British Standard

Packaging code —

Section 6: Protection of metal surfaces against corrosion during transport and storage —

Subsection 6.1 Cleaning and drying of metal surfaces

Committees responsible for this British Standard

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BCIRA
British Lubricants Federation Limited
British Non-ferrous Metals Federation
British Rubber Manufacturers' Association
Engineering Equipment and Materials Users' Association
Institute of Marine Engineers
Institute of Packaging
Institute of Petroleum
Institute of Refrigeration
Institution of Mechanical Engineers
Ministry of Defence
Oil and Colour Chemists' Association
Timber Packaging and Pallet Confederation

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Contents

Foreword

This Subsection of BS 1133 was prepared under the direction of the Packaging and Freight Containers Standards Policy Committee. It constitutes a revision of sections A and B of the 1966 version of BS 1133-6, and brings information on techniques for cleaning and drying of metal surfaces up-to-date. The importance of cleaning and drying to the prevention of corrosion is believed to be of sufficient justification to publish these sections as a separate Subsection of BS 1133.

Information on the selection, application and removal of temporary protectives is published as Subsection 6.2 and constitutes a revision of sections C and D of the 1966 version of BS 1133-6.

It is envisaged that performance standards for temporary protectives contained in section E of the 1966 version of BS 1133-6 will be revised and published as a separate British Standard specification for temporary protectives; with its publication, BS 1133-6:1966 will be superseded and therefore withdrawn.

BS 7195 gives information regarding a source of corrosion not covered by BS 1133-6.

The information given in this Subsection is intended as a general guide and does not cover specific requirements for which specialist advice should be sought.

WARNING. This British Standard calls for the use of substances and procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

BS 1133 now consists of the following Sections, all of which are published separately, with the exception of Sections 1 to 3, which are published in one volume.

— *Sections 1 to 3: Introduction to packaging*;

— *Section 4: Mechanical aids in package handling*;

— *Section 5: Protection against spoilage of packages and their contents by micro-organisms, insects, mites and rodents*;

— *Section 6: Protection of metal surfaces against corrosion during transport and storage*;

— *Subsection 6.1: Cleaning and drying of metal surfaces*;

— *Subsection 6.2: Temporary protectives and their application*;

— *Section 7: Paper and board wrappers, bags and containers*;

— *Subsection 7.1: Wrapping papers*;

— *Subsection 7.2: Bags and envelopes*;

— *Subsection 7.3: Cartons and boxes*;

— *Subsection 7.4: Fibreboard drums*;

— *Subsection 7.5: Fibreboard cases*;

— *Subsection 7.6: Moulded pulp packaging*;

— *Subsection 7.7: Composite containe*rs;

— *Section 8: Wooden containers*;

— *Section 10: Metal containers*;

— *Section 12: Methods of protection against shock (excluding cushioning devices)*;

— *Section 13: Twines and cords for packaging*;

— *Section 14: Adhesive closing and sealing tapes*;

— *Section 15: Tensional strapping*;

— *Section 16: Adhesives for packaging*;

— *Section 18: Glass containers and closures*;

— *Subsection 18.1: Terminology*;

— *Section 19: Use of desiccants in packaging*;

— *Section 21: Regenerated cellulose films, plastics films, aluminium foil and flexible laminates*;

— *Section 22: Packaging in plastics containers*.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 26, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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1 Scope

This Subsection of BS 1133 gives guidance on methods of cleaning and drying metal surfaces just before employing an appropriate temporary protective treatment (see BS 1133-6.2).

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 General information on cleaning

2.1 The need for cleaning

Freedom from contamination of all kinds is essential in preventing corrosion of metallic surfaces. The best protective against corrosion can be rendered worthless when applied over a contaminated surface.

Contaminants, i.e. unwanted deposits on the surface of an article, are usually present on items, unless preventive precautions are taken during processing. Strict attention should be given to thorough cleaning and also to keeping items as clean as possible during all stages of manufacture.

The cleaning and drying process should be followed as quickly as possible by treatment with an appropriate temporary protective (see BS 1133-6.2).

2.2 Choice and application of cleaner

2.2.1 *General*

There is no single, universal method of cleaning by which all surfaces can be prepared for the application of protective coatings, and the particular cleaning method for any given type of article should be carefully selected and properly carried out. In this Subsection of BS 1133, information is given about the most common cleaning problems and the most widely used cleaning methods. It is impossible to give complete details of all applications, and complex problems should be referred to specialists in the particular fields. The following factors should be considered:

a) nature of contaminants to be removed (see **2.2.2**);

b) nature of the materials of which the articles to be cleaned are constructed (see **2.2.3**);

c) complexity of construction (see **2.2.4**);

d) nature of the surface (see **2.2.5**);

e) availability of cleaning materials and equipment (see **2.2.6**);

f) hazards of cleaning materials (see **2.2.7**);

g) stage at which cleaning is carried out (see **2.2.8**);

h) number of articles to be treated (see **2.2.9**).

Information concerning the selection of an appropriate cleaning process is summarized in Table 1. However Table 1 should be used only in conjunction with the detailed information given in the text of this Subsection of BS 1133.

2.2.2 *Nature of contaminants to be removed*

Residues to be removed are frequently present in association with oil or grease. Cleaning with solvents, such as 1,1,1-trichloroethane, trichloroethylene or a petroleum solvent, can remove grease and dislodge mechanically entrained material, such as metallic or abrasive residues, without affecting saline material adherent to the metal, e.g. perspiration residues. Aqueous alkaline cleaners are usually capable of dealing with all these residues, by a combination of solution, emulsification and mechanical dispersal, but should be followed by careful rinsing and drying. Rust and other corrosion products, and certain other surface deposits, which cannot be dissolved or emulsified by these methods, may require acid treatment or mechanical removal by abrasives.

WARNING. Safety precautions are necessary when using halogenated solvents (see **3.1.2.4**, **3.1.3.2** and **3.1.3.3**). 1,1,1-trichloroethane is preferable to trichloroethylene in terms of safety with respect to user exposure to the solvent and its vapour.

NOTE The use of chlorofluorohydrocarbons should be strictly controlled as they are suspected of causing serious damage to the upper atmosphere.

2.2.3 *Nature of the materials of which the articles to be cleaned are constructed*

Two of the basic questions to be considered are whether the cleaning material will attack an article to the article's detriment and whether it will leave residues which will cause corrosion later. These questions apply particularly to certain degreasing methods.

1,1,1-trichloroethane, trichloroethylene or petroleum solvents, when they are properly employed, will not attack metals. This also applies to mild alkaline cleaners, provided the type chosen is appropriate to the particular metal; strong alkalis are commonly used for cleaning steel, but they should not be used where they can cause attack, e.g. on aluminium and magnesium and their alloys; tin; zinc and brass.

All assemblies incorporating non-ferrous parts require careful consideration. It may be preferable to clean unit parts before assembly.

Articles that are porous or have fine capillary spaces should not be cleaned in alkaline solutions, since complete removal of cleaner residue is then very difficult and corrosion may eventually result. Extended lap-joints or riveted areas, spot welded additions and other similar constructions and some cast iron articles are in this class.

For articles which are partially painted or varnished, 1,1,1-trichloroethane, trichloroethylene and alkali solutions are not generally suitable. Certain emulsifiable solvent cleaners or petroleum solvents can be used.

2.2.4 *Complexity of construction*

Care should be taken when aqueous cleaners are used for parts or assemblies of complex construction owing to the risk of trapping cleaning solution. Aqueous residues can be removed by dipping in water-displacing protectives such as those classified as TP 2b (see BS 1133-6.2).

If such assemblies are to be coated with protective and it is impracticable to clean the parts and apply the protective before assembling, 1,1,1-trichloroethane, trichloroethylene or another solvent cleaner should be used, but it may be necessary to incorporate special devices in the cleaning apparatus to ensure the removal of any trapped solvent.

Complex assemblies, such as generators, motors, starters, gauges, meters and timing devices, made up from dissimilar materials, such as copper, steel, rubber, carbon, plastics, paper, etc., should not be cleaned by immersion methods. The metallic parts of these assemblies should be cleaned before assembling, and the assemblies themselves should be kept clean and free from corrosion by careful handling with gloves and the use of clean covered boxes, protective bags etc. After cleaning it may be necessary to handle and store parts in an air-conditioned room having controlled low humidity.

2.2.5 *Nature of the surface*

The degree of finish or polish and of dimensional accuracy should be considered. For example, light rust stain from fingerprints might be tolerated on a casting, but would spoil a highly finished surface. Great care should be taken in degreasing highly finished surfaces made to fine dimensional limits, to avoid any deposit or staining. Such deposits can be caused by incorrect operation of the particular cleaning method and are more likely to occur with alkaline cleaners. Rough machined, stamped or drawn articles can be cleaned by any easily applicable method.

2.2.6 *Availability of cleaning materials and equipment*

The availability of cleaning materials and equipment should be a determining factor in the selection of a cleaning method only after the nature of the contaminant, degree of cleanness required, composition of the part, etc. as detailed in **2.2.2** to **2.2.5**, have been given full consideration. Corrosion can actually be caused by the application of inappropriate methods of cleaning. Table 1 and Table 2 indicate the materials, equipment and services required for each method of cleaning.

2.2.7 *Hazards of cleaning materials*

All the cleaning materials present some hazards. Halogenated hydrocarbons, such as trichloroethylene and trichloroethane, can burn in certain circumstances and are a health hazard if the vapour is inhaled. Other solvents, such as petroleum-based liquids, present greater fire hazards. All organic solvents can degrease the skin and make it liable to infection; alkalis, dry or in solution, have a similar effect and can cause burns, damage to eyes, etc. Hot aqueous solutions and hot solvent baths can also cause burns. It is essential that the appropriate precautions are taken to avoid risk to health. The Control of Substances Hazardous to Health Regulations 1988, SI No 1657, and the HSE Code of Practice 29 "Control of Substances Hazardous to Health — Control of Carcinogenic Substances" 1989, require employers to assess the risks which may arise from hazardous substances at work and then to determine the measures needed to prevent or control adequately exposure to them. It may be possible to eliminate the hazardous substance by changing the process or substituting a safe, or safer, substance. Where this is not practicable, exposure should be controlled e.g. by enclosure, the use of ventilation equipment, general ventilation, safe systems of work and handling procedures, to levels below the limits listed in HSE Environmental Hygiene 40 "Occupational Exposure Limits" 1990. Personal protective equipment should only be used where other measures cannot adequately control exposure.

2.2.8 *Stage at which cleaning is carried out*

Although the application of cleaning at the proper point in the processing line may be difficult, every effort should be made to clean articles and apply a temporary protective wherever necessary to prevent deterioration. The articles should be cleaned in as simple a unit state as possible and the cleaning should be carried out after the final operation, e.g. machining, forming, gauging or testing. Up to this stage, articles should be carefully handled to keep them as free as possible from contamination. If testing of a complex assembly results in contamination the assembly should be cleaned as thoroughly as possible after the test.

2.2.9 *Number of articles to be treated*

Most of the recommendations in this Subsection of BS 1133 relate to the treatment of relatively large numbers of parts. Where there are only small numbers of articles, as in small repair and maintenance workshops, elaborate plant may not be justified; petroleum solvent cleaning or emulsifiable solvent cleaning may then be found most convenient and economical as these methods require only the simplest equipment.

2.3 Special methods of application

2.3.1 *General*

Many of the cleaning processes described in clauses **3** to **5** are generally applied by immersing the article in a tank of cleaning medium. It is nearly always necessary to aid the physical or chemical action of the cleaner by mechanical means, e.g. movement of the article itself or agitation of the cleaner by boiling, introduction of air, or pump circulation. The following two methods of assisting the cleaning action are also applicable in some cases and reference is made to them in the appropriate clauses.

2.3.2 *Electrolytic cleaning*

This is applicable to inorganic solutions 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. The formation and escape of these bubbles to the surface of the solution exerts a scrubbing action which aids cleaning.

2.3.3 *Ultrasonic cleaning*

This makes use of vibrations in the cleaning liquid, usually at frequencies between 18 kHz and 1 MHz, produced by exciting a magnetostrictive or ceramic transducer at its resonant frequency by means of a current produced in a mechanical generator or, more usually, an electronic oscillator. The exact choice of frequency should be made in consultation with the equipment manufacturer and will depend on the nature of the cleaning problem. The vibrations in the liquid produce cavitation, i.e. the successive formation and rapid collapse of many minute bubbles which exert a scrubbing action on the articles and are particularly effective in detaching insoluble fine solid matter from crevices; a subsequent rinse in the cleaning medium may be necessary to effect the final removal of the solid matter. The vibration generates heat in the cleaning liquid which may need to be cooled to keep it below the maximum safe temperature if ceramic transducers are used. Because of the increased fire risk, the use of ultrasonic techniques with flammable solvents should be avoided. This method can be used to assist grease removal by solvents (see item d) of **3.1.2.1**) or aqueous detergents (see item c) of **3.4.2.1**) or rust and scale removal by acids (see **4.2.2.2**).

2.4 Handling

The handling of parts or assemblies, after cleaning, should be kept to a minimum and the cleaning and drying process should be followed as quickly as possible by treatment with an appropriate temporary protective (see BS 1133-6.2). When handling is necessary, clean gloves or similar protection should be used. Canvas, PVC or leather are suitable materials for gloves.

3 Removal of oil, grease, dirt and swarf

3.1 Trichloroethylene cleaning

WARNING. 1,1,1-trichloroethane is preferable to trichloroethylene in terms of safety with respect to user exposure to the solvent and its vapour.

3.1.1 *General information on trichloroethylene cleaning*

Subclause **3.1** gives information on the complete removal of oil, grease, dirt and swarf from unit parts or simple assemblies, with the solvent trichloroethylene. Several methods of processing are available; the appropriate process depends upon the type and degree of contamination.

Trichloroethylene degreasing should not be used on assemblies containing fabric, rubber or other non-metallic materials unless it is known that no damage will result. Assemblies containing such materials can often be cleaned without damage using 1,1,2-trichloro-1,2,2-trifluoroethane (this is generally known by its trade name followed by the figures 113) by similar processes and in similar equipment to those used with trichloroethylene.

3.1.2 *Procedure for trichloroethylene cleaning*

3.1.2.1 *Processes*

The four main processes are described below. The precise details of the equipment and method of operation for each process depend on the quantity and characteristics of the parts or assemblies to be cleaned. The plant manufacturer's recommendations should be followed.

a) *Trichloroethylene vapour process*

To remove simple films of oil and grease, articles can be subjected to the vapour process, in which the parts are suspended in a bath of solvent vapour; the vapour 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 maximum condensation, the temperature of articles should be less than or close to room temperature at the time of immersion; they should be passed through or suspended in the solvent vapour until condensation ceases to occur, after which no further degreasing will take place.

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

b) *Trichloroethylene liquid process*

Loosely bound contamination that is too great for vapour treatment, e.g. swarf, road dirt, can be removed by immersing the parts in vigorously boiling trichloroethylene.

The articles should be passed through or suspended in the boiling solvent until all oil and dirt have been removed. Heavily oiled articles should be immersed in two or even three separate compartments containing progressively cleaner solvent. Immersion in one bath of boiling trichloroethylene may be followed, after cooling, by immersion in solvent vapour until condensation ceases to occur (see item a) of **3.1.2.1**).

c) *Trichloroethylene jetting process*

Articles with dirt deposits that cannot be removed with boiling trichloroethylene may require jetting at high pressure with the hot solvent. The jetting should be carried out only in apparatus especially designed for the purpose.

d) *Trichloroethylene ultrasonic cleaning process*

An alternative method of removing fine solid particles as well as grease is to introduce ultrasonic agitation into a compartment of cool solvent; this, unlike high pressure jetting, is practicable in open plants and is particularly useful for small intricate parts on which there is polishing or lapping compound. After treatment in the ultrasonic compartment the work should pass through a vapour zone so that it dries as it leaves the plant.

3.1.2.2 *Drying*

After trichloroethylene degreasing the articles are hot and normally dry. Articles of a complex construction with crevices, capillaries, etc. may require further drying at 100 °C to 120 °C.

3.1.2.3 *Handling precautions*

During processing the articles should be placed on hooks or racks or in suitable containers. They should be arranged so that the solvent is able to drain from holes, crevices and other irregularities. Parts or assemblies that would trap solvent should be rotated or tilted during the degreasing process so that trichloroethylene drains out freely. Any assemblies that would trap solvent even though rotated or tilted should either be dismantled before cleaning or be so handled that cleaning is not necessary after final assembly. Handling can be reduced by using mechanical and conveyor type degreasing plants which automatically rotate or tilt the articles. After cleaning, articles should not be handled with bare hands; clean gloves or similar protection should be used and handling should be kept to a minimum.

NOTE If no further processing, such as de-rusting, is required, the appropriate protective should 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 (see BS 1133-6.2).

3.1.2.4 *Safety precautions*

Since trichloroethylene is narcotic, adequate ventilation should be provided and care taken to avoid breathing the vapour. Smoking should not be allowed near degreasing equipment. Contact of the trichloroethylene liquid or vapour with the hands should be avoided as the solvent will remove the natural grease from the skin. Protective gloves, clothing and goggles should be worn. Appropriate safety precautions are given in HSE Guidance Note Environmental Hygiene 5 "Trichloroethylene: Health and Safety Precautions", 1985.

No person should enter a pit or vessel which contains trichloroethylene or in which the solvent vapour may be present, unless suitable precautions are taken. Detailed advice on the necessary precautions is given in HSE Guidance Note General Series 5 "Entry into Confined Spaces", 1977.

Trichloroethylene is non-flammable, but naked flames can cause decomposition of the solvent vapour with the production of harmful acidic gases and should not be allowed near degreasing equipment.

3.1.3 ***Materials and equipment for trichloroethylene cleaning***

3.1.3.1 *Material*

The trichloroethylene used should be stabilized against decomposition by the action of heat, light or hydrolysis, and should comply with BS 580, Type 1 or Type 2. Type 2 should be used for cleaning light alloys, when free fatty acids are present or when ultrasonics are employed.

3.1.3.2 *Equipment*

In order to comply with the above safety precautions, only correctly designed degreasing plants should be used. These consist of one or more vessels or compartments having means of heating the liquid trichloroethylene contained in the lower part and a condensing zone near the top, provided by water-cooled coils, to control the vapour level. Pure solvent condensate from the coils is collected by a trough from which it can be led outside the plant for recovery purposes, or to a stock tank for use with an auxiliary spray pump, or back to the plant to provide a replenishment of clean solvent in liquid compartments. One compartment of the plant may include one or more transducers, so that ultrasonic agitation can be applied to the solvent as one stage in the cleaning process. It is usually necessary to limit the temperature of the solvent in such a compartment in order to avoid damage to the transducers; the parts to be cleaned pass in succession through boiling solvent, ultrasonically agitated cool solvent and vapour. Equipment may be manually operated or of the continuous or automatic type.

Heating may be by steam, gas, high pressure hot water, electricity or oil. Automatic safety devices are necessary for all forms of heating to prevent trichloroethylene vapour rising above the condensing coils if the water supply fails or becomes insufficient. Overheating of the liquid solvent is prevented by the use of automatic sump controls in the case of gas, electricity or oil, and by restricting the pressure of steam or high pressure hot water. With gas or oil heating, the flue gases should be discharged to the outside atmosphere as they may be corrosive and affect the degreased parts.

The required heat input to the plant will vary with the amount of material being degreased. It should be sufficient to maintain a vapour level on the condensing coils. There should be an adequate flow of cold water through the coils.

Open top degreasing plants should be fitted with rim ventilation ducting along one or more sides, through which a gentle current of air can be drawn by an extraction fan to the atmosphere. Suitable extraction arrangements are normally incorporated in the upper part of all types of mechanized plants.

3.1.3.3 *Maintenance*

In addition to the correct operation during processing, satisfactory trichloroethylene cleaning is also dependent upon the maintenance described in **3.1.3.3.1** to **3.1.3.3.7**.

3.1.3.3.1 *Maintenance of cooling coils and exhaust ventilation*

It is essential that adequate flows of water through the cooling coils and efficient extraction around the rim of the degreasing plant are maintained to prevent vapour escaping into the workspace.

3.1.3.3.2 *Maintenance of the correct level of the liquid trichloroethylene*

If the heating element in the sump becomes exposed, insufficient vapour may be generated. If the level falls below the automatic control the solvent may become overheated, causing acidic and corrosive conditions through decomposition.

3.1.3.3.3 *Distillation of the trichloroethylene from the sump*

Trichloroethylene should be distilled from the sump at sufficiently frequent intervals to prevent such a degree of contamination that the production of solvent vapour is inadequate. The amount of oil or grease present in the solvent in a vapour compartment should not exceed around 50 % and can be determined sufficiently accurately and simply from the density. Plants are designed to enable distillation to be carried out readily, alternatively a separate still may be employed for large plants or for a number of smaller units.

3.1.3.3.4 *Thorough cleaning out and removal of solid matter from the sump after distillation*

This should be done at least once a week if aluminium or magnesium alloys are being degreased unless specially stabilized solvent complying with BS 580 Type 2 is being used.

3.1.3.3.5 *Cleanliness of internal surfaces*

All internal surfaces should be kept clean and free from deposits, especially those through which the liquid is heated.

3.1.3.3.6 *Exclusion of water from the degreasing plant*

If there is a possibility of water being introduced, e.g. when an oil/water cutting emulsion has been used, a water separator should be fitted.

3.1.3.3.7 *Chemical check of solvent*

Pure trichloroethylene is readily decomposed by heat, producing hydrochloric acid and other products. The commercial product is stabilized to give some protection against this effect by the addition either of an alkaline stabilizer or of neutral "acid acceptors". If there is any possibility of aluminium or magnesium or their alloys in finely divided form collecting in the plant, or of accumulation of fatty acid lubricants in the plant, the use of a neutral stabilized trichloroethylene is preferable. If an appropriate grade of solvent is used and the plant is operated and maintained according to the manufacturer's recommendations, control tests on the solvent should not be necessary.

If the presence of acid in the solvent is suspected, a rapid qualitative test can be carried out by shaking vigorously about 25 mL of solvent condensed from the vapour and 25 mL of distilled water with a few drops of bromophenol blue. If the colour of the mixture is green or yellow the possible presence of acid is indicated. In this case an accurate determination should be made by one of the following methods as appropriate.

a) *For alkaline stabilized solvent (see BS 580, Type 1).* To 100 mL of solvent condensed from the vapour add 50 mL of distilled water and 4 to 6 drops of bromophenol blue indicator. Titrate slowly with hydrochloric acid, $c(\mathrm{HCl}) = 0.1$ mol/L, shaking vigorously with each addition until the colour of the upper aqueous layer changes from blue to yellow and remains so on shaking for 30 s.

The total quantity of HCl needed to obtain this colour change should not be below 0.2 mL when ferrous, brass or copper articles are being treated, or 0.5 mL when aluminium and magnesium alloy articles are being treated. When these conditions are being approached, the contaminated solvent should be mixed with an aqueous solution of sodium carbonate and distilled.

b) *For neutral stabilized solvent (see BS 580, Type 2).* Carry out the titration in alcoholic solution. The reagents required are a solution of sodium hydroxide in AR methanol approximate concentration $c(\mathrm{NaOH}) = 0.1$ mol/L, standardized against potassium hydrogen phthalate; dioxan– HCl, made up freshly for each test by adding concentrated aqueous HCl to dioxan in the proportion of 0.8 mL per 100 mL, in a glass-stoppered vessel, and shaking well (it is essential that the mixture is not cloudy); neutral ethanol obtained by titrating AR ethanol or industrial methylated spirit with methanolic NaOH in the presence of cresol red indicator until the solution just turns violet.

Pipette a 25 mL portion of the dioxan– HCl into a 250 mL ground neck conical flask, and add 10 mL of the trichloroethylene sample. Insert a glass stopper, swirl the liquid to ensure mixing, and leave the flask to stand for 15 min at room temperature. Add 25 mL of the neutral ethanol and titrate the unreacted HCl with the methanolic alkali, until a violet colour is obtained which persists for 30 s (ignore the change of the cresol red indicator from pink to yellow).

Simultaneously carry out a blank titration with the trichloroethylene sample omitted.

With the above quantity of sample taken, and taking 1.46 g/mL as the density of stabilized trichloroethylene,

the acid acceptance value

$$= (b-c)f \times \frac{40.0}{1\ 000} \times \frac{100}{10 \times 1.46}\ \%\ \text{NaOH}$$

$$= (b-c)f \times 0.274\ \%\ \text{NaOH}$$

where

b is the titre (in mL) of the blank titration;

c is the titre (in mL) with the sample present;

f is the molarity of the methanolic NaOH.

The acid acceptance value of new solvent usually approaches 0.17 % NaOH. Solvent recovered by distillation may show a lower figure but can be used in a mixture with new solvent as long as it has a positive acid acceptance value.

3.2 Cold solvent cleaning

3.2.1 *General information on cold solvent cleaning*

Subclause **3.2** gives information on the use, in the cold, of petroleum solvents, and 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. The storage and use of petroleum and highly flammable liquids is subject to the Petroleum (Consolidation) Act 1928, Petroleum (Mixtures) Order 1929, Statutory Rules and Orders No 993 and the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972 SI No 917.

Several methods of processing are available; choice of the appropriate process depends upon the type and degree of contamination and the size and shape of the parts to be cleaned.

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

3.2.2 *Procedure for cold solvent cleaning*

3.2.2.1 *Processes*

The three main processes are described below; precise details depend upon the quantity and characteristics of the parts or assemblies to be cleaned.

a) *Immersion cleaning*. This method is suitable for unit parts or assemblies when contamination is light and where a high degree of cleanness is not essential. It is particularly suitable for cleaning by hand in small tanks. The articles should be immersed in the solvent long enough to allow removal of the contaminants, and in no case for less than 1 min. Agitation is desirable, and brushing or scrubbing will aid and speed cleaning. Articles with cavities that can hold solvent should 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.

It is undesirable to use ultrasonic techniques with flammable solvents but if such a procedure is intended the manufacturer of the generating equipment should be consulted. The energy dissipated in the liquid can be high (depending on the type of generator used) and intense local heating can occur, with consequent fire risks. If a halogenated solvent is used in ultrasonic cleaning equipment, this should incorporate means for preventing escape of solvent vapour, which otherwise would increase the toxic hazard.

After the first cleaning process the articles may be immersed in a second tank of clean solvent (agitated if possible) for at least 1 min to remove the film of contaminated solvent from the first tank; care should be taken to carry over as little solvent as possible from one tank into the other.

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

b) *Brushing or wiping*. This method is suitable 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 should 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 should be repeated until all the contamination has been removed. Care should be taken to apply the solvent to the contaminated metal areas only.

c) *Spray or jet cleaning.* This method is suitable for the removal of 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 and for small parts which can be held in a cleaning zone and turned over if necessary while a hand jet or spray is directed on them.

3.2.2.2 *Drying*

Immediately after cleaning the articles should be dried with compressed air or, if their size permits, in a vented oven at 65 °C. Articles too large for an oven can be dried by wiping. For further information on these methods see **6.2**, **6.6** and **6.7** but note that the methods described in **6.2.2** and **6.2.3** are not suitable for use when volatile or corrosive vapours are present.

NOTE As soon as the parts are finally clean and dried the appropriate protective should be applied without delay otherwise corrosion may occur very quickly (see BS 1133-6.2).

3.2.2.3 *Handling precautions*

Articles should be placed on hooks or racks or in suitable containers that permit draining. After cleaning they should not be handled with bare hands; clean gloves or similar protection should be used and handling kept to a minimum.

3.2.2.4 *Safety precautions*

Petroleum solvents are flammable and suitable fire precautions should be taken when they are used (see **3.2.3.1**). Advice on the storage of highly flammable liquids can be found in HSE General Guidance Publication 51 “Storage of Flammable Liquids in Containers”[1].

The vapour of most halogenated solvents is narcotic. Adequate local exhaust ventilation and general ventilation of the workshop should be provided.

Oil-resistant gloves should be worn when handling articles during cleaning to protect the articles from sweat residues and to avoid any possible effect of the solvent on the skin. Goggles and protective clothing should also be worn.

Smoking should not be allowed in atmospheres which may contain solvent vapour, and care should be taken to avoid breathing the vapour unnecessarily.

3.2.3 ***Materials and equipment for cold solvent cleaning***

3.2.3.1 *Materials*

The petroleum solvent used is generally a neutral water-white petroleum distillate having a minimum flash point of 34 °C (white spirit). Provided that special fire precautions are taken, solvents of lower flash point may be used for cleaning by immersion or by brushing or wiping. However petroleum distillate solvents of higher flash point are also available.

The halogenated hydrocarbons have the advantages of being less flammable (see **2.2.7**) and are free from high boiling constituents. Articles cleaned with these solvents dry completely in air. Halogenated hydrocarbons have varying degrees of toxicity, the least toxic being the chlorofluoro hydrocarbons. Because of their low solvency properties towards certain insulating materials they are particularly useful for the cleaning of electrical components. Of the chlorinated hydrocarbons 1,1,1-trichloroethane is most commonly used owing to its relatively low toxicity. A range of mixed solvents is also available and manufacturers’ advice should be sought regarding their use.

3.2.3.2 *Equipment*

Cold solvent immersion cleaning can be carried out in a simple steel tank when non-flammable solvents are used. Ultrasonic cleaning equipment can generate heat and should not be used if the cleaning solvent is flammable unless the equipment is also capable of cooling the solvent adequately.

Jet or spray cleaning can be carried out in a specially designed machine fitted with a conveyor and with rows of fixed jets so placed and directed that all surfaces of the article are reached. 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 onto them through a nozzle held in a gloved hand.

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[1] In preparation.

3.2.3.3 *Maintenance*

The solvent should be checked periodically for dirt and moisture and replaced when contamination causes unsatisfactory cleaning, or when the dirt content (determined by evaporating a measured volume of solvent until only the oily and solid residues remain, and then weighing those residues) reaches 2 % of the solution, or when entrained moisture can be seen. Any moisture separating from a petroleum solvent should be drained from the bottom of the tank, whilst moisture separating from a halogenated solvent should be skimmed from the surface. Solvents may be reclaimed by distillation. When solvent tanks are not in use, they should be kept tightly covered to minimize contamination by dirt and moisture.

If two immersion tanks in series are used the solvent from the second (rinsing) tank should be transferred to the first (cleaning) tank whenever the solvent in the cleaning tank is removed because of high dirt content. The rinsing tank should then be re-filled with clean solvent. Spray cleaning equipment should be inspected frequently to ensure that spray nozzles are not clogged and are properly directed. The screens or filters in the solvent re-circulating system should be cleaned or replaced daily.

3.3 Emulsifiable solvent cleaning

3.3.1 *General information on emulsifiable solvent cleaning*

3.3.1.1 *Applicability*

Subclause **3.3** gives information on the removal of oil, grease and dirt from unit 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.This method gives a lesser degree of cleanness than trichloroethylene or aqueous cleaning methods but may be employed if a residual trace of the cleaning medium can be tolerated by the subsequent process (e.g. phosphating) or if the size of the parts makes in situ cleaning essential.

Emulsifiable solvent cleaning can in general be used on any metallic parts, but care should be taken with metals and aluminium or magnesium alloys, zinc and brass. Emulsifiable solvent cleaning should not be used on assemblies containing fabrics, rubber or other organic material, unless it has been reliably ascertained that no harm will result.

3.3.1.2 *Material*

The cleaning agent consists of a solvent, such as kerosene or white spirit, and an emulsifying agent capable of producing an oil-in-water emulsion. A range of quick-break emulsion cleaners, exhibiting low foaming characteristics and formulated to maximize demulsification of the water/oil mixture, is available. When used in accordance with the manufacturer's instructions the water/oil mixture separates in approximately 4 h thus obviating the need for large volume settling or storage tanks.

Resultant slop waters may contain as little as 15 p.p.m. by volume of oil under favourable conditions, and the oil phase is free from water. After separation the slop water may be discharged directly to the drains, subject to local authority regulations, and the oil phase reclaimed for refining or use as fuel oil.

3.3.2 *Procedure for emulsifiable solvent cleaning*

3.3.2.1 *Processes*

The choice of process will depend on the size and portability of the article.

a) *Immersion process.* This method is used for cleaning small articles with accessible surfaces.The articles should first be immersed in a bath of the concentrated emulsifier/solvent mixture for 1 min to 10 min or longer, depending upon the degree of contamination. After immersion the articles should be removed from the mixture and all excess liquid allowed to drain back into the tank. This can require up to 30 s. The articles should then be sprayed with cold water, producing an emulsion that is washed away along with loosely adhering solid particles. This spraying should be continued until no milky mixture remains on the surface and should be followed by a dip in clean running water. If the articles need to be dried, they can be immersed in hot water (80 °C to 95 °C) for 30 s to 60 s.

b) *In situ process.* When comparatively large simple assemblies cannot be dismantled, the external surfaces may be cleaned by the in situ method, provided that the necessary subsequent water washing is not inappropriate to part of the assembly.

The concentrated emulsifier/solvent mixture should be applied to the article or assembly by hand spray or brush and should remain on the surfaces for a period of time dependent upon the degree of contamination. The applied mixture and loosened dirt should then be removed by the application of water, until no milky mixture remains on the surface. If large amounts of water cannot be used, thorough wiping with wet cloths might be adequate.

3.3.2.2 *Drying*

Immediately after final rinsing the parts should be dried in accordance with clause **6**, unless further cleaning in accordance with clauses **4** and **5** (removal of rust and miscellaneous residues) is to be undertaken.

NOTE As soon as the parts are finally clean and dried the appropriate protective (see BS 1133-6.2) should 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.

3.3.2.3 *Handling precautions*

During immersion and spraying, the articles should be placed on hooks or racks or in suitable containers. After cleaning they should not be handled with bare hands; clean gloves or similar protection should be used and handling kept to a minimum.

3.3.2.4 *Safety precautions*

The mixture may contain a flammable solvent and as it is first used without water precautions against fire risk should be taken.

Emulsifiable solvent mixtures will quickly degrease the skin and any contact should be followed immediately by rinsing with water. In general, goggles, gloves and protective clothing are necessary when handling the concentrated material. If hand sprays are used for in situ cleaning there is a further hazard from the atomized spray and adequate ventilation and, if necessary, respiratory protection should be provided.

3.4 Aqueous alkaline and aqueous detergent cleaning

3.4.1 *General information on aqueous alkaline and aqueous detergent cleaning*

Subclause **3.4** gives information on 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; 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.

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

3.4.2 *Procedure for aqueous alkaline and aqueous detergent cleaning*

3.4.2.1 *Processes*

The four main processes are described below. Precise details of the equipment and method of operation for each process depend upon the quantity and characteristics of the parts or assemblies to be cleaned and the type of cleaning solution being used. The recommendations of material and equipment suppliers should be followed.

a) *Immersion process.* For removing simple films of oil and grease from articles having easily accessible surfaces, the immersion process can generally be used. The articles should be immersed in a hot solution of a suitable mixture for 1 min to 10 min according to the degree of contamination. The cleaning action can be assisted by agitating the solution and by low pressure sprays, particularly if small amounts of loosely bound dirt are present.

b) *Electro-cleaning process.* Electro-cleaning in an alkaline solution (see **2.3.2**) is more effective than simple immersion, especially in the removal of solids. Treatment may be cathodic, i.e. with the work as the cathode so that hydrogen is liberated at its surface, or anodic in which case oxygen is produced; the former gives the greater volume of gas but there is the possibility of hydrogen absorption by the metal.

If two tanks, or one tank with current reversing switches, are provided, articles for which cathodic cleaning is permissible should be cleaned as the cathode for 1 min to 5 min, and then as the anode for 15 s to 30 s. If only one tank without current reversing switches is available the articles should be cleaned for 1 min to 5 min as the anode only.

The solution can be used hot or cold, depending upon the particular application. If the articles have had no previous cleaning, the solution is usually heated.

Alkaline electro-cleaning (cathodic or anodic) should 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 aluminium, magnesium and zinc, and alloys consisting principally of one of these metals; it also applies to electroplated coatings, which may suffer blistering.

The risk of hydrogen embrittlement (see **4.1.3**) should be borne in mind when electro-cleaning. Thus, cathodic alkaline electro-cleaning should 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.

NOTE The use of mixed loads, i.e. different ferrous-based alloys, may generate a variable cleaning efficiency within the load.

c) *Ultrasonic cleaning process.* Ultrasonic vibrations (see **2.3.3**) can be used to assist the action of unheated aqueous solutions containing alkalis, organic detergents or both. This process is particularly valuable if finely divided solid matter is to be removed, but requires special equipment and is therefore only used when simpler processes are not effective. Heating the solution is unnecessary and it may need to be cooled.

d) *Jet cleaning process.* Unit parts or simple assemblies, particularly those on which the contaminant consists largely of dirt rather than grease, may be cleaned by jetting or spraying with detergent solution or emulsion. This method 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 jigged, suspended or placed in baskets, in such a position that the jets or sprays can reach all surfaces that require cleaning.

3.4.2.2 *Rinsing*

All detergent cleaning should 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 should follow draining. In jetting and spraying machines that incorporate a conveyor rinsing is usually with water jets. In other cases, the articles should be transferred from the cleaning tank to a cold running water rinse tank. Some articles require a final rinse in distilled or de-ionized water to remove the last traces of dissolved salts. 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 greatly 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 s to 60 s in clean hot water (80 °C to 95 °C) will avoid staining and facilitate drying.

3.4.2.3 *Drying*

Immediately after final rinsing the parts should be dried in accordance with clause **6**, unless further cleaning in accordance with clauses **4** and **5** (removal of rust and miscellaneous residues) is to be undertaken.

NOTE As soon as the parts are finally clean and dried the appropriate protective (see BS 1133-6.2) should 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.

3.4.2.4 *Handling precautions*

During processing, the articles should be placed on hooks or racks or in suitable containers; for electro-cleaning these supports should maintain good electrical contact and be adequate to conduct the current.

After cleaning, articles should not be handled with bare hands; clean gloves or similar protection should be used and handling kept to a minimum.

3.4.2.5 *Safety precautions*

Strong alkalis attack the eyes and skin, and therefore, goggles, rubber gloves and suitable protective clothing should be worn when handling alkaline mixtures or their solutions.

3.4.3 *Materials and equipment for aqueous alkaline and detergent cleaning*

3.4.3.1 *Materials*

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

Solutions containing alkalis should be used with care when metals other than iron and steel are present. A typical strong alkaline cleaner for metals other than iron and steel consists 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).

Aluminium, zinc, and tin, including galvanized surfaces and tinplate, are liable to be damaged by any alkaline cleaner 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 sulphite may be included as a means of preventing feathering of tinplate 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 % of an organic surfactant, commonly a sulphated 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 in only a very small proportion.

NOTE Where hard water only is available this may be softened by the addition of a small proportion of sodium hexametaphosphate; usually 1 g/L is adequate.

Solutions of organic surfactants alone are usually harmless to metals, 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 tinplate without damage but not all surfactants are suitable for this purpose and selection should therefore be made in consultation with the manufacturer.

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

An 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.

3.4.3.2 *Equipment*

All apparatus for cleaning with aqueous detergent solutions or emulsions should be provided with heating arrangements unless one of the cold processes given in **3.4.2.1** is to be used. In immersion tanks the heating can be so arranged that convection currents assist the circulation of the cleaning medium round the articles; agitation can also be provided by means of compressed air or with an air impeller or circulating pump. The cleaning tank should preferably have a weir leading to an overflow compartment so that solution displaced by a load is not lost, but surface scum does not remain to be picked up by the articles on withdrawal. If a circulating pump is provided it can be arranged to return the solution from the overflow compartment through a filter to spray pipes which assist the skimming of the surface.

The electrical equipment for alkaline electro-cleaning should supply a direct current of density 270 A/m^2 to 540 A/m^2 of surface being cleaned. The voltage will normally be between 4 V and 8 V, but will depend upon the electrical resistance of the cleaning solution, the articles, the suspension racks, etc.

Equipment is available for spray or jet cleaning in which small articles are placed in a cabinet provided with a transparent hood and cleaning solution or emulsion is directed on them through a hand-held nozzle. The cleaner drains to a sump from which a pump circulates it through a filter to the nozzle. More usually, jet or spray cleaning is carried out in a specially designed machine similar in principle but fitted with rows of fixed jets and with a conveyor to carry the articles continuously through cleaning, rinsing and drying stages.

Equipment for immersion cleaning, electro-cleaning and ultrasonic cleaning may also be provided with conveyors for continuous or automatic operation.

3.4.3.3 *Maintenance*

Regular checks should be made on the concentration of alkaline solutions. The solutions should be completely renewed when the oil and sludge content prevent satisfactory cleaning.

Accumulation of sludge should be prevented by periodic cleaning out of tanks; heating surfaces particularly should be kept clean. The screens in recirculating systems should be cleaned regularly, and jet nozzles should be checked frequently to ensure that they are clear and properly directed.

3.5 Steam cleaning

3.5.1 *General information on steam cleaning*

Subclause **3.5** gives information on the use of a jet of high pressure steam for the in situ cleaning of large unit parts, assemblies and machinery that cannot be accommodated in cleaning apparatus. Steam cleaning should not be used on delicate mechanisms. Cleaning can be carried out with pure steam or with aqueous detergent solution/steam mixtures.

After steam cleaning, the parts can 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.

3.5.2 *Procedure for steam cleaning*

3.5.2.1 *Processes*

Where a steam supply is available it can be used in conjunction with a steam gun, or with an injector that will entrain detergent solution into the steam jet, to remove oil and dirt contamination from the whole surface of the article. Steam will remove most oil and grease, and loosely adhering dirt; detergent solution/steam mixtures will readily remove closely adhering dirt as well as oil and grease. The alkaline or other detergent should be chosen to suit the metal to be cleaned (see **3.4.3.1**). The mechanical action of the steam usually permits the use of lower concentrations of detergent than are required for immersion cleaning. Steam cleaning equipment is available which produces steam at pressures up to 980 kN/m^2 within a few minutes of starting from cold and permits an immediate change-over from detergent solution/steam to steam only or vice versa.

3.5.2.2 *Rinsing*

On completion of detergent solution/steam cleaning, steam alone 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.

3.5.2.3 *Drying*

The raised temperature of surfaces subjected to high pressure steam helps the drying, but parts retaining moisture should immediately be dried by blowing with compressed air (see clause **6**), unless further cleaning in accordance with clauses **4** and **5** (removal of rust and miscellaneous residues) is to be undertaken.

Certain types of equipment are provided with means for spraying a water-displacing fluid over wet surfaces.

NOTE As soon as the parts are finally clean and dried, the appropriate protective (see BS 1133-6.2) should 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.

3.5.2.4 *Handling precautions*

During processing, the articles should be positioned to allow draining of the steam condensate. Care should be taken to ensure that steam does not enter delicate mechanisms, armature windings or other working parts from which water cannot easily be removed.

After cleaning, articles should not be handled with bare hands; clean gloves or similar protection should be used and handling kept to the minimum.

3.5.2.5 *Safety precautions*

Strong alkalis attack the eyes and the skin; goggles and protective clothing should be worn when carrying out alkaline solution/steam cleaning with strong alkalis, particularly in confined places. Care should be taken to avoid being scalded by steam.

4 Removal of rust and scale

4.1 General information on removal of rust and scale from steel parts

4.1.1 *General*

Rust may be present after degreasing due to exposure to corrosive conditions during manufacture. Owing to its hygroscopic nature, rust retains a certain amount of water, and further corrosion can occur underneath a deposit of rust. It is therefore necessary to remove rust before protectives are applied.

Scale may be present from operations during manufacture (e.g. hot rolling, forging, welding or heat treatment). Both rust and scale can cause protective coatings to fail prematurely.

Rust and scale can be removed by one of the following two methods or by a combination of the two:

a) mechanical method (e.g. shot-blasting, grit-blasting, barrelling, abrasive treatment);

b) chemical method (e.g. acid pickling or electro-chemical treatment).

4.1.2 ***Methods***

The choice of the method of de-scaling or de-rusting depends on the character and thickness of the deposit to be removed, on the size, shape, material and construction of the article, and on the finish required. For example, the removal of heavy mill scale requires prolonged pickling in acid or heavy shot blasting; it cannot be effected by scratch brushing. On the other hand, light rust can be rapidly removed by abrasive treatment, or, if the number of articles is large, by a dilute acid pickle. In general, the least severe treatment necessary to attain the desired result should be used.

The following information is of a general character only; it is not possible in the code to give recommendations for all circumstances. It should be emphasized that, whatever method is used, the dry de-rusted surface should be coated with a protective coating without delay in order to prevent re-formation of rust. Special methods of pickling may be required for high alloy steels and experts should be consulted.

4.1.3 ***Hydrogen embrittlement***

When iron or steel is pickled in acids hydrogen embrittlement may occur through absorption of hydrogen evolved in the process. It may also result when the iron or steel is made the cathode in electro-chemical pickling. Articles of high tensile strength are particularly prone to this embrittlement especially if they are of thin section or are in a state of stress.

Acid pickling or cathodic treatment should not be used on steel having an ultimate tensile strength greater than 1 kN/mm^2. If it cannot be avoided the pickling should be followed immediately with a heat treatment at 190 °C to 220 °C provided the properties of the steel are not adversely affected by heating at 190 °C or higher.

The duration of heat treatment depends on microstructure, composition etc. For steels of tensile strength 1.0 kN/mm^2 to 1.4 kN/mm^2 the duration is at least 3 h, for 1.4 kN/mm^2 to 1.8 kN/mm^2 at least 18 h and for steels over 1.8 kN/mm^2 at least 24 h. Shorter times and higher temperatures can be used if they have been shown not to be detrimental. Tempered steels should not be heated above a temperature that is at least 50 °C below the tempering temperature.

If the components have been stressed, e.g. machined, ground, cold formed, a stress relief treatment should also be carried out prior to acid pickling or cathodic treatement.

The risk of hydrogen embrittlement is considerably reduced if anodic pickling is used and it is eliminated by the use of mechanical cleaning.

4.1.4 ***Safety precautions***

Appropriate safety precautions should be taken and statutory regulations should be observed with both mechanical and chemical methods. Acids attack the eyes and the skin, and therefore goggles, gloves and suitable protective clothing should be worn when handling them. Articles should not be handled with bare hands during or after cleaning; clean gloves should be used and handling kept to a minimum.

4.2 Methods of removal of rust and scale

4.2.1 ***Mechanical methods***

Shot or grit blasting or abrasive treatments should not be applied to finish-machined parts, but are valuable for use on articles immediately after fabrication or heat treatment, when hard scales are often present. The method chosen depends on the finish required. Barrelling with various types of abrasives is effective, but has the disadvantage that corners may become rounded in the process. Scratch brushing will remove only loosely adherent scale or rust; the closely adherent underlying layers, though burnished, are not removed.

4.2.2 ***Chemical methods: sulphuric or hydrochloric acid pickling***

4.2.2.1 *Applicability*

Pickling with these acids is of particular value in de-scaling, but should be used only for parts that can be easily and thoroughly washed free from acid. It can 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 normally be treated with these acids:

a) parts built up by riveting, spot welding, or similar methods;

b) cast-iron parts owing to the possibility of occlusion of pickling acid in porous surface layers;

c) ferrous articles with associated non-ferrous or non-metallic parts because of the risk of attack or of electrolytic effects, and because acid may be trapped at the join.

4.2.2.2 *Pickling*

Various types of acid-resistant tanks are available for sulphuric or hydrochloric acid pickling, e.g. lead (for sulphuric acid), glass, glazed earthenware, wood, steel, concrete lined with rubber or other acid-resisting materials.

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 can be varied between 1 % and 50 % of concentrated hydrochloric acid by volume, according to the nature and amount of scale or rust and time available for pickling. Higher concentrations of acid remove rust and scale more rapidly but can attack 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 °C to 40 °C and then quite rapid pickling takes place.

In sulphuric acid pickling the concentration can be varied between 5 % and 20 % of sulphuric acid by volume and the bath should be heated (e.g. by steam coils) to a temperature of about 60 °C to 85 °C. It is very uneconomical to pickle in cold sulphuric acid solutions because of the relative slowness of attack.

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

Pickling may be accelerated to some extent by mechanical agitation of the parts in the solution, and 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 **2.3.3**). Completion of pickling is best judged by periodic inspection.

The acid content of the bath should be checked frequently and additions of acid made to maintain the correct strength. The pickle should be discarded when the iron content has risen to such an extent as to retard seriously the rate of pickling, i.e. when iron (Fe) contents are of the order of 35 g/L for hydrochloric acid pickle and 16 g/L for sulphuric acid pickle.

4.2.2.3 *Washing*

After removal from the sulphuric acid pickling bath, the parts should be thoroughly washed in running water to remove all traces of acid. It is advisable to follow washing by a treatment in one of the following alkaline solutions.

Sodium carbonate 10 g/L to 20 g/L

Sodium carbonate crystals 25 g/L to 50 g/L

Sodium silicate 3 % to 6 % solution of sodium silicate 1.7 g/cm^3

Sodium hydroxide 5 g plus sodium

orthophosphate 7.5 g, in 1L of water.

The alkalinity of these solutions should be checked from time to time; solutions should be renewed at intervals to avoid contamination becoming too high.

After removal from the solution, parts should be thoroughly swilled in clean hot water, dried in accordance with clause **6**, and coated with protective as soon as possible.

4.2.3 *Chemical methods: phosphoric acid pickling*

4.2.3.1 *General*

While phosphoric acid is more expensive than sulphuric acid, it involves 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. Phosphoric acid pickling is suitable for removing rust prior to the application of phosphating surface treatment processes of the type covered by BS 3189.

4.2.3.2 *Rust removal with phosphoric acid*

Light rust can be removed by immersion in cold phosphoric acid, or in commercially available mixtures 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 % by volume. Application is generally by dipping or brushing as follows.

a) *Dip application.* Any oil or grease should be removed by one of the processes described in clause **3**.

Immerse in the rust-removing solution. If necessary assist the de-rusting action by brushing with a steel-wool pad or warm the solution to 60 °C to accelerate rust removal. The immersion should not last longer than is required for complete de-rusting; normally up to 1 h (or 15 min at 60 °C) is sufficient. A lead-lined tank is recommended for the rust-removing solution.

Rinse well in clean cold water, and then in clean hot water. Dry as quickly as possible (see clause **6**) and apply the appropriate protective without delay.

If composite articles are to be treated, care should 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, hardened and tempered or spring steels should be given a further treatment for 30 min in boiling water. Sodium chromate in the proportion of 0.5 g/L can be added to this water as a rust inhibitor.

WARNING. Chromates can cause allergic reactions such as dermatitis or eczema and safety precautions are necessary when using them; protective gloves, clothing and goggles should be worn.

b) *Brushing application (light rust).* Remove any oil or grease by wiping down with white spirit or other solvent. Remove rust as far as possible mechanically, e.g. by means of a stiff wire brush.

Apply the rust remover with a brush or swab, rubbing where necessary with a steel-wool pad to assist rust removal. Keep the surface well wetted with rust-removing solution. A long handled brush minimizes the likelihood of hands or clothing being splashed.

Wash off the solution thoroughly after de-rusting, paying particular attention to seams and crevices. Dry as quickly as possible (see clause **6**) and apply the appropriate protective without delay.

4.2.3.3 *Scale removal with phosphoric acid*

Heavy scale can be removed by phosphoric acid only at higher temperatures, e.g. 85 °C for 25 % (*V*/*V*) acid. It is not generally necessary to use an inhibitor in the bath. After pickling is complete, the treatment of the articles by washing, drying, etc., is as given in item a) of **4.2.3.2**. The bath should be discarded when the concentration of iron (Fe) reaches 20 g/L, otherwise powdery deposits may be formed on the metal surfaces.

4.2.4 *Chemical methods: duplex sulphuric/phosphoric acid*

A more economic method in which less phosphoric acid is used for de-scaling steel plate and other forms of structural steel prior to the application of protective coating is the Footner process. This process consists of the following stages.

a) Pickling in 5 % (*V*/*V*) to 10 % (*V*/*V*) sulphuric acid at 60 °C to 65 °C for 12 min to 15 min, or until all scale and rust is removed. The bath should contain an inhibitor. Further sulphuric acid should be added when the pickling time increases appreciably. The bath should be discarded when the accumulation of sediment 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 density reaches about 1.18 g/mL to 1.20 g/mL or there is 1.6 % of iron (Fe) (16 g/L) in the solution. After the article is lifted from the acid bath it should be allowed to drain for 15 s to 30 s before immersion in the water bath.

b) Washing in warm water at 60 °C to 65 °C by immersing twice before passing to the final bath. There should be a very small flow of water through the water-wash bath to prevent the total acidity, as determined by titration using phenolphthalein indicator, from exceeding 0.1 g H_2SO_4 per 100 mL.

NOTE The flow of water required can be established with experience of the process.

c) Immersing for 3 min to 5 min in 2 % phosphoric acid solution maintained at a minimum temperature of 85 °C. When the iron (Fe) content exceeds 5 g/L, a proportion of the bath should be discarded and the bath restored by suitable additions of clean water and phosphoric acid.

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

The process is also applicable to material that is lighter than structural steel, but drying in an oven may then be necessary as the parts may carry insufficient heat from the bath to dry in air.

4.2.5 ***Chemical methods: alkaline de-rusting***

Alkaline de-rusting materials are available commercially. When parts with fine tolerances have to be cleaned or de-rusted, an alkaline solution containing a complexing agent can be used without fear of attack on the base metal. Complexing agents react with certain metals to form chemically inactive complexes, i.e. they show none of their usual chemical properties. They can also cause insoluble metal compounds to dissolve rapidly by formation of the corresponding metal complexes.

4.2.6 ***Electrochemical treatment***

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

a) *Cathodic treatment in acid solution.* The advantages of this method are more rapid removal of rust and scale than with ordinary pickling, more economical use of acid and reduced attack on the metal; however hydrogen embrittlement may be serious.

Inhibitors such as tin or lead salts are often used as in the Bullard-Dunn process. This process is useful for descaling irregular shaped objects and those with difficult recesses. The work is made cathodic at 645 A/m^2 in hot 10 % (*V*/*V*) sulphuric acid containing a small amount of lead or tin salts. The descaled areas become plated with tin or lead and the action is diverted to other areas. The plated tin or lead is usually removed by electrolytic alkali cleaning.

NOTE Some organic inhibitors can substantially reduce metal losses during cathodic pickling.

b) *Cathodic treatment in alkaline solution.* Hydrogen embrittlement is less than in item a) but de-rusting is usually slower than in acid solutions.

c) *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 but 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:

1) an anodic process for parts entirely of steel based on sulphuric acid solution (density 1.22 g/mL) 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 1 075 A/m^2);

2) an anodic alkaline process for parts entirely of steel, based on a solution of caustic soda containing cyanide or an organic complexing agent.

5 Removal of miscellaneous residues (heat-treatment salts, fluxes and sweat residues)

5.1 Heat-treatment salts

Heat-treatment salts may contain the water-soluble cyanides, carbonates, chlorides or fluorides of sodium or potassium, with or without less readily soluble barium chloride. To avoid corrosion it is essential that they are completely removed by washing in clean hot water. This takes from 5 min for articles of simple shape, to 1 h for those that have crevices or are coated with salts containing barium chloride. After removing the soluble salts in this way it is desirable to rinse the articles in a second tank of clean hot water to remove residues of contaminated wash water.

To facilitate the removal of barium salts soak in hot water as above, transfer for a few minutes while hot to a cold solution containing 10 % to 30 % hydrochloric acid and an inhibitor, swill in cold running water and finally rinse in clean hot water. Do not use this acid treatment if any cyanide remains on the articles.

After cleaning, the articles should be dried (see clause **6**) and a protective applied to them without delay.

5.2 Fluxes

Fluxes used in soldering, brazing or welding, with the exception of certain materials, e.g. rosin flux, should be completely removed in order to avoid corrosion. This applies particularly to those containing hygroscopic chlorides and/or fluorides. They can be removed by thoroughly washing the articles in water, e.g. by immersing them in clean hot water for 5 min to 10 min, and if necessary dipping in dilute sulphuric acid; additionally, scrubbing with a bristle brush may be required to remove incrustations. The removal of flux residues from articles which have been brazed with a borate flux can be assisted by soaking in dilute sulphuric acid before thoroughly washing and scrubbing in water. Fluxes of an organic nature (used for instance in soldering) should be removed by appropriate degreasing methods. Where a chloride flux is compounded with a greasy medium, as with certain soldering fluxes, a degreasing treatment is required prior to washing with water.

Particular attention should be paid to removing flux residues in crevices or seams.

5.3 Sweat residues

Sweat residues left on surfaces can cause rusting or staining, particularly on highly finished bare steel or brass surfaces. It is preferable to avoid such contamination by using gloves, and in particular by not touching highly finished surfaces. If contamination has occurred, however, it should be removed without delay because corrosion can proceed rapidly. These residues are not removed by petroleum or chlorinated solvents; however aqueous processes such as alkaline cleaning (see **3.4**), methanol to which 5 % water has been added and certain oil-in-water emulsions do have sweat-removing properties. Special sweat-removing processes are not common practice and are not detailed here.

6 Information on drying

6.1 General

Clause **6** gives information on the removal of moisture from surfaces of articles before the final protection against corrosion.

There are six methods for the removal of moisture:

a) drying by heating (see **6.2**);
b) centrifuging (see **6.3**);
c) drying with hot solvent (see **6.4**);
d) immersion in a water-displacing fluid (see **6.5**);
e) blowing with compressed air (see **6.6**);
f) drying by wiping (see **6.7**).

6.2 Drying by heating

6.2.1 *General*

There are several methods of drying by heating:

a) hot air oven;
b) infra-red radiation;
c) blown warm air;
d) hot water.

6.2.2 *Hot air oven*

Heating in an oven at a controlled temperature of 120 °C to 170 °C will effectively dry articles which have been cleaned in aqueous solutions then rinsed in water. It is important that liquid trapped in pockets should have been adequately drained to avoid saturating the atmosphere in the oven with vapour. Lower temperatures will be essential when materials such as low melting point solder, plastics, etc. are part of the construction of the article or, in the case of some light alloys, to avoid a possible change of properties. The air in the drying oven should be circulated to accelerate drying and be continuously replaced by means of a fan to prevent it becoming saturated with moisture. Drying times should be adjusted according to the amount of residual moisture, the mass of the article and the oven temperature.

6.2.3 *Infra-red radiation*

Articles can be dried by passing them 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, the length of the tunnel and the speed of the conveyor. Very large articles may be dried by a build-up of elements around the article. The temperature at the surfaces of the articles being dried should not exceed 175 °C. Lower temperatures may be necessary depending on the nature of the articles.

6.2.4 *Blown warn air*

Blown warm air provides an effective means of drying. The source can be either fixed or portable and a suitable flexible nozzle or extension used as necessary.

6.2.5 *Hot water*

Drying by means of hot water can be convenient after an aqueous cleaning operation. The articles are heated by immersion in clean water at 80 °C to 95 °C until they have reached that temperature. After draining off excess water the articles are exposed to a clean, dry atmosphere. If water is trapped in pockets, it should be blown out with clean dry air as soon as possible after removing the article from the hot water.

6.3 Centrifuging

Centrifuging is recommended only for the drying of small metal parts which have been cleaned or immersed in an aqueous solution prior to treating with corrosion preventives. Typical equipment comprises an enclosed perforated drum approximately 480 mm in diameter, 270 mm deep, and of approximately 14 L capacity which is belt-driven from an external motor. It should have an electrically heated air intake to raise the temperature. The drum should not be filled to more than three-quarters capacity.

6.4 Drying with hot solvent

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, the trichloroethylene liquid cleaning process described in item b) of **3.1.2.1** and calls for specially designed equipment containing a drying compartment and one or more rinsing compartments.

Articles to be dried in hot solvent should first be rinsed at least twice with cold running water.

NOTE 1 The use of soft water for these is not essential.

They should then be dipped in the boiling solution containing the additive for 1 min or less; this removes the water from the metal.

NOTE 2 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 1 min or less in clean boiling solvent in the rinsing compartment; this replaces the solution film by one of pure solvent, which evaporates as the articles are withdrawn through the vapour zone of the plant. 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. The 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 evaporation of hard water. It is not normally used after cleaning by the methods described in clause **3** except where emulsifiable solvent cleaning is used without being followed by cleaning as described in clauses **4** and **5**.

6.5 Immersion in a water-displacing fluid

These materials are volatile solvents containing special substances which 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 Figure 1.

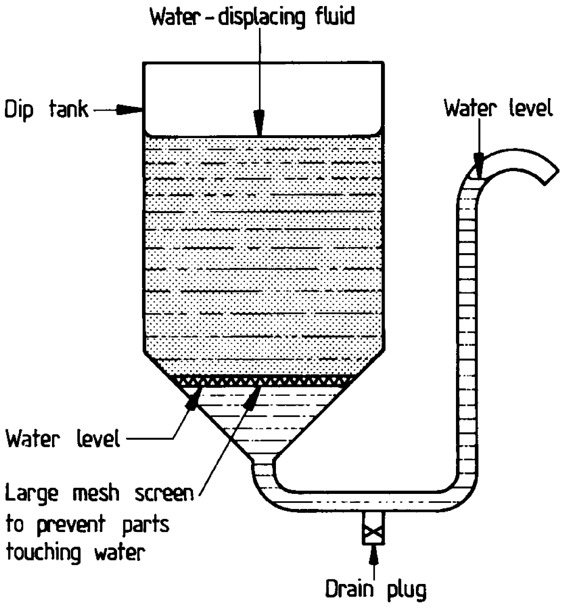

Figure 1 — Possible design of dip-tank for water-displacing fluid

Most of the fluids contain protective bases and so come into the category of temporary protectives against corrosion type TP 1 or TP 2 as described in BS 1133-6.2; by the use of such materials it is possible to dry and protect an article in one operation. These fluids should not be applied to articles having non-metallic parts liable to be damaged by the solvent.

Certain applications may require a water-displacing fluid that does not leave a residual film (e.g. for drying articles that cannot be subjected to heat but which will subsequently be painted or protected by some means other than the application of temporary protectives against corrosion). Such materials are available and recommendations for them are given in Appendix A. Since these solvents are volatile, the articles dry in a reasonably short time, however, they have low flash points and suitable precautions against fire need to taken; on no account should a heated centrifuge be used to accelerate the drying.

6.6 Blowing with compressed air

The compressed air should be dry and free from oil and dirt. Moisture traps should 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 should be fitted. Traps should 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 should be opened when the receiver is not in use and left open until the compressor is used again. On re-using the compressor, air should 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 should 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 air pressure need not be above 0.62 N/mm^2.

6.7 Drying by wiping

This method of drying should be used only if no other method is available.

Cloth or waste used for wiping should be clean and dry, and should not leave lint on dried surfaces. The process should be carried out in two steps; the first should leave an apparently dry surface, and this should then be wiped with a second, clean, dry cloth, to ensure a thoroughly dried surface. Canvas gloves or similar protection should be worn to avoid contamination of cleaned surfaces by sweat.

Table 1 — Guide to selection of cleaning process

Contaminant to be removed	Cleaning materials or process	Scope	Variations of cleaning process	Clause reference in text	Condition of surface after treatment	Cleaning apparatus (see Table 2)	Special points	Safety precautions
Oil, grease, dirt, swarf	Trichloroethylene	All metals and all types of surface and shape	Vapour immersion	**3.1.2.1** a)	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	Local exhaust ventilation, adequate shop ventilation and correct operation of plant to avoid excessive inhalation of narcotic vapour No smoking
			Liquid immersion	**3.1.2.1** b)				
			Jetting	**3.1.2.1** c)				
			Ultrasonic cleaning	**3.1.2.1** d)				
	Petroleum or halogenated solvents used cold	All metals and all types of surface and shape, not heavily contaminated	Immersion or ultrasonic immersion	**3.2.2.1** a)	Dry or from petroleum solvents slightly oily	Tanks or apparatus of special design Continuous or batch operation	Complete grease removal not certain Soaps, sweat or chemical residues not removed	Local exhaust ventilation, adequate shop ventilation No smoking Strict provision against fire risk if petroleum solvents are used
			Brushing or wiping	**3.2.2.1** b)				
			Spray	**3.2.2.1** c)				
	Emulsifiable solvent mixtures	Most metals Parts of accessible shape, not heavily contaminated Care is required when aluminium magnesium, zinc or brass are present	Immersion	**3.3.2.1** a)	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
			In situ	**3.3.2.1** b)		Steam or water jet apparatus	Suitable for large assemblies which cannot be dismantled	

Table 1 — Guide to selection of cleaning process

Contaminant to be removed	Cleaning materials or process	Scope	Variations of cleaning process	Clause reference in text	Condition of surface after treatment	Cleaning apparatus (see Table 2)	Special points	Safety precautions
Oil, grease, dirt, swarf *(continued)*	Strong alkaline cleaning solutions or detergents	Ferrous parts of an accessible shape	Immersion	**3.4.2.1** a)	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, eye-shields and rubber gloves to prevent possible damage to eyes and skin during handling
			Electrolytic immersion	**3.4.2.1** b)				
	Mildly alkaline or neutral cleaning solutions or detergents	Non-ferrous metal parts of an accessible shape and general purpose cleaning	Ultrasonic immersion	**3.4.2.1** c)				
			Jetting	**3.4.2.1** d)				
	Organic detergent alone (solution or emulsion) or steam cleaning	Tin plate parts of an accessible shape and light duty cleaning	In situ	**3.4.3.1** **3.5.1**	Wet and possibly slightly oily	Steam injector apparatus	Suitable for large assemblies which cannot be dismantled	
Rust and scale	Mechanical treatment	Ferrous metals Parts of accessible shape and without highly finished surfaces	Shot or grit blasting, barrelling, abrasive treatment	**4.2.1**	Dry	As required for method used	Finish required will decide the particular process used Prior removal of oil, grease, dirt and swarf required	Protection of eyes, skin, lungs and hearing
	Acid pickling or electro-chemical treatment	Ferrous metals Parts of accessible shape	Immersion	**4.2.2**, **4.2.3**, **4.2.4** and **4.2.5**	Wet	Acid-resisting tanks	Avoid hydrogen embrittlement Prior removal of oil, grease, dirt and swarf required	General safety precautions in handling acids and alkalis — protection of eyes, skin, etc Special precautions for cyanide if appropriate
			Electrolytic immersion	**4.2.6**	Wet	Special fittings for electrolytic application	Electrolytic alkaline derusting processes can be used Avoid hydrogen embrittlement Prior removal of oil, grease, dirt and swarf required	
Miscellaneous residues	Washing in water and acid	All metals	Removal of heat-treatment salts	**5.1**	Wet	No special apparatus	Acid not to be used if cyanide is present	As required for the removal of oil, grease, dirt and swarf
			Removal of fluxes	**5.2**	Wet	No special apparatus		
			Removal of sweat residues	**5.3**				

Table 2 — Cleaning flow chart (see Table 1)

Contaminant to be removed	**Cleaning materials or process**	**Handling stages from cleaning to protection**						**Services required**
Group I Oil, grease, dirt, swarf	A Trichloroethylene	Cleaning stage (Group I, A)	→ Group II or III cleaning (as required)	→ Drying as required	→ Protection			Heating cooling water power
	B Cold petroleum or halogenated solvents	Cleaning stage (Group I, B)	→ Cleaning stage (if two-stage method is used)	→ Drying	→ Group II or III cleaning (as required)	→ Drying as required	→ Protection	Heating (for drying) power (for special machines)
	C Emulsifiable solvent mixtures	Cleaning stage (Group I, C)	→ Water rinses	→ Drying (except where Group II or III cleaning follows)	→ Group II or III cleaning (as required)	→ Drying as required	→ Protection	Rinse water
	D and E Aqueous solutions and aqueous solution/steam mixtures	Cleaning stage (Group I, D or E)	→ Water rinses	→ Drying (except where Group II or III cleaning follows)	→ Group II or III cleaning (as required)	→ Drying as required	→ Protection	Heating rinse water power
Group II Rust and scale	F Acid pickling or electro-chemical treatment	Group I cleaning	→ Cleaning stage (Group II, F)	→ Cold water rinse	→ Hot water rinse	→ Drying	→ Protection	Heating rinse water power (for special machines)
	G Mechanical treatment	Group I cleaning	→ Cleaning stage (Group II, G)	→ Protection				Power
Group III Miscellaneous residues (flux, heat-treatment salts, sweat residues, etc	H Washing in water or acid	Cleaning stage (Group III, H)	→ Drying	→ Protection				Heating (as applicable) power (as applicable)

Appendix A Recommended characteristics for water-displacing fluids

A.1 Description

Water-displacing fluids are mobile volatile solvents capable of displacing water from metal surfaces but depositing no perceptible film on evaporation. They are usually hydrocarbon solvents containing suitable wetting agents.

A.2 Recommended characteristics

A.2.1 ***Application***

The water-displacing fluid should be suitable for application by dipping at temperatures of 10 °C to 25 °C.

A.2.2 ***Flash points***

The flash point of the water-displacing fluid should be not lower than 23 °C when tested in accordance with one of the methods for the determination of flashpoint given in Part IV of Schedule 1 of the Classification Packaging and Labelling of Dangerous Substances Regulations 1984, SI No 1244, for example BS 2000-34, BS 2000-170.

A.2.3 ***Stability***

No separation should take place at any stage when the water-displacing fluid is tested in accordance with Appendix B.

A.2.4 ***Water displacement***

When tested in accordance with Appendix C, the test panel, when it is removed from the fluid, should be free from drops of moisture and additionally, after the specified period of exposure under controlled conditions, should show no greater corrosion than the control panel tested at the same time.

A.2.5 ***Emulsifying properties***

Not less than 60 mL of the water-displacing fluid should separate from the sodium chloride solution when tested as described in Appendix D.

A.2.6 ***Non-volatile residue***

The amount of residue should not exceed 1.5 % by weight after heating 50 mL of the water-displacing fluid for 4 h in a flat-bottomed glass dish, about 75 mm diameter by 25 mm deep, on a boiling water bath.

A.2.7 ***Mineral acidity***

When 50 mL of the water-displacing fluid is shaken with 10 mL of neutral distilled water, the water should remain neutral to methyl orange.

Appendix B Stability test

Fill a test tube, 150 mm × 25 mm, to within 25 mm of the top with the material to be tested. Close the tube with a vented cork and subject it to the appropriate temperature cycle shown in Table 3.

Table 3 — Stability test temperature cycle

Type	Temperature cycle
TP 3	100 °C for 16 h room temperature for 8 h
TP 1, TP 2, TP 4a, TP 5, water-displacing solvents	0 °C for 2 h 50 °C for 2 h room temperature for 20 h

Carry out the appropriate cycle on five consecutive days. Allow the tube to stand undisturbed for a further nine days at room temperature.

Examine the contents of the tube closely at each of the stages above for separation of phases or sedimentation of sludge or other material.

Type TP 2 is an exception in this respect and should be examined only at the conclusion of the test.

Appendix C Method of test for water-displacing properties

Select a panel of mild steel, 150 mm × 100 mm × 1.25 mm, complying with CR 3, CS 3, HR 3 or HS 3 of BS 1449 and free from deep pits, scratches or surface imperfections, and drill a 6 mm diameter hole halfway along and close to one of the shorter edges. Burnish with aluminium oxide 240 grit or equivalent on both sides. Thoroughly clean and degrease the burnished panel by swabbing vigorously with pieces of clean cloth or filter paper soaked in petroleum spirit 40/60. Rinse in methanol and dry in a stream of warm dry air. Allow to attain room temperature. Take care not to handle the test surface with bare hands during and after the degreasing process. Immerse the prepared test panel completely in a 3 % aqueous solution of sodium chloride for 30 s. Withdraw momentarily to ensure that the film is complete and re-immerse for a further 90 s. Remove the panel, hang it vertically and allow to drain for 10 s. Completely immerse the panel, avoiding any lateral movement, in the water-displacing temporary protective or water-displacing solvent for 2 min. Withdraw the panel and hang it vertically for 1 h at room temperature.

Suspend the test panel and an uncoated but otherwise similarly prepared control panel vertically in a closed vessel for 72 h at room temperature above a saturated solution of sodium carbonate containing an excess of sodium carbonate.

After 72 h examine the panels for any sign of corrosion.

NOTE Considerable difficulty is frequently experienced in cleaning and degreasing panels in order to obtain metal surfaces that may be wetted completely by water. The method detailed above has been found satisfactory but should it be impossible to obtain a complete aqueous film then the panel should be refinished with aluminium oxide 240 grit or equivalent and the procedure repeated.

Appendix D Method of test for emulsifying properties

Measure 75 mL of the water-displacing temporary protective or water-displacing solvent and 25 mL of a 3 % solution of sodium chloride in distilled water into a 100 mL stoppered graduated cylinder. Shake the cylinder and its contents vigorously for 2 min and then allow to stand undisturbed for 1 h at room temperature.

Record the volume of the separated layers after 5 min and 1 h, or a shorter time provided complete separation is achieved.

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Publication(s) referred to

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BS 1133, *Packaging code.*

BS 1133-6.2, *Temporary protectives and their application.*

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[2] Referred to in the foreword only.

[3] In preparation.

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