exposure in which the surface is in direct contact with fresh or salt water.

3.79 Wood Preservation

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

3.80 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.

4. REQUIREMENTS

4.1 General

4.1.1 Surface preparation is (are) the method(s) of treating the surface of substrate prior to application of Coating (painting, coating and lining, etc.). Unless otherwise specified by the company. The method(s) of surface preparation shall be selected with references to 4.2, 4.3 and 4.4.

4.1.2 Typical contaminants that shall be removed during surface preparation are moisture, oil, grease, corrosion products, dirt and mill scale.

4.1.3 The surface preparation must achieve a level of cleanliness and roughness suitable for the proposed Coating and permit good adhesion of the Coating expenditure on the preparation work shall be in a reasonable proportion to the purpose and to the nature of the Coating. The contractor carrying out surface preparation work must have the personnel and technical know-how to enable them to carry out the work in a technically satisfactory and operationally reliable manner.

The surfaces must be accessible and adequately illuminated. The relevant accident prevention regulations and safety provisions must be observed.

All surface preparation works must be properly quality controlled and inspected. Each subsequent Coating may only be applied when the surface to be coated has been prepared in accordance with the principles of this construction Standard.

4.1.4 The handling of parts or assemblies, after cleaning, shall be kept to a minimum when handling is necessary, clean gloves or similar protection shall be used. Canvas, PVC or leather are suitable materials for gloves.

4.1.5 Cleaned surfaces shall be Coated as soon after cleaning as is practical and before detrimental corrosion or recontamination occurs.

4.1.6 There is no single, universal method of cleaning by which all surfaces can be prepared for the application of protective Coatings, and cleaning method for any given type of article must be carefully selected and properly carried out.

4.1.7 The company may require the contractor to furnish an affidavit that all materials and work furnished under the company's order will comply or have complied with the applicable requirements of this Standard.

4.1.8 The contractor's equipment for surface preparation shall be of such design and manufacture and in such condition as to comply with the procedure and obtain results prescribed in this Standard.

4.1.9 All materials furnished by the contractor shall be of the specified quality. The entire operation of surface preparation shall be performed by and under the supervision of experienced workers skilled in the cleaning of surfaces.

4.2 Selection of Cleaning Method(s)

4.2.1 The cleaning method(s) shall be selected with reference to following consideration and also to 4.3.2. The choice between blast-cleaning, acid-pickling, flame-cleaning, and manual cleaning is partly determined by the nature of the Coating to be applied. It should be appreciated, however, that Coating applied to a properly prepared (e.g. blast-cleaned) surface will always last longer than similar coating applied to flame-cleaned or manually cleaned surfaces. The method shall be approved by NIOC.

4.2.2 Initial condition of surface (rust grade)

The initial condition of surfaces for preparation, which, among other factors, determines the choice and mode of execution of the preparation measures and the relevant reference sample to be used, must be known. For this, the information given in Sections 4.2.3 and 4.2.4 is of particular importance.

4.2.3 New construction (uncoated surfaces)

4.2.3.1 Grade of steel, special treatments or methods that have an effect on the preparation, e.g. use of cold rolling or deep drawing methods (see Fig. 1).

4.2.3.2 Rust level in accordance to SIS 05 59 00 or ISO 8501-1

A = Steel surface covered with firmly adhesive scale and largely free of rust.

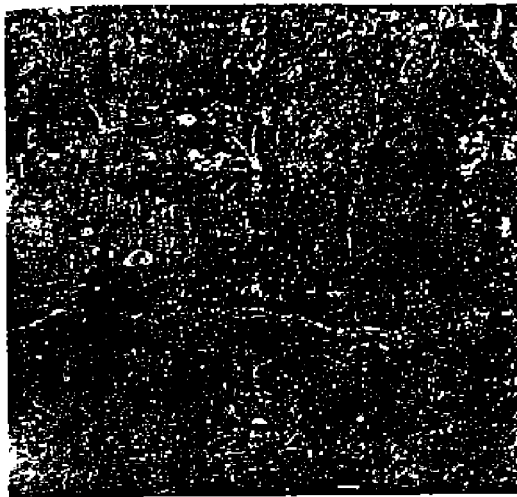
B = Steel surface with beginning of spalling of scale and beginning of rust attack.

C = Steel surface from which scale has been rusted away or can be scraped off but which exhibits only a few rust pits visible to the eye.

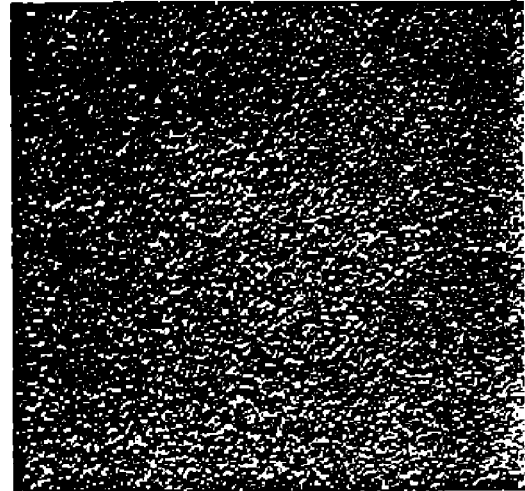
D = Steel surface from which the scale has been rusted away and exhibiting numerous visible rust pits.

4.2.4 Maintenance (coated surface)

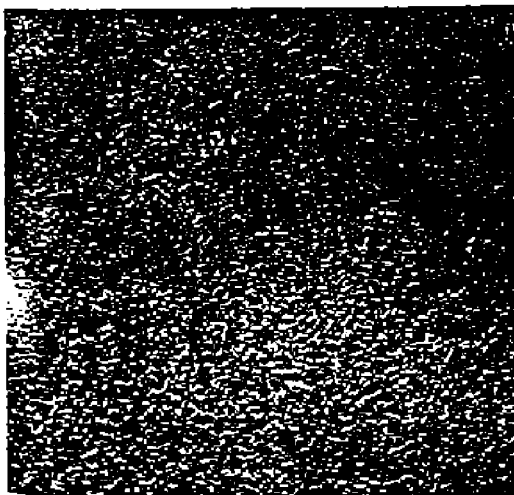
- a)** Rust level of coated surfaces according to DIN 53210 and ASTM D 610 (see Fig. 2);
- b)** Type of coating (e.g. type of binder and pigment, metal coating), approximate coat thickness and date when carried out;
- c)** Extent of blistering according to DIN 53209, and ASTM D 714
- d)** Additional information, e.g. on adhesion, cracking, chemical and other contaminants and also other significant phenomena.



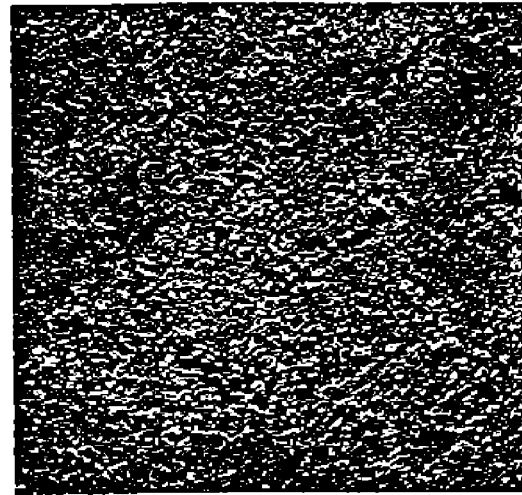
A
Adherent Mill Scale



C
Rusted

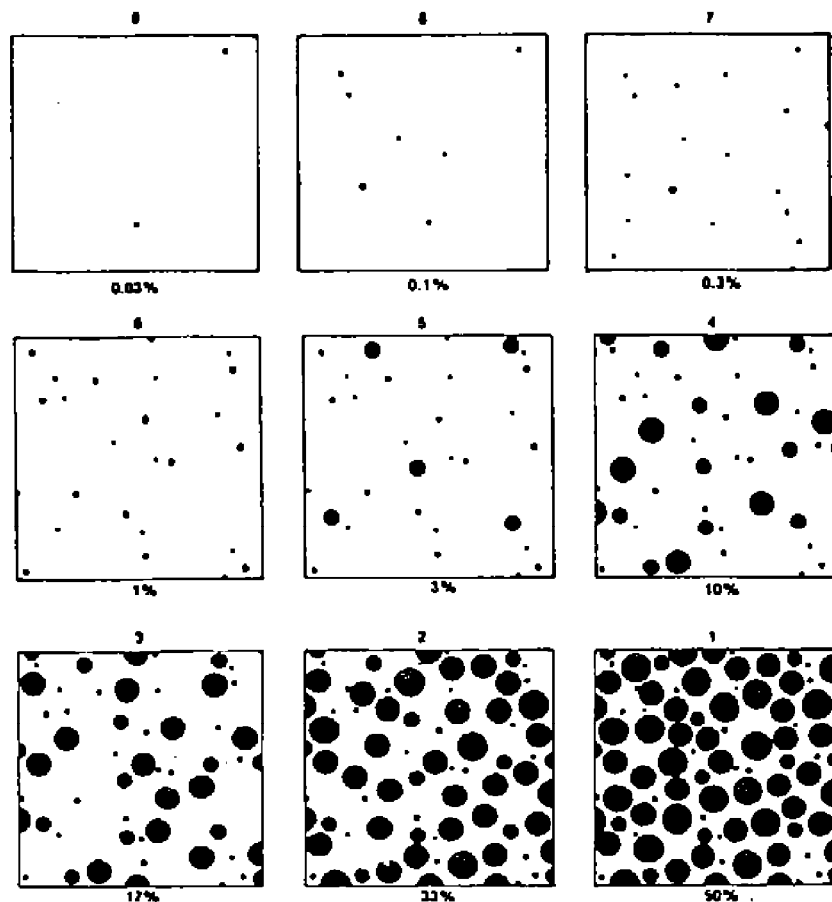


B
Rusting Mill Scale



D
Pitted & Rusted

RUST GRADES OF UNCOATED SURFACES
Fig. 1



RUST GRADE OF COATED SURFACES (EXAMPLE OF AREA PERCENTAGE)

Fig. 2

4.3 Cleanliness of the Surfaces

4.3.1 Removal of contaminants / coats of material different from the metal

This includes removal of:

Dirt, dust, soot, ash, concrete, coal slag, sand, moisture, water, acids, alkalis, soap, salts, encrustations, growths, fluxes, oily and greasy contaminants, earlier Coatings and cementations that are loose, rusted under or unusable as an adhesion surface and corrosion products of metallic coatings. Unless otherwise specified by the company the best cleaning method for the job shall be selected. The cleaning methods described in this Standard.

4.3.2 Removal of coats of material related to the metal (scale and rust removal)

4.3.2.1 Removal of firmly adherent scale is only possible with the following methods of removing rust:

- a) Blasting (see section 8).
- b) Flame cleaning(see section 9).
- c) Pickling (see section 6).
- d) Manual cleaning (see section 7).

With each of these methods only specific surface condition can be produced and particular levels of cleanliness achieved correspondingly, the appearance of the prepared surface is dependent not only on the level of cleanliness but also on the method of removing rust used.

4.3.2.2 Standard level of cleanliness (see also Table 1 and 2)

Standard level of cleanliness for prepared steel surfaces listed in table 1 and 2 shall apply. Unless otherwise specified by the company, the level of cleanliness of uncoated surfaces shall be in accordance with 8.1.9 for blasting and with 7.4.1 for manual cleaning and to provision of table 1 for flame cleaning and pickling.

4.3.2.2.1 Blasting (see Section 8)

During blasting, parts that are not to be worked, parts already coated and the environment should be protected against the blasting abrasives thrown out. With chemically contaminated surfaces, pre-washing may be advisable and with coarse coats of rust on plates, preliminary derusting with impact tools may be advisable.

The standard level of cleanliness for blasted surfaces are described as follows:

Sa1 Light blast-cleaning

When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from poorly adhering mill scale rust, paint coatings and foreign matter (see Table 1). Reference photographs are BSa1, CSa1 and DSa1.

Sa2 Thorough blast-cleaning

When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from most of the mill scale, rust, paint coatings and foreign matter. Any residual contamination shall be firmly adhering (see Note 1). The reference photographs are BSa2, CSa2 and DSa1 (see Table 1).

Staining shall be limited to no more than 33 percent of 1300 square mm of surface area and may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied paint. Slight residues of rust and paint may also be left in the bottoms of pits if the original surface is pitted.

Sa2½ Very thorough blast-cleaning

When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from mill scale, rust paint coatings and foreign matter. Any remaining traces of contamination shall show only as slight stains in the form of spots or stripes. The reference photographs are ASa2½, CSa2½ and DSa2½ (see Table 1).

Sa3 White blast-cleaning

Blast cleaning to visually clean steel when viewed without magnification, the surface shall be free from visible oil, grease and dirt, and shall be free from mill scale, rust, paint coating and foreign matter. It shall have a uniform metallic colour. The reference photographs are ASa3, BSa3, CSa3 (see Table 1).

Note 1:

For previously painted surfaces that have been prepared for renewed painting, only photographs with rust grade designations D or C (for example DSa2½ or CSa2½) may be used for the visual assessment.

4.3.2.2.2 Manual rust removal (see Section 7)

Standard levels of cleanliness St2, St3 are used for Hand and Power Tool Cleaning of Surface.

St1- This grade is not included as it would correspond to a surface unsuitable for painting.

St2- Thorough hand and power tool cleaning:

- When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from poorly adhering mill scale, rust, paint coating and foreign matter. This grade is only accepted for spot cleaning. The reference photographs are BSt2, CSt2, DSt2 (see Table 1).

St3- Very thorough hand and power tool cleaning

- As for St2 but the surface shall be treated much more thoroughly to give a metallic sheen arising from the metallic substrate.

The reference photographs are BSt3, CSt3, DSt3 (see Table 2).

4.3.2.2.3 Thermal rust removal, flame cleaning (see Section 9)

Standard level of cleanliness Fl according to Table 1.

"Fl" - When viewed without magnification, the surface shall be free from mill scale, rust, paint, coatings and ISO foreign matter. Any remaining residue shall show only as a discoloration of the surface (shades of different colors). The reference photographs are AFl, BFl, CFl and DFl (see Table 1).

4.3.2.2.4 Chemical rust removal, pickling (see Section 6)

Standard level of cleanliness Be according to Table 1.

Be - When viewed without magnification the surface shall be free from coating residues, scale and rust (see Table 2).

Comparison of standard levels of cleanliness according to sis 055900 with other rust removal levels is shown in Table 2.

TABLE 1 - STANDARD LEVELS OF CLEANLINESS FOR PREPARED STEEL SURFACES

STANDARD LEVEL OF CLEANLINESS	RUST REMOVAL METHOD	INITIAL CONDITION OF STEEL SURFACE		REFERENCE SAMPLE PHOTOGRAPHS	ESSENTIAL CHARACTERISTICS OF THE PREPARED STEEL SURFACE	REMARKS
		UNCOATED ACCORDING TO SECTION 4.2.1	COATED ACCORDING TO SECTION 13			
Sa 1	BLASTING ACCORDING TO SECTION 8	B C D	SEE SECTION 13.	B Sa 1 C Sa 2 D Sa 1	ONLY LOOSE SCALE, RUST AND LOOSE COATINGS ARE REMOVED	THESE STANDARD LEVELS OF CLEANLINESS APPLY TO BLASTING. a) OF UNCOATED STEEL SURFACE (SEE 4.2.3) b) OF COATED STEEL SURFACES IF THE COATINGS ARE ALSO REMOVED SUFFICIENTLY TO OBTAIN THE REQUIRED LEVEL OF CLEANLINESS. (SEE 4.2.4)
Sa 2		B C D		B Sa 2 C Sa 2 D Sa 2	VIRTUALLY ALL SCALE, RUST AND COATINGS ARE REMOVED, i.e. ONLY AS MUCH FIRMLY ADHESIVE SCALE RUST AND COATING RESIDUES REMAIN (NO CONTINUOUS COATS) AS TO CORRESPOND WITH THE OVERALL IMPRESSION OF THE REFERENCE SAMPLE PHOTOGRAPHS (SEE EXPLANATIONS)	
Sa 2½		A B C D		A Sa 2½ B Sa 2½ C Sa 2½ D Sa 2½	SCALE, RUST, AND COATINGS ARE REMOVED TO THE EXTENT THAT THE RESIDUES ON THE STEEL SURFACE REMAIN MERELY AS FAINT SHADING AS A RESULT OF COLORING OF THE PORES.	
Sa 3		A B C D		A Sa 3 B Sa 3 C Sa 3 D Sa 3	SCALE, RUST AND COATINGS ARE COMPLETELY REMOVED (WHEN OBSERVED WITHOUT MAGNIFICATION)	
St 2	MANUAL OR MECHANICAL RUST REMOVAL ACCORDING TO SECTION 7	B C D		B St 2 C St 2 D St 2	LOOSE COATINGS AND LOOSE SCALE ARE REMOVED; RUST IS REMOVED TO THE EXTENT THAT THE STEEL SURFACE AFTER SUBSEQUENT CLEANING EXHIBITION A FAINT LUSTRE FROM THE METAL.	NORMALLY REQUIRES MACHINING
St 3		B C D		B St 3 C St 3 D St 3	LOOSE COATINGS AND LOOCS SCALE ARE REMOVED; RUST IS REMOVED TO THE EXTENT THAT THE STEEL SURFACE AFTER SUBSEQUENT CLEANING EXHIBITS A DISTINCT LUSTRE FROM THE METAL. IN SPECIAL CASES REMOVAL OF FIRMLY ADHESIVE COATINGS, e.g. BY GRINDING, SCRAPING OR BY USING PICKLING AGENTS IS POSSIBLE. IF REQUIRED, THIS SHOULD BE ADDITIONALLY AGREED.	
Fl	FLAME CLEANING ACCORDING TO SECTION 9	A B C D		A Fl B Fl C Fl D Fl	COATINGS, SCALE AND RUST ARE REMOVED TO THE EXTENT THAT RESIDUES ON THE STEEL SURFACE REMAIN MERELY AS SHADES IN VARIOUS HUES.	SUBSEQUENT THOROUGH MECHANICAL BRUSHING IS ALWAYS NECESSARY.
Be	PICKLING ACCORDING TO SECTION 6	A B C D			COATING RESIDUES, SCALE A AND RUST ARE COMPLETELY REMOVED.	

TABLE 2 - COMPARISON OF STANDARD LEVELS OF CLEANLINESS ACCORDING TO SIS 055900 WITH OTHER RUST REMOVAL LEVELS OR QUALITY CLASSES

STANDARD LEVEL OF CLEANLINESS	RUST REMOVAL METHOD ACCORDING TO IPS-C-TP-101	SIS 055900	DIN 18364	BS 4232 (ONLY FOR BLASTING)	SSPC-VIS
Sa 1	BLASTING ACCORDING TO SECTION 8 MANUAL OR MECHANICAL RUST REMOVAL ACCORDING TO SECTION 7	Sa 1	—	—	BRUSH OFF SP 7
Sa 2		Sa 2		THIRD QUALITY	COMMERCIAL SP 6
Sa 2½		Sa 2½		SECOND QUALITY	NEAR WHITE SP 10
Sa 3		Sa 3	RUST REMOVAL LEVEL 3	FIRST QUALITY	WHITE METAL SP 5
St 2		St 2	ESSENTIALLY LESS THAN RUST REMOVAL LEVEL 1	—	HAND TOOL CLEANING SP 2
St 3		St 3	LESS THAN RUST REMOVAL LEVEL 1	—	POWER TOOL CLEANING SP 3
Fl	FLAME CLEANING ACCORDING TO SECTION 9	—	RUST REMOVAL LEVEL 2	—	FLAME TOOL CLEANING SP 4
Be	PICKLING ACCORDING TO SECTION 6	—	RUST REMOVAL LEVEL 3	(CP 3012)	PICKLING SP 8

4.3.3 Rust converters, rust stabilizers and penetrating agents

The use of so-called rust converters, rust stabilizers and similar means for chemically converting the corrosion products of the iron into stable iron compounds. This also applies to penetrating agents intended to inhibit rust. The use of this materials are not permitted in this Standard.

4.3.4 Influence of environmental conditions on the cleaning and cleanliness of surfaces

Storing of unprotected steel in urban, industrial or marine atmospheres-including the practice of "rusting off" scale by weathering shall be avoided, because otherwise a higher level of cleanliness may be necessary owing to the deposit of corrosive substances that will occur. Steel shall as far as possible be prepared and protected in state A or A to B (see Table 1).

No surfaces shall be prepared for coating during rain or other precipitation. If the possibility of condensation is to be absolutely excluded, the temperature of the surface to be worked must with certainty remain above the dew point of the surrounding air. If the works still have to be carried on, even under conditions deviating from those required, provision shall be made at the planning stage for special measures, e.g. covering, enclosing in a tent, warming the surfaces or drying the air, as special works.

Preparatory works in the region of plants subject to explosion or fire risk require special measures (e.g. lowspark or flame-free methods).

4.3.5 Testing of the cleanliness of the prepared surfaces

The surfaces shall be tested after subsequent cleaning. For all the standard levels of cleanliness according to Table 2 visual testing is in practice sufficient. A check shall be made;

- as to whether the prepared surfaces exhibit the essential characteristics stated for the appropriate level of cleanliness in Table 1 and shown by way of example in the corresponding reference sample photograph, or
- whether there is adequate conformity to any agreed reference surfaces.

The reference sample photographs shall in particular show the interrelationships between the levels of cleanliness.

The comparison is made without magnification (magnifying glass).

For standard level of cleanliness Be (see Tables 1 and 2), by nature of the method, reference samples are unnecessary.

If there are doubts as to be freedom from oil or grease of the surface, this shall be checked. For possible testing methods see section 5.7.

The visual and instrumental test method of blasted surface are described in section 8.5.

4.4 Degree of Roughness (Surface Profile)

4.4.1 Blast-cleaning produces a roughened surface and the profile size is important. The surface roughness (average peak-to valley height) achieved for each qualities of surface finish, depends mainly upon the type and grade of abrasive used. Unless otherwise specified by the company the amplitude of surface roughness of steel work shall be within 0.1 mm to 0.03 mm for painting, coating and lining. Table 3 gives the range of maximum and average maximum profile heights of some abrasive to be expected under normal good operation conditions (wheel and nozzle). If excessively high air pressure or wheel speed is used, the profile may be significantly higher.

4.4.2 Methods of measurement

The methods described herein are some of the suitable methods for measuring surface roughness. The Company shall decide for the method(s) of measurement to be used.

4.4.2.1 Sectioning

A metallurgical section is prepared and the surface profile measured under a suitable microscope using a micrometer eyepiece.

4.4.2.2 Grinding

The thickness of the blast-cleaned specimen is measured with a flat-ended micrometer. The surface is then ground until the bottoms of only the deepest pits are just visible. A further thickness measurement is then taken.

4.4.2.3 Direct measurement by microscope

The blast-cleaned specimen, or a replica, is viewed through a suitable microscope, first focussing on the peak and then focussing on the lowest adjacent through, noting the necessary adjustment of focus.

4.4.2.4 Profile tracing

A blast-cleaned specimen is traversed with a diamond or sapphire stylus and the displacement of the stylus as it passes over peaks and roughs is recorded. For instruments and the procedures for the measurement see ISO 3274 and ISO 4288.

4.4.2.5 Comporator disc

The comparator disc (kean-tator) is a field instrument to determine anchor pattern profile depth of blasted surface. Comparator disc is composed of five section, each with a different anchor pattern depth (0.0125 to 0.1 min.). To use this instrument, place the disc on the blasted surface and visually select the reference section most closely approaching the roughness.

TABLE 3 - TYPICAL MAXIMUM PROFILES PRODUCED BY SOME COMMERCIAL ABRASIVE MEDIA (SEE ALSO APPENDIX B)

ABRASIVE	TYPICA PROFILE MAXIMUM (mm)	HEIGHT (mm) Av. MAXIMUM
STEEL ABRASIVE:		
SHOT S 230	0.074	0.056
SHOT S 280	0.089	0.064
SHOT S 330	0.096	0.071
SHOT S 390	0.117	0.089
GRIT G 50	0.056	0.04
GRIT G 40	0.086	0.061
GRIT G 25	0.117	0.078
GRIT G 14	0.165	0.13
MINERAL ABRASIVES:		
FLINT SHOT (MEDIUM. FINE)	0.089	0.068
SILICA SAND (MEDIUM)	0.10	0.074
BOILER SLAG (MEDIUM)	0.117	0.078
BOILER SLAG (COARSE)	0.152	0.094
HEAVY MINERAL SAND (MEDIUM. FINE)	0.086	0.066

Profile heights shown for steel abrasives were produced with conditioned abrasives of stabilized operating mixes in recirculating abrasive blast cleaning machines. Profile heights produced by new abrasives will be appreciably higher.

Cast steel shot: Hardness 40 to 50 Rockwell C.

Cast steel grit: Hardness 55 to 60 Rockwell C.

4.5 Temporary Protection of Prepared Surfaces Against Corrosion and/or Contamination

Temporary protection is necessary if the proposed Coating (primer or total Coating) cannot be applied to the prepared surface before its level of cleanliness has changed (e.g. by formation of initial rust). The same applies to part areas on which the Coating is not to be applied.

It is normal to use:

Wash primers, shop primers as well as phosphatizing. (See IPS-C-TP-102) adhesive papers, adhesive films, strippable varnishes and protective materials that can be washed off (see IPS-E-TP-100 Appendix B).

4.6 Preparation of Surfaces Protected by Temporary Coats or by only Part of the Purposed Coats until Subsequent Coating Are Applied

Before further Coating, all contaminants as well as any corrosion and weathering products that have been produced in the mean time shall be removed in an appropriate manner described in this standard. Assembly joints and damaged areas of the primer Coating shall be again derusted.

4.6.1 Preparation of joint areas (welded, riveted and bolted joints)

The best method of removing residues of welding electrodes and welding or riveting scale, is blasting or manual cleaning. The method shall be approved by the company.

4.6.2 Preparation of surfaces of shop primers, base coating or top coatings for further coating

It may be necessary to apply a little solvent to existing Coating or, for example in the case of two-component Coating that have cured, to roughen them with sand paper, steel wool or by lightly blasting and then to remove the dust so that the following Coating adheres satisfactorily. Surfaces of existing Coatings (especially primers rich in zinc) must not be burnished or smeared by mechanical brushing or similar methods so that later Coatings no longer adhere satisfactorily.

If an existing shop primer or base Coating is not in a condition suitable to provide a base for further Coatings or is not compatible with such further Coating, it shall be removed. The methods of surface preparation shall be approved by the company.

4.6.3 Preparation of hot-dip galvanized or hot-dip aluminium coated surfaces for other coatings

4.6.3.1 Defective areas in the production of the metal coating:

Defective areas in the metal coating must be prepared and repaired in such a manner that the corrosion protecting action of the Coating is restored and that the adhesion and protective action of further Coating are not impaired. For preparation of weld areas paragraph 4.6.1 shall be observed. Defective areas repaired by building up with solder, or sprayed zinc or shall be prepared for subsequent Coating in the same way as the hot-dip galvanized or hot-dip aluminum Coated surfaces, sprayed zinc coated and sprayed aluminium Coated surfaces shall not however be cleaned with alkaline detergents.

4.6.3.2 Preparation of unweathered hot-dip galvanized or hot-dip aluminium coated surfaces:

During subsequent treatment, transport or assembly, contaminations may occur for example by grease, oil, marking or coding inks. These shall be removed, for example by brushing off and rising with special detergent or solvents (see section 5). In the case of damage to the metal coating during transport or assembly, the method shall be as in section 4.6.3.1.

4.6.3.3 Preparation of weathered hot-dip galvanized or hot-dip aluminium coated surfaces:

According to the period of weathering and the site where the surfaces are located, a part from surface contaminations various corrosion products of the coating metal or steel may be formed soluble or poorly adherent contaminants shall be removed, according to the extent and nature of the deposits.

- In the case of hot-dip galvanized surfaces e.g. oxidic compounds and various salts, by dry brushing (brushes with plastics bristles - see section 7) or washing with water with a detergent added, or by water or steam cleaning (see 5.5 & 5.6).
- In the case of hot-dip aluminium coated surfaces by brushing or washing with suitable solvents, cold detergents or emulsion cleaner be used. If necessary, it may also be advisable to clean by water or steam cleaning, steam cleaning with addition of weak phosphoric acid cleaner may also be used (see 5.6).

- For mechanical preparation of severely attacked surfaces wire brushes, scraper, emery discs and blasting methods are suitable.

The method(s) of surface preparation shall be approved by the Company.

4.7 Inspection and Testing

4.7.1 The quality control system shall include as a minimum the requirements listed in Table 31.

4.7.2 If in the opinion of Company after examination or test, any component has not been cleaned in accordance with this construction standard the contractor shall reclean the component to the satisfaction of the Company.

4.8 Quality Systems

4.8.1 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.

4.8.2 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.

4.8.3 The Company shall have 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 of raw material or purchased components.

4.9 Procedure Qualification

4.9.1 General

Before bulk preparation of components commences the requirements of 4.9.2 shall be met and a detailed sequence of operations to be followed on the preparation of components shall be submitted to Company for checking the compliance with this Standard and approval.

The Company shall also specify which cleaned components are to be subjected to the tests specified in 4.9.3 for formal approval of the preparation procedure. No preparation shall be done until the cleaning procedure has been approved and approval confirmed in writing by the Company.

4.9.2 Preparation procedure specification

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

- a) cleaning of components and method of cleaning including oil and grease;
- b) cleaning medium and technique;
- c) blast cleaning finish, surface profile and surface cleaning, in the case of blast cleaning;
- d) dust and abrasive removal;
- e) post drying time and temperature;
- f) reclean technique.

4.9.3 Preparation procedure approval test

A batch of 15 to 20 components shall be cleaned in accordance with the approved preparation procedure (see 4.9.2). The preparation operations being witnessed by Company (see Appendix F).

Three cleaned components shall be selected by company for preparation procedure approval tests and shall be subjected to the complete set of tests in Section 16. Testing shall be witnessed by company and a full set of records shall be submitted to company for consideration. Cleaning shall not be performed until the procedure has been certified in writing as being acceptable to Company.

5. DEGREASING

5.1 General

Degreasing is used for complete removal of oil, grease, dirt and swarf from the surfaces which is to be protected by painting, coating and lining. The five following main cleaning methods, which in turn may consist of different processes, are generally used for surface cleaning of substrates.

- Hot solvent cleaning,
- Cold solvent cleaning,
- Emulsifiable solvent cleaning,
- Aqueous Alkaline and Detergent cleaning,
- Steam cleaning.

The choice of method(s) depends upon the material of the substrate type, shape and condition of the surface which is to be cleaned.

Table 4 gives a guide to selection of degreasing methods. The specified shall specify the degreasing method(s) as appropriate (see 5.8). For application process of degreasing methods see Appendix A.

TABLE 4 - GUIDE TO SELECTION OF DEGREASING METHODS

DEGREASING METHOD	SCOPE	SUB-METHOD	CLEANING MATERIAL	VARIATION OF CLEANING PROCESS (SEE APPENDIX A)	CONDITION OF SURFACE AFTER TREATMENT	CLEANING APPARATUS	SPECIAL POINTS	SAFETY PRECAUTIONS
HOT SOLVENT CLEANING (5.2)	ALL MATERIALS AND ALL TYPE OF SURFACES	NOT WATER RINSABLE (5.2.1)	TRICHLOROETHYLEN TO BS 580 1, 1, 1, TRICHLOROETHANE TO BS 4487 METHYLENE CHLORIDE PERCHLOROETHYLENE TO BS 1593 TRICLOROTRIFLUORETHANE	1- VAPOR IMMERSION 2- LIQUID IMMERSION 3- JETTING 4- ULTRASONIC CLEANING	DRY	SPECIALLY DESIGNED APPARATUS ESSENTIAL. CONTINUOUS OR BATCH OPERATION	WILL NOT REMOVE SOAPS, SWEAT OR CHEMICAL RESIDUES. NOT SUITABLE FOR PAINTED ARTICLES, OR PARTS CONTAINING RUBBER AND CERTAIN OTHER NON-METALLIC MATERIALS. ULTRASONIC CLEANING SPECIALLY SUITABLE FOR REMOVING FINE SOLID PARTICLES.	ADEQUATE SHOP VENTILATION, AND CORRECT OPERATION OF PLANT TO AVOID EXCESSIVE INHALATION OF NARCOTIC VAPOR. NO SMOKING
		WATER RINSABLE (5.2.2)	EMULSIFIABLE BLEND OF CRESYBIC ACID (BS 524) AND O-DICHLOROBENZENE (BS 2944 GRADE B)	1- IMMERSION (BATH TEMP 60°C)				
COLD SOLVENT CLEANING (5.3)	ALL METALS AND ALL TYPES OF SURFACES AND SHAPES NOT HEAVILY CONTAMINATED	NOT WATER RINSABLE (5.3.1)	TRICHLOROETHYLEN TO BS 580 1, 1, 1- TRICHLOROETHANE TO BS 4487 PERCHLOROETHYLENE TO BS 1593 TRICHLOROTRIFLUOROETHANE WHITH SPIRIT TO BS 245 WHITE SPIRIT/SOLVENT NAPHTHAS TO BS 479 AROMATIC SOLVENTS COAL TAR SOLVENTS	1- IMMERSION 2- BRUSHING 3- OR WIPINGS 4- SPRAYING 5- ULTRASONIC SYSTEM	DRY OR FROM PETROLEUM SOLVENTS SLIGHTLY OILY	THANKS OR APPARATUS OF SPECIAL DESIGNED. CONTINUOUS OR BATCH OPERATION	COMPLETE GREASE REMOVAL NOT CERTAIN. SOAPS, SWEAT OR CHEMICAL RESIDUES NOT REMOVED	ADEQUATE SHOP VENTILATION, NO SMOKING, STRICT PROVISION AGANISI THE RISK IF PETROLEUM SOLVENTS ARE USED
		WATER RINSABLE (5.3.2)	DICHLOROMETHANE BASED MIXTUR TO BS 1994 TRICHLOROETHYLENE BASED MIXTURE	1- IMMERSION (LIQUID) 1- BRUSHING				
EMULSIFIABLE SOLVENT CLEANING (5.4)	ALL METALS PARTS OF ACCESSIABLE SHAPE, NOT HEAVILY CONTAMINATED		HYDROCARBON, e.g. WHITE SPIRIT WITH AN EMULSIFYING AGENT	- IMMERSION (LIQUID) BRUSHING	WET AND POSSIBLY SLIGHTLY OILY	TANKS OR APPARATUS OF SPECIAL DESIGN. CONTINUOUS OR BATCH OPERATION	WILL REMOVE SWEAT AND CERTAIN CHEMICAL RESIDUES. SUITABLE FOR PAINTED SURFACES	PRECAUTIONS AGAINST CONTACT OF CONCENTRATED MATERIAL WITH SKIN. FIRE PRECAUTIONS IF PETROLEUM SOLVENTS ARE USED
				SPRAYING	WET AND POSSIBLY SLIGHTLY OILY	STEAM OR WATER JET APPARATUS	SUITABLE FOR LARGE ASSEMBLIES WHICH CANNOT BE DISMANTLED	
AQUEOUS ALKALINE AND DETERGENT CLEANING (5.5)	PARTS WITHOUT A HIGHLY FINISHED SURFACE AND OF ACCESSIBLE SHAPE STRONG ALKALIS FOR FERROUS METALS: Milder ALKALIS FOR NON-FERROUS METALS AND GENERAL PURPOSES CLEANING, ORGANIC DETERGENT ALONE (AS SOLUTION OR EMULSION) FOR TIN-PLATE AND LIGHT DUTY CLEANING.	HOT ALKALINE (5.5.1)	MIXTURE OF SODIUM HYDROXIDE AND SODIUM METASILICATE PENTAHYDRATE	1- IMMERSION 2- ELECTROLYTIC CLEANING 3- ULTRASONIC CLEANING	WET	TANKS OR APPARATUS OF SPECIAL DESIGN. CONTINUOUS OR BATCH OPERATION	WILL REMOVE SWEAT AND CERTAIN CHEMICAL RESIDUES. Milder ALKALIS SUITABLE FOR CERTAIN TYPES OF PAINTED SURFACE. NOT SUITABLE FOR COMPOSITE ITEMS CONTAINING RUBBER, LEATHER, FABRIC OR WOOD. ULTRASONIC CLEANING SPECIALLY SUITABLE FOR REMOVING FINE SOLID PARTICLES.	STRONG ALKALIS REQUIRE PROTECTIVE MEASURES EYESHIELDS AND RUBBER GLOVES TO PREVENT POSSIBLE DAMAGE TO EYES AND SKIN DURING HANDLING
		MILD ALKALINE (5.5.2)	MIXTURE OF METASILICATE PENTAHYDRATE AND SODIUM CARBONATE					
		DETERGENT (5.5.3)	DETERGENT	ULTRASONIC IMMERSION	WET AND POSSIBLY SLIGHTLY OILY	ULTRASONIC APPARATUS	SUITABLE FOR LARGE ASSEMBLIES WHICH CANNOT BE DISMANTLED	
STEAM CLEANING		5.6	STEAM ALONE OR MIXTURE OF STEAM WITH DETERGENT OR ALKALINE MATERIAL	STEAM CLEANING	WET	STEAM INJECTORY APPARATUS		

5.2 Hot Solvent Cleaning Method

These cleaning methods relate to the complete removal of oil, grease, dirt and swarf from unit parts or simple assemblies, with chlorinated solvents. Several methods of processing are available (see Table 4) choice of appropriate process depends upon the type and degree of contamination.

5.2.1 Hot solvent cleaning - not water rinsable

5.2.1.1 Trichloroethylene (BS 580 type 1) and other chlorinated solvent is used for cleaning of ferrous metals in this method. When parts of aluminium, magnesium, zinc, titanium or their alloys are degreased in trichloroethylene, the grade of solvent shall comply with the requirements of BS 580 type 2.

5.2.1.2 Trichloroethylene degreasing shall not be used on assemblies containing fabric, rubber or other non-metallic material unless it is known that no harm will result. Assemblies containing such materials can often be cleaned without damage using 1.1.2- trichloro- 1.2.2 trifluoroethane.

5.2.1.3 Trichloroethylene is non-flammable, but naked flames can cause decomposition of solvent vapor with the production of harmful acidic gases and shall not be allowed near degreasing equipment. Contact of solvent with hand should be avoided as the solvent will remove the natural grease from skin.

5.2.1.4 Hot solvent-not water rinsable method is applied in immersion (vapor and liquid), jetting or ultrasonic processes (see Appendix A). Heavily contaminated thin sheet may not degrease satisfactorily with one treatment in vapor, but spraying with clean condensed solvent after vapor treatment or immersion in boiling liquor is preferred in such cases.

5.2.1.5 The articles shall be placed on hooks or racks or in suitable containers, during hot solvent processing. After cleaning and drying, articles shall not be handled with bare hands, clean gloves or similar protection shall be used and handling kept to the minimum.

5.2.1.6 The articles after hot solvent degreasing are hot and normally dry. Articles of a complex construction with crevices and capillaries, etc. may require further drying at 100-120°C.

Notes:

- 1) Method of chemical check of solvent are described in BS-1133 section 6 and BS 580.
- 2) Standard guidelines of emission control in vapor process are described in ASTM D 3640-80.

5.2.2 Hot solvent cleaning-water rinsable

5.2.2.1 This method is normally used for paint removal or for assisting in the removal of carbonaceous deposits. It is based on an emulsifiable blend of cresylic acid and o-dichlorobenzene. It is normally used with a water seal in a bath (immersion) operated at temperatures up to 60°C.

5.2.2.2 After processing the article shall be rinsed with clear water and then dried (see Appendix C).

5.3 Cold Solvent Cleaning

These cleaning methods are related to the use in the cold of petroleum solvents, also halogenated hydrocarbons other than trichloroethylene, for the removal of oil, grease, dirt and swarf from unit parts or simple assemblies having easily accessible surfaces. These solvents may also be applied to the "in situ" cleaning of large units, assemblies or machinery which cannot be accommodated in degreasing equipment.

Several methods of processing are available (see Appendix A). Choice of the appropriate process depends upon the type and degree of contamination and the size and shape of the parts.

These solvents should not be used for assemblies containing fabrics, rubber or other non-metallic materials, unless it is known that no harm will result.

5.3.1 Cold solvent - not water rinsable

Choice of solvent in this method is largely governed by consideration of toxicity, volatility and flammability of solvents and also environmental condition in which method is operated. Some solvent especially coal tar solvents and aromatics will also dissolve the vehicle of paint, but they are more toxic and have low flash point.

Benzol (benzene) is the most toxic and shall not be used. Xylol, toluol and high flash naphtha may be used when their concentration in air that is being breathed does not exceed the safe limit (see Table 5). Petroleum solvent are flammable and suitable fire precautions shall be taken when they are used.

Immediately after cleaning the articles shall be dried with compressed air or if their size permits, in a vented oven at 65°C. Articles too large for an oven may be dried by wiping (see also Appendix C). Cold solvent, not water rinsable is operated by immersion brushing or wiping spraying and ultrasonic processes (see Appendix A).

5.3.2 Cold solvent-water rinsable

5.3.2.1 Dichloromethane base mixture

The dichloromethane based mixtures are mainly used for the removal of paint and carbonaceous deposits but also act as effective cleaner. It should contain a minimum of 70% (wt/wt) of dichloromethane, thickening and emulsifying agent. Corrosion inhibitors may also be added for applications on close tolerance parts or where slight etching of metal surface is undesirable. In immersion operation also contain cresylic acid for increased efficiency and are usually used under a 100 mm water seal.

5.3.2.2 Trichloroethylen base mixture

The trichloroethylene based mixtures can be used on metal surfaces adjacent to certain plastics materials which would be affected by dichloromethane based mixtures.

A typical composition is as follows:

Trichloroethylene to BS 580, Type 1	70 Parts by weight
Toluene to BS 805	6 parts by weight
Industrial methylated spirits to BS 3591	10 parts by weight
Cresylic acid to BS 524, Grade D	4 parts by weight
2-Ethoxyethanol to BS 2713	4 parts by weight

Paraffin wax	Remainder to a total of
A cellulose ether	6 parts by weight but
Emulsifier	paraffin wax should not
Corrosion inhibitors	exceed 2 parts by weight

This method is operated by immersion and brush, application (see Appendix A).

After cleaning the article shall be rinsed with clear water and then dried (see Appendix C).

Note:

Standard guidelines for emission control in cold solvent-cleaning operation are described in ASTM D 3640.

TABLE 5 - THRESHOLD LIMIT VALUES (TLV) FOR SOLVENTS

SUBSTANCE	ADOPTED VALUES TWA. TLV (1)		ADOPTED VALUES STEL. TLV(2)	
	ppm	mg/cu m	ppm	mg/cu 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)	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
STANDARD 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

Notes:

1) TWA. TLV (Threshold Limit Value-Time Weighted 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.

5.4 Emulsifiable Solvent Cleaning

5.4.1 These cleaning methods relate to the removal of oil, grease and dirt from until parts or simple assemblies by leaving them in contact with a cleaning mixture in which grease and dirt are loosened but not detached and then washing away the solid contaminants with water. The method has the advantage that no heating is required and that a succession of dirty articles can be cleaned without rapidly fouling the cleaning medium itself.

5.4.2 This method gives a degree of cleanness less than that obtained by hot solvent or aqueous alkaline cleaning methods but may be employed if a residual trace of the cleaning medium may be tolerated by the subsequent process (e.g. phosphating-see IPS-C-TP-102) or if the size of the parts makes "in situ" cleaning essential.

5.4.3 Emulsifiable solvent cleaning can in general be used on any metallic parts, but shall not be used on assemblies containing fabrics, rubber or other organic material, unless it has been reliably ascertained that no harm will result.

5.4.4 Emulsion cleaners are broadly classified into three groups, on the basis of stability; stable, unstable and diphasic emulsion cleaners.

5.4.5 Stable emulsion cleaners are applied by immersion or spray process. These cleaners shall not be used for cleaning of heavily contaminated surfaces.

5.4.6 Unstable emulsion cleaners perform more efficiently in removing heavy shop soils such as oil- base rust and many lubricants used in stamping and extruding. This method is applied by immersion or spray process. (see Appendix A). Typical cycles for immersion and spray process is shown in Table 6.

5.4.7 Diphasic emulsion cleaners are utilized for removing the most difficult hydrocarbon soil, such as lapping compounds, buffing compounds, and oxidized oils. They are capable of providing a higher degree of cleanness than can be obtained with stable or unstable emulsions. Diphasic cleaners are most commonly used in immersion process.

5.4.8 Typical compositions and operating temperatures of different types of emulsion cleaners are shown in Table 7.

TABLE 6 - TYPICAL CYCLES FOR IMMERSION AND SPRAY EMULSION CLEANING

PROCESS SEQUENCE	CYCLE TIME, MINUTE			
	EASY CLEANING (a)		DIFFICULT CLEANING (b)	
	IMMERSION (c)	SPRAY (d)	IMMERSION (e)	SPRAY (f)
CLEAN (g)	2 TO 4	½ TO 1	4 TO 10	1 TO 2½
RINSE (h)	¼ TO ½	¼ TO ½	¼ TO ½	¼ TO ½
RINSE (j)	¼ TO 1	¼ TO 1	¼ TO 1	¼ TO 1
AIR DRY (k)	½ TO 2	¼ TO 2	½ TO 2	¼ TO 2
<p>a) REMOVING CUTTING OILS AND CHIPS FROM MACHINED SURFACES, SHOP DIRT AND OIL FROM SHEET METALS, AND DRAWING COMPOUNDS FROM AUTOMOTIVE TRIM.</p> <p>b) REMOVING EMBEDDED BUFFING COMPOUNDS IMPREGNATED CARBONIZED OILS FROM CAST IRON UNIT PARTS AND QUENCHING OIL FROM HEAT TREATED FORGINGS.</p> <p>c) CONCENTRATION OF CLEANER, (15 TO 60 g/litre)</p> <p>d) CONCENTRATION, (3.75 TO 15 g/litre)</p> <p>e) CONCENTRATION, (30 TO 90 g/litre)</p> <p>f) CONCENTRATION, (7.5 TO 15 g/litre)</p> <p>g) (60 TO 71°C)</p> <p>h) UNHEATED RINSE.</p> <p>j) (54 TO 71°C)</p> <p>k) (21 TO 71°C)</p>				

TABLE 7 - TYPICAL COMPOSITIONS AND OPERATING TEMPERATURES FOR EMULSION CONCENTRATES

COMPONENT	COMPOSITION, PARTS BY VOLUME		
	STABLE	UNSTABLE	DIPHASE
PETROLEUM SOLVENT (a)	250 TO 300	350 TO 400	250 TO 300
SOAPS (b)	10 TO 15	15 TO 25	NONE
PETROLEUM (SULFONATES) (c)	10 TO 15	NONE	1 TO 5
NONIONIC SURFACE-ACTIVE AGENTS (d)	5 TO 10	NONE	1 TO 5
GLYCOLS, GLYCOL ETHERS (e)	1 TO 5	1 TO 5	1 TO 5
AROMATICS (f)	5 TO 10	25 TO 50	5 TO 10
WATER (g)	5 TO 10	NONE	NONE
TYPICAL COMPOSITIONS AND OPERATING TEMPERATURE RANGE(h)			
	27 TO 66°C	27 TO 66°C	27 TO 60°C

a) Two commonly used hydrocarbon solvents are deodorized kerosine and mineral seal oil.

b) Most commonly used soaps are based on rosin or other short-chain fatty acids, saponified with organic amines or potassium hydroxide.

c) Low-molecular-weight petroleum sulfonates ("mahogany sulfonates") are used for good emulsification plus some rust protection. High-molecular weight sulfonates (with or without alkaline-earth sulfonates) offer good rust inhibition and fair emulsification.

d) Increased content generally improves stability in hard water, but increases cost.

e) Glycols and glycol ethers are generally used in amounts necessary to act as "couplers" in the stable and unstable types of emulsions. These agents are frequently used with diphase and detergent cleaners to provide special cosolvency of unique or unusual types of soils.

f) Aromatic solvents are frequently used to provide cosolvency for special or unique soils; sometimes they serve also to inhibit odor-causing or rancidifying bacteria.

g) Water or fatty acids, or both, are used to adjust the clarity and stability of the emulsion concentrate, particularly those of the stable and unstable types.

h) Maximum safe temperature depends on the flash point of hydrocarbon (petroleum) solvent used as the major component.

5.5 Aqueous Alkaline and Detergent Cleaning

5.5.1 These cleaning methods relate to the use of cleaning solutions containing alkalis, organic materials or both for the removal of oil, grease, dirt, and swarf from unit parts or simple assemblies having easily accessible surfaces.

Several methods of processing are available (see Appendix A); choice of the process depends upon the nature of the metal to be cleaned, the type and degree of contamination and the composition and size and shape of the articles. After cleaning the parts require rinsing and drying.

5.5.2 Solutions containing alkalis should be used with caution on articles with highly finished surfaces, owing to the possibility of dulling the surface. Porous articles, of parts and assemblies that would trap liquid, shall not be cleaned with such solutions owing to the difficulty of rinsing away all traces of the solution, and of drying.

5.5.3 Alkaline have advantages over other solvent in the removal of certain types of contaminants including soaps and salts. The cleaning action is based on the saponifying and emulsifying effects of aqueous alkalis, often reinforced by sequestering, complexing and surface active agents. The ingredients are usually selected from sodium hydroxide, sodium carbonate, sodium metasilicates, trisodium phosphate, sodium pyrophosphate, sodium borates, complexing agents (such as EDTA*, gluconates, heptonates, polyphosphates, and cyanides) and organic surfactants.

5.5.4 Application is normally by immersion, electrolytically, ultrasonic immersion or steam mixture jetting, with subsequent water rinsing (see Table 8).

5.5.5 All detergent and alkaline cleaning shall be followed by adequate draining, but the drainage time should not be so long as to allow the cleaning solution to dry on the articles. Water rinsing shall follow draining.

In conveyORIZED jetting and spraying machines the rinsing is usually with water jets; otherwise the articles should be transferred from the cleaning tank to a cold running water rinse tank.

Rinsing should be thorough and unless the cleaning solution has contained little or no alkali, it is preferable to arrange two rinse tanks in cascade with the water flowing the opposite way from the articles; this much reduces the amount of water needed to give effective rinsing.

If the articles are not to pass to other aqueous processes, a final immersion for 30-60 seconds in hot water (80-95°C) will facilitate drying.

5.5.6 immediately after final rinsing the parts shall be dried in accordance with Appendix C, unless further cleaning (removal of rust and miscellaneous residues) is to be undertaken.

*: Ethylen diamine tetra acetic acid

Note:

As soon as the parts are finally clean and dried the appropriate protective shall be applied without delay otherwise corrosion may occur very quickly; it is usually desirable to allow the article to cool to 5°C above room temperature before applying the protective. Cooling to room temperature may cause microscopic condensation on bare metal surfaces.

In immersion tanks the heating can be so arranged that convection currents assist the circulation of the cleaning medium round the articles; preferably, agitating may be provided by compressed air or with an air impeller or circulating pump.

5.5.7 A wide variety of proprietary cleaning mixture is available for cleaning ferrous and non-ferrous metals.

Solutions containing caustic alkalis should be used only when no metals other than iron and steel, copper, nickel, chromium and titanium are present. A typical strong alkaline cleaner for these metals may consist of a mixture of sodium hydroxide (caustic soda), sodium metasilicate (or other silicates of a higher soda/silica ratio), trisodium phosphate (or other phosphates) and sodium carbonate (soda ash).

5.5.8 Aluminium, lead, zinc, and tin, including galvanized surfaces and tin-plate, are liable to be damaged by any alkaline cleaners not specifically formulated for use with such metals. Mild alkaline cleaners made up of sodium metasilicate (or sodium silicates of a lower soda/silica ratio), a sodium, phosphate and a suitable proportion of surfactant may be used; sodium carbonate is permissible if silicate is present in such a proportion as to keep the soda/silica ratio below 1:2.

A proportion of sodium sulfite may be included as a means of avoiding feathering of tin-plate by mild alkaline cleaners.

The action of both strong and mild alkaline mixtures used in simple immersion cleaning is much improved by the inclusion of up to 5 per cent of an organic surfactant, commonly a sulfated fatty alcohol or a fatty alcohol/ethylene oxide condensate; but in electro-cleaning tanks or jetting systems such ingredients usually cause foaming and should be omitted or included only in very small proportion. Table 8 shows typical alkaline cleaner formulations for various metals.

5.5.9 Where hard water only is available this shall be softened. The addition of a small proportion of sodium hexametaphosphate is useful; usually 1g/litre will be adequate (see also Table 9).

5.5.10 Solutions of organic surfactants alone are usually harmless to any metal, but as they have a less vigorous action they require a longer period of contact than alkaline cleaners and are unsuitable for dealing with very greasy surfaces. Such solutions are an effective means of cleaning tin-plate without damage but not all surfactants are suitable for this purpose and a selection should therefore be made in consultation with the manufacturer.

5.5.11 Aqueous cleaning solutions should be made up in accordance with the manufacturer's recommendations, if any. Generally a concentration of 30-60 g/litre of water of an alkaline mixture is necessary for immersion cleaning, and of 5-30 g/litre water for jet cleaning spraying, an operating temperature of 80-95°C is generally recommended. If surfactants are used alone then concentrations of the order of 1-10 g/litre of water are normally used at room temperature though should jet cleaning be employed the concentration should be low to avoid excessive foaming.

A alternative method of applying similar active ingredients is to dissolve a proportion of an organic emulsifying agent in a solvent such as kerosene or white spirit and use this in the form of a weak emulsion in water to which a small proportion of a mild alkali such as sodium metasilicate may be added. Such an emulsion is generally used in a spraying machine at an elevated temperature.

TABLE 8 - TYPICAL ALKALINE CLEANER FORMULATIONS FOR VARIOUS METALS

	ALUMINUM		COPPER			CU PLATE	IRON & STEEL			MAGNESIUM		ZINC		
	A	B	A	B	C	C	A	B	C	A	B	A	B	C
BUILDERS:	COMPOSITION OF CLEANER, % BY WEIGHT													
SODIUM HYDROXIDE, GROUND .....	...	...	20	15	15	55	20	20	55	20	20	...	15	15
SODIUM CARBONATE, DENSE .....	...	...	18	...	...	8	18	29	8.5	18	29	...	...	...
SODIUM BICARBONATE	21	24	...	34	34	...	...	...	...	...	...	...	35	34
SODIUM TRIPOLYPHOSPHATE	30	30	...	...	10	...	20	20	10	20	20	90	10	10
TETRASODIUM PYROPHOSPHATE .....	...	...	20	10	...	10	...	...	...	...	...	...	...	...
SODIUM METASILICATE, ANHYDROUS	45	45	30	40	40	25	30	30	25	30	30	...	40	40
SURFACE ACTIVE (WETTING) AGENTS:														
SODIUM RESINATE .....	...	...	5	...	...	...	5	...	...	5	...	5	...	...
ALKYL ARYL SODIUM SULFONATE	3	...	5	...	...	...	5	...	1	5	...	5	...	...
ALKYL ARYL POLYETHER ALCOHOL .....	...	...	2	...	...	1	2	...	...	2	...	...	...	...
NONIONICS HIGH IN ETHYLENE OXIDE	1	1	...	1	1	1	...	1	0.5	...	1	...	...	1
	OTHER CONDITIONS													
OPERATING TEMPERATURE OF SOLUTION °C	71	71	82	76	71	82	93	76	82	93	76	82	76	82
CONCENTRATION OF CLEANER g/litre	30	7.5	60	7.5	60	60	60	7.5	60	60	7.5	30	7.5	45

A = Immersion
B = Spray
C = Electrolytic

TABLE 9 - MINIMUM PHOSPHATE ADDITIONS REQUIRED FOR SOFTENING WATER (a)

HARDNESS OF WATER PPM CaCO ₃	MINIMUM ADDITION FOR SOFTENING 100 litre,g	
	TETRASODIUM PYROPHOSPHATE	SODIUM TRIPOLYPHOSPHATE
WATER AT 25°C		
75	520	115
150	810	230
300	1020	450
WATER AT 60°C		
75	250	70
150	420	150
300	620	260
(a) ACTUAL (NOT THEORETICAL) MINIMUM AMOUNTS REQUIRED FOR WATER SOFTENING ONLY.		

5.6 Steam Cleaning

5.6.1 This cleaning method relate to the use of a jet of high pressure steam for the "in situ" cleaning of large unit parts, assemblies and machinery that cannot be accomodated in a cleaning apparatus.

Steam cleaning should not be used where delicate mechanisms are found. The cleaning may be carried out with pure steam or with aqueous detergent solution / steam mixtures. After cleaning the parts may have traces of the original contamination and of water or cleaning solution on their surfaces.

This method is not applicable to the cleaning of interior surfaces of assemblies that cannot be drained readily.

5.6.2 The steam and hot water themselves tend to remove the oils, greases, and soaps by thinning them with heat, emulsifying them, and diluting them with water. When used to remove old paint, the steam cooks the vehicle of the old paint so that it loses its strength and its bonding to the metal. It can then be easily removed by further washing. When detergent is used its higher affinity for the metal also causes the oil, grease, and paint to loosen, thereby increasing the rate of cleaning.

The mechanical action of the steam usually permits the use of lower concentration of detergent than are required for immersion cleaning.

5.6.3 Alkali cleaners used in steam cleaning will attack aluminum and zinc alloys, unless specifically inhibited against such action.

They should be used selectively over painted surfaces to assure no damage to the paint if removal is not desired. The equipment required is a pressure jet steam cleaners (see Appendix A).

5.6.4 On completion of detergent solution/steam cleaning, straight steam should immediately be directed over all cleaned surfaces so as to wash away deposits from the solution, especially if an alkaline solution has been used.

The raised temperature of the surfaces subjected to high pressure steam helps the drying, but parts retaining moisture should immediately be dried by blowing with compressed air.

5.6.5 Strong alkalis attack the eyes and the skins; goggles and protective clothing should be worn when carrying out alkaline solution / steam cleaning with strong alkalis, particularly in confined places. Due care should be taken to avoid steam burns.

5.7 Test for Freedom from Grase (see also ASTM A 380-88)

5.7.1 Water breaks test

A commonly used test for the removal of greases and oils is the inspection for water breaks. This is best done after pickling or activation. This involves visual observation after a final rinse in clear, cool water. A continuous sheet of water on the part usually indicates a clean surface (certain precious-metal surfaces, such as gold, may exhibit water break even though clean). Some experience is necessary to judge the appearance of a break in the film of water. A specific drainage time, about 30s shall be used before observation, water breaks method, alone.

5.7.2 Grease red testing

Application of a drop of a 0.1% solution of the dye (grease red BB*) in ethanol.

On a grease-free horizontal surface, the drop quickly opens out and there remains a circular outline, on a grease-free vertical surface, the run-off path is short and there remains an oval outline. On a horizontal surface not free of grease, the drop remains at its original size and after evaporation there is a sharply serrated outline; on a vertical surface not free of grease a long run-off path forms.

The tested areas must be carefully cleaned before coating.

***: Information on sources of supply can be obtained from committee on paint and similar coating materials (Din) Burggrafenstrasse- 4-10 , 1000 Berline 30.**

5.7.3 Fluorescence testing

Various oils and greases exhibit fluorescence effects when irradiated with UV light (must be screened from incident daylight). If the type of contamination and its fluorescence properties are known, this method can be used for testing cleaned surfaces.

5.8 Some Notes on Degreasing

5.8.1 Selection of solvent

5.8.1.1 Strong alkalis are commonly used for cleaning steel, but they are not used where they can cause attack e.g. on aluminium, tin, zinc and brass. Mild alkaline cleaner will not attack metals. Articles that are porous or have fine capillary spaces shall not be cleaned in alkaline solutions.

5.8.1.2 For articles which are partially painted or varnished, trichloroethylene and alkali solutions are not generally suitable. Certain emulsifiable solvent cleaners or petroleum solvents may be used.

5.8.1.3 Only unit parts or very simple assemblies, shall be cleaned in aqueous cleaners. Parts or assemblies of complex construction shall not be cleaned owing to the risk of trapping cleaning solution that would not be removed by subsequent rinsing and drying.

5.8.2 Re-use of cleaning solution

5.8.2.1 Cleaning agents are weakened and contaminated by material and soil being removed from surface as they are cleaned. It may be impractical or uneconomical to discard solution after a single use, even in precision cleaning operations. When solution are re-used, care must be taken to prevent the accumulation of sludge in the bottom of cleaning tanks. Periodic cleaning of vats and degreasing tanks, decanting periodic bottom-drain, agitation of solution and similar provisions are essential to maintain the effectiveness of solution. Care must be taken to prevent water contamination of trichloroethylene and other halogenated solvents, both while in storage and in use.

5.8.2.2 Re-distillation and filtering of solvents are necessary before reuse.

5.8.2.3 Make up is often required to maintain concentrations and PH of cleaning solution of effective levels. Do not over use chemical cleaners, particularly vapor-degreasing solvents, if light films or oily residues remain on the metal surfaces after use of such solvents, additional scrubbing with hot water and detergent, followed by repeated rinsing with large quantities of hot water, may be necessary.

5.8.3 Protection of cleaned surfaces

5.8.3.1 Walking on cleaned surfaces shall be avoided, where unavoidable, personnel shall wear clean shoe covers each time they enter, or protective material shall be laid areas where personnel are required to walk.

5.8.3.2 Workmen handling cleaned surfaces of critical items shall never wear clean lint-free cotton, nylon or dacron cloth or polyethylene film gloves. Rubber or plastic gloves are suitable during pre-cleaning operation or cleaning of non-critical surfaces.

5.8.3.3 Keep opening of hollow items (pipe, tubing, valves, tanks, pump, pressure vessels, etc.) capped or sealed at;

- all times except when they must be open to do work on,
- the item, using polyethylene, nylon, TFE-Flouro carbon plastic,
- or stainless steel caps, plugs, or seals.
- The reuse of caps, plugs, or packaging materials shall be avoided unless they have been cleaned prior to reuse.
- Do not remove wrapping and seal from incoming materials and components until they are at the use site, ready, (to be used or installed.)

5.8.4 Solvent hazardous

5.8.4.1 All solvents are potentially hazardous and they shall be used under such conditions that their concentration in air being breathed by workmen is low enough for safety. (see Table 6 Threshold limit valve) when used in closed spaces (pit or vessel) where the safe concentration is exceeded, fresh air masks shall be worn.

5.8.4.2 Smoking shall not be allowed near degreasing equipment.

6. PICKLING

6.1 General

6.1.1 Pickling is a method of preparing metal surfaces by chemical reaction, electrolysis, or both. In pickling method the rust and scales are removed by chemical reaction with mineral acids and also with certain alkine materials.

Various acids used in commercial pickling are sulfuric, hydrochloric or muriatic, nitric, hydrofluoric, phosphoric and mixtures of these.

6.1.2 Pickling is considered a desirable method of removing rust and mill scale from structural shapes, beams, plates in workshop, when the cost of such removal is felt to be justified. Properly accomplished, pickling produces a surface that will promote long paint life with most coating.

6.1.3 Steelworks prepared by pickling methods shall be primed as soon as dry and while still warm with the specified primer to a specified dry film thickness and/or to a minimum dry film thickness of 50 microns. (see IPS-E-TP-100, Table 1).

6.2 Pickling Methods

6.2.1 The six main pickling methods, which in turn may consist of different processes, may be used for pickling of metals:

These methods are as follows:

- Sulfuric or hydrochloric acid pickling method
- Phosphoric acid pickling method
- Footner pickling method
- Sulfuric acid-sodium dichromate pickling method
- Alkaline derusting method
- Electrochemical treatment method

6.2.2 Selection of pickling method depends on nature of rust and scale, material of articles, degree of desired pickled surface and availability and cost of pickling material and equipments. The specifier shall specify the pickling method as appropriate.

6.3 Hydrogen Embrittlement

When metal dissolves in acid during pickling process, a definite volume of hydrogen is produced. It is apparently atomic hydrogen, absorbed or dissolved in steel, that affects its flexibility and ductility.

Bubbles of molecular hydrogen that form at the metal surface from conjugation of atomic hydrogen are extremely light. This is "hydrogen embrittlement" or "acid embrittlement". Blisters on sheet or plate during pickling and galvanizing are from the same cause.

Hydrogen bubbles, rise rapidly through a poorly inhibited bath. As they reach the liquid surface, they break violently and form fumes. The produced fumes can affect the health of workers and rapidly corrode any metal work and masonry in the pickling room. Inhibitors minimize acid fumes by reducing hydrogen that causes them.

6.4 Cleaning and Preparation of Metal Prior to Pickling

6.4.1 Heavy deposits of oil, grease, soil, drawing compounds, and foreign matter other than rust, scale or oxide must be removed by any appropriate cleaning method described in section 5 unless certain method(s) of section 5 is (are) specified by the company. Small quantities of such foreign matter may be removed in the pickling tanks provided no detrimental residue remains on the surface.

6.4.2 Heavy deposits of rust, rust scale, and all paints by suitable mechanical method(s) described in sections 7 and 8. Rust deposits which can be removed without unduly prolonging the pickling time may be removed in the pickling tanks. Paints and other types of marking can normally be removed mechanically or with solvents.

6.5 Pickling Process

6.5.1 Sulfuric or hydrochloric (muriatic) acid pickling

6.5.1.1 Pickling with these acids is of particular value in descaling, but should be used only for parts that can be easily and thoroughly washed free from acid. It may thus be unsuitable for parts of complicated shape particularly those containing narrow channels or blind holes that cannot be properly washed out, or parts with porous surface layers. The following types of components should, therefore, not be treated with these acids:

- Parts built up by riveting, spot welding, or similar methods. Cast-iron parts owing to the possibility of occlusion of pickling acid in porous surface layers.
- Ferrous articles with associated non-ferrous or non-metallic parts should not be pickled because of the risk of attack or of electrolytic effects, and because acid may be trapped at the join.
- High strength constructional alloy and heat-treated alloy steels shall not be pickled by sulfuric acid which can be used for low carbon structural steels. Some higher carbon and alloy steels burn in acid very easily, making surface smut more of a problem. One method to help solve this is to add rock salt to the sulfuric acid bath, some specifications call for the bath to contain 1.5% wt. sodium chloride.
- For acid pickling of stainless steel and metals other than ferrous metals see sections 11 and 12.

6.5.1.2 Operation

For the operation of sulfuric or hydrochloric acid pickling, various types of acid-resistant tanks are available, e.g. lead (for sulfuric acid), glass or glazed earthenware; wood, steel or concrete lined with rubber or other acid resisting materials may also be used. (see IPS-E-TP-350 "Lining"). Several efficient inhibitors to reduce acid attack on the base metal are available commercially and one of these should be employed; it is necessary to adhere strictly to the manufacturer's instructions regarding suitability, concentration and method of addition.

In hydrochloric acid pickling the concentration of acid may be varied between 1 and 50 per cent of concentrated hydrochloric acid by volume, according to the nature and amount of scale or rust and the time available for pickling. Higher concentrations of acid remove rust and scale more rapidly but may attack the steel more severely. Hydrochloric acid pickles work reasonably well without external heating; often the heat of reaction between the acid and the scale is sufficient to keep the bath at 30-40°C and then quite rapid pickling takes place.

In sulfuric acid pickling the concentration may be between 5 and 20 percent of sulfuric acid by volume and the bath should be heated (e.g. by steam coils) to a temperature of about 60-85°C. It is very uneconomical to pickle in other than hot sulfuric acid solutions because of the relative slowness of the attack.

Note:

To avoid accident from overheating when making up, always add the acid slowly to cold water stirring continuously. Do not add the water to the acid.

Pickling may be accelerated to some extent by mechanical agitation of the parts or of the solution, and sometimes by lightly scrubbing off deposits that have loosened in the acid bath. Alternatively, the pickling action may be facilitated by the use of ultrasonic vibrations (see Appendix A.5). Completion of pickling is best judged by periodic inspection.

The acid content of the bath shall be checked frequently and additions of acid made to maintain the correct strength (see 6.9.3.1). The pickle shall be discarded when the iron content has risen to such an extent as to retard seriously the rate of pickling. The limiting iron (Fe) contents are of the order of 35 g/litre for hydrochloric acid pickle and 16 g/litre for sulfuric acid pickle (see 6.9.3.2).

After removal from the sulfuric acid pickling bath, the parts shall be treated as specified in 6.7.

6.5.2 Phosphoric acid pickling

Phosphoric acid pickling is less danger of corrosion from residues or during drying, and is therefore preferable to the other mineral acids. Nevertheless, with certain exceptions, it is necessary to wash the articles thoroughly after the pickling treatment, particularly if the parts are of complicated shape, contain narrow channels or blind holes or are built up by such methods as riveting or spot-welding.

6.5.2.1 Rust removal with phosphoric acid

Light rust can be removed by immersion in cold phosphoric acid, or proprietary liquids based on phosphoric acid and substantially free from other mineral acids, diluted for use according to the manufacturer's instructions. The optimum strength of acid is approximately 25 percent by volume. Generally the procedure is dip application.

In dipping process, immerse in the rust-removing solution, if necessary assisting the de-rusting action by brushing with a steel-wool pad. Alternatively, warm the solution to 60°C to speed up rust removal. The immersion should not be longer than is required for complete de-rusting; normally up to an hour (or 15 minutes at the higher temperature) should suffice. A lead-lined tank is recommended for the rust removing solution.

Rinse well in clean cold water, and finally in clean hot water. Dry as quickly as possible according to Appendix C.

If composite articles are to be treated, care shall be taken to avoid excessive attack on non-ferrous metals. Generally, the solution should not be used for leaf springs or springs under stress.

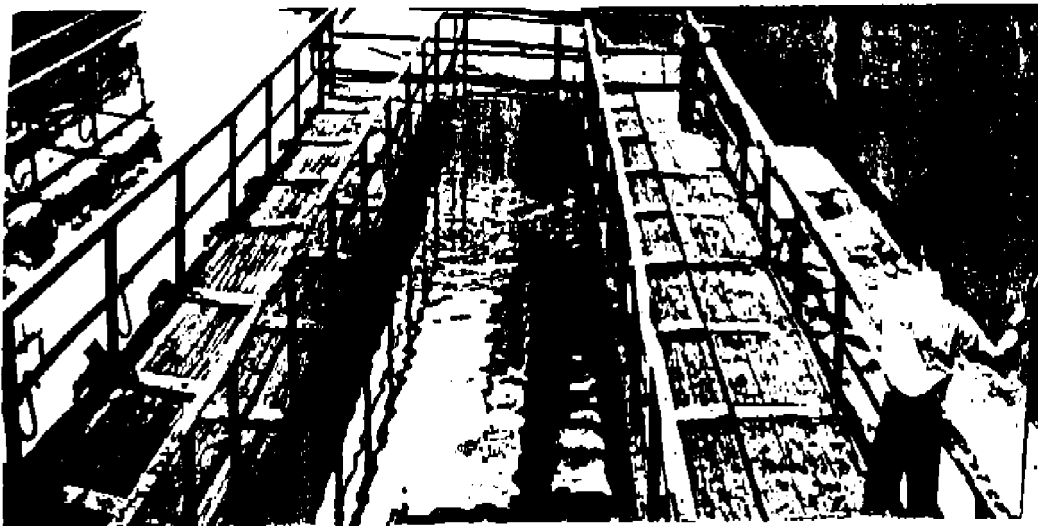
Locally hardened or hardened and tempered steel and spring steels shall be given a further treatment for 30 minutes in boiling water.

6.5.2.2 Scale removal with phosphoric acid

Heavy scale can be removed by phosphoric acid only at higher temperatures, e.g. 85°C for 25 percent v/v acid. It is not generally necessary to use an inhibitor in the bath. After pickling is complete, the treatment of articles by washing, drying, etc. is the same as in 6.5.2.1. The bath shall be discarded when the concentration of iron (Fe) reaches 20 g/litre (see 6.9.4), otherwise powdery deposits may be formed on the metal surfaces.

6.5.3 Duplex sulfuric / phosphoric acid (footner process) pickling

Economy in the use of phosphoric acid may be effected by the use of the Footner process for, de-scaling steel plate and other forms of structural steel prior to the application of a protective coating. This process consists in:



PICKLING SET UP FOR SULFURIC-PHOSPHATE PICKLING (FOOTNER PROCESS) SULFURIC ACID TANK IS ON THE RIGHT, RINSE TANK IN THE MIDDLE, AND PHOSPHATE TANK ON THE LEFT. A PICKLED PLATE IS BEING WITHDRAWN FROM THE SULFURIC ACID BATH.

Fig. 3

6.5.3.1 Pickling in 5-10 percent v/v sulfuric acid at 60-65°C for 12-15 minutes, or until all scale and rust is removed. The bath shall contain an inhibitor. Further sulfuric acid shall be added when the pickling time increases appreciably. The bath shall be discarded when the accumulation of sediment, etc. and the concentration of iron in the solution interfere with the pickling and result in deposits on the surface of the article.

This occurs when the specific gravity reaches about 1.18-1.20 or there is 1.6 percent of iron (Fe) (16 g/litre) in the solution. After the article is lifted from the acid bath it shall be allowed to drain for 15-30 seconds before immersion in the water bath.

6.5.3.2 Washing in warm water 60-65°C by immersing twice before passing to the final bath. There shall be a very small flow of water through the water-wash bath to prevent the total acidity as determined by titration against phenolphthalein, from exceeding 0.1 g H₂SO₄ per 100 cm³. The necessary flow of water can be established after a short experience of the process.

6.5.3.3 Immersing for 3-5 minutes in 2 percent phosphoric acid solution maintained at a minimum temperature of 85°C. When the iron (Fe) content exceeds 5 g/litre proportion of the bath shall be discarded and the bath restored by suitable additions of clean water and phosphoric acid.

The lower phosphoric concentration and shorter immersion tends to produce thinner and less porous phosphate coating. This type of coating is an excellent base for most paint.

When removed from the hot phosphoric acid bath in the Footner process, the plates, etc. dry rapidly, and carry a protective dull grey phosphate film. No subsequent washing is required. Protective coatings shall be applied immediately after the pickled surfaces are dry and while they are still warm.

The process is also applicable to lighter material than structural steel, but drying in an oven may be necessary for light materials that do not carry sufficient heat from the bath to dry in air.

Fig. 3 shows a pickling setup for footner process.

6.5.4 Sulfuric acid-sodium dichromated pickling

This method is often used in shipyards. The procedure is as follows:

Pickling is performed by 5% (by volume) sulfuric acid at 75-80°C, with sufficient inhibitor added to minimize attack on the base metal, until all rust and scale is removed, followed by a two minute rinse in hot water at 75-80°C.

Next, immerse the pickled and rinsed steel for at least two minutes in a hot, inhibitive solution maintained above 85°C and containing about 0.75% sodium dichromate and about 0.5% orthophosphoric acid.

6.5.5 Alkaline pickling

Rust and scale may be removed and the surface prepared for electroplating or painting of non-ferrous metals by one of the following alkaline pickling method.

6.5.5.1 Remove of light rust

Immerse in a solution based on caustic soda and a chelating agent such as sodium heptonate or gluconate.

6.5.5.2 Remove of heavy rust

Electrolytic treatment in an alkaline solution consisting essentially of sodium hydroxide in water, the concentration being adequate to ensure good electrical conductivity. They may contain substances which assist in the removal of the rust, such as sodium cyanide (solution a) and ethylenediamine tetracetic acid (solution b). Typical compositions are:

a) Sodium hydroxide	200 g/litre to 300 g/litre
Sodium cyanide	20 g/litre to 30 g/litre
Anionic surface active agent	1.0 g/litre to 1.5 g/litre

b) Sodium hydroxide	100 g/litre to 200 g/litre
Ethylene diamine tetracetic acid (EDTA)	100 g/litre to 150 g/litre
Non-ionic wetting agent	1.0 g/litre to 1.5 g/litre

The solutions may be operated from room temperature to 60°C, but it is recommended that solution (a) not taken above 40°C to prevent rapid decomposition of the cyanide.

The parts should be treated anodically or cathodically or with periodic reversal of the current (at current) densities of the order of 250 A/m² to 500 A/m².

After de-rusting, parts should be washed thoroughly in running water, special attention being paid to any crevices.

6.5.5.3 Remove of scale (descaling in molten caustic alkali)

Molten caustic alkali descaling processes, which are based on molten caustic alkalis containing additives such as sodium hydride, have less tendency to induce hydrogen embrittlement in steel than pickling but their use on high strength steel is not allowed. These processes are particularly suitable for castings, and for parts in heat resisting steel stress relieved after fabrication. Molten hydride is, however liable to embrittle titanium alloys by hydrogen absorption.

6.6 Electrochemical Pickling

It is possible to remove rust and scale by the following electrolytic methods:

6.6.1 Cathodic treatment in acid solution

Removal of rust and scale may be accelerated compared with ordinary pickling, acid is economised and attack on the metal is reduced, but hydrogen embrittlement may be serious.

Inhibitors such as tin or lead salts shall be used. This process is useful for descaling irregular shaped objects and those with difficult recesses. The work is made cathodic at 645 ampere/m² in hot 10 per cent v/v sulfuric acid containing a small amount of lead or tin salts. Tin or lead plates on the descaled areas and the action is diverted to other areas. The plated tin or lead is usually removed by electrolytic alkali cleaning. Some organic inhibitors can substantially reduce metal losses during cathodic pickling.

6.6.2 Cathodic treatment in alkaline solution

Hydrogen embrittlement is less than with 6.6.1 method but de-rusting is usually slower than in acid solutions.

6.6.3 Anodic treatment

Anodic treatment may be carried out in either acid or alkaline solutions. Passivating conditions are established and oxygen, not hydrogen, is produced at the surface.

Hydrogen embrittlement is usually avoided with the anodic process where there is a slight risk, especially with highly stressed parts of hydrogen being formed in the acid process when the current is switched off and while the work is being removed from the bath.

Examples are:

- An anodic process for parts entirely of steel based on sulfuric acid solution (sp.gr : 1.22) used at a temperature not exceeding 25°C in a lead tank with lead cathodes, with a high anodic current directly maintained on the steel surfaces (not less than 1075 ampere/m²).
- An anodic alkaline process for parts entirely of steel based on a solution of caustic soda containing cyanide or an organic complexing agent.

6.7 Treatment of Metal after Pickling**6.7.1 Cold rinsing**

When metal is removed from the pickle bath, a thin film of pickling acid and salts, resulting from reaction of acid with metal, clings to it. The acid and salts, with the exception of some produced from phosphoric acid, actually stimulate rust formation and must be completely removed before they dry. An ample supply of clean water must be available for rinsing, which may be accomplished by any convenient means. Steel, wood, or concrete tanks provided with a skimming trough to take care of an ample overflow of water are generally used, although water can be applied liberally with a hose.

Pickled work should be rinsed promptly, particularly if the acid is hot. If the film dries, it is difficult to rinse away residues that can cause trouble in many of the following operations.

6.7.2 Final (hot) rinsing - neutralizing

When pickling acid and iron salts are removed or diluted, metal must be suitably treated in preparation for operations that follow. Treatment prevents steel from rusting and prepares it for painting. Weak alkali solutions, such as 1.9 to 3.7 g/litre of sodium carbonate or trisodium phosphate, are used in a boiling rinse following a cold rinse, previously described.

The alkaline surface does not rust rapidly, but if it is to be stored indefinitely or exposed to weather, it shall be oiled. Alkali cleaning solutions (Neutralizing) are suitable for application of oil but are not suited for application of paint. Also, there are other treatments that can be used to prevent rusting.

6.7.3 Preparing metal for painting (see IPS-C-TP-102 painting)

Most paints do not adhere well and blister in a humid atmosphere if applied to an alkaline or neutral surface. For best painting results the surface pH should be slightly acid. Best results occur when the surface has a pH between 3 and 5. There are exceptions when using special paints, such as inorganic zincs, which normally are applied to neutral surfaces. In pickling processes for inorganic zinc applications, no further treatment is normally used after the hot water rinse.

For most paints, other than inorganic zincs, it is important that proper be used to produce the proper pH. Phosphoric or chromic acids, or mixtures, produce best results. Muriatic or sulfuric acids shall not be used because their residues stimulate rust under paint.

It is desirable to further clean and treat pickled and rinsed steel in a phosphoric acid solution prior to painting. Good results can be obtained by adding approximately 0.25% by weight of concentrated phosphoric acid to the hot rinse bath, contained in a steel tank, and maintaining this rinse at a pH of 3 to 5 by addition of acid as small quantities are needed.

The cleanliness of the boiling rinse is important, since it is here that a satisfactorily cleaned surface can be spoiled for painting. For best results the bath should be discarded daily and the tank cleaned before making a new bath. This is not practical for large scale structural pickling operations, and good painting results can be obtained by merely maintaining a water rinse temperature at 60°C or higher and painting promptly while steel is warm and dry.

6.8 Appearance of Pickled Surface

6.8.1 The surface shall be pickled to a degree suitable for the specified painting system.

6.8.2 Uniformity of color may be affected by the grade, original surface condition, and configuration of the material being cleaned, as well as by discolorations from mill or fabrication marks and the shadowing from pickling patterns.

6.8.3 Visual standards of surface preparation agreed upon by the contracting parties should be used to further define the surface.

6.9 Test Methods-Determining of Acid and Iron Content of Pickle Baths

Methods regularly used in the laboratory shall be used to titrate pickle baths for both acid and iron. It is recommended to install such apparatus near the pickle or measuring tanks and to have titrations made at regular intervals, usually by the pickle foreman, who sees to it that acid is added in measured and recorded quantities to maintain the proper strength.

6.9.1 Equipment required

1-5 cm ³ pipette	1- burette stand
1-1 cm ³ pipette	2- 250 cm ³ glass beakers
2-25 cm ³ burettes	2- stirring rods
1-5 cm ³ measuring cylinder	1- glass indicator bottle

6.9.2 Reagents required

- 1.0 normal sodium hydroxide solution
- 0.1 normal potassium permanganate solution
- Methyl orange -1 g/litre of H₂O
- C.P* sulfuric acid, concentrated

6.9.3 Determining acid and iron content in sulfuric and hydrochloric acid baths

6.9.3.1 Determining acid content

a) Measurement

- Measure a 5 cm³ sample of the pickling solution with a 5 cm³ pipette and transfer it to a clean 250 cm³ beaker.
- Add about 100 cm³ (half a beaker) of clean, fresh tap or city water and 2 or 3 drops of indicator solution (methyl orange).
- Fill a burette exactly to the zero mark with 1.0 normal sodium hydroxide.

*: C.P (chemically pure): without impurities detectable by analysis.

- Stir the test sample constantly with a stirring rod and slowly run in 1.0 normal sodium hydroxide until the red color has changed to yellow. Stop adding this titrating solution at the moment the color of the test sample becomes pure yellow.
- Record the reading taken on the graduated burette. This is the number of cm³ of 1.0 normal sodium hydroxide used.

b) Calculation

The number of cm³ of 1.0 normal sodium hydroxide used, multiplied by the appropriate factors shown in table 10, gives the desired quantity of 66° or 60° Be * sulfuric acid or 20° or 18° Be* muriatic acid.

TABLE 10 - CONVERSION FACTORS FOR SULFURIC AND HYDROCHLORIC (MURIATIC) ACID CONCENTRATIONS

	66°BE SULFURIC	60°BE SULFURIC
PERCENT BY VOLUME....	0.573	0.740
GRAMS PER 100 ml.....	1.053	1.263
POUNDS PER gal.....	8.771	10.525
	20°BE MURIATIC	18°BE MURIATIC
PERCENT BY VOLUME....	1.999	2.288
GRAMS PER 100 ml.....	2.319	2.612
POUNDS PER gal.....	19.353	21.796

6.9.3.2 Determining iron content

a) Measurment

- Measure a 1 cm³ sample of the pickling solution, With the 1 cm³ pipette and transfer it to a clean 250 cm³ beaker.
- Add about 100 cm³ (half a beaker) of fresh, clean water. Measure 5 cm³ of concentrated sulfuric by means of the 5 cm³ measuring cylinder and pour it slowly with constant stirring into beaker.
- Fill a burette exactly to the zero mark with 0.1 normal potassium permanganate.
- Stir the test sample continuously with a stirring rod and slowly run in the permanganate solution until the color changes to a faint pink, which persists at least fifteen seconds. Stop adding solution when pink is obtained.
- Record the reading taken on the graduated burette. This is the number of cm³ of 0.1 normal potassium permanganate used.

***: Be ;(Baume hydrometer scale): A calibration for liquids that is reducible to specific gravity by the following formulas: for liquid heavier than water speacific gravity = $145 \div (145 - n)$ (at 60°C) ; for liquid lighter than water specific gravity = $140 \div (130 + n)$ (at 60°C). (n) is the reading an the Baume scale, in degrees Baume.**

b) Calculation

The number of cm^3 of 0.1 normal potassium permanganate used, multiplied by 0.5580, equals grams of iron (Fe) per 100 cm^3 of pickling solution.

6.9.4 Determination of iron content in phosphoric acid bath**a) Measurement**

- Take 1 cm^3 phosphoric acid bath sample measured accurately with pipette and add to 125 cm^3 Erlenmeyer flask.
- Add 1 cm^3 of 50% C.P* sulfuric acid and about 25 cm^3 of distilled water.
- Add 0.18 normal potassium permanganate from titration burette, with stirring, to solution in the 125 cm^3 Erlenmeyer flask until the solution first turns a permanganent pink color. Record number of cm^3 of permanganate solution used.

b) Calculation

Each cm^3 of permanganate solution used is equivalent to 0.96 grams of iron per 100 cm^3 of phosphoric acid bath.

If 3.0 cm^3 were required to obtain the pink color then $3.0 \times 0.96 \text{ g}/100 \text{ cm}^3 = 2.88 \text{ g}/100 \text{ cm}^3$ iron in pickle bath. A titration requiring 12 cm^3 of permanganate solution would equal an iron concentration of 12 $\text{g}/100 \text{ cm}^3$.

6.9.5 Records

With facilities to analyze the bath, pickling can be efficient. Complete records are essential. A simple procedure for recording strength and temperature of the pickle bath, its iron content, when and how much acid is added, the number of tons pickled, etc., is to plot the data at regular intervals on a chart.

These records show consumption of acid per ton. Other pertinent data can be calculated. The graph indicates whether the bath has been discarded with too much acid or before enough iron has been dissolved. Records like this show the effect of different pickling procedures over periods of time.

Other records help in cost accounting or comparing one practice with another. An example is comparing the effect of an inhibitor throughout the life of a pickle bath. Data and calculation sheets provide for calculation of the "necessary cost" per ton. When this figure is compared for two or more pickling practices advantages can be seen.

6.10 Precautionary Notes

6.10.1 Do not stack pickled steel surfaces in contact with one another until completely dry and apply paint before visible rusting occurs.

6.10.2 Water shall never be added to strong acids. Even when properly adding concentrated sulfuric acid to water, enough heat generates to boil and blow the acid about.

6.10.3 Proper personnel protection, including face shields, rubber gloves, and rubber protective clothing, must be provided when handling acids.

*: C.P (chemically pure): without cm purities detectable by analysis.

7. MANUAL CLEANING (HAND AND POWER TOOL CLEANING)

7.1 General

Manual cleaning is the method of surface preparation metals, using hand or powered tools such as wire brushes, chipping hammers, chisels, scrapers and vibratory needle guns. It is the least satisfactory method of preparation especially for steelwork exposed to "severe" or "moderate" conditions although the size of the areas or other circumstances may preclude the use of more effective methods. It does not provide a satisfactory base for many coatings. (see IPS-E-TP-100 Tables 1 to 10)

Hand cleaning is acceptable only for spot cleaning and power tool cleaning is acceptable where blast cleaning is impractical or not economical. The case shall be specified by the company. The surface produced shall be in accordance with SIS 055900 St3 (see also 4.3).

7.2 Surface Preparation Before and After Manual Cleaning

7.2.1 Before manual cleaning, remove visible oil, grease, soluble welding residues, and salts by degreasing methods and remove flux residues and loose mill scale (see section 5).

7.2.2 After manual cleaning and prior to painting, reclean the surface if it does not conform to this specification.

7.2.3 After manual cleaning and prior to painting, remove dirt, dust, or similar contaminants from the surface. Acceptable methods include brushing blow off with clean, dry air, or vacuum cleaning. This type of mechanically cleaned surface shall receive primer in the same day.

7.3 Hand Tool Cleaning

7.3.1 Hand tool cleaning is one of the oldest process for preparing surfaces prior to painting. Hand cleaning does not remove tight mill scale and all traces of rust, so it is only acceptable for extremely small areas, i.e. spot cleaning. The tools used for hand cleaning include wire brushes, non woven abrasive pads, scrapers, chisels, knives, chipping hammer, and, in some instances, conventional coated abrasives. Specially shapes or knives are sometimes necessary.

7.3.2 Wire brushed may be of any practical shape and size. Two general types are the oblong with a long handle and the Block type. Bristles are of spring wire. Brushes shall be discarded when they are no longer effective because of badly bent bristles.

7.3.3 Non-woven abrasives are used in simple pad form or applied to a backup holder with handle. They are conformable and can be cut to it various applicators.

7.3.4 Scrapers may be of any convenient design. They should be made of tool steel, tempered and kept sharp to be effective. Some scrapers are made by sharpening the ends of 3.5-5 cm wide flat files or rasps and fastening them to a handle. The handle may be up to 1.5 m long to increase the area that can be reached. Other chipping and scraping tools made from old files or rasps a both ends sharpened. Several centimeters from one end, the file is bent at right angles.

7.3.5 Hand -chipping hammers are advisable in maintenance work where rust scale has formed. A chipping hammer is about 10-15 cm long with two wedge-shaped faces at either end of the head, one face perpendicular to the line of the handle and the other at right angles to the first face.

7.3.6 Auxiliary equipment includes dust brushes, brooms, various sizes of putty knives and conventional painters, scrapers, coated abrasives, and safety equipment such as goggles and dust respirators.

7.3.7 Hand-cleaning of painted surfaces shall remove all loose non-adherent paint in addition to any rust or scale. If paint is thick, edges of the old paint should be feather to improve the quality of the paint job. After cleaning, the surface is brushed, swept, dusted and blown off with compressed air to remove all loose matter.

7.4 Power Tool Cleaning

7.4.1 General

7.4.1.1 Power tool cleaning provides a better foundation for the priming of paint than hand tool cleaning, especially when surface are covered with heavy rust, scale or other firmly adherent deposits. Generally power tool cleaning is suitable only for small area because it is relatively slow. Power tool do not leave as much residue or produce as much dust as abrasive blasting and they are frequently used where blasting dust could damage sensitive surrounding.

7.4.1.2 However they may polish and/or damage the surface if they are used at too high a speed or kept in one spot for too long.

7.4.1.3 Power tool cleaning shall overlap by a minimum of 25 mm into any adjacent coated surfaces. Power tool cleaning shall produce the surface of grade st3 in accordance with SIS 055900 (see also 4.3).

7.4.1.4 Power tools used for surface cleaning fall into three basic families:

- Impact cleaning tools (see 7.4.2)
- Rotary cleaning tools (see 7.4.3)
- Rotary impact cleaning tools (see 7.4.4 and note in paragraph 7.4.4.2)

Tools in each family have unique characteristics that make them adaptable to different cleaning operations and requirements.

The type of power tools to be used depends upon whether or not an acceptable profile exists on the surface to be cleaned (see 4.4).

7.4.1.5 Rotary cleaning tools produce a profile of approximately 10-15 microns, whereas impact and rotary impact tools produce a profile of 25 microns or more. The profile depends on the abrasive embedded in the rotary flaps or the diameter of the needles in needle guns.

7.4.2 Impact cleaning tools

7.4.2.1 Impact cleaning tools are characterized by chipping and scaling hammers. With these tools, a chisel is struck by an internal piston and strikes the work surface.

7.4.2.2 Chisels can be adapted for scraping and chipping. This type of tool is useful when heavy deposits of rust scale, mill scale, thick old paint, weld flux, slag and other brittle products must be removed from metal. Chisels have different shapes and are made of various materials.

7.4.2.3 Cleaning surface with scaling and chipping hammers is comparatively slow. When considerable rust scale or heavy paint formation must be removed, it may be the best and most economical method.

7.4.2.4 The other impact power cleaning tools included in needle gun scalers and piston scalers. Needle scalers are most effective on brittle and loose surface contaminations.

7.4.2.5 Piston scaler can be used for cleaning of large surface area.

7.4.2.6 The impact cleaning tools may be used to remove tight mill scale and surface rusting, but they are not the most practical or economical tools because they gauge metal which must be smoothed to do a through job. Tools must be sharp or they may drive rust and scale into the surface.

7.4.3 Rotary cleaning tools

7.4.3.1 Rotary power tools do most hand cleaning jobs rapidly. There are three basic types of cleaning media for these tools:

- Non-woven abrasive,
- Wire brushes,
- Coated abrasive,

These media can be used on two basic types of tools:

- Straight or in-line machine,
- Vertical or right angle machines.

7.4.3.2 The straight or in -line machine style is used with radial wire brushes, coated abrasive flap wheels and non-woven abrasive wheels. The vertical machine style is suited for cup wire brushes, coated abrasive discs, non-woven abrasive discs, cup wheels and wheels. The type of machine varies with job conditons. It is advisable to have both types on hand and generally both are used on field jobs.

7.4.3.3 Rotary cleaning machines may be operated by pneumatic or electric motor.

The machine should be compatible with the size and speed rating of the cleaning media and should produce enough power to perform the operation efficiently. Most air powered machines contain governors to limit the free operating speed. Governors respond to tool load resulting from thrust applied to the work surface and supply more air to the motor, increasing power output and maintaining its rated speed while under load. Electrically driven machines operate at a fixed speed.

7.4.3.4 Non-woven abrasive come in cup wheel, radial (wheel) and disc form.

Non-woven abrasive wheels are recommended where base metal should not be removed but where wire brushes are not aggressive enough. Non-woven abrasive wheels wear at a controlled rate. Fresh working abrasive provides a constant rate of surface cleaning with minimal loading. Non-woven abrasives are also recommended for removal of light mill scall and coatings because of lowerd susceptibility to loading, as compared to coated abrasive.

7.4.3.5 Wire brushes come in radial (wheel) and cup form. Wire brushes can be composed of differently shaped and sized wire bristles. Bristles may be crimped (crinkled) or knotted. Selection of style and type of bristle or non-woven abrasive composition should be based on trials.

In power wire brushing it is possible to cut through some mill scale by using the toe of a very stiff brush and bearing down hard. It is impractical to remove tight mill scale by power wire brushing. Generally, removal of only loose mill scale and rust is required. Too high a speed shall not be used with rotary wire brushes and the brush shall not be kept on one spot for too long. Detrimental burnishing of the surface may occur. Under such circumstances the surface is smooth and develops a polished, glossy appearance that provides a poor anchor for paint. It is clear that doing too much surface work is detrimental. Rotary wire brushes are particulary notorious for spreading oil and grease over the surface. Oily or greasy surfaces must be cleaned with solvent before power brusing (see section 5).

7.4.3.6 Coated abrasives are used in Discs and flap wheels forms. Coated abrasives are used for metal removal such as weld grinding. Tight mill scale cannot be removed with such media, but loose scale can be.

Discs and flap wheels are used to remove loose mill scale, old paint, etc. similar to wire brush application.

7.4.4 Rotary impact tools

7.4.4.1 Rotary impact tools operate on the same basic principle as other impact tools, through cutting or chipping action, but rotary tools use a centrifugal principle where cutters or hammers are rotated at high speed and thrown against the surface.

7.4.4.2 Rotary chipping tools use three major types of media:

cutter bundles (or stars), rotary hammers, and heavy duty rotary flaps. All three can be used on pneumatic or electric powered tools.

Note:

Surface preparation using rotary impact tools is not allowed in this standard.

7.5 Manual Cleaning of Non-Ferrous Metals

7.5.1 Adhesion of paint to non-ferrous metals may be assisted by abrading the surface with fine emery cloth, or abrasive paper, and white spirit; this method may be used for small areas prepared on site.

Care shall be taken not to abrade through thin films of pure aluminium on composite ("clad") sheets; steel wool or hard abrasives shall never be used on these surfaces.

7.5.2 Unless metal sprayed coatings receive a protective coating corrosion products may develop fairly rapidly, especially in damp or chemically-charged atmospheres. Although they are not necessarily detrimental to the metal coating, they may affect paint adhesion and shall be removed before painting. Scrubbing with clean water, and stiff bristle or nylon (not wire) brushes, followed by rinsing with clean water is usually effective.

7.5.3 Removal of the layer of corrosion products which may form on aluminium after several years exposure can be difficult and abrasion may be necessary, e.g. with stainless steel wire wool or nylon pads, using water or white spirit as a lubricant. Mild steel, brass or copper wire should not be used as broken strands may become embedded in the surface and stimulate corrosion.

7.5.4 If non-ferrous metal coatings on iron and steel are damaged or become eroded on long exposure, rusting of the exposed base metal is likely to occur. Rusted areas should be cleaned to bright metal by wire-brushing or abrasion, care being taken to avoid damage to adjacent sound zinc or aluminium.

7.6 Precautionary Notes

7.6.1 Safety practices include the following considerations. Tool users and other people in the area should wear eye protection to guard against flying particles. Ear protection should be considered when impact tools are used. Particular attention should be paid when using several tools simultaneously in close proximity.

7.6.2 Hand tools shall be properly selected for the purpose and properly maintained. Hammers shall be properly heat-treated and striking faces maintained to eliminate "mushrooming" and flying fragments. All sharp-edged tools deserve respect and proper consideration.

7.6.3 Electrical tools should be run in dry environments. They should be grounded or double insulate. Power cords should be kept in good repair.

7.6.4 Impact tools shall be operated only when the scaling tool is in position and in contact with the workpiece. Tools shall not be used if ejection of an accessory might endanger personnel.

7.6.5 Rotary wire brushes shall be run at or below manufacturer's rated maximum operating speed. Gloves and leather aprons are additional safeguards to avoid injury from loose wires. Recommended guards shall always be used.

7.6.6 Coated and non-woven abrasives shall be run at or below manufacturer's rated maximum operating speed. Non-woven abrasive wheels shall be operated in the proper direction of rotation. The wheel or disc shall be put on the tool and tightened securely while the tool is disconnected from the power supply. Guards shall be used. Protective clothing shall be considered. Proper air pressure to pneumatic tools is important. Proper rpm should be checked with a tachometer on all tools before use.

7.6.7 Respirators shall be used if contaminants in the breathing zone exceed applicable threshold limits (see Table 5). This is of particular importance when cleaning paints containing lead, chromate or coal tar products.

7.6.8 Since the cleaning operations can produce sparks, care must be exercised when cleaning in the area of combustibles and volatile vapors. When such conditions cannot be avoided, only special nonsparking tools shall be used.

7.6.9 If fire or explosive hazards are present, proper precaution shall be taken before any work is done. If the structure previously contained flammable materials it shall be purged of dangerous concentrations. If the structure being cleaned is near flammable material or fumes non-sparking tools shall be used.

8. BLAST CLEANING

8.1 General

8.1.1 Blast cleaning is a method of surface preparation in which abrasive particles are directed at high velocity against the metal surface. They may be carried by compressed air or high-pressure water, or thrown by centrifugal force from an impeller wheel (see Appendix B). Application methods of blast cleaning. Unless otherwise specified by the company the contractor shall choose a suitable method for blast cleaning (see 8.2).

8.1.2 Blasting operations shall never be allowed in the vicinity of painting work or near to a wet paint surface, or anywhere that blast abrasive, grit or fall-out shall impinge on a freshly painted surface, or on any uncovered primed surface.

8.1.3 Blast cleaning operations shall not be conducted on surfaces that will be wet after blasting and before coating, when the surfaces temperature are less than 3°C above the dew point, when the relative humidity of the air is greater than 85%, or when the ambient temperature is below 3°C.

8.1.4 Blast cleaning is permitted only during the day light.

8.1.5 Where rectification has been necessary on blast-cleaned surface, the particular area shall be re-blasted to remove all rust and slag, and to provide adequate paint adhesion.

8.1.6 Blast cleaning shall overlap by a minimum of 25 mm into any adjacent coated areas. Any steel work not primed and/or wetted by rain or moisture shall be re-blasted prior to being painted if rust develops.

8.1.7 Steel may be blast-cleaned either before or after fabrication. Sometimes it may be necessary both before and after.

Where steel is cleaned before fabrication it shall be protected with a suitable blast-primer to avoid rusting before fabrication is completed. During fabrication, the blast-primer will inevitably be destroyed or damaged in places, e.g. by welding. Such areas shall be cleaned and re-primed as soon as possible.

Where steel is cleaned after fabrication it may still be necessary to apply a blast-primer, but often the first coat of the full protective system can be applied.

8.1.8 Roughness (surface profile). The roughness of a prepared surface results from primary roughness already present in the initial state and which is exposed by the mechanical preparation methods, in particular by blasting. The roughness parameters (the peak-to valley height) give some basis for determining the minimum coat thickness necessary for satisfactory embedment and covering of roughness peaks.

The surface roughness of steel work shall be within 0.1 mm to 0.03 ± 0.005 mm for painting, coating and lining.

For methods of measuring peak to valley height see section 4.4.

8.1.9 Standard level of cleanliness (see 4.3.2.2) unless otherwise specified by the company, the level of cleanliness for prepared steel surfaces shall be Sa3 for zinc silicate and zinc rich epoxy primers and Sa2½ for other primers and organic coatings and for metal coatings, claddings and lining.

8.1.10 For inspection and controlling the quality of surface finish see 8.5 and section 19.

8.1.11 A qualified well trained operator shall be employed for the blast-cleaning job. The qualification of operator must be approved by Company.

8.1.12 When sheets of less than 4 mm thickness are blasted, deformation may occur. This shall be avoided by:

- a) Low air pressure, small grain sizes and the use of a blasting abrasive of low bulk density;
- b) A low angle of blasting with sharp edged grain and a short duration of blasting. With adhesive scale or fairly thick rusting it may be necessary to carry out preparatory work by some other methods, e.g. manual cleaning or pickling, before cleaning, measures a) and b) will result in less efficient blasting.

8.1.13 All blasted steel surfaces shall be primed before visible rerusting occurs or within 4 hours whichever is sooner.

8.2 Choice of Method of Blast-Cleaning

The choice will be determined mainly by the following factors:

8.2.1 Shape and size of steelwork

Centrifugal methods are economic for plates and simple sections; they can also be used for large prefabricated sections, e.g. bridge sections, but only in specially designed plants. Misses discovered by inspection can be cleaned with air blast techniques. For large throughput of shaped items, e.g. pipes, both pressure and vacuum air-blasting techniques can be used in continuous and automatic plants (See Appendix B).

8.2.2 Effect of the stage at which is carried out

For blast-cleaning on site, pressure or vacuum air-blasting methods have to be used as on large fabricated sections, it may be impracticable to use centrifugal methods.

8.2.3 Throughput

Centrifugal plants are economic for a high throughput, but even with a low throughput the method may still be preferable to large-scale air blasting.

8.2.4 Environmental conditions

Despite its relatively high costs, vacuum air-blasting may be necessary to avoid contamination of the immediate area with abrasive. It shall be ensured that the blast-cleaning process does not affect adjacent materials.

8.2.5 Types of surface deposit to be removed

Water blasting methods, with abrasives are particularly suitable for removing entrapped salts in rust and for abrading hand-painted surfaces, e.g. two-pack epoxies, before recoating. Various methods are listed in table 11 with notes on their advantages and disadvantages.

8.3 Abrasive (See also Appendix B)

The grades of metallic and non-metallic abrasive have been selected with the target of surface roughness defined by a maximum amplitude of 0.1 mm and the grade of non-metallic abrasive have been selected with the target of a surface roughness (see also 4.4) defined by a maximum amplitude of 0.18 mm. For size grades of abrasives see Appendix B.1. It is essential to avoid the use of contaminated abrasives, as the following three types of contamination may occur.

- a) Dry dust and detritus from the surface and the smaller fines from the breakdown of abrasives. They can be removed by automatic and recirculatory plants. Without such a cleaning process, abrasives shall not be re-used.
- b) Water, either on the surface, in the compressed air, or from conditions of very high humidity, forms agglomerates of dust and abrasive particles, which will inhibit cleaning processes. In this case the abrasive shall be dry before cleaning.
- c) Oil and grease on the surface or from the equipment preclude the re-use of abrasives. Such oil and grease shall be removed before blast-cleaning.

The choice of abrasive will be determined mainly by economic considerations, but cast iron grit is recommended, particularly for surfaces to be metal-coated.

TABLE 11 - METHOD OF BLAST-CLEANING

METHODS	ADVANTAGES
DRY METHODS USING COMPRESSED AIR OR CENTRIFUGAL FORCE	
CENTRIFUGAL BLASTING (SEE B.2.2)	HIGH PRODUCTION RATES, LOWEST COSTS, NO MOISTURE PROBLEMS, CAN BE COUPLED TO AUTOMATIC APPLICATION OF PRIMER, DUST PROBLEMS CONTAINED
AIR BLASTING (PRESSUR AND SUCTION TYPE) (SEE B.2.1.2 AND B.2.1.3)	SIMPLE TO OPERATE, VERY FLEXIBLE AND MOBILE IN USE IN BOTH INDOOR CABINET OR SPECIAL ROOMS OR ON SITE, LOW CAPITAL AND MAINTENANCE COSTS
AIR BLASTING (VACUUM TYPE) (SEE B.2.1.4)	NO DUST PROBLEMS, NO SPECIAL PROTECTIVE CLOTHING FOR OPERATORS, FAIRLY LOW CAPITAL COSTS
WATER BLASTING (HYDROBLASTING) (SEE B.2.3)	
WATER BLASTING (BASED ON PROJECTING WATER AT VERY HIGH PRESSURE)	SIMPLE TO OPERATE, VERY FLEXIBLE AND MOBILE IN USE, SUITABLE FOR REMOVING SOLUBLE CONTAMINANTS, AT VERY HIGH PRESSURE CAN REMOVE MILL-SCALE, NO DRY DUST HAZARDS
WATER BLASTING BASED ON PROJECTING WATER AT HIGH PRESSURE AND ENTRAINING ABRASIVE INTO THE WATER STREAM	SIMPLE TO OPERATE, VERY FLEXIBLE AND MOBILE IN USE SUITABLE FOR REMOVING ALL FIRMLY HELD CONTAMINANTS AS WELL AS SOLUBLE CONTAMINANTS
WATER BLASTING BASED ON INJECTING LOW PRESSURE WATER INTO A COMPRESSED AIR STREAM WHICH IS CARRYING AN ABRASIVE	AS ABOVE
WATER BLASTING (SEE 5.6) USING STEAM-CLEANING	
DISADVANTAGES	
HIGH CAPITAL COST, HIGH MAINTENANCE COST, LACK OF FLEXIBILITY, i.e. NOT SUITABLE FOR RECESSED AREAS etc.	
HIGH COST OF COMPRESSED AIR, LOW EFFICIENCY, LIABLE TO MOISTURE ENTRAINMENT FROM THE COMPRESSED AIR, MANUALLY OPERATED AND A VARIABLE PROFILE CAN RESULT, OPERATOR REQUIRES PROTECTIVE CLOTHING, SERIOUS DUST PROBLEMS	
CAN BE VERY SLOW AND THEREFORE EXPENSIVE ON AWKWARD PROFILES AND GIRDER SECTIONS. WHERE FLAT-PLATE OR GUN-HEAD AUTOMATION IS POSSIBLE IT MAY BE CONSIDERED, BUT LIABLE TO MOISTURE ENTRAINMENT FROM THE COMPRESSED AIR	

(to be continued)

TABLE 11 - (continued)

<p>SLOW IF FIRMLY HELD CONTAMINANTS ARE TO BE REMOVED, DANGEROUS AT VERY HIGH PRESSURE IF PROPER PRECAUTIONS ARE NOT TAKEN, LIMITATION OF DRYING SURFACE BEFORE PAINTING UNLESS APPROVED WATER-BASED OR WATER MISCIBLE PRIMERS ARE USED, REQUIRES AVAILABILITY OF WATER AND DRAINAGE, OPERATORS REQUIRE PROTECTIVE CLOTHING</p> <p>DANGEROUS AT VERY HIGH PRESSURE IF PROPER PRECAUTIONS ARE NOT TAKEN, LIMITATION OF DRYING SURFACE BEFORE PAINTING UNLESS APPROVED WATER-BASED OR WATER-MISCIBLE PRIMERS ARE USED, PARTICULATE DUST HAZARD REMAINS, REQUIRES AVAILABILITY OF WATER AND DRAINAGE, OPERATORS REQUIRE PROTECTIVE CLOTHING</p> <p>HIGH COST OF COMPRESSED AIR, LOW EFFICIENCY, LIMITATION OF DRYING SURFACE BEFORE PAINTING UNLESS APPROVED WATER-BASED OR WATER-MISCIBLE PRIMERS ARE USED, DUST HAZARD REDUCED, OPERATORS REQUIRE PROTECTIVE CLOTHING</p> <p>SIMILAR TO THE ABOVE ACCORDING TO WHETHER ABRASIVE IS OR NOT ENTRAINED</p>
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8.4 Before and After Blast Cleaning

8.4.1 Before blast cleaning

8.4.1.1 The steel to be blast-cleaned by dry methods shall be dry and the operating conditions shall be such that condensation does not occur on it during the work. When compressed air is used, this shall be dry and free from oil.

8.4.1.2 Weld defects such as pin holes and discontinuities shall be rectified.

8.4.1.3 Weld undercutting shall be filled or dressed.

8.4.1.4 Excessive weld spatter shall be dressed off (Only light spatter will be adequately removed by blast cleaning).

8.4.1.5 Welding slag shall be cleaned off.

8.4.1.6 Laminations, laps and shelling shall be dressed off completely.

8.4.1.7 Sharp edges shall be smoothed off.

8.4.1.8 Burrs shall be removed.

8.4.1.9 Grease or oil contamination shall be removed by appropriate method described in section 5.

8.4.2 After blast cleaning

The following shall be done after blast cleaning:

8.4.2.1 Residual shot, grit and dust shall be completely removed after blasting, preferably by vacuum cleaning, but otherwise by oil and water free air blast or fibre brush.

8.4.2.2 Care shall be taken not to contaminate blast cleaned surfaces prior to painting.

8.4.2.3 Blast cleaned surfaces may be protected for short periods by a thin coat of pre-treatment or pre-fabrication primer (see IPS-C-TP-102). It is imperative that such primers should 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.

8.4.2.4 The prepared blast cleaned surface shall be completely primed the same day as blasted, and before any visible rusting or deterioration of the surface occurs. No blasted surface shall stand overnight before coating. If such surfaces are not primed in accordance with the above they shall be reblasted.

8.4.2.5 Care should be taken not to contaminate blast cleaned surfaces prior to painting.

8.5 Testing the Cleanliness of Blasted Surface

8.5.1 Visual or field tests

8.5.1.1 Photographs (see SIS 055900, ISO 8501-1)

The rust grades for steel surfaces and preparation grade prior to protective Coating, are useful for assessing cleanliness. See section 4.3 (grade of cleanliness).

8.5.1.2 Wipe tests

Rubbing of a surface with a clean, lint-free, white cotton cloth, commercial paper product, or filter paper moistened (but not saturated) with high-purity solvent, may be used for evaluating the cleanliness of surfaces not accessible for direct visual inspection. Wipe tests of small diameter tubing are made by blowing a clean white felt plug, slightly larger in diameter than the inside diameter of the tube, through the tube with clean, dry, filtered compressed air. Cleanliness in wipe tests is evaluated by the type of contamination rubbed off on the swab or plug. The presence of a sludge on the cloth is evidence of contamination. In cases of dispute concerning the harmful nature of the contamination, a sample of the sludge may be transferred to a clean quartz microscope slide for infrared analysis. The wipe test is sometimes supplemented by repeating the test with a black cloth to disclose contaminants that would be invisible on a white cloth.

8.5.1.3 Water-wetting and drying

Formation of rust stains may be accelerated by periodically wetting the surface with preferably distilled or deionized water or clean, fresh, potable tap water. The wet-dry cycles shall be such that the sample remains dry for a total of 8 hr. in a 24 hr. test period. After completion of this test, the surface shall show no evidence of rust stains or other corrosion products.

8.5.1.4 Test for detecting soluble rust-producing salts remaining on blast-cleaned steel

When blast-cleaning heavily rusted and rust-pitted steel a surface appearance suggesting a standard of cleanliness equivalent to white metal or Swedish Standard Sa2½ or Sa3 can be obtained, which, after an hour or two and sometimes after standing overnight, develops rust-spotting at points corresponding to the rust-pitting. In such circumstances it is not allowed to apply protective coatings until the cause of the rust-spotting has been eliminated. The cause is the presence of rust-producing soluble salts of iron which are practically colorless and are located at the lowest point of the rust pits. In the presence of moisture they hydrolyse to iron oxides and acids; the acids dissolve more iron to form more iron salts thus producing, in time, large volumes of rust which will break the adhesion bond of protective coatings if applied before the salts are removed.

Using potassium ferricyanide test papers any remaining soluble iron salt contaminants can be detected as follows:

- a) Spray a fine mist of water droplets on to a small area of the blast-cleaned surface using a hand spray (a scent-spray type of bottle if satisfactory).
- b) Allow the water droplets to evaporate and at the moment when they have disappeared but the surface is just perceptibly wet apply a small piece of test paper and press with the thumb for 2 to 5 seconds.

If soluble salts remain, these will be drawn by capillary action into the test paper and will react with the potassium ferri-cyanide to give a characteristic prussian blue complex as blue dots on the paper corresponding to the contaminated pits on the blast-cleaned steel.

8.5.2 Instrumental or laboratory test

8.5.2.1 Electrical testing

The contact resistance between the blasted steel surface to be tested and a probe (sprung contact in the form of a sphere of 1 mm diameter) is measured with an ohmmeter not requiring a mains supply and which provides the highest possible accuracy of reading in the range 0 to 1Ω . The position of the measurement points is selected arbitrarily and the number of such points shall be agreed. The arithmetic mean is calculated from the individual measured values. Reproducible measured values can only be obtained if the inherent short circuit impedance of the measuring circuit is eliminated. The information provided by this method will be improved if, instead of reading the measured values and calculating the mean value, a determination is made, using an electric counter, of the number of points of application of the probe at which the contact resistance is so small (i.e. the surface is so clean) that a current flows in a particular measurement circuit.

The measured results are affected by the blasting abrasive and the blasting method (type and number of impacts) and also by the initial state of the blasted surface.

8.5.2.2 High-humidity test

Subject the surface to a 95 to 100% humidity at (38 to 46°C in a suitable humidity cabinet for 24 to 26 hr. After completion of this test, the surface show no evidence of rust stains or other corrosion products.

8.5.2.3 Residual pattern

Dry the cleaned surface after finish-cleaning at 49°C for 20 minutes. The presence of stains or water spots on the dried surfaces indicates the presence of residual soil and incomplete cleaning. The test is rapid but not very sensitive.

8.5.2.4 Copper sulfate test for passivated surfaces

- a) Swab the component for a few minutes with an aqueous solution containing:

Copper sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$)	4 g/l (approx.)
Sulfuric acid ($d=1.84$)	1.5 ml/l (approx.)

After drying, the presence of any areas of deposited copper will confirm that the surface is unsatisfactory and shall be re-passivated before being submitted for re-approval.

- b) Alternative test; an alternative test may be carried out on a component, if suitable, or on a test piece with a flat smooth surface made from material of similar composition to the parts being processed.

Within 30 minutes of processing, place one spot of the following solution on a flat passivated surface and allow it to remain for 3 minutes.

Palladium chloride	0.5 g
Hydrochloric acid (d=1.16)	20 cm ³
Water	98 cm ³

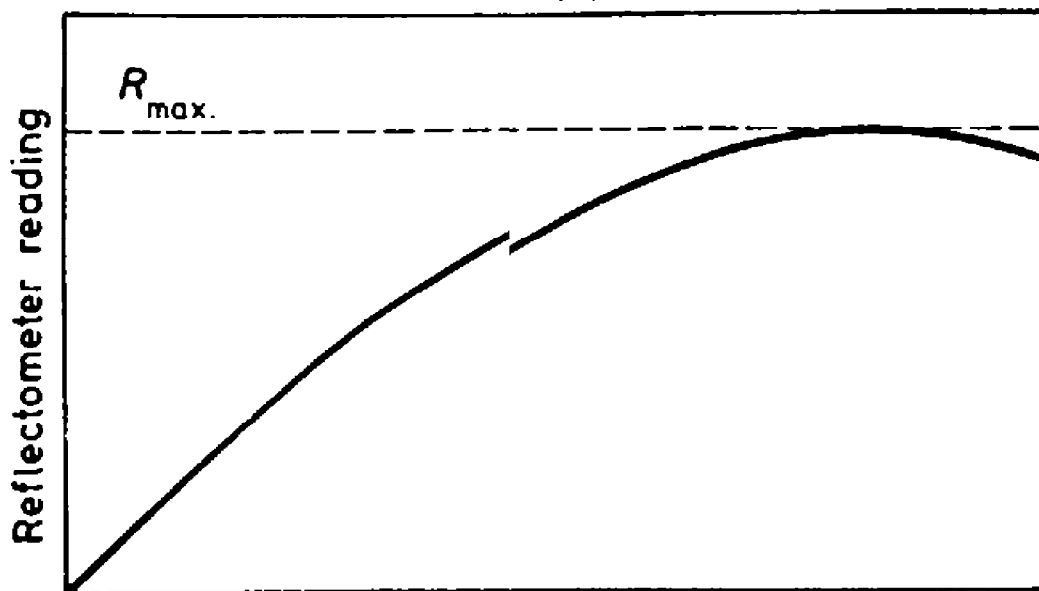
Wash off the spot with cold running water. Do not swab.

If passivation has been effected no trace or only a slight trace of a dark deposit will be evident on the area tested.

8.5.2.5 Refractometric method (surclean)

Grades of blast-cleaning are selected by the specifier in relation to the conditions of use and the protective system chosen. Specifications for blast-cleaning include pictorial standards (Swedish Standard SIS 055900) or sketches (BS 4232) but these can be used for site control only if the lighting is good and the inspectors are highly experienced. Steel coupons blast-cleaned to an agreed standard are better but should be carefully stored and handled to prevent deterioration.

For convenience and to reduce disputes it is best to use instruments which enable figures to be recorded. A light reflectometer can be used to assess effectiveness of removal of mill-scale, freedom from rust, and general approach to "white metal" condition. This instrument measures the amount of blue light reflected from the surface compared with that from a standard grey tile. Repeatedly blasting the same area of steel causes an increase in reflection until a steady value R_{\max} is reached corresponding to white metal (dependent on the abrasive and the steel) as shown in Fig. 4. The acceptance level shall be fixed as a percentage of R_{\max} for Sa2½, the average of all readings on the work shall be at least 90% of R_{\max} and not more than one reading in ten shall be below 80% of R_{\max} . When using this control method the value of R_{\max} and the acceptance levels shall be defined by the company at the start of the work.



ASSESSMENT OF STEEL CLEANING

Fig. 4

8.6 Precautionary Notes

8.6.1 Dry blasting

8.6.1.1 If fire or explosion hazards are present, proper precautions shall be taken before any work is done. If the structure previously contained flammable materials, it shall be purged of dangerous concentrations.

8.6.1.2 Nozzle blast operators exposed to blast dust shall wear a suitable helmet.

8.6.1.3 Filter type air respirators shall be worn by all others who are exposed to blast dust environment. Adequate protection for personnel from flying particles shall also be provided in any blasting operation.

8.6.1.4 Safety goggles shall be worn by all persons near any blasting operation.

8.6.1.5 Blast nozzle shall be properly grounded through use of hose with anti-static lining. Blasting pot will be equipped with ground wire.

8.6.2 Water blasting

8.6.2.1 Hydroblast cleaning use high pressures. Extreme caution shall be exercised with the equipment.

8.6.2.2 Instruction and training of operators about correct use and equipment operation is essential.

8.6.2.3 Surfaces, other than metal, can be damaged with high pressure water and shall be protected from effects of the high pressure water blast.

8.6.2.4 The operator of a hydroblast unit must have sound, safe footing. Extra caution shall be taken on rigid scaffolding. Swinging stages and bosun chairs are not normally recommended for use with hydroblasting.

The operator shall wear a rain suit, face shield, hearing protection and gloves.

8.6.2.5 The blast gun shall have automatic control to release pressure when the operator releases the trigger. A dump valve on the gun serves this purpose.

8.6.2.6 Everyone within 17 meters of the work area should be warned of hazards associated with hydroblast cleaning.

No electrical power shall be in the work area.

9. FLAME CLEANING

9.1 In flame-cleaning a high temperature, oxyacetylene flame is passed over the surface to be cleaned. The effect of the heat is to remove scale and rust, partly by differential expansion and partly by evolution of steam from moisture in the rust.

9.2 Surface preparation by flame cleaning is designated by the letters "f" according to Tables 1 and 2.

9.3 Prior to flame cleaning any heavy layers of rust shall be removed by manual cleaning (see section 7).

9.4 This method does not remove all rust and scale and is in no way a substitute for blast cleaning. The coating applied to a blast cleaned surface will always last longer than similar coating applied to flame cleaned. Reasonably portable flame-cleaning equipment can be used in some location where blast-cleaning is not practicable.

9.5 Flame-cleaning is not allowed for new work, but may be used to prepare surface for maintenance painting, particularly in damp weather.

9.6 Care is needed to ensure that surface temperatures are not allowed to become excessive.

In the case of structural steelwork an upper limit of 200°C surface temperature is considered.

Thinner section may have to be cleaned at a lower temperature. Uncoated surface thinner than 0.5 mm shall not be flame-cleaned. Care shall be taken to consider the effect of heat transference to other parts of the structure, and particularly to any materials in contact with the other side of the steel.

The existence of pipes and cables shall be noted.

9.7 Execution by injector-mixing chamber burners and oxyacetylene flame (surplus oxygen), which is passed one or more times over the surface with cooling after each passage.

Ensure that rate of flame movement is sufficiently slow to avoid deposition of moisture.

9.8 Selection of correct mixture ratio of gases to give best results is essential.

9.9 Flame cleaning shall not be used near high-strength. Friction grip bolts or cold-worked high-tensile steels, the existence of pipes and cables should be noted. Flame cleaning of high-strength friction grip bolted joints is totally prohibited.

9.10 Flame cleaning shall not be used to remove thick coating of tar or bitumen, and it is not recommended for stripping old intact paint. As a rough guide, its use should be considered only when the breakdown on the old paint has reached grade Re 6 (roughly 20% of rust by area) of the European scale* or beyond.

9.11 It shall be noted that flame cleaning does not provide a suitable surface for many coating such as zinc silicate, epoxide and polyurethane two-pack coating, etc.

9.12 After flame cleaning, the surface shall be cleaned by power tool wire-brushing. Hand wire-brushing does not achieve a satisfactory surface for painting.

9.13 Apply priming paint to surface that are still warm but not hot from the flame cleaning process. It may, however, be desirable to limit the surface temperature to a maximum of 40°C before paint is applied.

9.14 Flame cleaning is usually the quickest and most economical for the removal of paint from general surfaces of woodwork. (See Appendix D) this method may also be used occasionally in cleaning decks on ships before repainting.

10. SURFACE PREPARATION OF IRON AND STEEL

10.1 Cast Irons

10.1.1 Cleaning prior to phosphating and painting

The parts should be cleaned with one or more method of degreasing (see section 5), pickling (section 6), hand and tool cleaning (section 7), blasting (section 8), anodic etching (10.4) and chemical smoothing process (see 10.3). If inhibited solution are used for acid pickling (section 6), it shall be necessary to remove absorbed inhibitor before phosphating or application of painting.

***: Re 6 is taken from "Echelle Europeenne de degres d'enrouillement pour peinture antriouille" obtainable from the paint-makers Association, Alembic House, 93 Albert Embankment, London S1, 7TY.**

10.1.2 Cleaning and preparation for hot dip galvanizing

Preparation shall be carried out using one of the following procedures:

- a) Abrasive blasting with chilled iron or steel, (see section 8) to remove moulding sand and iron scale. After blasting, pickling (see section 6) may be used and where necessary a flux coating should be applied.
- b) Hydrofluoric acid (30% HF) diluted to 10% by volume aqueous solution may be used, followed by hosing with water to remove any gelatinous products. After hosing, pickling (section 6) is used and if necessary a flux should be applied.

10.1.3 Cleaning prior to metal spraying (for protection against corrosion and high temperature oxidation)

The surface should be degreased, (see section 5) and then roughened by compressed air or centrifugal blasting with a suitable abrasive grit (see section 8). Immediately before spraying it should be free from grease, scale, rust, moisture or other foreign matter. It should be comparable in roughness with a reference surface produced in accordance with Appendix F and should provide an adequate key for the subsequent sprayed metal coating.

10.1.4 Cleaning prior to electroplating

The part shall be cleaned according to 10.2.4.

10.2 Steels, Non-Corrosion-Resisting

10.2.1 Cleaning prior to phosphating and coating

The parts shall be cleaned by one or more of the following methods:

- a) Degreasing in an organic solvent (see section 5).
- b) Degreasing in an aqueous alkaline solution (see section 5) with applied anodic direct current of desired. Neither cathodic nor alternating current treatment should be used.
- c) Alkaline de-rusting (see 6.5.5).
- d) Blast cleaning (section 8) with grit abrasive (It is preferred for high tensile steels and some alloy steels).
- e) Anodic etching (see 10.4).
- f) Acid pickling is an inhibited acid solution (see section 6), is, followed with rinsing prior to phosphating.

10.2.2 Cleaning and preparation for hot dip galvanizing

10.2.2.1 Steel (other than castings)

Preparation shall be carried out using one of the following procedures:

- a) The degreasing procedures described in section 5 followed by acid pickling (section 6). Where necessary a flux coating of dried iron salts, zinc ammonium chloride, or a proprietary flux, shall be applied.

- b) Abrasive blasting with chilled iron or steel grit (see section 8). To remove welding slag or paint. After blasting, the pickling methods in section 6 may be used and where necessary a flux shall be applied.

10.2.2.2 Steel castings

Preparation shall be carried out using one of the following procedures:

- a) Abrasive blasting with chilled iron or steel grit, (section 7), to remove moulding sand and iron scale. After blasting, the methods in section 7 may be used and where necessary a flux coating shall be applied.
- b) Hydrofluoric acid (30% HF) diluted to 2% to 10% by volume aqueous solution may be used, followed by hosing with water to remove any gelatinous products.

10.2.3 Cleaning prior to metal spraying (for protection against corrosion and high temperature oxidation)

The surface shall be degreased, (see section 5) and then roughened by compressed air or centrifugal blasting with a suitable abrasive grit (see section 8). Immediately before spraying it shall be free from grease, scale, rust, moisture, or other foreign matter. It shall be comparable in roughness with a reference surface produced in accordance with Appendix F, and shall provide an adequate key for the subsequent sprayed metal coating.

For sheet steel of thickness up to and including 1.6 mm, some relaxation on the degree of roughness may be agreed between the Company and contractor in order to minimize distortion during surface preparation. Distortion can be reduced by blast cleaning on both sides.

10.2.4 Cleaning prior to electroplating

The part shall be cleaned as follows:

- a) Degreasing with cold solvent (see 5.3), hot solvent (see 5.2) emulsifiable solvent (see 5.4), detergent cleaning (see 5.5) or steam cleaning with or without alkaline or solvent emulsion (see 5.6)
- b) Alkaline cleaning (Intermediate cleaning)

Intermediate alkaline cleaning removes solvent residues and residual soil which has been softened by degreasing the operation data are described in section 5.5.

- c) Rinse

Double rinses are desirable to reduce the concentration of cleaner in the rinse.

Warm rinse (60°C) is desirable following alkaline immersion cleaning. In any case, agitation of the rinse water is desirable, and, in the case of cold-water rinses, a spray upon leaving the tank is beneficial. The time of rinsing depends in part upon the shape of the part, but shall be no less than 10s.

- d) Anodic etching according to section 10.4
- e) Acid pickling according to section 6

The part shall be rinsed in cold water after pickling.

- f) Activation

If electroplating is to be done in alkaline solutions, such as cadmium, copper, tin, or zinc, no further treatment shall be necessary. For nearly neutral or acid electroplating processes, however, parts shall be immersed.

For 5 to 15 seconds, in a room-temperature, in solution containing 50 to 100 ml of sulfuric acid. Activated parts shall be rinsed in cold water.

10.3 Chemical Smoothing Process for Steel (RARDE Process)

The parts shall be treated as follows:

- a) Degreased with solvents or alkaline. (see section 5).
- b) Acid dipped using sulfuric acid (see section 6)
- c) Rinsed thoroughly in cold water.
- d) Immersed in an aqueous solution containing:

Oxalic acid ($C_2O_4H_2 \cdot 2H_2O$). 25 g/litre

Hydrogen peroxide. 13 g/litre, e.g. 40 cm³/litre of "100 vols" hydrogen peroxide.

Sulfuric acid, 0.053 cm³/litre

The solution shall be used at room temperature.

The time of treatment may be a few minutes or several hours depending on the application. The rate of metal dissolution, for mild steel, is approximately 10 m per hour. The process is ineffective on corrosion resisting steels and on low alloy steels containing more than about 1% chromium.

Hydrogen peroxide decomposes quite rapidly so additions equal to the original quantity need to be added for every 20 minutes of use. The complete solution shall be replaced when the rate of dissolution falls to an unacceptable level.

10.4 Anodic Etching for Ferrous Metals

Etching of ferrous metals shall be carried out using one of the following methods:

10.4.1 Method A (preferred method, suitable for all parts)

The parts shall be immersed in an aqueous solution of the following make-up composition:

Sulfuric acid ($d=1.84$) 300 cm³/litre

The solution strength is maintained by periodic additions of sulfuric acid to keep the relative density $d>1.30$.

The voltage shall be set so that the initial current density is not less than 1000 A/m² (4 to 8 volts) and is preferably twice this. The temperature shall preferably not exceed 25°C. but for removal of scale a temperature of up to 70°C may be used. An inhibitor which is stable in the solution may be added, if desired, to reduce formation of smut and absorption of hydrogen by the steel, but wetting agents shall be avoided as they promote absorption of hydrogen.

Removal of scale can be made easier by prior soaking in an alkaline solution of sodium gluconate at up to boiling point. The current density required to remove scale can be reduced by interrupting the current for a few seconds from time to time. If current interruption is to be used on steels of tensile strength 1400 N/mm² and stronger, a safe procedure shall be established to the satisfaction of the purchaser.

10.4.2 Method B

The parts shall be immersed in an aqueous solution ($d=1.74$) containing:

- a) Sulfuric acid ($d=1.84$), $750 \text{ cm}^3/\text{litre}$ with or without a small addition of chromic acid.

The solution strength is maintained by periodic additions of sulfuric acid to keep the relative density $d > 1.70$.

An initial current density of at least 1000 A/m^2 (4 to 12 volts) shall be applied. The temperature shall not exceed 25°C .

10.4.3 Method C

An alternative aqueous solution ($d= 1.22$) for use on stainless steel prior to a nickel strike, shall contain:

Sulfuric acid ($d=1.84$), $200 \text{ cm}^3/\text{litre}$

The solution strength is maintained by periodical additions of sulfuric acid to keep the relative density $d > 1.20$

A current density of 2000 A/m^2 to 2500 A/m^2 (approximately 6 volts) shall be applied. The temperature shall not exceed 20°C .

Immersion time 1 minute to 3 minutes.

Notes on anodic etching:

- 1) Contamination of the solutions with chloride shall be avoided.
- 2) The essential requirement of anodic etching of steel, is to render the steel passive, a condition that will be indicated by:
 - a) a sharp rise in voltage between the part and the cathode.
 - b) a corresponding fall in current and
 - c) the onset of gas evolution from the part.
- 3) Passivity shall be maintained until the surface has acquired a light grey colour, free from dark smut.
- 4) The parts may be withdrawn for examination, and if necessary, replaced in the bath for further treatment.
- 5) Anodic etching may not be effective and may cause pitting on the inner surfaces of tubular parts unless auxiliary cathodes are employed. Where it is desired to clean only the external surfaces, the part shall be plugged to prevent ingress of the electrolyte.

10.5 Cleaning of Shop Primed Steel Surfaces Prior to Over Coating

10.5.1 Any primed surface which has been exposed for more than a few days will have become contaminated and shall be cleaned down with fresh water and allowed to dry before overcoating.

10.5.2 Prefabrication primer or blast primer exposed longer than 6 months to the atmosphere shall be removed by blast cleaning before applying the specified Coating system.

10.5.3 Prefabrication primer or blast primer less than 6 months old and still in a good condition shall be cleaned thoroughly with clean fresh water before applying the paint system and shall only be removed if they are not compatible with the subsequently specified paint system.

10.5.4 If it is necessary to protect austenitic stainless steel surfaces during transport and storage at site, a proofed material, e.g. plastic sheeting shall be used, unless the surfaces are provided with a prefabrication primer or blast primer (see Appendix B of IPS-E-TP-100)

10.5.5 Shop-primed surfaces shall be cleaned thoroughly with clean fresh water before applying the subsequent layers.

10.5.6 The cleaning and patch painting of damage spots and of weld areas shall be in addition to the complete specified Coating system.

10.5.7 If previously Coated pipework is to be cut and welded on site, all Coatings must first be removed from the area of welded joint.

10.5.8 Primed and Coated surfaces which have been exposed to marine environments including shipment, will be contaminated with salt and shall be lightly wire brushed, then washed with fresh water before overcoating.

10.5.9 Although zinc rich primers are very effective in preventing rusting, extended exposure develops a surface contaminated of zinc-corrosion products which can impair the adhesion of subsequent coats. Zinc rich primers, both organic and inorganic, which have been exposed long enough to develop white surface staining, shall be prepared for overcoating by one of the following methods:

- a) Light blast cleaning and dust removal.
- b) Wirebrushing, followed by water washing.
- c) Scrubbing with fresh water, using bristle brushes.

10.5.10 Damaged surfaces should be repaired with 0.10 m. overlap.

11. SURFACE PREPARATION OF STAINLESS STEEL

For preparation of stainless steel prior to metal spraying, and painting, parts shall be cleaned by one or more of the following methods as appropriate with regards to the requirements of the Coating to be applied and the surface condition of the substrate. For preparation of stainless steel prior to electroplating see 11.7.

11.1 Degreasing (see section 5) of Stainless Steel

Prior to descaling, degreasing of stainless steel shall be applied according to section 5. The degreasing material e.g. alkaline, emulsion, solvent (cold, hot and vapor forms) synthetic detergent, steam and cleaning agents can be used.

For effectiveness of preparation the cleaned surfaces shall be inspected with tests of freedom from grease (5.7) and tests of cleanliness for blasted surfaces (8.5).

11.2 Cleaning of Welds and Weld-Joint Areas

The joint area and surrounding metal for several centimeters back from the joint preparation, on both faces of the weld, shall be cleaned immediately before starting to weld. Cleaning may be accomplished by brushing with a clean stainless steel brush or scrubbing with a clean, lint-free cloth moistened with solvent, or both. When the joint has cooled after welding, remove all accessible weld spatter, welding flux, scale, arc strikes, etc., by grinding. According to the application, some scale or heat temper may be permissible on the nonprocess side of weld, but shall be removed from the process side if possible. If chemical cleaning of the process side of the weld is deemed necessary, all precautions must be observed. Austenitic stainless steels in the sensitized condition shall not be descaled with nitric-hydrofluoric acid solution. Welds shall be cleaned as described in Table 12.

TABLE 12 - CLEANING WITH OTHER CHEMICAL SOLUTION

PURPOSE-GENERAL CLEANING				
ALLOYS	CONDITION	SOLUTION VOLUME %	TEMPERATURE °C	TIME MINUTES
200, 300, AND 400 SERIES (EXCEPT FREE-MACHINING ALLOYS) PRECIPITATION HARDENING ALLOYS AND MARAGING ALLOYS SAME	FULLY ANNEALED ONLY	CITRIC ACID, 1 WEIGHT % PLUS NaNO ₃ , 1 WEIGHT %	21	60
	SAME	AMMONIUM CITRATE, 5-10 WEIGHT %	49-71	10-60
ASSEMBLIES OF STAINLESS AND CARBON STEEL (FOR EXAMPLE, HEAT EXCHANGER WITH STAINLESS STEEL TUBES AND CARBON STEEL SHELL)	SENSITIZED	INHIBITED SOLUTION OF HYDROXYACETIC ACID, 2 WEIGHT % AND FORMIC ACID, 1 WEIGHT %	93	6 h
SAME	SAME	INHIBITED AMMONIA-NEUTRALIZED SOLUTION OF EDTA (ETHYLENE-DIAMINE-TETRAACETIC ACID) FOLLOWED BY HOT-WATER RINSE AND DIP IN SOLUTION OF 10 PPM AMMONIUM 100 PPM HYDRAZINE	121	6 h

11.3 Acid Pickling of Stainless Steel (see also section 6)

11.3.1 Suggested solution contact times and solution temperatures for descaling of various types of stainless steel are given in Table 13.

TABLE 13 - ACID PICKLING OF STAINLESS STEEL

ALLOY (1)	CONDITION	TREATMENT		
		SOLUTION, VOLUME, % (2)	TEMPERATURE °C	TIME, MINUTES
200, 300, AND 400 SERIES, PRECIPITATION HARDENING, AND MARAGING ALLOYS (EXCEPT FREE-MACHINING ALLOYS)	FULLY ANNEALED ONLY	H ₂ SO ₄ , 8-11% (3)	66-82	5-45 MAX (4)
200 AND 300 SERIES; 400 SERIES CONTAINING Cr 16% OR MORE; PRECIPITATION-HARDENING ALLOYS (EXCEPT FREE-MACHINING ALLOYS)	FULLY ANNEALED ONLY	HNO ₃ 15-25% PLUS HF, 1-8% (5,6)	21-60	5-30 (4)
ALL FREE-MACHINING ALLOYS AND 400 SERIES CONTAINING LESS THAN Cr 16%	FULLY ANNEALED ONLY	HNO ₃ 10-15% PLUS HF, ½-1½ % (5,6)	UP TO 140 WITH CAUTION	5-30 (4)

1) This table is also applicable to the cast grades equivalent to the families of wrought materials listed.

2) Solution prepared from reagents of following weight %; H₂SO₄, 98; HNO₃, 67; HF, 70.

3) Tight scale may be removed by a dip in this solution for a few minutes followed by water rinse and nitric-hydrofluoric acid treatment as noted.

4) Minimum contact times necessary to obtain the desired surface should be used in order to prevent over-pickling. Tests should be made to establish correct procedures for specific applications.

5) For reasons of convenience and handling safety, commercial formulations containing fluoride salts may be found useful in place of HF for preparing nitric-hydrofluoric acid solutions.

6) After pickling and water rinsing, an aqueous caustic permanganate solution containing NaOH, 10 weight % and KMnO_4 , 4 weight %, (71 to 82°C) 5 to 60 min, may be used as a final dip for removal of smut, followed by thorough water rinsing and drying.

11.3.2 For removing light scale from austenitic stainless steel suggested solution, given as follows:

-Ferric sulfate liquor (40% by weight) (d=1.5)	200-300 cm ³ /litre
-Hydrofluoric acid (40% by weight)	50-75 cm ³ /litre
-Temperature	60-70°C
-Time	2-30 minutes

11.3.3 Over pickling must be avoided continuous exposure to pickling solution for more than 30 minutes not recommended. The item shall be drained and rinsed after 30 minutes and examined to check the effectiveness of the treatment. Most pickling solution will loosen weld and heat treating scale but many not remove them completely.

11.3.4 After chemical descaling, surface must be thoroughly rinsed to remove residual chemicals, a neutralization step is sometimes necessary before final rinsing. To minimize staining, surfaces must not be permitted to dry between successive steps of the acid descaling and rinsing procedure and thorough drying shall follow the final water rinse. (see also 6.7.2).

11.4 Manual Cleaning of Stainless Steel (see section 7)

11.4.1 Manual cleaning methods include power brushing, sanding with coated abrasive tools, grinding and chipping are used for descaling of stainless steel surfaces. Grinding is usually the most effective means of removing localized scale such as that which result from welding (see 11.2).

11.4.2 Particular care must be taken to avoid damage by manual methods when descaling thin section, polished surfaces and closetolerance parts. After manual descaling, surfaces should be cleaned by scrubbing with hot water and fiber brushes, followed by rinsing with clean hot water.

11.4.3 Grinding wheels shall not contain iron, iron oxide, zinc, or other undesirable materials that may cause contamination of the metal surface.

Grinding wheel, sanding material and wire brushes previously used on other metals shall not be used on stainless steel.

Wire brushes shall be of a stainless steel which is equal in corrosion resistance to the material being worked on.

11.5 Abrasive Blasting of Stainless Steel (see also section 8)

Clean, previously unused glass beads or iron-free silica or alumina sand are recommended for abrasive blasting. Steel shot or grit is not recommended because of the possibility of embedding iron particles.

After blasting, surfaces shall be cleaned by scrubbing with hot water and fiber-brushes, followed by rinsing with clean, hot water.

11.6 Final Cleaning

If proper care has been taken in earlier fabrication and cleaning, final cleaning may consist of little more than scrubbing with hot water or hot water and detergent (such as trisodium phosphate, TSP) using fiber brushes.

Detergent washing must be followed by a hot water rinse to remove residual chemicals, spot cleaning to remove localized contamination may be accomplished by wiping with a clean solvent-moistened cloth.

11.7 Passivation* of Stainless Steel

When the stainless steel parts are to be used for applications where corrosion resistance is a prime factor to achieve satisfactory performance and service requirements, or where product contamination must be avoided, passivation followed by thorough rinsing several times with hot water and drying thoroughly after the final water rinse is recommended, whenever practical.

This treatment may be essential if iron or iron oxide remains embedded in the surface e.g. from abrasive blasting or from pickling.

A suitable process consists of immersion for 10 to 30 minutes at 20-50°C in a solution made up to contain:

Nitric acid ($d=1.42$) 200 to 300 cm³/litre

Sodium dichromate ($\text{Na}_2\text{Cr}_2\text{O}_7, 2\text{H}_2\text{O}$) 25 g/litre (which may be omitted when "passivating" austenitic stainless steels).

This treatment shall be followed by rinsing in water and, in the case of ferritic and martensitic steels, by immersion for approximately 30 minutes in a solution containing 50 g/litre of sodium dichromate at approximately 65°C and final rinsing in water.

11.8 Preparation of Stainless Steel for Electroplating

Parts shall be cleaned by one or more of the following methods as appropriate:

11.8.1 Degreasing (see section 5)

With applied anodic direct current if desired. Neither cathodic nor alternating current treatments shall be used.

11.8.2 Alkaline pickling (see 6.5.5)

11.8.3 Blast cleaning (see section 8)

This method, especially blasting, with grits leaves the surface very readily corrodible, and further processing shall be given without any delay.

11.8.4 Anodic etching

Anodic etching in a sulfuric acid solution (see 10-4), subject to close control. Additionally, parts shall be connected and the current switched on before the parts are immersed in the solution, and after treatment the parts shall be withdrawn rapidly before the current is finally switched off, and washed immediately. The sulfuric acid shall at no time contain more than 11pp m. oxidizable material calculated as sulfur dioxide. (This precaution is necessary because reduced sulfur, phosphorus and arsenic compounds in the acid promote hydrogen absorption during washing.)

11.8.5 Acid pickling

Acid pickling in an inhibited acid solution, (see 11.3) and then by baking prior to further treatment, at not less than 190°C for not less than four hours.

* The term passivation is used to indicate a chemically inactive surface condition of stainless steel.

11.8.6 Electrolytic de-rusting

Electrolytic de-rusting using an alkaline electrolyte and anodic current. Cleaning should normally be followed by a nickel strike. (See 11.8.7) before plating with the metal(s) required.

11.8.7 Nickel strike

One of the following treatments shall be applied:

a) Parts should preferably be etched anodically, (see 10.4) for not more than two minutes and then treated cathodically for five minutes at approximately 1500 A/m^2 to 2000 A/m^2 in an aqueous solution containing approximately:

Nickel sulfate ($\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$)	225 g/litre
Sulfuric acid ($d=1.84$)	27 ml/litre

Maintain the temperature of the electrolyte at 35°C to 40°C .

Insoluble anodes, e.g. lead, should normally be used, the use of nickel anodes or a proportion thereof is also permissible.

b) The parts shall be made anodic in an aqueous solution of the following approximate composition for not more than two minutes, and the current then reversed, so that they are cathodic, for about five minutes:

Nickel chloride ($\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$)	250 g/litre
Hydrochloric acid ($d=1.16$)	100 ml/litre

Nickel electrodes to BS 558 shall be used. The solution shall be maintained at room temperature and a current density of about 300 A/m^2 employed.

c) When current reversal is not feasible, the short anodic treatment described in (b) may be replaced by immersion in the solution without current flow for 15 minutes. The work then being made cathodic for about five minutes.

Separate tanks may be used with advantage for the anodic (or immersion) and the cathodic treatments.

After treatments a, b, or c, rinse the parts and transfer them to the final plating bath.

12. SURFACE PREPARATION OF NON-FERROUS METALS (see also BS 3012)

Surface Preparation of Non-Ferrous Metals shall be according to Tables 14 to 29 as follows:

Table 14	Preparation of Aluminum and its Alloys
Table 15	Etching Treatment of Aluminum and its Alloys
Table 16	Acid Pickling of Aluminum and its Alloy
Table 17	Polishing of Aluminum and its Alloys
Table 18	Pickling and Zincate Treatment of Aluminum
Table 19	Preparation of Zinc Plate and Zinc Coated Parts
Table 20	Preparation of Copper and its Alloy
Table 21	Treatment of Copper and its Alloys
Table 22	Preparation of Nickel and its Alloys
Table 23	Treatment of Nickel and its Alloys
Table 24	Preparation of Titanium and its Alloys
Table 25	Treatment of Titanium and its Alloys
Table 26	Preparation of Magnesium Alloys
Table 27	Treatments of Magnesium Alloys
Table 28	Preparation of Tin and its Alloys
Table 29	Preparation of Chromium and lead Parts

TABLE 14 - SURFACE PREPARATION OF ALUMINUM AND ITS ALLOYS

SURFACE PREPARATION FOR PROTECTIVE COATINGS (SEE IPS-C-TP-102)	PERMISSIBLE METHODS						
	14-A DEGREASING	14-B ETCHING	14-C PICKLING	14-D CHEMICAL POLISHING	14-E ELECTRO POLISHING	14-F ZINCATE TREATMENT	14-G BLASTING
1- PREPARATION PRIOR TO ANODIZING (APPLY PROCESS OF 14-A AND THEN ONE OR MORE OF 14-B TO 14-E)	SEE SECTION 5	SEE TABLE 15	SEE TABLE 16	SEE TABLE 17	SEE TABLE 17		
2- PREPARATION PRIOR TO CHEMICAL CONVERSION COATINGS (APPLY PROCESS OF 14-A AND THEN ONE OR MORE OF 14-B TO 14-E)	SEE SECTION 5	SEE TABLE 15	SEE TABLE 16	SEE TABLE 17	SEE TABLE 17		
3- PREPARATION PRIOR TO METAL SPRAYING (APPLY PROCESS 14-A AND 14-G)	SEE SECTION 5						SEE 8.3 & B.1.2
4- PREPARATION OF UNANODIZED PARTS FOR PAINTING (APPLY PROCESS 14-A AND 14-B)	SEE 5.3.1 AND/OR 5.5	SEE TABLE 15 (NOTE 1)					
5- PREPARATION FOR ELECTROPLATING (APPLY PROCESS 14-A ONE OF 14-B OR 14-C AND THEN 14-F)	SEE 5.3.1 AND/OR 5.5	SEE TABLE 18 (NOTE 2)	SEE TABLE 18			SEE TABLE 18	

Note 1:

Prior to application of primer other than pre treatment primer, etching treatment (14-13) shall be used.

TABLE 15 - ETCHING TREATMENT OF ALUMINUM AND ITS ALLOYS

PROCESSES	CLEANING SOLUTION	OPERATING CONDITION	
		TEMPERATURE °C	TIME (APPROX) MINUTES
1- BATH (IMMERSION) ETCHING TREATMENT (SEE NOTES 1, 2, 3)	SULFURIC ACID (d=1.84) 150 cm ³ /litre CHROMIC ACID (CrO ₃) 50 g/litre DEMINERALIZED WATER	50 TO 65	25
2- BRUSH OR SPRAY ETCHING TREATMENT (SEE NOTES 4,5)	PHOSPHORIC ACID IN AQUEOUS ALCOHOLS IN WHICH IS SUSPENDED KAOLIN AND A GREEN PIGMENT		
3- ETCHING AND DESMUTTING TREATMENT (SEE NOTES 6,7)	SODIUM HYDROXIDE 25 TO 50 g/litre SODIUM HEPTONATE OR SODIUM GLUCONATE 0.75 TO 1.0 g/litre	60 TO 65	¼ TO 1

Notes:

1- Bath treatment is unsuitable for alloys containing 6% or more copper or aluminum parts is in contact with steel or copper alloys.

2- The etched part shall be washed thoroughly and rapidly in water (not exceeding 65°C) and dried. The final rinse shall be in demineralized or distilled water.

3- Contamination of the solution with chloride, copper or iron may cause pitting of the metal. The chloride content shall not exceed the equivalent of 0.2 g/litre. Sodium chloride and the copper or iron contents shall not exceed 1 g/litre each. (see 6.9)

4- The free acidity shall be equivalent of 6% to 6.5% by weight of phosphoric acid (see 6.9).

5- Where parts are unsuitable for bath process, brush or spray process shall be applied.

6- This process is used prior to anodizing if a polished finish is not required.

7- The smut from alloying metals in the aluminum is left on the surface and this is removed by dipping in 30% to 50% by volume nitric acid (d= 1.42). For high silicon-containing alloys 10% hydrofluoric acid (40 wt% HF) is added to the nitric acid de-smutting solution.

TABLE 16 - ACID PICKLING OF ALUMINUM AND ITS ALLOYS

CLEANING SOLUTION		OPERATING TEMPERATURE	NOTES
1- SULFURIC ACID (d=1.84) SODIUM FLUORIDE (Na F)	90-120 cm ³ /litre 7.5-15 g/litre	ROOM TEMP.	SEE NOTE 2
2- SULFURIC ACID (d=1.84) POTASSIUM FLUORIDE (KF)	100 cm ³ /litre 40 g/litre	ROOM TEMP.	SEE NOTE 2
3- SULFURIC ACID (d=1.84) HYDROFLUORIC ACID (40 wt% HF)(1)	100 cm ³ /litre 15 cm ³ /litre	ROOM TEMP.	SEE NOTE 2
4- ORTHOPHOSPHORIC ACID (d=1.50) HYDROFLUORIC ACID (40 wt% HF)(1m)	200 cm ³ /litre 7.5 cm ³ /litre	ROOM TEMP.	SEE NOTE 2
5- SULFURIC ACID (d=1.84) O-TOLUIDINE ACID STABLE WETTING AGENT	100 cm ³ /litre 10 cm ³ /litre	90-98°C	—

Notes:

1. %wt=grams of HF in 100 grams of water.

2. After acid pickling the part shall be rinsed in cold water and transferred to a cold aqueous solution containing approximately 500 cm³/litre Nitric Acid (d=1.42) for approximately one minute and then thoroughly washed in clean water at a temperature not exceeding 50°C.

TABLE 17 - POLISHING OF ALUMINUM AND ITS ALLOYS

PROCESSES	CLEANING SOLUTION		OPERATING CONDITION	
			TEMPERATURE	IMMERSION TIME MINUTES
1- CHEMICAL POLISHING TREATMENT (SEE NOTES 1, 2, 3)	PHOSPHORIC ACID (d=1.75) SULFURIC ACID (d=1.84) NITRIC ACID (d=1.42)	75 cm ³ /litre 20 cm ³ /litre 5 cm ³ /litre	95-105°C	1 TO 2
2- ELECTROPOLISHING TREATMENT (SEE NOTES 4, 5, 6)	PHOSPHORIC ACID (H ₃ PO ₄) SULFURIC ACID (d=1.84) CHROMIC ACID (CrO ₃)	400 TO 800 g/litre 100 TO 200 g/litre 40 TO 100 g/litre	70-80°C	2 TO 5

Notes:

1. During operation Nitric Acid is lost and shall be maintained in the range 5% to 10% by volume.

2. This process gives rise to the emission of nitrous fumes which must be removed by adequate exhaust equipment. This solution is strongly acid and appropriate precaution shall be taken to protect the operator.

3. After chemical polishing the work rinsed and further cleaned by immersion in a 30% by volume solution of Nitric Acid (d=1.42) or 10 g/litre Chromic Acid (CrO₃) followed by further rinsing.

4. The current density of this process is approximately 200 A/m² and DC voltage is 12 to 15 volts.

TABLE 18 - PICKLING AND ZINCATE TREATMENT OF ALUMINUM PRIOR TO ELECTROPLATING

PROCESSES	CLEANING SOLUTION	OPERATING CONDITION	
		TEMPERATURE °C	IMMERSION TIME MINUTES
1. ACID PICKLING (SEE NOTES 1, 2, 3)	HYDROFLUORIC ACID (40%wt HF) 100 cm ³ /litre	Max. 40°C	1
	NITRIC ACID (d=1.42) 100 cm ³ /litre		
2. ZINCATE TREATMENT (SEE NOTE 4)	ZINC OXIDE (ZnO) 100 g/litre SODIUM HYDROXIDE (NaOH) 540 g/litre	ROOM TEMP.	3

Notes:

1. This solution evolves toxic fumes and efficient fume extraction shall be provided.
2. Alternatively etch in chromic acid/sulfuric acid solution (see Table 15-batch etching treatment). This etching solution has been found to be less satisfactory than acid pickling (process 1 of this Table), but its less vigorous attack on the material, provides a smoother cleaned surface.
3. Rinse thoroughly and proceed immediately to the zincate treatment.
4. Prior to zincate treatment immerse parts for one minute in an aqueous solution containing approximately 500 cm³/litre Nitric Acid and then rinse thoroughly.

TABLE 19 - SURFACE PREPARATION OF ZINC PLATE AND ZINC COATED PARTS

SURFACE PREPARATION FOR PROTECTIVE COATINGS	PERMISSIBLE METHODS			
	19-A HAND TOOL	19-B DEGREASING	19-C ELECTROLYTIC CLEANING	19-D ACID PICKLING
REMOVAL OF CORROSION PRODUCT FROM ZINC COATED PARTS	SEE SECTION 7 (NOTE 1)	SEE SECTION 5 (NOTE 2)	—	—
PREPARATION FOR COATING (SEE NOTE 6)	SEE SECTION 5 (NOTE 3)			
PREPARATION FOR ELECTROPLATING (SEE NOTE 4)		SEE SECTION 5.2 AND/OR 5.4	WITH ALKALINE CLEANER SEE 5.5	(NOTE 5)

Notes:

1. Scrubbing with clean water and stiff bristle on nylon brushes.
2. Degreasing with white sprit.
3. When parts are to be treated with wash primer (see IPS-C-TP-102 Section 5) they shall be degreased. When other primer (chrome and phosphate treatment) are to be used, will not require degreasing.
4. After process 19-C and after process 19-D rinse thoroughly the part in cold, running water.
5. Dip in very dilute sulfuric acid (e.g. 0.5% by volume) (see also section 6).
6. The method of preparation of zinc for coating is also applicable to cadmium.

TABLE 20 - SURFACE PREPARATION OF COPPER AND ITS ALLOYS

SURFACE PREPARATION FOR PROTECTIVE COATINGS	PERMISSIBLE METHODS				
	20-A DEGREASING	20-B BLASTING	20-C ETCHING	20-D PICKLING	20-E ELECTRO POLISHING
PREPARATION FOR COATING (APPLY PROCESS 20-A AND THEN ONE OR MORE OF PROCESS OF 20-C TO 20-E)	SEE SECTION 5	BLASTING WITH NONMETALLIC ABRASIVE SEE SECTION 8	SEE TABLE 21	SEE TABLE 21	SEE TABLE 21
PREPARATION FOR ELECTROPLATING (APPLY PROCESS 20-A AND THEN ONE OR MORE OF PROCESS)	SEE SECTION 5	WATER BLASTING WITH NONMETALLIC ABRASIVE SEE SECTION 8	SEE TABLE 21 (NOTES 1, 2)	SEE TABLE 21	SEE TABLE 21

Notes:

1. Etching treatment is suitable for beryllium copper parts and shall be followed by rinsing in water and immersion in a solution containing 100 cm³/litre of sulfuric acid when plating in an acid electrolyte is to be the next treatment.
2. Soft soldered parts (other than beryllium copper parts) shall be dipped in a solution containing approximately 100 ml/litre Fluoroboric Acid (40% wt HBF₄) and rinsed thoroughly in water and copper flashed in an alkaline copper electrolyte at a PH of 10 to 12 and a temperature of 60 ± 10°C.

TABLE 21 - TREATMENT OF COPPER AND ITS ALLOYS

PROCESS	CLEANING SOLUTION	OPERATING CONDITIONS	
		TEMPERATURE	TIME
1. ETCHING TREATMENT (NOTE 1)	SODIUM DICHROMATE (Na ₂ Cr ₂ O ₇ , 2H ₂ O) SULFURIC ACID (d=1.84) 200 g/litre 40 cm ³ /litre	ROOM TEMPERATURE	UP TO 2 MINUTES
2. SCALE DIP PICKLING	SULFURIC ACID (d=1.84) 100 cm ³ /litre	25°C-50°C	—
3. BRIGHT DIP PICKLING (NOTE 1)	SULFURIC ACID (d=1.84) 500 cm ³ /litre	ROOM TEMPERATURE	—
4. CHEMICAL SMOOTHING (NOTE 2)	HYDROGEN PEROXIDE SULFURIC ACID (d=1.84) 33 TO 50 g/litre 103 cm ³ /litre	ROOM TEMPERATURE	15-60
5. NITRIC ACID PICKLING	NITRIC ACID (d=1.42) (15% to 20%) BY VOLUME	ROOM TEMPERATURE	2-5 MINUTES
6. ELECTROPOLISHING (NOTE 3)	ORTHOPHOSPHORIC ACID (d=1.75) ALIPHATIC ALCOHOL WATER 70% wt — —	20 TO 25°C	—

Notes:

1. Efficient fume extraction is essential as the process results in the evolution of highly toxic fumes.
2. After applying chemical smoothing the part shall be immersed for 20 seconds in sulfuric acid (see safe dip pickling-process 21.2).
3. Current density of 200 to 500 A/m² and copper cathodes shall be used.

TABLE 22 - SURFACE PREPARATION OF NICKEL AND ITS ALLOYS

SURFACE PREPARATION FOR PROTECTIVE COATINGS	PERMISSIBLE METHODS						
	22-A DEGREASING	22-B BLASTING	22-C ALKALI PICKLING	22-D ACID PICKLING	22-E CHEMICAL POLISHING	22-F ELECTRO POLISHING	22-G STRIKE & ETCHING TREATMENT
1. PREPARATION FOR COATING (APPLY ONE OR MORE OF PROCESS 22-A TO 22-F)	SEE SECTION 5	SEE SECTION 8	SEE 6.5.5.3	SEE SECTION 6 (NOTE 2)	SEE TABLE 23	SEE TABLE 23	—
2. PREPARATION FOR ELECTROPLATING (NOTE 3)	SEE SECTION 5	SEE SECTION 8	SEE 6.5.5.3 (NOTE 1)	SEE SECTION 6 (NOTE 2)	SEE TABLE 23	SEE TABLE 23	SEE TABLE 23 (NOTE 4)

Notes:

1. Desaling in molten caustic alkali.
2. Acid pickling solution are based on nitric/hydrofluoric acid, with or without the addition of ferric sulfate.
3. Parts shall be treated as in 22-G (see Note 4) preceded by one or more of the process 22-A to 22-F.
4. After etching treatment and nickel strike, rinse the parts thoroughly and transfer to the final plating bath.

TABLE 23 - TREATMENT OF NICKEL AND ITS ALLOYS

PROCESSES	CLEANING SOLUTION	OPERATING CONDITION	
		TEMPERATURE	TIME MINUTES
CHEMICAL POLISHING	GLACIAL ACETIC ACID NITRIC ACID (d=1.42) PHOSPHORIC ACID (d=1.75) SULFURIC ACID (d=1.84)	50% BY VOLUME 30% BY VOLUME 10% BY VOLUME 10% BY VOLUME	—
ELECTROPOLISHING (NOTE 1)	SULFURIC ACID (d=1.84) WATER	70% BY VOLUME	ROOM TEMPERATURE
ETCHING TREATMENT	FERRIC CHLORIDE (FeCl ₃) OR FERRIC CHLORIDE (FeCl ₃ · 6H ₂ O) HYDRO CHLORIC ACID (d=1.16)	150 TO 200 g/litre 250 TO 330 g/litre 150 TO 200 cm ³ /litre	ROOM TEMPERATURE
NICKEL STRIKE (NOTES 2,3)	NICKEL CHLORIDE (NiCl ₂ · 6H ₂ O) HYDROCHLORIC ACID (d=1.16)	250 TO 400 g/litre 100 cm ³ /litre	ROOM TEMPERATURE

Notes:

1. A current density of 250 A/m² is employed with the work anodic to the lead lining of the tank. Great care shall be taken in making up this solution and the sulfuric acid must be added slowly to the water with thorough mixing. The solution becomes hot during mixing and shall be cooled to room temperature before use.
2. This process is not required prior to chromium plating.
3. A cathode current density of approximately 1500 A/m² shall be maintained for not more than two minutes.

TABLE 24 - SURFACE PREPARATION OF TITANIUM AND ITS ALLOYS

SURFACE PREPARATION FOR PROTECTIVE COATINGS	PERMISSIBLE METHODS				
	DEGREASING	BLASTING	ALKALI PICKLING	ACID PICKLING	ETCHING TREATMENT
1. PREPARATION FOR COATING	SEE 5.2 OR 5.3 & 5.5 (NOTES 1, 2)	SEE SECTION 8	SEE 6.5.5.3	SEE TABLE 25	—
2. PREPARATION FOR ELECTROPLATING	SEE 5.2 OR 5.3 & 5.5	SEE SECTION 8	SEE 6.5.5.3	SEE TABLE 25	SEE TABLE 25

Notes:

1. The parts of Ti-Al-Sn alloy made by cold forming or welding shall not be exposed to hot chlorinated hydrocarbon solvents prior to stress relief.
2. The time of immersion in hot trichloroethylene liquid and/or vapor shall not exceed 30 minutes for any one degreasing operation.

TABLE 25 - TREATMENT OF TITANIUM AND ITS ALLOYS

PROCESS	CLEANING SOLUTION	OPERATION CONDITION	
		TEMPERATURE	TIME MINUTES
ACID PICKLING (SEE NOTE 1)	HYDROFLUORIC ACID 50 cm ³ /lit (40% wt% HF) NITRIC ACID (d=1.42) 200 cm ³ /lit	UP TO 65°C	—
ACID PICKLING (SEE NOTE 1)	HYDROFLUORIC ACID 120 cm ³ /lit (40% wt HF) NITRIC ACID (d=1.42) 400 cm ³ /lit	ROOM TEMPERATURE	
ETCHING TREATMENT (SEE NOTES 2, 3)	HYDROCHLORIC ACID (d=1.18)	30°C	10 TO 120

Notes:

1. These solution must be handled with care. Efficient fume extraction is essential.
2. If the solution is maintained at 90°C to 110°C an immersion time of approximately five minutes is adequate.
3. After etching treatment transfer rapidly to a rinsing solution containing 50 g/litre. Rochelle salt (sodium potassium tartrate) at room temperature and agitate the work thoroughly in this solution.

TABLE 26 - SURFACE PREPARATION OF MAGNESIUM ALLOYS

SURFACE PREPARATION FOR PROTECTIVE COATINGS	PERMISSIBLE METHODS				
	DEGREASING	BLASTING	FLUORIDE ANODIZING	REMOVE OF FLUORIDE FILM	ACTIVATING
PREPARATION FOR COATING	SEE 5.2, 5.3, 5.4, 5.5	SEE SECTION 8	SEE TABLE 27	SEE TABLE 27	—
PREPARATION FOR ELECTROPLATING	CATHODIC DEGREASING SEE TABLE 27	—	—	—	SEE TABLE 27

TABLE 27 - TREATMENTS OF MAGNESIUM ALLOYS

PROCESSES	CLEANING SOLUTION	OPERATING CONDITION	
		TEMPERATURE	TIME MINUTES
FLUORIDE ANODIZING (NOTES 1, 2)	AMMONIUM BIFLUORIDE (NH_4HF_2) WATER	150 TO 250 g/litre UP TO 30°C	10 TO 15
REMOVE OF FLUORIDE FILM (SEE NOTES 3, 4)	a) CHROMIC ACID (CrO_3) b) CAUSTIC SODA c) HYDROFLUORIC ACID	100 TO 150 g/lit 50 g/lit 150-200 g/litre	BOILING SOLUTION BOILING SOLUTION ROOM TEMP. UP TO 15 10 5
CATHODIC DEGREASING (NOTE 5)	SODIUM HYDROXIDE SODIUM CYANIDE SODIUM CARBONATE	30 g/lit (APPROX.) 30 g/lit (") 15 g/lit (")	ROOM TEMP. 1
ACTIVATING (NOTE 5)	PHOSPHORIC ACID ($d=1.75$) POTASSIUM FLUORIDE	130 TO 150 cm^3 /lit 60 TO 80 g/lit	ROOM TEMP. 30 SECOND

Notes:

1. The bath shall be lined with hard rubber or suitable plastic material resistant to acid fluoride solution.
2. Alternative current is applied and the voltage raised to 90 to 120 volts.
3. The fluoride film shall be removed by process a (chromic acid) followed by process b (caustic soda) or process c (hydrofluoric acid)
4. This process is not necessary if the subsequent chromate treatment is carried out in an acid bath capable of removing fluoride film.
5. After this process the part shall be rinsed.

TABLE 28 - SURFACE PREPARATION OF TIN AND ITS ALLOYS

SURFACE PREPARATION FOR PROTECTIVE COATINGS	PERMISSIBLE METHODS		
	SOLVENT DEGREASING	ALKALI DEGREASING	ACID PICKLING
PREPARATION FOR PAINTING	SEE SECTION 5.2 and 5.3	—	—
PREPARATION FOR ELECTRO PLATING	SEE SECTION 5.2 and 5.3	SEE (NOTES 1, 3)	SEE (NOTES 2, 3)

Notes:

1. Clean either by immersion or electrolytically, in a mild alkaline cleaner (see 5.5).
2. Dip for approximately two minutes in a solution containing 10% by volume of hydrochloric acid ($d=1.18$). For tin alloys containing lead approximately 100 cm^3 /litre fluoroboric acid (40% wt HBF_4) shall be substituted.
3. After this process rinse thoroughly the part in cold, running water.

TABLE 29 - SURFACE PREPARATION OF CHROMIUM AND LEAD PARTS

SURFACE PREPARATION FOR PROTECTIVE COATINGS	CHROMIUM COATING	DEGREASING
PREPARATION OF CHROMIUM FOR PAINTING	SEE NOTE 1	—
PREPARATION OF LEAD FOR PAINTING	—	SEE 5.2 and 5.3

Note:

1. Electroplated coatings of chromium shall be immersed in chromic acid solution (10 g/litre). The solution is used at room temperature with an immersion time of approximately five minutes.

13. SURFACE PREPARATION OF METALLIC SURFACES FOR MAINTENANCE

All painted or metallic coated structure, no matter how good the protective system, eventually need maintenance treatment.

13.1 Choice of Maintenance Method

The decision whether to patch-paint or re-coat completely is largely an economic one. It will be influenced by the accessibility of the structure. If much scaffolding is needed, so that the cost of access is a high proportion of the total cost, it may be economical to re-coat the whole structure while on site. This is certainly so when an excessive amount of patch-painting of small areas, say upwards of 10% would be involved.

If maintenance is undertaken at the right time, it should not be necessary to strip all the old coating before repainting the structure. The ideal condition, in which none of the old paint needs more than thorough washing down, is rare. Some parts of the structure will need repainting before the main body of the paint has neared the end of its life. Where the majority is in good condition and only a small proportion is poor to very poor, it may be better to repair the defective areas by spot repair and to leave the rest alone until later.

13.2 Choice of Procedures

Unless otherwise specified the method by the company, surface preparation shall be carried out to a satisfactory standard for the material to be applied (see IPS-E-TP-100 Table 1, IPS-E-TP-270, IPS-E-TP-350 and IPS-E-TP-620) by suitable method(s) described in this Standard.

13.3 Spot Repair (Patch Paint) only

13.3.1 This option would be favored under the following circumstances:

13.3.1.1 Repairs are hidden or in low visibility area and thus unimportant to the aesthetics.

13.3.1.2 Agency maintenance crews are available for this type of work.

13.3.1.3 Structures are small, not requiring extensive scaffolding or hard-to-access areas.

13.3.1.4 Corrosion and degradation are limited to isolated areas and relatively small sections which amount to less than 10% of total area.

13.3.1.5 Decision has been made to upgrade small isolated areas such as bearing areas, crevices, or areas subject to leakage or condensation or chemical splash.

13.3.2 It is important that the procedure used to do spot surface preparation be appropriate to provide a good surface for painting and that it does not adversely affect the other areas. The spot cleaning procedures include abrasive blast cleaning, manual cleaning and pressurized water blasting.

13.3.3 Blast cleaning the damaged areas will be spot blasted to remove all the rust and paint to achieve Sa2 or greater. The remaining areas of intact paint will then receive sa1 to remove loose paint or other surface contaminants. Great care must be exercised when spot blasting to avoid over-blast damage to the adjacent intact paints. Spot blasting is not recommended for areas less than about 0.1 m² or for more than 5 to 10% of the surface area.

13.3.4 Manual cleaning (hand and power tool cleaning) are more suitable for small areas (see Section 7).

13.3.5 Pressurized water jet cleaning which is capable of removing loose rust and mill scale under normal conditions.

13.3.6 After spot cleaning the repaired areas are to be coated with a suitable primer. In this particular option, the remaining paint is not over coated.

13.4 Spot Repair Plus Full Topcoat

This technique is similar to section 13.3 with the addition of a full finish coat over the entire surface, including spot repaired areas and the intact paint areas.

13.4.1 This approach is favored under the following circumstances:

13.4.2 The existing paint is in relatively good condition and still resilient and does not have excessive film build (e.g, not above 0.38 mm).

13.4.3 Structure access is relatively difficult.

13.4.4 Intact surface can be readily cleaned with pressurized air, water, (Appendix B 2.1.2) hand tool or power tool cleaning (section 7) or solvent or detergent wiping (Appendix A.3).

Procedures for spot repair plus full topcoat are similar to section 13.3 (spot repair only).

13.5 Complete Repaint

13.5.1 When the paint condition is poor or bad and when funds are available, a decision to repaint the structure in its entirety is usually made. This involves removing the old coating and all of the corrosion product before applying the primer, intermediate coats, and topcoat finish. Painting a sub-unit of a structure may be a variation of this alternative when funds are short or when the remaining portions of the structure are in good condition.

13.5.2 Available surface preparation procedure for complete repainting include dry abrasive blast cleaning, wet abrasive blast cleaning, vacuum blasting, and pressurized water jetting (see section 8 and Appendix B). Normally this latter method requires sand or abrasive injection to effect complete removal of existing rust scale, paint and to add a profile. An important consideration in blast cleaning is the disposal of the abrasives and paint residue, particularly if paint contains lead or other potentially hazardous materials. The surface shall be degreased prior to blast cleaning.

Flame cleaning is also capable of removing old paint and shall be used in damp weather when blast cleaning is not practicable (see Section 9).

13.6 General Notes for Guidance

13.6.1 All removable parts impeding access to the work shall be removed before work commences.

13.6.2 Treatment of organic growths on painted surfaces. The treatment shall be according to Appendix E and must be applied prior to blast cleaning if growths of algae impeding access to the work.

13.6.3 Washing down before repainting is always desirable, especially in marine environments, because it may remove chlorides from the surface, but it is unlikely to remove sulfates. Consideration shall be given to problems of drying after washing.

13.6.4 Some paints become very hard when fully cured and special preparation, such as light blasting or the use of emery (with coated abrasive tools as section 7) may be required to obtain good undercoat adhesion.

13.6.5 Thick films such as those obtained with pitches or bitumens often develop deep cracks. These materials can be overpainted but the cracking cannot be eliminated without complete removal of the film.

13.6.6 The maintenance system chosen depends to some extent on the original process and the standard of surface preparation which can be achieved. Some two-pack materials are not always suitable for maintenance and trials and compatibility tests shall be carried out before using them.

13.6.7 The standard of protection required varies with atmospheric pollution and for different parts of the structure, i.e. areas subject to condensation and restricted air movement require better protection than fully exposed steelwork.

13.6.8 Sometimes the film becomes embrittled and loses its adhesion. In these cases complete stripping is essential.

13.6.9 Coatings on old structures frequently have numerous lengthy cracks and fissures. When recoating it will save time and produce a better result to caulk them after applying the primary coat.

13.6.10 Alkaline and solvent-type paint remover may be used to remove oil-based paint from metallic or non-metallic surfaces when the nature of the substrate preclude removal by other method of preparation.

Paint remover attack aluminium and zinc and their residues are difficult to remove especially from porous surfaces.

13.6.11 Particular attention shall be paid to the cleaning out of crevices and other places where dust and dirt have coated. Derbis tends to build up at ground level.

13.6.12 Crevices frequently occur that are so positioned or dimensioned that standard scrapers, brushes, and other tools will be ineffective. In such cases it is essential that special tools shall be devised to ensure adequate cleaning and painting.

The contractor shall design such tools and obtain the approval of the Company or his representative.

14. SURFACE PREPARATION OF IMPERFECTION METALLIC SURFACE

Surface imperfections such as edges, projections, crevices, pits, weld prosoity, laminations, etc. can cause premature failure when the service is severe. The timing of such surface repair work may occur before, during, or after preliminary surface preparation operations have begun.

14.1 Weld Spatter

Weld spatter shall be removed prior to blast cleaning. Most weld spatter, except that which is very tightly adherent, can be readily removed using a chipping hammer, spud bar, or scraper. Tightly adhering weld spatter may require removal by grinding.

14.2 Porosity

Areas of unacceptable porosity shall be filled with suitable filler material (see Appendix D.6) or closed over with a needle gun or peening hammer (see also 7.4) prior painting.

14.3 Sharp Edges

Sharp deges, such as those normally occurring on rolled structural members or plates, as well as those resulting from flame cutting, welding, grinding, etc. and especially shearing, may be removed by any suitable method (e.g. grinding, mechanical sanding, filling). Care shall be taken to ensure that during the removing operations, new sharp edges are not created.

14.4 Pits

Deep corrosion pits, gouges, clamp marks, or other surface discontinuities may require grinding prior to painting. The surface will require filling.

14.5 Laminations, Slivers

Rolling discontinuities (laps) may have sharp protruding edges and deep penetrating crevices and such defects shall be eliminated prior to painting. Various methods can be used to eliminate minor slivers (e.g., scraping and grinding). All sharp fins, projections, or edges shall be removed.

14.6 Crevices

Areas of poor design for corrosion protection, such as tack or spot welded connections, back-to-back angles, crevices, etc., may require special attention. Where possible, such deficiencies shall be corrected by structural or design modification. Where this is not possible, particular consideration shall be devoted to minimize the effect of such deficiencies.

15. SURFACE PREPARATION OF CONCRETE

15.1 General

15.1.1 Concrete is a durable material which does not usually require painting for protection, except to prevent further penetration of water and salts after repair of deteriorated concrete, or even on new concrete if the thickness of concrete over reinforcement is insufficient to provide protection.

15.1.2 Concrete shall be permitted to age at least 28 days under good conditions prior to applying a coating system. Paintable curing compounds may be used to permit coating in seven days.

15.1.3 Air and water blasting, hand and power tool cleaning is the most effective methods of surface preparation.

15.1.4 There shall be no evidence of laitance* on the concrete surfaces before coating, and all soft or loosely bond surfaces should be cleaned down to a hard substrate, preferably by abrasive blasting.

15.1.5 Mechanical cleaning, in most cases, is preferred to etching, because concrete surfaces shall be dry to a humidity of not more than 4% wt before paint is applied.

15.1.6 Acceptable cleaned surfaces shall be free of oil, grease, loosely adhering concrete, laitance*, and other contamination.

15.1.7 For painting of concrete see IPS-C-TP-102 "Painting".

15.2 Types of Exposures

Three types of exposure are included in this Standard.

* Laitance is the very fine, light powder which is floated to the surface when concrete is cast. removed by the use of a light sand blast or by light wet blasting.

15.2.1 Architectural

Cementitious surfaces coated primarily for aesthetic purposes or weathering resistance.

15.2.2 Light duty maintenance

Cementitious surfaces subject to occasional chemical spillage or moderate fumes or for ease of cleaning, or to minimize damage due to freezing and thawing.

15.2.3 Heavy duty maintenance or immersion

Cementitious surfaces to be protected from continuous immersion, continuous or frequent spillage, heavy chemical fumes, severe abrasion, or physical abuse. Examples of such use include tank linings, pump bases, waste water sewers, tank bases, pumps, floors and building foundations.

15.3 Types of Cementitious Surfaces (see Table 30)

15.3.1 Poured concrete or precast slab

These surfaces have two problems. First, a weak surface layer (laitance), will cause poor adhesion of coating unless removed. Secondly, various sized air bubbles ranging from minute up to 50 mm or larger, present at surface.

15.3.2 Concrete block walls

Concrete block walls have an irregular surface and do not have a weak surface or air pockets.

15.3.3 Guniting surfaces (shotcrete)

When concrete is sprayed on to a vertical surface, the resultant surface is named Guniting surface.

15.3.4 Concrete floors

These surfaces have a weak surface layer, without surface air bubbles. Concrete floors must be cleaned and neutralized to pH 7-8 and washed before painting (see 15.6.1).

15.4 Types of Preparation (see Table 30)

Surface preparation of concrete surfaces include the following methods as appropriate with reference to grade 1, (best) of Table 14 the service condition shall define by the company.

15.4.1 Air blasting (see Appendix B)

This method is intended to remove debris, dust, loosely adherent laitance from concrete wall or ceilings. Air blast cleaning shall consist of cleaning the surface with a compressed air stream at 5.5-7 bar through a blasting nozzle held approximately 0.6 m from the surface (see also section 8). Vacuum cleaning may be required to remove redeposited dust.

15.4.2 Water blasting

This method shall consist of cleaning the surface with a jet of high pressure water (see Appendix B) or steam (see 5.6) with 240-308 bar sufficient to remove heavy deposits of grease and oil.

When detergent or other emulsifying agents are mixed with water or steam, after cleaning and before the surface dries, the surface shall be thoroughly flushed with portable water. The surfaces cleaned with detergent or nonsolvent emulsifying agents shall be tested for pH in accordance with Test Method 15.6.1 and may be tested for moisture content in accordance with test method 15.6.3 prior to applying coating.

15.4.3 Hand or power tool preparation

The use of hand impact, hand and power grinding, hand wire-brushing using detergent solution (following by rinsing) removes loose and powdery weak concrete and also oil, grease on the surface.

TABLE 30 - SURFACE PREPARATION OF CONCRETE

TYPE OF SURFACE SERVICE	SERVICE	WATER BLAST	SAND BLAST	TOOL CLEANING
POURED CONCRETE OR PRECAST SLAB	LIGHT DUTY MAINTENANCE	3	4	2
	HEAVY DUTY MAINTENANCE	NR (a)	1	2 (b)
	ARCHITECTURAL	2	NN	2
CONCRETE BLOCK	CHEMICAL OR ARCHITECTURAL	2	NN	1
GUNITED SURFACE	CHEMICAL OR ARCHITECTURAL	2	3	1
FLOORS	CHEMICAL OR ARCHITECTURAL	NR	1	2(c), (d)

NR = Not recommended

NN = Not Needed

a) Not recommended for dense concrete, as it cannot open voids but may used in some instances.

b) Hand impact tools will do an adequate job but are not recommended as they are too slow.

c) May be used if concrete is hard and irregular such as broom finish. Broom finish shall consist of sweeping the surface with a clean industrial stiff-bristled broom or similar device

d) Power scarification may also be used on smooth floors.

No. 1 to 4 indicate the preference order of surface preparation methods (1 is the best).

15.4.4 Treatment of organic growths

Concrete surfaces on which organic growths are present shall be treated according to Appendix E.

15.4.5 Stopping and filling

Large voids and air-holes shall be filled with masonry cement or epoxy resin mortars.

Minor surface defects shall be made good with interior or exterior grade of water-mixed filler or with masonry cement.

Alternatively, in oil-based paint systems, oil-based stoppers and fillers may be used after priming. Application of cement paint or "bagging" with a cement/sand slurry will reduce surface roughness and fill minor imperfections (see also Appendix D.6).

15.5 Maintenance of concrete surfaces

15.5.1 When repainting with the same type of existing paint system, and the old paints are in good condition (if loose paints curled edges and blistered paints do not observe). The painted surface shall be cleaned with hand wire-brush, using detergent solution or solvent, followed by rinsing.

If the old paints are not in good condition the paints shall be removed according to 15.5.2.

15.5.2 When repainting with paint system other than the existing paint system, the old paints shall be removed completely, using air blasting [with fine sand abrasive (see 15.4.1)], water blasting (see 15.4.2) or paint strippers (see 13.6.9). Filling of any cracks and holes in the concrete shall be done in the same manner as for new concrete (see 15.4.5).

15.6 Test Methods

15.6.1 Standard test method for pH measurement of chemically cleaned concrete surface

Residual chemicals not removed by water rinsing may adversely affect the performance and adhesion of coatings applied over prepared concrete surfaces. It is the intent of this test method to determine that residual chemicals have been removed by measuring the acidity or alkalinity of the final rinsed surface.

15.6.1.1 Apparatus

pH test paper, with a minimum range from 1 to 11 pH units with a capability of measuring in increments of 0.5 pH units.

15.6.1.2 Materials

15.6.1.2.1 potable water, for rinsing chemically cleaned or etched concrete surfaces.

15.6.1.2.2 Wet concrete surface, following the final water rinse and before the rinse water has completely drained off the surface.

15.6.1.3 Procedure

Tear off a strip of test paper, wet with test water and after the color develops, compare with color chart to determine pH.

The pH of the water used for rinsing shall be determined to establish acceptance criteria. Reading shall be taken at the beginning and end of the final rinse cycle.

At least two surface pH readings shall be taken for each 50 square meters or portion thereof. Readings shall be taken at randomly selected locations immediately following the final rinse and before all the rinse water has drained off the surface.

Unless otherwise specified by the company, tests shall be conducted in accordance with this procedure.

15.6.1.4 Acceptance criteria

The pH readings following the final rinse shall not be more than 1.0 pH lower or 2.0 points* higher than the pH of the rinse water (see 15.6.1.3) unless otherwise specified by the Company.

15.6.2 Test for laitance

The presence of laitance may be detected by scraping the surface with a putty knife. If a loose powdery material is observed, excessive laitance is present. Adhesion could be adversely affected by this laitance, and therefore shall be removed.

15.6.3 Standard test method for indicating moisture in concrete by the plastic sheet method

Capillary moisture in the concrete may be detrimental to the performance of certain coating systems that cannot tolerate moisture on or within the surface boundary.

This test method is used prior to the application of coatings on concrete.

15.6.3.1 Materials

- a) Transparent Polyethylene Sheet, commercially available, approximately 0.1 mm thick.
- b) Adhesive Tape that will adhere to the substrate, (50 mm wide).

15.6.3.2 Cautions

This test method shall be conducted when the surface temperature and ambient conditions are within the established parameters for application of the coating system.

15.6.3.2.3 Avoid direct sunlight, direct heat, or damage to the plastic sheet, as such treatment affects the reliability of the results.

15.6.3.3 Procedure

15.6.3.3.1 Tape a segment of plastic sheet, approximately 457 by 457 mm, tightly to the concrete surface making sure that all edges are sealed.

15.6.3.3.2 Allow the plastic sheet to remain in place a minimum of 16 h.

15.6.3.3.3 After the allowed time has elapsed, remove the plastic sheet and visually inspect the underside of the sheet and the concrete surface of the patch for the presence of moisture.

15.6.3.4 Sampling

15.6.3.4.1 Floors one test area per 46 m² or portion thereof, of surface areas unless otherwise specified by the Company.

15.6.3.4.2 Walls and Ceilings-One test area per 46 m² or portion thereof, of surface area unless otherwise specified by the Company.

* Points: For pH test paper with a capability of measuring increments of 0.5 pH units, each points is equal to 0.5 pH units.

15.6.3.4.3 The recommended practice is a minimum of one test for each 3m of vertical rise in all elevation starting within 300 mm of the floor.

15.6.3.5 Report the presence or absence of moisture.

15.7 Surface Preparation of Precast Concrete Blocks (see also BS 6073)

15.7.1 Types

The main types of blocks are as follows:

15.7.1.1 Aerated concrete blocks are usually made from mixtures of cement and siliceous materials, such as sand or pulverized fuel ash or a mixture of these, together with an aerating agent and water.

15.7.1.2 Dense and lightweight blocks are made from cement and dense or lightweight aggregates, moulded and compacted by vibration or pressure.

15.7.2 Cleaning

Brushing down with stiff (not wire) brushes to remove loose material is usually that is required.

15.7.3 Stopping and filling (see also Appendix D.6)

Cracks, holes and damaged areas shall be made good with cement mortar, masonry cement, or, in dry interior conditions, with water-mixed fillers.

The overall filling of the surface of blockwork by conventional methods is not recommended. On the finer-surfaced blocks, a cement/sand slurry or cement paint according to BS 4764 scrubbed into the surface will reduce texture and fill small holes. Thick textured coatings are also useful in this respect.

16. INSPECTION AND REJECTION

16.1 Surface Inspection

The prepared surfaces shall be inspected, by qualified inspector (see 16.6) for adequate surface preparation.

16.2 Access of Inspector

The inspector shall have access to construction site and to those parts of all plants that are concerned with the performance of work under this Standard.

16.3 Facilities for Inspector

The contractor shall furnish the inspector reasonable facilities and space, without charge, for the inspection, testing, and obtaining of such information as desired regarding the character or equipment and materials used, application, method(s) of surface preparation, progress and manner of the work, and the results obtained.

16.4 Inspection Guide

The inspection guide (see Table 31) shows many of the types of defect that may be found during or after the various preparation operations.

The suggested action in the guide shall be followed by the contractor. The aim shall be not only to remedy defects already evident but to prevent their recurrence.

It is emphasized that the inspection guide shall be used in conjunction with the specification and the inspection schedule (see IPS-E-TP-100). Where defects arise from processes not covered in these Standard, agreement between the parties concerned is necessary before remedial action is taken.

Under the various "work stages" in Table 31 are listed suggestions for inspection instruments and equipment. In addition the Inspector shall have available for general inspection work items such as liquid-sample containers, specimen bags, torch, mirror, magnifying glass, sharp knife, marking chalks and all the appropriate standards, material data sheets, specification, etc. which are appropriate to the work in hand.

16.5 Rejection

The company or an authorized representative may reject articles if the surface condition does not comply with the requirements of this Standard. Articles rejected because of inadequate cleaning shall be recleaned and reinspected for coating at no cost to the Company.

16.6 Qualified Inspectors

All inspections' whether for the user or the applicator shall be performed only by a qualified inspector. The extent and time of any inspection by the user, or his duly appointed representative, should be a part of the job specifications.

A qualified inspector should have the following prerequisites:

16.6.1 Complete knowledge of the job specifications and their requisites.

16.6.2 A practical knowledge of all phases of coating application work including (a) pre-application surface finish requirements such as grinding of welds, sharp edges, etc. (b) surface preparation, (c) coating application techniques and workmanship, (d) coating materials, (e) continuity, thickness and cure tests and tolerances of standards and (f) equipment and tools used in all phases of coating application work.

16.6.3 Adequate experience and training in the inspection of coating applications and the instruments used for inspection and evaluation of coating applications.

The specification should so stipulate if final acceptance of the work is to be made by a duly appointed representative of the user. If so it is wise for that representative to be a qualified inspector.

The qualification of inspector shall be conform by the Company.

TABLE 31 - INSPECTION GUIDE

Work stage and code	Potential defects	How determined	Likely cause	Suggestions for action	Note
4	Residual rust	Visual	Inadequate blasting	Re-blast to the required standard (heavily corroded steel may require smaller size abrasive), then check for removal of soluble corrosion products (see § 9)	
5	General darkening or rusting	Visual and/or "Sun-clean" comparison with standard	Too long delay between cleaning and coating or conditions too humid or metal too cold	Re-blast to the required standard and coat quickly. Improve conditions	
6	Lamination/shelling	Visual	Poor rolling of steel (1 mil)	Refer to Steel Inspector/Engineer for possible quality regrading of steel. Grind out	
C. Pickled steel					
1	Rough and/or pitted surface	Visual	(a) Incorrect concentration of acid and/or inhibitor (b) Too long in pickling tank (c) Corroded surfaces before pickling	Correct acid and inhibitor concentrations and temperatures of the pickling bath	
2	Dark patches	Visual	Residual mill scale or rust	Re-pickle	
3	Dark patches with sticky surface	(a) Test with pH paper	Residual acid	Re-rinse or scrub small areas with clean water	
4	Powdery or crystalline deposits	(b) Test with chloride paper	Residual chlorides	Re-rinse	
5	Carbon deposits or smut	Visual or pH-paper test	Poor rinsing	Brush off and re-treat if severe. Filter reagents and replace rinse	
6	Acid surface	Visual or with white cloth	Contamination of pickling baths	Re-rinse or re-treat after pH adjustments of tanks concerned	
7	Too heavy phosphate deposits	pH-paper	Poor rinsing or over-acidity of final process	Special re-treatment necessary	
8	Cold surface	Laboratory check	Too long or too strong a process	Adjust programme to ensure that advantage of coating on warm surface is maintained	

(to be continued)

TABLE 31 - INSPECTION GUIDE (Continued)

Work steps and code	Potential defects	How determined	Likely cause	Suggestions for action	Notes
D. Flame-cleaned steel					
1	Moisture deposits	Visual or filler paper	Rate of travel of flame too high	Reduce rate of travel until no moisture is deposited	
2	Damorous residues	Visual or adhesive tape	Poor wire-brushing and cleaning	Improve removal of dust and debris after flame-cleaning by air blow or vacuum	
3	Cold surface	Touch or contact thermometer	Too long delay before priming	Adjust programme so that coating is applied to warm surface	
4	Distortion	Visual	Too much heat on too low a gauge material	Refer to the Engineers concerned	
E. Manually cleaned steel (includes use of hand-held power tools)					
	See A.2 and A.4 of this table	-	-	-	Prior removal of the following is essential: a) Loose mill-scale and other debris by most suitable means b) Flux residues by scrubbing with fresh water c) Oil and grease by emulsion cleaning
1	Rust, slag and loose scale	Visual comparison with standard and/or written instructions	Inadequate work and/or tools	Further work with less worn or more suitable tools, if necessary	
2	Burns, sharp cuts, peaks of steel	Visual and touch	Improper use of power tools	Remove defects by most appropriate means and control methods of working with power tools	When chipping, avoid gouging and production of sharp edges
3	Burnished surfaces	Visual	Too vigorous brushing (manual or power)	Mark area for emulsion cleansing before painting and control more closely the wire brushing operations. Use of a pre-treatment primer would also help subsequent adhesion	
F. Environment during application					
1	Too cold	Air and contact thermometers	Poor air conditioning in works or externally (inclement weather)	Improve temperature to acceptable level, but little or no licence should be allowed with limit specified. Open flame heaters should not be used	
2	Too hot	Contact thermometer	Heated surfaces	Reduce temperature below 38 °C or to whatever higher temperature is allowed with special paints	If necessary, rearrange programme to avoid over-hot conditions

(to be continued)

TABLE 31 - INSPECTION GUIDE (continued)

Work stage and code	Potential defects	How determined	Likely cause	Suggestions for action	Notes
A. Raw steel					
1	Inconducibility for treatment of surfaces	Visual	Design precludes access for specified treatment	Inform Engineer that the work cannot be performed as specified. Provide him with a record of work actually done	(see section 5) Not applicable for galvanizing
2	Oil or grease	Visual	Cranes, lift machinery, trucks etc	Scrub with emulsion cleaner (see A-3) Rinse with fresh water	Where appropriate, refer to Steel Inspector
3	Excessive corrosion with pitting	Visual	Old stock or severe storage conditions	Allow for longer or improved surface preparation; then check for removal of soluble corrosion products (see B-5)	Refer to Engineer for re-welding as necessary; remove ripples and spatter.
4	Welding discontinuities, ripples, spatter	Visual	Poor welding practice	Refer to Engineer for re-welding as necessary; remove ripples and spatter.	Refer to Engineer to prevent repetition
5	Sharp edges, rough welds, burrs, laminations, stalling, undercut welds	Visual	Poor fabrication	Round edges; fettles welds and burrs as necessary; Grind out laminations and stalling. Undercut welds (extent of treatment dependent on type of coating and severity of exposure)	
6	Distortion, dishing, buckling, undercut welds	Visual	Poor fabrication	Refer to Steel Inspector	
B. Blast-cleaned steel					
1	Oil or grease, dirt, dust, dirt, water	Visual or adhesive tape or filter paper or reflectometer	(a) Poor working conditions (b) Contaminated grit	Treat oil or grease as in Section 5 Shield working area from contamination. Improve vacuum cleaning Discard grit and re-blast with fresh supply if gritty, treat as Section 5	See Section 8
2	Surface too rough relative to coating thickness	Visual	(c) Contaminated compressed air (d) Excessively corroded raw steel	Improve oil and water traps on air supply. If greasy treat as Section 5 Longer blasting time and extra coats. Refer to Steel Inspector	For sprayed-metal coating a much rougher surface is acceptable than for paint coatings
3	Residual mill-scale	By instrumental comparison of blast profile with standard (see A-4) Visual and/or "Surclean" comparison with standard (see B-5)	(b) Incorrect grit size and/or angle of blast Inadequate blasting	Change grit for subsequent work and/or improved angle of blast Re-blast to the required standard. Heavy mill-scale may require initial treatment with larger size abrasive or a switch to a mixture of grit and shot	"Surclean" may have limitations in the determination of percentage of mill-scale

APPENDICES

APPENDIX A APPLICATION OF DEGREASING METHODS

The cleaning methods described in section 5 are applied by several processes as follows:

A.1 Immersion Cleaning Processes

A.1.1 Vapor immersion process

To remove simple films of oil and grease, articles may be subjected to the vapor process, in which the parts are immersed in a bath of solvent vapor; the vapor condenses on the cold surfaces of the articles and the condensate dissolves the oil and grease, taking it away to the base of the tank. To ensure the maximum condensation, the articles shall be as near as possible to room temperature (or below) at the time of immersion; they shall be passed through or suspended in the solvent vapor until no further condensation occurs, after which point no further degreasing will take place.

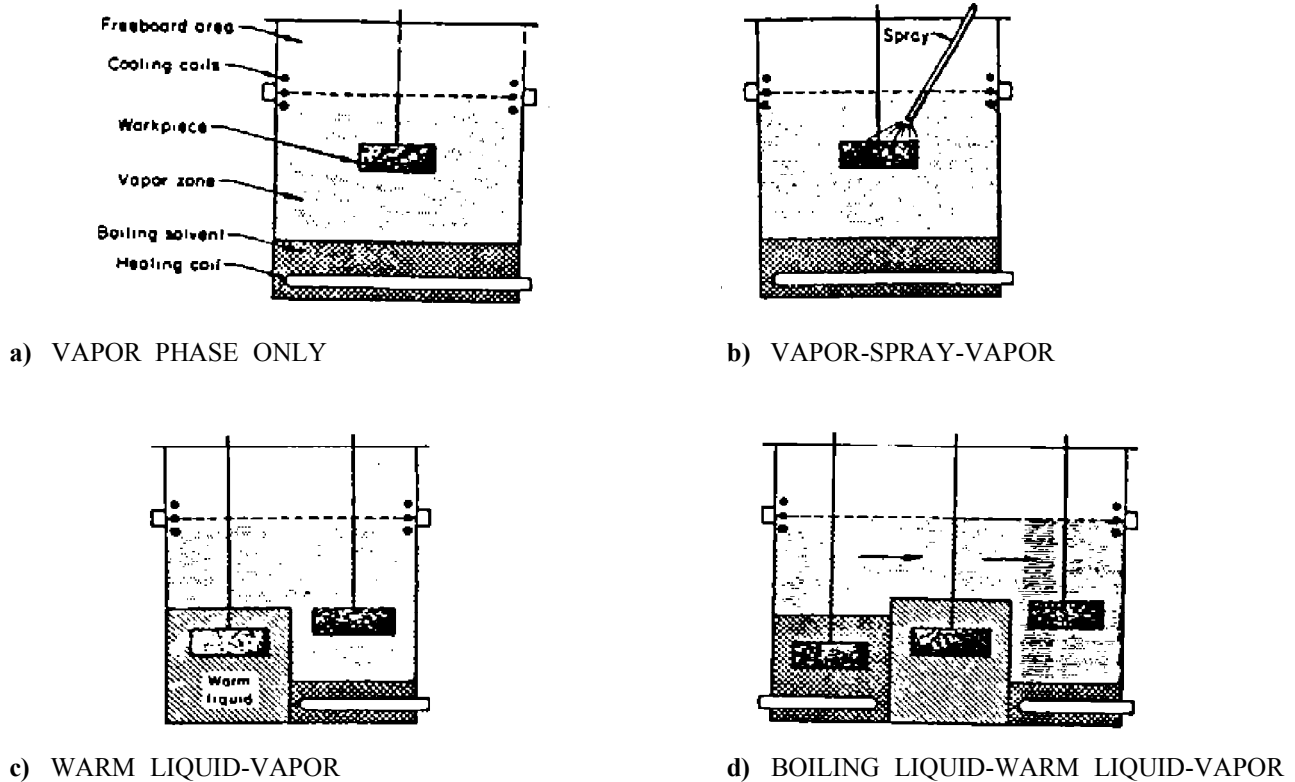
Light metal articles that reach the vapor temperature rapidly and articles with a very heavy film of grease may need a second immersion after cooling. Alternatively, before removal from the vapor, a stream of liquid solvent may be applied over the surfaces, and this also removes loose dirt deposits.

This process used for cleaning of various classes of work by the commonly used degreasing systems are described in Table (A-1) and indicated schematically in Fig. (A-1).

The vapor immersion equipment consist of one or more vessels or compartment having means of heating the liquid solvent contained in the lower part by heating coils and a condensing zone near the top, provided by water cooled coils, to control the vapor level.

**TABLE A-1 - TYPICAL PROCEDURES USED IN VAPOR IMMERSION PROCESSES
WITH TRICHLORETHYLENE CLEANING SOLVENT**

SYSTEM	STEP 1	STEP 2	STEP 3
FOR CLEANING FLAT PARTS WITH LIGHT SOILS AND LITTLE CONTAMINATION			
VAPOR ONLY.....	VAPOR; 87°C; 1 min.	NONE	NONE
FOR CLEANING PARTS WITH ADHERING PARTICLES			
VAPOR-SPRAY-VAPOR	VAPOR 87°C 15 TO 30 SEC	SPRAY 60 TO 71°C 15 TO 30 SEC	VAPOR 87°C 30 TO 45 SEC
FOR CLEANING PARTS WITH RELATIVELY LITTLE CONTAMINATION			
WARM LIQUID-VAPOR (a)	WARM LIQUID 60 TO 71°C 30 TO 45 SEC	VAPOR 87°C 30 TO 45 SEC	NONE
FOR CLEANING HEAVILY SOILED PARTS(b)			
BOILING LIQUID- WARM LIQUID-VAPOR (a)	BOILING LIQUID 87 TO 90°C 30 TO 45 SEC	WARM LIQUID 60 TO 71°C 15 TO 30 SEC	VAPOR 87°C 30 TO 45 SEC
(a) WORK MAY BE HELD IN VAPOR ZONE UNTIL CONDENSATION CEASES BEFORE BEING PLACED IN LIQUID.			
(b) SOME PARTS MAY REQUIRE A SOLVENT DIP BEFORE STEP 1.			



PRINCIPAL SYSTEMS OF VAPOR IMMERSION DEGREASING PROCESS

Fig. A-1

A.1.2 Liquid immersion process

Loosely bond contamination that is too great for vapor immersion such as swarf and road dirt, can be removed by immersing the parts in vigorously boiling solvent or hot solvent or cold solvent. It is particularly suitable for hand cleaning in small tank.

Agitation is desirable and brushing or scrubbing will aid and speed cleaning. Articles with cavities that may hold the solvent shall be immersed so that the holes are filled and then removed at an angle which will ensure that they are emptied.

Repeated dipping and agitation may be necessary to flush out solid material such as swarf. After the first cleaning process the articles may be immersed in a second tank of clean solvent (agitated if possible) for at least one minute to remove the film of contaminated solvent from the first tank; care shall be taken to carry over as little solvent as possible from one tank into the other.

After cleaning, all excess solvent shall be drained from the articles.

A.2 Spray or Jet Cleaning Process

This process may be used to remove oil, grease and light dirt or swarf contamination from unit parts or very simple assemblies capable of being rigidly suspended in a draining position while passing through the spraying zone, also for small parts which may be held in a cleaning zone (solvent, detergent, or steam) and turned over if necessary while a hand held jet or spray is directed on them.

A.2.1 Solvent/detergent cleaning

The article with obstinate dirt deposits which can not be removed by immersion, may require jetting at high pressure with hot or cold solvent, emulsifiable solvent and detergent solution. This process is mainly used in specially designed machines, which may be hand or mechanically operated; in the latter it is essential for the articles to be rigidly by jugged, suspended or place in basket, in such a position that jets or sprays can reach all surface and it may need to be cooled. Proprietary equipment is also available for spray or jet cleaning in which small articles are placed in a cabinet provided with a transparent hood and solvent is directed on them by a nozzle held in a gloved hand.

More usually jet or spray cleaning is carried out in a specially designed machine similar in principle but filled with rows of fixed jets and with a conveyor to carry the articles continuously through cleaning, rising and drying stages.

A.2.2 Steam cleaning

A.2.2.1 The equipment required is a pressure jet steam cleaner. A separate solution tank or drum may be required for preparation of the cleaning compound. One type of steam cleaner stores the concentrated cleaning solution and mixes it with water at a constant rate to produce a uniform cleaning solution through a heating unit in which it is partially vaporized and put under pressure.

The hot solution and steam are forced through the nozzles onto the surfaces to be cleaned. The same equipment can be used for cleaning with dry steam or with cold water under high pressure. This type of steam cleaner may be either portable or stationary.

A.2.2.2 Another type of portable pressure jet steam cleaner sometimes called a hydro-steam unit, requires an outside steam source. The cleaning solution is mixed and stored in a container or tank that is not part of the steam cleaner. No water is mixed with the solution in the steam cleaner, so that the solution is made up at a lower concentration than that used for the other type of cleaner. The solution and steam are mixed in the cleaner and discharged through the nozzle of a steam cleaning gun. The same equipment can be used for cleaning with dry steam.

The cleaning guns may be furnished with interchangeable nozzles. A round one is used for most cleaning. Flat nozzles are used for flat surfaces.

A.3 Brushing or Wiping Process

This process is intended for the removal of oil, grease and light contamination from bare metal areas of assemblies containing painted surfaces or non-metallic inserts that might be damaged by a general application of solvent. It may also be used for the "in situ" cleaning of articles too large for immersion tanks or spray cleaning systems.

Solvent shall be applied to the contaminated areas with a clean brush or a cloth soaked in the solvent; the application of clean solvent with scrubbing or wiping shall be repeated until all the contamination has been removed. Care shall be taken to apply the solvent to the contaminated metal areas only.

If large amounts of water cannot be used, wiping with wet cloths may suffice if done thoroughly.

This method is used for removal of contamination of metal with cold solvent or emulsifiable solvent.

A.4 Electrolytic Cleaning Process

A.4.1 This is applicable to solutions that are electrolytes, such as alkaline cleaners and acid pickles. The articles to be cleaned are attached to suitable fixtures and immersed in a solution kept at room temperature. A low voltage current is then passed through the articles and solution, liberating gas bubbles at the surfaces being cleaned: in forming and escaping to the surface of the solution, these bubbles exert a "throwing off" and scrubbing action which aids cleaning.

A.4.2 Electro-cleaning in an alkaline solution is more effective than simple immersion; especially for the removal of solids.

The electrical equipment for alkaline electro-cleaning shall furnish direct current of density 270-540 amp/m² of surface being cleaned. The voltage will normally be between 4 and 8 volts, but will depend upon the electrical resistance of the cleaning solution, the articles, the suspension racks, etc.

A.4.3 If two tanks, or one tank with current reversing switches, are provided, articles for which cathodic cleaning is permissible shall be cleaned as the cathode for 1-5 minutes, and then as the anode for 15-30 seconds. If only one tank without current reversing switches is available the articles shall be cleaned for 1-5 minutes as the anode only.

The solution can be used hot or cold, depending upon the particular application but, if the articles have had no previous cleaning, the solution is usually heated.

A.4.4 Alkaline electro-cleaning (cathodic or anodic) shall not be used for non-ferrous metals or components partly of non-ferrous metal, unless it has been reliably ascertained that the process will not be harmful. This applies particularly to aluminum, magnesium and zinc and alloys consisting principally of one of these metals, it also applies to electro-plated coatings, which may suffer blistering.

A.4.5 The risk of hydrogen embrittlement shall be born in mind when electro-cleaning treatment may be cathodic or anodic. Thus, cathodic alkaline electro-cleaning shall not be used on hardened steels, in particular spring steels, when under stress, owing to the danger of cracking. Anodic alkaline electro-cleaning is, however, safe for use on these steels. hydrogen embrittlement through cathodic treatment is not prevented by a short subsequent anodic treatment.

A.5 Ultrasonic Cleaning Process

A.5.1 Ultrasonic energy can be used in conjunction with several types of cleaners, but it is most commonly applied to chlorinated hydrocarbon solvents, water and water with surfactants. Ultrasonic cleaning, however, is more expensive than other methods, because of higher initial cost of equipment and higher maintenance cost, and consequently the use of this process is largely restricted to applications in which other methods have proved inadequate.

A.5.2 Typical areas of application in which ultrasonic methods have proved advantageous are as follows:

- a) Removal of tightly adhering or embedded particles from solid surface.
- b) Removal of fine particles from powder metallurgy parts.
- c) Cleaning of small precision parts, such as those for cameras, watches or microscope components.
- d) Cleaning of parts made of precious metals.
- e) Cleaning of parts with complex configurations, when extreme cleanliness is required. For example, precision parts used in fuel injection or control, which require the ultimate in cleanness; even a few minute particles of soil may impair the functioning of such components.

f) Cleaning of parts for hermetically sealed units. For example, one manufacturer utilizes ultrasonic cleaning for hermitically sealed refrigerator parts. In this application, parts are placed in aluminum racks and cleaned ultrasonically (400 kc per sec.) in trichlorethylene.

Despite the high cost of ultrasonic cleaning, it has proved economical for applications that would otherwise require hand operations.

A.5.3 Size of part

It is a limitation, although no definite limits have been established.

The commercial use of ultrasonic cleaning has been limited principally to small parts, such as those indicated in the above examples. The process is used as a final cleaner only, after most of the soil is removed by another method.

A.5.6 Ultrasonic transducer which convert electrical energy into ultrasonic vibrations, are of two basic types, electrostrictive (barium titanate) and magnetostrictive. The latter is capable of handling larger power inputs. Barium titanate transducers generally are operated over a range of 30 to 40 kc per sec.; magnetostrictive transducers usually operate at about 20 kc per sec., but may operate at frequencies up to about 50 kc per sec.

A.5.7 Cleaning efficiency in the liquid phase of a vapor degreasing cycle can be considerably augmented by the application of ultrasonic energy. However, ultrasonic cleaning is expensive and is seldom used in a degreasing cycle unless other modifications have failed to attain the desired degree of cleanness. It is often applied to parts that are too small or too intricate to receive maximum benefit from conventional degreasing cycles.

A.5.8 The inside walls of hypodermic needles can be thoroughly cleaned by ultrasonic degreasing. Other examples of parts cleaned by ultrasonic because they failed to respond to conventional degreasing. Other examples of parts cleaned by ultrasonics because they failed to respond to conventional degreasing methods are: small ball bearing and shaft assemblies, printed circuit boards (removal of soldering flux), intricate telephone relays, plug-type valve inserts (contaminated with lapping compounds), and strands of cable (removal of oil and other manufacturing contaminants trapped between the strands).

A.5.9 Because of the increased fire risk the use of ultrasonic techniques with flammable solvents shall be avoided.

APPENDIX B APPLICATION PROCESS OF BLASTING

B.1 Guide to Specification of Abrasives

Selection of a suitable abrasive for a specific application is influenced by the type of surface contamination to be removed, size and shape of work piece, surface finish specified, type and efficiency of cleaning equipment and required production rate (see Table B5).

B.1.1 Metallic abrasives

Metallic abrasives used for blast cleaning may be classified as following:

- Cast steel shot and grit
- Chilled iron shot and grit
- Malleable iron shot and grit
- Cut steel wire shot

The two first types of abrasives commonly used to blasting of steel, but the two last types are not recommended. The types of metallic abrasives recommended for some typical application are given in Table B1.

Shot and grit shall be designated by the letters "S" and "G" and graded by the shot or grit number according to SAE specification see Tables B2 and B3.

**TABLE B1 - TYPES OF STEEL ABRASIVES MOST COMMONLY USED FOR VARIOUS
STRUCTURAL STEEL BLAST CLEANING OPERATIONS**

	Abrasive Type		Size Range (1)	Hardness (RC) (2)	
	Shot	Grit		40 to 50	55 to 60
New Steel	×		S170 to S390	×	
Fabricated New Steel	×	×	S170 to S390 G50 to G25	×	×
Heat-Treated Steel		×	G50 to G25		×
Heavy Steel Plate	×		S230 to S390	×	
Corroded Steel		×	G50 to G25		×
Weld Scale	×		S170 to S280	×	
Brush Blast	×		S170 to S280	×	
Repair Work		×	G50 to G40	×	
Maintenance		×	G80 to G18	×	×

1) Size range refers to working mix (operating mix) for recirculating abrasive blast systems. For additional information see Volume 1. Chapter 2 of the "Steel Structures Painting Manual".

2) RC = Rockwell - unit of hardness method for measurement of size and hardness of metallic abrasive is described in BS 2451-1963.

**TABLE B2 - SAE SHOT SIZE SPECIFICATIONS WITH SUGGESTED REMOVAL SIZES⁽¹⁾ CAST
SHOT SPECIFICATIONS FOR SHOT PEENING OR BLAST CLEANING**

The shot number is roughly the nominal size of the shot pellets in ten-thousands of an inch amounts are percentages by weight of the total sample. For example, 90% min. means that at least 90 percent by weight is retained and at most 10 percent pass .

NBS Screen No.	Standard mm (3)	Screen Size (in)	Screen Opening Sizes and Screen Numbers with Maximum and Minimum Cumulative Percentages Allowed on Corresponding Screens SEA Shot Number													
			S 1320	S 1110	S 930	S 790	S 660	S 550	S 490	S 390 (4)	S 330	S 290	S 230	S 170	S 110	S 70
4	4.75	(0.187)	All Pass	—	—	—	—	—	—	—	—	—	—	—	—	—
5	4.00	(0.157)	—	All Pass	—	—	—	—	—	—	—	—	—	—	—	—
6	3.35	(0.132)	90% min	—	All Pass	—	—	—	—	—	—	—	—	—	—	—
7	2.80	(0.111)	97% min	90% min	—	All Pass	—	—	—	—	—	—	—	—	—	—
8	2.36	(0.0937)	—	97% min	90% min	—	All Pass	—	—	—	—	—	—	—	—	—
10	2.00	(0.0787)	—	—	97% min	85% min	—	All Pass	All Pass	—	—	—	—	—	—	—
12	1.70	(0.0661)	—	—	—	97% min	85% min	—	5% max	All Pass	—	—	—	—	—	—
	1.40	(0.0555)	—	—	—	—	97% min	85% min	—	5% max	All Pass	—	—	—	—	—
	1.18	(0.0469)	—	—	—	—	—	97% min	85% min	—	5% max	All Pass	—	—	—	—
18	1.00	(0.0394)	—	—	—	—	—	—	96% min	85% min	—	5% max	All Pass	—	—	—
20	0.850	(0.0331)	—	—	—	—	—	—	—	96% min	85% min	—	10% max	All Pass	—	—
25	0.710	(0.0278)	—	—	—	—	—	—	—	—	96% min	85% min	—	10% max	—	—
30	0.600	(0.0234)	—	—	—	—	—	—	—	—	—	96% min	85% min	—	All Pass	—
35	0.500	(0.0197)	—	—	—	—	—	—	—	—	—	—	97% min	—	10% max	—
40	0.425	(0.0165)	—	—	—	—	—	—	—	—	—	—	—	85% min	—	All Pass
45	0.355	(0.0139)	—	—	—	—	—	—	—	—	—	—	—	97% min	—	10% max
50	0.300	(0.0117)	—	—	—	—	—	—	—	—	—	—	—	—	80% min	—
80	0.180	(0.007)	—	—	—	—	—	—	—	—	—	—	—	—	90% min	80% min
120	0.125	(0.0049)	—	—	—	—	—	—	—	—	—	—	—	—	—	90% min
200	0.075	(0.0029)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Suggested Removal Size for Cleaning Structural Steel ⁽²⁾						0.0232	0.0165	0.0165	0.0138	0.0117	0.0117	0.0082	0.0070	0.0059	0.0049	0.0029

- 1) US. Courtesy society of automotive engineering (SAE J444a).
- 2) See discussion of work mix (SSPC volume 1).
- 3) Corresponding to ISO recommendations.
- 4) This is coarsest size in common use for blast cleaning structural steel for painting.

TABLE B3 - SAE CAST GRIT SIZE SPECIFICATIONS FOR BLAST CLEANING⁽¹⁾

The grit number is roughly the nominal size of the shot pellets in ten-thousands of an inch. Amounts are percentages by weight of the total sample. For example, 90% means that at least 90 percent by weight is retained and at most 10 percent pass.

NBS Screen No.	Standard mm (3)	Screen Size (in)	Screen Opening Sizes and Screen Numbers with Minimum Cumulative Percentages Allowed on Corresponding Screens SEA Grit Number											
			G10	G12	G14	G16	G18 (4)	G28	G40	G50	G80	G120	G200	G228
4	4.75	(0.187)	—	—	—	—	—	—	—	—	—	—	—	—
5	4.00	(0.157)	—	—	—	—	—	—	—	—	—	—	—	—
6	3.35	(0.132)	—	—	—	—	—	—	—	—	—	—	—	—
7	2.80	(0.111)	All Pass	—	—	—	—	—	—	—	—	—	—	—
8	2.36	(0.0937)	—	All Pass	—	—	—	—	—	—	—	—	—	—
10	2.00	(0.0787)	80%	—	All Pass	—	—	—	—	—	—	—	—	—
12	1.70	(0.0661)	90%	80%	—	All Pass	—	—	—	—	—	—	—	—
14	1.40	(0.0555)	—	90%	80%	—	All Pass	—	—	—	—	—	—	—
16	1.18	(0.0469)	—	—	90%	75%	—	All Pass	—	—	—	—	—	—
18	1.00	(0.0394)	—	—	—	85%	75%	—	All Pass	—	—	—	—	—
20	0.850	(0.0331)	—	—	—	—	—	—	—	—	—	—	—	—
	0.710	(0.0278)	—	—	—	—	85%	70%	—	All Pass	—	—	—	—
	0.600	(0.0234)	—	—	—	—	—	—	—	—	—	—	—	—
35	0.500	(0.0197)	—	—	—	—	—	—	—	—	—	—	—	—
40	0.425	(0.0165)	—	—	—	—	—	80%	70%	—	All Pass	—	—	—
45	0.355	(0.0139)	—	—	—	—	—	—	—	—	—	—	—	—
50	0.300	(0.0117)	—	—	—	—	—	—	80%	65%	—	All Pass	—	—
80	0.180	(0.007)	—	—	—	—	—	—	—	75%	65%	—	All Pass	—
120	0.125	(0.0049)	—	—	—	—	—	—	—	—	75%	60%	—	All Pass
200	0.075	(0.0029)	—	—	—	—	—	—	—	—	—	70%	55%	—
325	0.045	(0.0017)	—	—	—	—	—	—	—	—	—	—	65%	20%
Suggested Removal Sizes for Cleaning Structural Steel ⁽²⁾			0.0232	0.0165	0.0165	0.0138	0.0117	0.0062	0.0059	0.0049	0.0029			

- 1) US. Courtesy Society of Automotive Engineers (SAE J444a).
- 2) See Discussion of Work Mix. (SSPC volume 1).
- 3) Corresponds to ISO Recommendations.
- 4) This is coarsest size in common use for blast cleaning structural steel for painting.

B.1.2 Non-metallic abrasive

B.1.2.1 None-metallic abrasives, used for blast cleaning may be classified as:

- 1) naturally occurring,
- 2) by-product,
- 3) manufactured abrasive.

Physical data are summarized in Table B4.

B.1.2.2 Silica sand (naturally) - consist of sand and flint with medium size of 0.85 to 0.425 mm size range are most commonly used and are an effective abrasive for new steel and for maintenance in non-critical area.

B.1.2.3 Non-silica sand or heavy mineral (naturally) - with medium size of 0.212 to 0.150 mm size range are tough and dense and generally finer than silica sand. Heavy mineral sand can be reused many times and are effective for blast cleaning of new steel.

B.1.2.4 Garnet (naturally) - is a high cost, tough, angular abrasive suitable for cleaning of steel parts and casting in a closed system that permits recycling the abrasives.

B.1.2.5 Zircon (naturally) - is high cost, tough and angular abrasive, suitable for removal of fine scale, leaving a smooth and mat finish.

B.1.2.6 Novaculite (naturally) - a very pure, siliceous rock, suitable to clean precision tools and castings.

B.1.2.7 Slag abrasives (By-product) - available in (2.36 mm to 0.150 mm) size range, have a Sharply angular shape and low (less than 1%) free silica content. slag abrasives are suitable for cleaning of new and painted surface and produced the least dust in operation.

The breakdown rating of slags are %29 to %51 and the resulting surface profile on steel are 0.083 to 0.092 mm (The surface profile were measured using elcometer gage see 4.4.2).

B.1.2.8 Agricultural shell (by-product) - such as walnut shells peach pits and corn cob available from 2.0 to 0.150 mm size range are excellent for removing paint. Fine scale, oil and grease without altering the metal substrate.

B.1.2.9 Manufactured abrasives are 10 to 15 times more costly than by-product slags, 30 to 40 times more expensive than sand, and generally adaptable to recycling as many as 20 times.

Manufactured abrasive suitable for special uses i.e silicon carbids for etching, aluminum oxides for blasting of stainless steel, glass beads for peening and removing oxide film on plastic molds.

TABLE B4 - PHYSICAL DATA ON NON-METALLIC ABRASIVES

Hardness (Mohr Scale)	Shape	Specific Gravity	Bulk Density kg/Litre	Color	Free Silica wt %	Degree of Dusting	Remarks
<u>Naturally Occurring Abrasives</u>							
Sands							
Silica	5	2.3	1.6	white	90 +	high	poor
Heavy Mineral	5-7	3-4	2	variable	<5	med	good
Flint	6.5-7	2.3	1.3	grey-white	90 +	med	good
Garnet	7-8	4	2.3	pink	nil	low	good
Zircon	7.5	4.5	2.5	white	nil	low	good
Novaculite	4	2.5	1.6	white	90 +	low	good
<u>By-Product Abrasives</u>							
Slags							
Bolter	7	2.8	1.3-1.4	black	nil	high	poor
Copper	8	3.3	1.6-1.9	black	nil	low	good
Nickel	8	2.7	1.3	green	nil	high	poor
Walnut shells	3	1.3	0.7	brown	nil	low	poor
Peach pits	3	1.3	0.7	brown	nil	low	poor
<u>Manufactured Abrasives</u>							
Silicon carbide	9	3.2	± 1.7	black	nil	low	good
Aluminum oxide	8	4.0	± 1.9	brown	nil	low	good

B.1.3 Abrasive breakdown

B.1.3.1 Forces that work to develop the cleaning capability of metallic abrasives also tend to reduce the size of abrasive particle and to cause its eventual breakdown to dust. The greater the particle breakdown caused the poorer the cleaning rate. From the stand points of relative metallic abrasive consumption. The following guidelines exist:

Chilled cast iron abrasives have a breakdown rate as much as one third greater than full hard (65 plus Rc*) untempered steel grit.

Malleable iron abrasives have a breakdown rate of 50% to 100% greater than steel abrasive in the 40-50 Rc hardness range.

Steel grit breaks down slightly faster than steel shot of the same size and hardness range. However, the smaller the size grit involved, the greater the difference in breakdown compared to shot.

Similarly, increasing the hardness of steel shot or grit in a given operation increases the breakdown rate. Obviously, however, the more rapid breakdown of a harder steel abrasive becomes academic if it has been determined that a lower hardness will not do the job.

The test method for measurement of abrasive breakdown is described in B.1.3.2.

B.1.3.2 Abrasive breakdown test and rating formula (see also SSPC Vol. 1 chapter 2.3)

B.1.3.2.1 Abrasive breakdown test procedure

- a) A sieve analysis as outlined in ASTM D451-63 is run on a representative split sample containing approximately 200 grams of test abrasive, and data is recorded.
- b) Breakdown test equipment is hooked to an air supply capable of maintaining 6.54 bar of dry air at the blast machine when the machine is in operation. A sample of the abrasive under test is run through the machine and the flow valve is adjusted to give free, unchoked abrasive flow. (The flow is free if a bluish-white hue is visible through the path of air and abrasive as it comes from the nozzle.) The equipment (both drum and blaster) is then cleaned so no dust or abrasive remains.
- c) Ten pounds of test abrasive having a sieve analysis as determined in (a) above is introduced into the blaster, and all of it is expelled at predetermined settings into the 208 litre drum fitted with a dust bag. After blasting, the cone shaped bottom of the drum is opened, all accumulated abrasive and dust collected and transferred to the original weighing container, and reweighed. The loss in weight is recorded.
- d) A split sample of approximately 200 grams is taken from the spent abrasive for sieve analysis.

B.1.3.2.2 Formula for calculating breakdown rate

The breakdown rate is calculated from the sieve analysis, as follows:

$$\text{Breakdown rate} = \frac{\% \text{ spent abrasive retained} \times \text{average sieve opening}}{\% \text{ as-received abrasive retained} \times \text{average sieve opening}}$$

For the following screens, the expression becomes:

* Rc = Rockwell - unit of hardness

		Abrasive	
		As-Received	After Breakdown
0.0559 × %retained	on 0.85 mm sieve opening	_____	_____
0.0248 × %retained	on 0.425 mm sieve opening	_____	_____
0.0124 × %retained	on 0.212 mm sieve opening	_____	_____
0.0071 × %retained	on 0.15 mm sieve opening	_____	_____
0.0043 × %retained	on 0.075 mm sieve opening	_____	_____
0.0013 × %retained	on pan & dust loss opening	_____	_____
TOTALS		_____	_____

Breakdown factors range from 1.0 for an abrasive showing no reduction from original size after blasting to approximately zero for large grains that are reduced to dust.

Most quality mineral abrasives will have a rating of approximately 0.6.

B.1.4 General notes on use of abrasives

B.1.4.1 The following general observation relating to performance of abrasive particles may be helpful:

- The smaller size, the finer surface finish
- The larger size, the greater impact
- The harder abrasive, the faster in its cleaning action

B.1.4.2 Table B5 is a guide for selection of a suitable abrasive for specific application.

**TABLE B5 - ABRASIVES AS USED IN ABRASIVE BLAST CLEANING
(X= MOST COMMONLY USED ABRASIVES; Y= PREFERRED ABRASIVES TO USE)**

Recommended Service	Silica Abrasives	Slag Sand	Slag Shot	Flint Abrasives	Mineral Mineral Abrasives	Synthetic Abrasives	Special Abrasives	Vegetable Abrasives	Glass Abrasives	Chilled Iron Grit	Chilled Iron Shot	Aluminized Abrasives	Steel Grit	Steel Shot
General blast cleaning where abrasives can be recycled and reused economically	X	X	X	X	X	Y		X		Y	X	X		
General blast cleaning where abrasives cannot be economically reclaimed	Y	X	X	X										
Pre-Metalizing blasting	X	X		Y	X	X				Y		X	X	
Blasting where metal tolerances cannot be changed							X	Y						
Blasting in rooms & cabinets	X	X	X	X	X	Y	X	X	X	Y	X	X		
Blasting where the elimination of food contamination or non-magnetic abrasives are required								Y						
Blasting to obtain a high luster on aluminum, brass, etc.							X	X	Y					
Liquid Flow-Hydro Flow-Wet Flow blasting	X				X	Y	Y	Y	Y					
Centrifugal wheel blasting												X	Y	Y

B.1.4.3 When abrasive that have become contaminated by dislodged fragments of coating or by grease, oil and like are re-used, there is a risk that the adhesion and effectiveness of the coating may be impaired. Blasting abrasive that have become contaminated in use by corrosive materials e.g. chlorides, sulfates or the like, must not be re-used.

B.1.4.4 Furnace slags and copper slags shall not be used in tank lining or other application, where abrasive residues embedded in the steel surface may have a detrimental effect on coating performance.

B.1.4.5 Surface preparation for coating whose thickness is less than 0.25 mm requires grit or sand, with size not larger than (1.18 mm) (16-mesh) for sand or G-40 for grit. Abrasive size for coating thicker than 0.2 mm is not as critical, as long as the profile is deep enough.

B.1.4.6 New thin film coating of 0.036 to 0.05 mm will require a shallower anchor pattern which is achieved with a finer abrasive to 0.25 mm (60 mesh) size.

B.1.4.7 When sheets of less than 4 mm thickness are blasted, deformation may occur. This shall be avoided by:

B.1.4.7.1 Low air pressure, small grain sizes and the use of a blasting abrasive of low bulk density.

B.1.4.7.2 A low angle of blasting with sharp edged grain and a short duration of blasting. With adhesive scale or fairly thick rusting it may be necessary to carry out preparatory work by some other methods, e.g. grinding or pickling, before blasting.

Measures B.1.4.7.1 and B.1.4.7.2 will result in less efficient blasting.

B.2 Blasting Process and Equipments

B.2.1 Air blast cleaning

B.2.1.1 General

B.2.1.1.1 Proper surface preparation by this method provides a foundation for the paint system, resulting in a clean surface, uniform etch, and a long, economical coating life. In abrasive air blast cleaning, surface preparation can be achieved on parts or weldments that are not uniform in size or shape.

B.2.1.1.2 Air blast equipment contains and meters abrasive into a compressed air stream through conveying hoses and nozzles to the work piece. In effect, the part being cleaned is eroded away by a mass of abrasive particles until a firm, clean surface results. Abrasive blast cleaning with a compressed air source, air hose, abrasive blast machine, abrasive hose, and nozzle imparts a velocity to the abrasive particle that becomes a working force.

B.2.1.1.3 Various abrasives are used in the process (see B.1.2), but the most widely used abrasive is silica sand that has been processed for a blasting abrasive. Respiratory protection must be given to the operator and workers in the blast cleaning area because of spent abrasive and the contamination being removed from the surface. Selection of the abrasive in this process becomes a major factor in cleaning speed, surface etch and coating adhesion. The trend is to a finer size of abrasive because of increased cleaning speed on new or lightly rusted steel; a coarser size of abrasive is used for more corroded steel or harder-to-clean surfaces. It is important to maintain a proper size of abrasive for air blast cleaning.

B.2.1.1.4 Air blast cleaning process shall be applied with one of following equipments as defined by the Company:

- Pressure type blast equipment
- Suction type
- Vacuum type

B.2.1.2 Pressure type blast equipment

In a pressure-type abrasive blast system the abrasive machine is under the same pressure as the entire system, i.e., the compressor, air lines, abrasive blast machine, abrasive blast hose and nozzle this cleaning method is the most productive of abrasive blast cleaning. The efficiency is largely dependent on actual nozzle pressure, which shall be 6.3 to 7 bars range. The pressure blast machine, or "pot", varies in size, but must be under pressure for an even flow of abrasives. Velocity of the abrasive in the pressure method is greater than the abrasive velocity found in suction equipment.

B.2.1.3 Suction blast equipment

This equipment utilizes the suction jet method of obtaining abrasive from the abrasive tank that is not under pressure. The jet of air blasts the abrasive against the surface after sucking abrasive from the container. Cleaning speed is approximately 1/3 slower than that of pressure blast cleaning with similar size air jets. Its use should be limited to touch-up or spot cleaning jobs, where high speed cleaning is not a factor.

B.2.1.4 Vacuum blast equipment

In the vacuum blast cleaning method, air and abrasive are captured in a rubber-hooded enclosure. They are drawn by suction back to the blast unit where reusable abrasive is separated from blast-cleaned surface contaminants, recycled, and reused.

This is considered a "dust free" abrasive blast cleaning because it shields the blast surface area from flying particles and dust. It will not disturb adjacent machinery and workmen. Cleaning speed is limited because the surface is not visible to the operator.

There are two methods of vacuum blast cleaning. In the suction type the abrasive is siphoned from container to the blast head. The pressure type machine delivers sand under pressure through a blast hose to the surface. The pressure method provides greater production. The process is limited to the use of reusable abrasives, such as metallic, steel shot or steel grit, aluminum oxide or garnet. In some cases, where moisture is a problem due to high humidity, a mixture of steel grit and aluminum oxide or garnet is recommended because it keeps the metal abrasive from "lumping" or congealing due to moisture.

B.2.1.5 Recommendations on air blasting

B.2.1.5.1 Component

Components of air blast equipment are air supply, air hose and couplings, abrasive blast machines, abrasive blast hose and couplings, nozzles, operator equipment, air-fed hoods and control valves, and oil and moisture separators.

A manager of an abrasive air blast operation shall have a check list of each component to ensure peak performance.

B.2.1.5.1.1 Compressed air supply

Compressed air supply for blast cleaning shall be adequate in pressure and volume to meet the work requirement and shall be sufficiently free from oil and water contamination to ensure that the cleaning process is not impaired.

Oil and moisture separators require solvent cleaning to remove oil and routine replacement of filters.

B.2.1.5.1.2 Nozzle

There are many types of blast nozzles. Ceramic and cast iron are short life nozzles and carbides are long life nozzles.

- Nozzle shapes provide great advantage to nozzle construction: Venturi style nozzles (large throat converging to the orifice and then diverging to the outlet) provide rapid speed of abrasive particles through the nozzle, increasing cleaning rate compared to a straight bore nozzle of the same length.

- The nozzle size in Table B6 indicates air consumption in litre per second at 7 bar without abrasive going through the nozzle. When determining the compressor size the next larger size compressor available for the nozzle shall be used. It is also wise to consider other air requirements from the compressor, such as for an air-fed hood 9.5 litre/second and air-driven ventilating equipment (approximately) 56.7 litre/second. A separate air source for air-fed hoods may be required, unless a carbon monoxide detector is installed in the air system. Insufficient air supply results in excess abrasive and slower cleaning rates.

TABLE B6 - AIR CONSUMPTION

NOZZLE ORIFICE mm (in.)	Litre/S REQUIRED 7 BAR (100 PSI)	ABRASIVE CONSUMPTION KILOGRAM PER HOUR
4.69 (3/16")	28	117
6.25 (1/4")	50	220
7.81 (5/16")	76	365
9.37 (3/8")	110	518
10.93 (7/16")	148	712
12.5 (1/2")	194	910
15.62 (5/8")	274	1133
18.75 (3/4")	396	1428

B.2.1.5.1.3 Hoses

Recommended size of air supply hose shall be 3 or 4 times the nozzle orifice, on lines over 30 meters, four times shall be the minimum size. Recommended size of blast hose is also 3 to 4 times the nozzle size, except near the nozzle end. Typical air supply hose, will be 30 m of 31.75 mm and blast hose will be 3 m of 25.4 mm for a 9.37 mm orifice nozzle.

Hose construction is normally 6.25 mm thick rubber tube with carbon black compounding for the dissipation of static electricity generated by an abrasive flow through the tube. Dissipating static electricity prevents build up and shock to operator.

The tube is covered by 2 or 4-ply wrapping to provide strength for pressure requirements. Normal working pressure shall not exceed 8.6 bar.

Normal pressure drop of air blast hose with 9.37 mm orifice nozzle is 0.35 bar per 15.2 m length.

Therefore it is important to use large hose as short as practical.

Aword of caution: too large an abrasive hose 25.4 mm on small nozzles 4.7 mm may result in un even abrasive flow.

B.2.1.5.2 Cleaning rate

As with any production job, efficiency results in good production rates and lower unit costs.

This is especially true in abrasive air blast operation where a small drop in pressure rapidly increase consumption of abrasive and decreases cleaning rate.

In a blast test of two minutes, differences in nozzle pressure were compared, at 4.1 bars the rate of cleaning is the rate at 7 bars and abrasive usage is more than double.

Special consideration shall be given to interior blast cleaning. A wide variation in production rates exists on interior cleaning, as much as 2:1 (½ exterior cleaning rate), because of visibility problems, ventilating problems, and inaccessibility. These variables can be minimized with good lighting, ventilation and good scaffolding techniques.

B.2.2 Centrifugal blasting

B.2.2.1 General

B.2.2.1.1 In centrifugal or Air-less blast cleaning the spinning of large paddle wheels creates the force that throws the abrasive at the surface.

B.2.2.1.2 Essential components of all centrifugal blast cleaning systems are blast wheels, blast enclosure, abrasive recovery and recycling system, and dust collector.

B.2.2.1.3 Among the most prominent application of centrifugal blast cleaning is surface preparation of structural steel for Coating. Major advantages of centrifugal blast cleaning, compared to air blast cleaning, are saving in time, labor, energy and abrasive consumption. A further advantage is automation of cleaning operation, which provides superior, more uniform cleaning of steel and more acceptable.

B.2.2.1.4 Centrifugal blast cleaning machines are divided into two groups: fixed place (included table type, continuous-flow and blasting-tumbling) for shop blasting and portable machines for onsite blasting. Selection of one of these machines depend on size and shape of article, shop layout and capability an degree of desire cleanliness.

B.2.2.1.5 Cleaning rates obtained with portable units are many times greater than those produced by airblast. Touch-up cleaning by airblast (or various types of powered hand tools) is required around narrow peripheral areas and protuberances. Otherwise, the operation is environmentally clean and economical. Because it is essentially an automated process, it provides greater consistency and uniformity of cleaning than airblasting does.

B.2.2.2 Table type machine

The table-type machine is a form of cabinet machine that contains a power-driven rotating worktable; within the cabinet, the blast stream is confined to approximately half the table area. The work is positioned on the slowly rotating table. The abrasive particles are propelled by an overhead centrifugal wheel. When the doors are closed, blast cleaning continues for a predetermined time cycle. Some machines of this type are designed with one or more openings in the cabinet.

These openings are shielded by curtains and permit manual adjustment of the parts during the blast cycle as well as continuous loading and unloading. Table type machine uses in batch system and provides single piece.

B.2.2.3 Continuous-flow machines

Continuous-flow machines equipped with proper supporting and conveying devices are used for continuous blast cleaning of steel strip, coil and wire. These machines are used also to clean castings and forgings at a high production rate, making use of skew rolls, monorails, and other continuous work-handling mechanisms.

In operation, the work is loaded outside the blast cabinet and is conveyed into it through a curtained vestibule, which is designed with 90-degree turns to prevent the escape of flying abrasive particles. The conveyor indexes the work to the center of each blast station and rotates it for complete blast coverage.

A machine of this type incorporates abrasive-recycling facilities and an exhaust system for removing dust and fines.

Continuous-flow machines can clean external surface of plate and structural members prior to fabrication or a wide variety of fabricated section including massive girders and trusses for highway, power plant and industrial building construction.

B.2.2.4 Blasting- tumbling machines

Blasting-tumbling machines consist of an enclosed, endless conveyor, a mechanical blast-propelling device, and an abrasive-recycling system. These machines simultaneously tumble and blast the work and are made in various sizes, to accommodate work loads from 28 to 2800 litres. The work usually is loaded into the conveyor by means of a skip-bucket loader. As the conveyor moves, it gently tumbles the work and exposes all workpiece surfaces to the abrasive blast. At the end of the cleaning cycle, the conveyor is reversed and the work is automatically discharged from the machine.

Blasting-tumbling machines are used for cleaning unmachined castings, forgings and weldments whose size, shape and material permit them to be tumbled without damage. This equipment is not employed for cleaning parts after machining, however, because tumbling would damage the machined surfaces. Blasting-tumbling machines remove dry contaminants, such as sand, rust, scale and welding flux, and provide surface preparation for enameling, rubber bonding, electroplating, or etching prior to tinning.

B.2.2.5 Portable equipments

When parts to be cleaned are too large to be placed in blasting machines, portable equipment can be brought to the workpiece. For structural steel cleaning, application presently include ship decks, ship hull bottom and sides, storage tank exteriors (both floater and cone tops and shell), the wet side of tank bottoms and also for removal of heavy, anti skid coating from air craft carrier decks. These machines are used during construction and also for maintenance painting operation. In principle, the portable machines use the basic components required for stationary installation, i.e., the blast wheel, abrasive recovery and re-circulation, system ventilation, dust removal and collection and a "work conveyor".

Machine incorporate one or two blast wheels and clean a swath approximately 0.7 to 1.9 m wide. Smaller units employ a single blast wheel and clean a swath 0.5 m wide.

In many applications, where small amounts of dust are generated during blasting or where minor dust effluent from the ventilation/collector system is permissible, blast cleaning units are completely self-contained except for power supply. for applications where great amounts of blast residues are generated and/or where effluent dust cannot be tolerated, the total system includes a supplementary, large capacity dust collector.

B.2.2.6 Some consideration on centrifugal blasting

B.2.2.6.1 Component

Centrifugal blast cleaning machines incorporate one or more wheel units, positioned so the abrasive blast will reach the entire surface. Generally, the abrasive from each wheel is thrown in a fanlike pattern covering an area about 70-100 mm wide and 0.9 m long. The number of wheels needed is determined by the size, complexity and shape of the surface.

Centrifugal blasting machine may be contain an air-wash separator system to remove contaminants from returned abrasives.

Centrifugal blast wheels are available in several sizes and be equipped with drive motors of up to (100 hp) 75kw for high production applications.

Generally, motor sizes of 11 to 45 kw (15 to 60 hp) with wheels ranging from 38 to 50 mm inches in diameter, are used for structural steel cleaning.

Under average operation conditions, velocities of abrasive from airless wheel are about 71 m/s (meter/second) for special application the velocity can be decreased to 91-96 m/s.

B.2.2.6.2 Abrasives

The abrasive used for structural steel cleaning consists of tiny particles of alloy steel, generally ranging in size from 0.12 to 1 mm in diameter. These particles, unlike sand, resist fracturing despite of repeated impacts at high velocity. Much greater wear result from the use of non metallic abrasive such as sand, aluminum oxide and silicon carbide.

B.2.2.6.3 Ventilation

It is essential to provide sufficient ventilation to ensure that air pressure within that blast enclosure is lower than the ambient pressure that allows dust generated by the blast cleaning to be drawn into the dust collector and prevents it from escaping from the blast enclosure into adjacent work areas.

B.2.3 Water blasting (hydro-blasting)

B.2.3.1 General

B.2.3.1.1 Water blast cleaning may be high or low pressure, hot or cold and with or without an abrasive and/or detergent to prepare metal prior to painting.

Water blast cleaning does not replace abrasive blast cleaning. Water alone cannot etch a metal surface.

Injection of dry cleaning abrasive at the nozzle achieves a surface etch. Water blasting has wide acceptance where dry abrasive blast cleaning dusts and contamination present a hazard to personnel and machinery (see also NACE, RP-01-72 surface preparation of steel by water blasting).

B.2.3.1.2 In maintenance painting, where job specifications require only removal of all loose paint scale and flaky rust and a thoroughly washed surface, the hydroblast method is very economical, compared to hand or power tool cleaning. Hydroblast cleaning may also be preferred where there are restrictions on dry abrasive blast cleaning.

B.2.3.1.3 Abrasive water blasting can be used to clean irregular shapes, back-to-back angles, corroded valves, marine vessels with sea water corrosion, heat exchangers, boilers, flaking tars, clogged piping, rubber molds, plant filter screens, and cleaning of latency from concrete surfaces. It is not used to shop cleaned new weldments and also it is not preferred prior to application of inorganic zinc primer, due to rust forming between the drying period and coating application.

B.2.3.1.4 Water alone, with low (upto 138 bar) or medium pressure (130-700 bar) can not etch a metal surface, and is especially suited for removing oil and grease accumulations, but high-pressure (upto 1380 bar) water jet, use to cleaning pipeline coating prior to maintenance or inspection of line for corrosion. Injection of dry abrasive at the nozzle achieves a surface etch.

B.2.3.2 Components

The basic water blast unit consists of an engine driven pump, inlet water filter, pressure gage, hydraulic hose, gun and nozzle combination.

The abrasive is injected into the system after water is pressurized by means of a suction head to prevent pump damage, It is usually injected at the blast gun before the nozzle.

B.2.3.3 Abrasive

Any type of abrasive that is commonly used with abrasive blast cleaning can be used in water blast cleaning. Because the abrasive is normally not dried, screened, and recycled, less expensive abrasives are commonly selected in this application. Sand is the most common abrasive.

Table B7 describes various abrasive used in water blasting and lists typical application.

The use of a very small percentage of abrasive would result in slight cleaning action, while too large a percentage of abrasive would result in the formation of a paste that could not be properly circulated. A range of 20 to 35% abrasive (by volume) is satisfactory for most applications.

When abrasive is injected into the water stream a secondary washing procedure must follow to remove spent slurry. This procedure includes a rust inhibitor, which must be compatible, with the Coating system.

B.2.3.4 Production rate

The speed of cleaning is dependent on highest manageable working pressure and volume of water. Depending on surface condition, hydroblasting compares favorably with dry or wet abrasive blasting. Table B8 is a guide to cleaning rates.

**TABLE B7 - CHARACTERISTICS AND TYPICAL APPLICATIONS OF ABRASIVES
USED IN WATER BLASTING**

ABRASIVE	SIZE mm (MESH)	CHARACTERISTICS AND APPLICATIONS
SILICA	0.425 TO 0.180 (40 TO 80)	FAST-CUTTING. USED FOR DEBURRING STEEL AND CAST IRON, REMOVING OXIDES FROM STEEL. CLOSE TOLERANCES CAN NOT BE HELD.
SILICA.....	0.180 (80)	FAST-CUTTING. USED FOR DEBURRING STEEL AND CAST IRON, ROUGHENING SURFACES FOR PLASTIC BONDING OR ROUGH PLATING. HAS PEENING ACTION. TOLERANCES CANNOT BE HELD.
QUATRZ (GROUND)....	0.180 (80)	VERY FAST-CUTTING. USED FOR REMOVING HEAVY BURRS, LIGHT OR MEDIUM SCALE, EXCESSIVE RUST. CAN BE USED ON NICKEL ALLOY STEELS. TOLERANCES CANNOT BE HELD.
NOVACULITE	0.150 (100)	FAST-CUTTING. USED FOR CLEANING CARBON FROM PISTON AND VALVE HEADS; DEBURRING BRASS, BRONZE AND COPPER. CAN BE USED ON CRANKSHAFTS. TOLERANCES CANNOT BE HELD.
QUARTZ (GROUND)...	0.150-0.106 (100, 140)	FAST-CUTTING. USED FOR BLENDING-IN PRELIMINARY GRIND LINES ON STEEL, BRASS AND DIE CASTINGS; REMOVING MEDUIM-HARD CARBON DEPOSITS; BLASTING RADII OF 0.012 TO 0.024 mm.
SILICA	0.106 (140)	USED FOR REMOVING SMALL BURRS FROM STEEL, COPPER, ALUMINUM AND DIE CASTINGS; ROUGH CLEANING OF DIES AND TOOLS; REMOVING METAL. TOLERANCES CANNOT BE HELD.
NOVACULITE	0.045 (325)	SLOW-CUTTING. USED IN FIRST STAGE FOR CLEANING MASTER RODS AND GLASS, AND IN SECOND STAGE FOR CLEANING ALUMINUM PISTONS, CRANKSHAFTS, IMPELLERS, VALVES. HOLDS TOLERANCES TO 0.006 mm
ALUMINUM OXIDE..	0.038 (400)	FAST-CUTTING. USED ON STAINLESS STEEL AND ON ZINC AND ALUMINUM DIE CASTINGS. EXCELLENT FOR OIL-CONTAMINATED SURFACES.
NOVACULITE	0.010 (1250)	USED IN SECOND STAGE FOR CLEANING CRANKSHAFTS, IMPELLERS, RODS, PISTONS, VALVES, GEARS AND BEARINGS. ALSO FOR POLISHING METALS, TOOLS, DIES AND DIE CASTINGS. TOLERANCES CAN BE HELD.
NOVACULITE	0.0025 (5000)	USED FOR OBTAINING EXTRA-FINE SURFACES ON PARTS.
BRIGHT SHOT..... (GLASS BEADS)	0.85 TO 0.038 (20 TO 400)	USED FOR REMOVING LIGHT SCALE OR DISCOLORATION AFTER HEAT TREATING, REMOVING LIGHT OXIDE FROM JET-ENGINE AND ELECTRONIC COMPONENTS. PRODUCE PEENING EFFECT.

TABLE B8 - SOME WATER BLAST CLEANING RATES

S.q m PER hour

SURFACE CONDITION	WATER ONLY=W SAND INJECTION = SI	0-138 BAR 1.1 m³ / hr	207-414 BAR 1.3-2.3 m³ / hr	640 BAR 2.3 m³ / hr
EASY TO CLEAN, DUSTY SETTLEMENT, FLAKY FLAT	W	14	32.5	46.5
SURFACE, LIGHT OIL OR GREASE	SI	18.6	41.9	60.5
AVERAGE RUSTY SURFACE	W	7	18.6	23.3
ANGLES AND PIPING	SI	9.3	21	32.5
HEAVILY CORRODED SURFACE	W	1.9	7	11.6
RUST SCALE, IRREGULAR SHAPE	SI	2.3	9.3	16.3

Note:

Hydroblast surface comparable to Sa2 condition.

Abrasive cleaned surface comparable to Sa2½ condition.

B.2.3.5 Inhibitors

Flash rusting is a light rust layer that concern when using water blast cleaning. To avoid flash rusting, rust inhibitors such as sodium and/or potassium dichromate or phosphate are often used during or after water blasting. These inhibitors may retard rusting for up to 7 days. This is particularly useful in tank work. The entire surface can be cleaned prior to Coating.

One inhibitive treatment after water blast cleaning is rinsing with water containing 0.32% sodium nitrate and 1.28% by weight secondary ammonium phosphate (di basic).

APPENDIX C

DRYING PARTS AFTER AQUEOUS CLEANING AND BEFORE COATING

All surfaces shall be dried before final protection against corrosion. There are five methods which can be used for the removal of moisture.

C.1 Drying by Heating

There are several procedures for drying by heating as follows:

C.1.1 Hot air oven

Heating in an oven at a controlled temperature of 120-170°C will effectively dry articles which have been cleaned in aqueous solution followed by rinsing in water.

The air in drying oven should be circulated to accelerate drying and be continuously replaced by means of a fan to prevent its becoming saturated with moisture.

C.1.2 Blown warm air

Drying by means of blown warm air is accomplished by means of a fan moving air through or across a heating element. The source may be fixed or portable and a suitable flexible nozzle or extension may be used as necessary.

C.1.3 Hot water and steam

Drying by means of hot water is usually employed as a continuation of an aqueous cleaning operation. The articles are immersed in clean water at 80-95°C until they have acquired the same temperature, then exposed to a clean dry atmosphere after draining off excess water. Should water be trapped in pockets, it must be blown out with clean dry air as soon as possible after taking the article out of the hot water.

C.1.4 Infra-red radiation

Drying by infra-red radiation is effected by conveying the articles through a tunnel fitted with infra-red elements. This method gives very flexible control of the drying time and heat by adjustment of the number of elements used and their spacing and distance from the articles, combined with the length of the tunnel and the speed of the conveyor.

C.2 Centrifuging Drying

Centrifuging is only recommended for the drying of small metal parts which have been cleaned or immersed in an aqueous solution prior to treating with corrosion protectives. Typical equipment comprises an enclosed perforated drum approximately 48 cm diameter by 27 cm/deep, capacity approximately (14 litre) belt-driven from an external motor. It has an electrically heated air intake to raise the temperature.

The drum shall not be filled to more than threequarters capacity.

C.3 Drying with Hot Solvent

C.3.1 Water can be quickly removed from any free-draining metal surface by immersing the article in a boiling chlorinated solvent containing a suitable additive; the procedure is similar to (though distinct from) trichloroethylene liquor degreasing as described in Appendix A.1.2 and calls for specially designed equipment containing a drying compartment and one or more rinsing compartments.

C.3.2 Articles to be dried in hot solvent should first go through at least two cold running water rinses, but the use of soft water for these is not essential.

They are then dipped into the boiling solution containing the additive for one minute or less; this removes the water from the metal. (In one process for which perchloroethylene is the recommended solvent the removal is effected by evaporating the water in the form of an azeotrope; in another using trichloroethylene the primary action is to displace the water from the metal surface by a film of the solution.) The articles are then dipped for one minute or less in clean boiling solvent in the rinsing compartment.

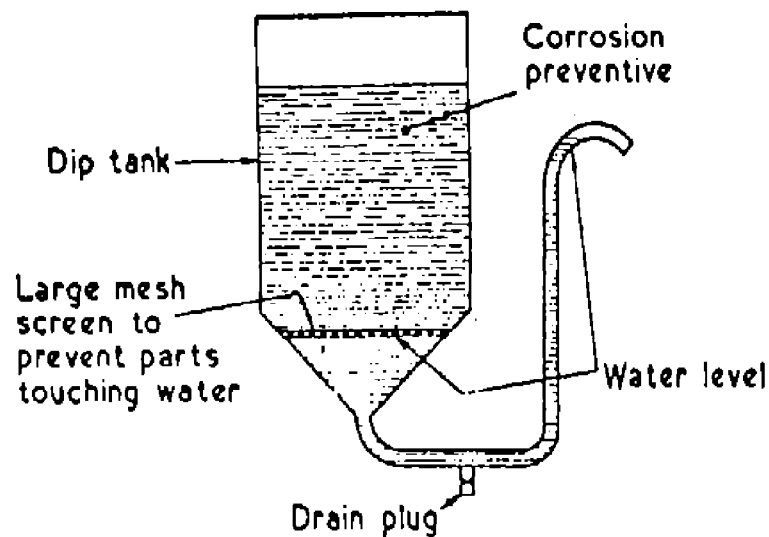
C.3.3 Some articles that are not free-draining can be dried by the hot solvent process if they are loaded in containers that can be tilted or rotated; more than one solvent rinse can be used if necessary.

C.3.4 This method is particularly applicable where articles have a bright surface (e.g. after acid pickling) which would be dulled by hot air drying or would show stains left by evaporating of hard water.

It is normally used after solvent cleaning methods (section 5) except where emulsifiable solvent cleaning is used without rust removing methods to follow.

C.4 Use of Water-Displacing Fluids

These materials are volatile solvents which by the addition of special substances are enabled to displace water in the cold from metal surfaces. The articles to be dried are immersed in the liquid without agitation and the water displaced falls to the bottom of the tank and can be drained away; the design of a dip-tank for automatic drainage of the water is shown in Fig. C-1



POSSIBLE DESIGN OF DIP-TANK FOR WATER-DISPLACING FLUID

Fig. C-1

C.5 Blowing with Compressed Air

The compressed air shall be dry and free from oil and dirt.

Moisture traps shall be placed at the lowest point in the air delivery pipe and as close as practicable to the jet. Air filters combined with or separate from the moisture traps shall be fitted. Traps shall be drained frequently during operation and filters cleaned regularly. Air receiver tanks usually have a drain valve or blow-off cock at the bottom; this shall be opened when the receiver is not in use and left open until the compressor is used again. On re-using the compressor, air shall be allowed to blow through the drain valve for a minute to blow out any condensed moisture in the receiver end and the valve closed.

The air jet shall then be tested for moisture at the delivery end by permitting the air to blow on a polished metal part at room temperature, and observing any condensation.

the pressure of air need not be above 6.17 bar.

APPENDIX D

SURFACE PREPARATION OF PLASTER, BRICK, STONE, AND WOOD

D.1 General

D.1.1 Brick, concrete, plaster, stone or similar surfaces to be painted shall be allowed to dry out completely. Any efflorescence shall be removed by wiping, first with a dry coarse cloth and then with a damp cloth and then the surface shall be left for 48 hours to ensure that no further efflorescence occurs. Plastered interior walls must be allowed to dry thoroughly, usually 30 days, before painting. Ventilation while drying is essential and in cold damp weather heat must be used. Damaged places shall be repaired and sanded smooth.

D.1.2 Treatment of organic growth shall be according to Appendix E.

D.2 Preparation of Plaster

D.2.1 Types of plasters

The plasters in general use for internal work comprise the following:

D.2.1.1 Calcium sulfate (gypsum) types (see BS 1191-Part 1), used neat.

D.2.1.2 Light weight plasters (see BS 1191 Part 2), initially hold more water than other types and may take longer to dry out particularly in winter. Premixed light weight cement plaster under coats may be used in some circumstances.

D.2.1.3 Thin wall plasters, are based on organic binders and, as they are used in this layers, dry out rapidly.

D.2.1.4 Cement plaster; cement/sand or cement/sand/lime plasters may be used where strong, hard or moisture resistant surfaces are required. Cement plaster and premixed light weight cement plaster (see D.2.1.2) are strongly alkaline and, until they substantially dried out, are likely to attack oil-based paints.

D.2.1.5 Lime plasters; non-hydraulic lime plasters made with high purity lime and clean sand are free from soluble salts and caustic alkali. It should be assumed that all lime plaster present a risk of alkaline attack until they have dried out.

D.2.2 Cleaning

D.2.2.1 Dirt and loose surface deposits can usually be removed by dry brushing. Plaster nibs and splashes shall be scraped off, care being taken to avoid damaging the surface. Mould growth may occur on plastered surface if drying out has been prolonged, especially in conditions of poor ventilation. The affected areas shall be treated as described in Appendix E.

D.2.3 Stopping and filling (see D.6)

Cracks, holes and surface imperfections shall be stopped and filled with plaster, water mixed filler or, in cement plasters, with masonry cement, before application of first or priming coats. Alternatively, in oil-based paint systems, oil-based stoppers and fillers may be used after priming.

D.3 Preparation of Brick and Stone

D.3.1 Types

Bricks and stones which is generally used for external and internal works comprise the following:

D.3.1.1 Clay bricks consist of common bricks, facing bricks and engineering bricks (see also BS 3921). Most clay bricks contain soluble salts and these, in combination with water and alkalis in cement mortars, may promote efflorescence (see D.1.1).

D.3.1.2 Calcium silicate (sand lime or flintlime) bricks (see also BS 187). The surface of calcium silicate bricks is usually smoother than that of clay bricks. Paint adhesion is generally satisfactory.

D.3.1.3 Concrete bricks

These are strongly alkaline, and oil-based paints are likely to be attacked if they are applied before the brick work has substantially dried out.

D.3.1.4 Stone

The many varieties of natural stone differ considerably in hardness and porosity, e.g. from virtually non-porous granite or marble to porous limestone or sand stone.

D.3.2 Cleaning

New surfaces e.g. fair-faced brick work, normally require little more than brushing down with stiff (not wire) brushes to remove loose material. Old unpainted surfaces require more vigorous treatment, including washing down, to remove accumulated dirt. If washing is necessary, time shall be allowed for drying out before painting. Organic growths may be present on old external surfaces and shall be treated as described in Appendix E.

D.3.3 Filling and stopping (see D.6)

On old, unpainted surfaces, repairs and re-pointing shall be carried out well in advance of painting to facilitate drying out.

Minor surface defects shall be made good with interior or exterior grade water-mixed filler or with masonry cement. Alternatively, in oil-based paint systems, oil-based stoppers or fillers may be used after priming.

D.4 Preparation of External Rendering

D.4.1 Types

The main types of external rendering are as follows:

D.4.1.1 Cement rendering

The rendering in general use are cement-based and may incorporate lime.

Note:

If repairs to old renderings are necessary. They should be used cement-based mixture (see also BS 5262).

D.4.1.2 Stucco

This term consist of lime/sand is often applied to the external rendering, usually painted, found in older building.

D.4.2 Cleaning

New surfaces normally require little more than brushing down with stiff (not wire) brushes to remove loose material. Efflorescence shall be treated as described in 16.1.1. Old unpainted surfaces, especially if rough or textured, require more rigorous treatment, including washing down, to remove accumulated dirt before painting. If washing is necessary, time shall be allowed for drying out. Organic growths may be present on old surfaces. These shall be treated as described in Appendix E.

D.4.3 Stopping and filling

Minor cracks, holes and surface defects shall be made good with exterior grade water-mixed filler or masonry cement before application of the primer or first coat of paint. Alternatively, in oil-based paint systems, oil-based stoppers or fillers may be used after priming. (see also D.6).

D.5 Preparation of Wood

D.5.1 General

Surface preparation for new or maintenance surface is depended on wood specification and also type of coating should be applied. The preparation procedures are used may consist of cleaning with chemicals (section 5) and flame (section 9), sanding with abrasive paper (section 7) and preservative treatment (D.5.4). Treatment of organic growth according to Appendix E.

D.5.2 Cleaning

Dirt and surface deposits, exuded resin and soluble salts arising from preservative treatment shall be removed. Light contamination shall be removed by wiping with a clean cloth and white spirit or household detergent follow by washing with cleaning and rinsing (see Appendix A.3).

The use of light pressure water cleaning equipment (see Appendix B.2.3) may be used when soiling is heavy and the area to be cleaned extensive. Flame cleaning (see section 9) is usually the quickest and most economical for the removal of paint from general surface of wood work.

D.5.3 Sanding

The main purpose in sanding is to smooth the surface, but it also helps to reduce paint penetration by closing the wood vessels, thus producing a thicker, more uniform film than on unsanded wood. Sanding may also be to remove the degraded outer layer of wood that has been exposed to weather. Wood may be sanded mechanically or manually; the latter, using abrasive paper is more common for site work. It is essential to use a grade of abrasive paper appropriate to the surface; excessively coarse grades will damage the wood fibers, impairing the appearance and possibly the performance of the paint system. Care shall also be taken not to damage moulding and arris edges.

D.5.4 Preservative treatment

The following notes indicate treatments likely to be suitable treatments for components subsequently to be painted:

D.5.4.1 Treatments for external wood working building and not in ground contact consist of:

- a) organic solvent preservatives e.g. copper naphthenate (BS 5056), pentachlorophenol (BS 5707), tributyl tin oxide, zinc naphthenates, which applied by immersion or vacuum process,
- b) treatment with disodium octoborate, which to be carried out on freshly filled timber and cannot be applied to seasoned timber.

D.5.4.2 Treatments for fencing and gates in or out of ground contact (see also BS 5589). The recommended treatment, of a paint or similar finish is required, is with copper/chrome/arsenic (CCA) water-borne preservatives by vacuum pressure process (BS 4072).

D.5.5 Stopping and filling (see D.6)

D.5.5.1 Paint system

Oil-based stoppers and fillers are generally preferred for wood, especially for external wood but shall be used only on primed surfaces, otherwise oil will be absorbed leaving the material underbound; the same requirement applies to linseed-oil glazing putty. Water-mixed (emulsion) stoppers and fillers may be used on primed or unprimed-wood; if used over primer, the stopped or filled areas may require repriming to prevent absorption of the binder from subsequent coats.

D.5.5.2 Natural finish system

With most natural finishes, putty glazing is not suitable. If stopping-up of nail holes is necessary on exterior work, oil-based hard stopper or linseed oil putty shall be used after application of the first coat of finish, the stopper or putty being tinted to match the color of the treated wood. For interior work, water-soluble fillers, similarly tinted, may be used before application of the first coat of finish.

D.6 Types and Application of Fillers* and Stoppers** for Non-Metallic Surfaces

D.6.1 Materials

D.6.1.1 Stoppers

Oil-based stoppers are preferred for woodwork, especially externally, and may be used on other substrates in oil-based paint systems. Cost considerations and the toxic hazards with lead pigments generally preclude the use of the traditional "hard stopping" made up by the painter from paste white lead, whiting and goldsize.

Proprietary oil-based lead-free stoppers are available.

*** Fillers:** Fillers are the paste (more fluid consistency than stopper) and used for filling and leveling shallow depressions, open grain, surface roughnesses, fine cracks.

**** Stoppers:** Stoppers are stiff pastes used for stopping up screwholes, wide cracks, open joints and similar imperfection.

Linseed oil putty is widely used as a stopper but is slow hardening and tends to shrink; it is improved by the addition of goldsize or oil-based undercoat.

Limited experience with emulsion-based fillers (D.6.1.2) indicates that some may be acceptable as stoppers for exterior woodwork. For stopping deep holes in woodwork and repairing damage, e.g. to mouldings and arrises, two-pack polyester or polyurethane fillers, as used for car body repairs, can give satisfactory results.

D.6.1.2 General purpose stoppers/fillers

The types in general use are usually water-mixed and comprise the following:

D.6.1.2.1 Powder fillers

These are supplied in powder form for mixing with water and are usually based on water-soluble cellulose and gypsum or white portland cement.

Those containing gypsum are suitable for general use as stoppers and fillers in dry interior situations. They are not usually suitable for use for external work, especially on wood, but the manufacturer's recommendations in this respect shall be observed.

Portland cement types are suitable for external use on masonry surfaces. They shall not be used on woodwork.

D.6.1.2.2 Emulsion-based fillers

These are usually based on vinyl or acrylic resin emulsions and are supplied in paste form, ready for use.

Materials of this type vary considerably in characteristics and usage. The manufacturer's recommendations, especially regarding suitability for exterior use, shall be observed; some emulsion-based fillers may be acceptable alternatives to oil-based stoppers for external wood-work.

D.6.1.3 Surface fillers

These are formulated specifically for use as fillers in the traditional sense, and are preferred to the "general purpose" types when a high standard of finish is required, especially with oil-based paint systems. They are supplied ready for use as smooth, finely-ground, creamy pastes, usually applied with a wide filling knife or spatula. The types in general used are emulsion-based, but oil-based formulations are available.

D.6.2 Application

D.6.2.1 General

Stopping and filling shall be carried out as early in the Coating system as the type of material used and the nature of the substrate allow. Most materials used for stopping and filling are absorbent and, if applied late in the system, e.g. immediately beneath finishing coats, may cause sinkage and variations in gloss, sheen or colour.

D.6.2.2 Stopping

The materials used for stopping are usually fairly stiff in consistency and are generally applied with a putty knife or stopping knife. The stopper shall be pressed firmly into cavities in order to drive out air which may prevent proper levelling. It shall be knifed flush with the surrounding surface and not allowed to spread beyond the cavity. Deep cavities may require stopping in two stages, allowing an interval for the first application to harden.

When oil-based stoppers are used, surfaces shall be primed and the primer allowed to dry before stopping. This prevents absorption of the binder from the stopper which may cause it to shrink and fall out. Priming is not usually required prior to the use of emulsionbased and powder fillers.

D.6.2.3 Filling

Depending upon their type and consistency, fillers may be applied with a wide, flexible filling knife or spreader or by brush. On broad surfaces, filling knives or spreaders, are generally used, brushes being used for mouldings.

Oil-based fillers are usually applied after priming, but some may be suitable for direct application to unprimed surfaces; manufacturer's recommendations in this respect shall be followed. Emulsionbased and powder fillers may be applied to unprimed surfaces but, on absorbent surfaces, priming may be necessary to facilitate uniform spreading.

Skilled application of fillers by knife or spreader shall leave a surface which requires little subsequent treatment, but some rubbing down may be required for final levelling. With oil-based fillers, waterproof abrasive paper* with water as a lubricant, may be used. Emulsionbased and powder fillers shall be rubbed down dry. After rubbing down, surfaces shall be rinsed or carefully dusted to remove residues of filler. If the surfaces have been wetted, time shall be allowed for drying before painting.

*** Water proof abrasive paper: It shall be used "wet" and is more effective for abrading painted surface. It shall also be used when rubbing down surfaces painted with lead-based paint.**

APPENDIX E

TREATMENT OF ORGANIC GROWTHS

E.1 General

The information in this Appendix is based upon that given in BRE Digest No. 139* to which reference is made for a more comprehensive treatment.

E.2 External Surface

E.2.1 Lichens and mosses are often found on roofs and external walls especially in rural areas. Their appearance is often regarded as pleasing but, if the surfaces are to be painted, the growths have to be removed. Algae occur in most districts when water runs freely over a surface; they cause unsightly green or black stain and have to be removed before painting. Moulds and algal growths resembling dirt deposits may occur outdoors on paints and wood stains; in the early stages they can be washed off, but moulds may penetrate and damage the existing coatings and affect the new one.

E.2.2 Where growths are present on surfaces that are to be painted, preparatory treatment shall include application of a toxic wash. BRE digest No. 139 lists a number of non-proprietary and proprietary materials, of which the main categories are as follows:

a) Sodium hypochlorite

E.g. Household bleach and some proprietary fungicides. Effective against many organic growths and will bleach the color of darker ones. May change the colour of paints and some building materials. No active residue. Use as a solution of 1 part bleach to 4 parts water or, with proprietary materials, as directed. Rinse with cold water after use.

b) Sodium borate

Use as 5% solution in water. Safe to handle. Wash off after use on non-porous surfaces.

c) Zinc or magnesium fluorosilicate

Formerly described as "silicofluoride". Use as 4% solution in water. Has a long-term effect.

d) Formalin (40% formaldehyde)

Use as 5 % solution in water. Choking smell; good ventilation essential. Has no bleaching action and evaporates leaving no active residue.

e) Sodium orthophenyl-phenate

Employed in proprietary materials, mainly fungicides. Use as 2% solution in water or as directed. Have some residual effect and may be left on for painting or papering.

* Building Research Establishment (BRE) Digest London-HMSO.

f) Quaternary ammonium compounds

E.g. Benzalkonium chloride BP and proprietary materials. Effective against algae and lichens. Use as 1 % solution in water or as directed. Low health hazard. Non-staining but wash off before applying emulsion paints.

g) Amino compounds

Proprietary materials effective against algae, lichens and moulds. Use as 1 % to 5% solution in water. Active residual film, non-staining and need not be washed off.

E.2.3 The efficiency of toxic washes will vary according to circumstances. Sodium hypochlorite, as household bleach, is readily available and is effective with a wide range of growths but has no residual activity.

When using toxic washes, precautions should be taken to protect eyes and skin against splashes.

E.2.4 Toxic washes take a few days to become effective and, in wet weather, may be washed out before they have had time to act. They should preferably be applied during a dry spell. Their action is hastened if thick surface growths are partly removed or torn with a wire brush before brushing the wash well in. The wash, repeated if necessary, kills the growth, but the dead organism takes some time to disappear. The dead matter shall be removed by scraping and wire brushing and this is often more effective when the growth is dry; however, it is important that asbestos-cement be not scraped or wire brushed except when wet. After removal of the dead growth, a further application of toxic wash (with types having a residual effect) can delay re-establishment of the growth.

E.2.5 Blast cleaning and high-pressure water cleaning are effective methods of removing heavy growths from external surfaces and are preferred when circumstances permit to warrant their use. Subsequent treatment with a toxic wash is advisable.

E.3 Internal surface

E.3.1 Mould (mildew) is the form of organic growth most likely to affect internal surfaces. The conditions and environments favourable humidity exceeds 70% to its development and measures to prevent or control it.

E.3.2 Preparatory treatment of painted or papered surfaces will depend upon the type of decoration and the extent to which it is affected. Surface coverings shall always be stripped if mould is evident on or beneath them. Removal of paint is advisable if it is severely affected and the growth is deep-seated. In disposing of stripped paper or paint, care shall be taken to avoid contaminating unaffected surfaces. After removal of surface coverings or paints, the surface shall be treated with a toxic wash and kept under observation for a week or so, a further wash being applied if growth is renewed. When growth has ceased and the surface is dry, it can be redecorated.

E.3.3 Where infection is slight and the coating is of a type which will withstand application of a toxic wash, it may be sufficient to clean down without removing the coating and then to apply the wash, allow to dry and repaint.

E.3.4 Of the types of toxic washes listed in E.2.2, those described in (a), (e), (f) and (g) are generally suitable for use on mould-infected internal surfaces.

APPENDIX F
METHOD OF PREPARATION OF A REFERENCE SURFACE FOR COMPARISON
(SEE 10.1.3, 10.2.3)

F.1 Basic Metal

A flat piece of medium-or low-carbon steel not less than 6.5 mm thick, having a vickers hardness of 180-220 HV 10 (BS 427).

F.2 Abrasive

Chilled iron grit of grade Gr 24 (see Appendix B).

F.3 Grit-Blasting Equipment

Any suitable direct-pressure equipment, such that the air pressure is (2.7-3.1 bar) at the pressure grit container, the blast hose being not more than 5 m and of diameter not less than three times the nozzle diameter.

F.4 Procedure

Grit-blast with the blasting nozzle approximately at right angles to and approximately 23 cm from the surface, until a uniformly rough, clean surface not less than 25 cm² in area has been obtained, and maintained without visible change for at least 25 percent of the total blasting time and preserved in that condition.

Note:

The blasting conditions given in this Appendix are not necessarily those for blasting the actual work.