

B.S. 1133 : SECTION 6 : 1966

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**TEMPORARY PROTECTION
OF METAL SURFACES
AGAINST CORROSION
(DURING TRANSPORT & STORAGE)**

**B.S. 1133
PACKAGING CODE**

BRITISH STANDARDS INSTITUTION

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BRITISH STANDARDS INSTITUTION

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THIS SECTION of B.S. 1133, 'Packaging Code', having been approved by the Packaging Standards Committee, was published under the authority of the General Council on 7th March, 1966.

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Second revision, March, 1966.

The Institution desires to call attention to the fact that this Packaging Code does not purport to include all the necessary provisions of a contract.

This standard makes reference to other sections of the 'Packaging Code' (see foreword) and to the following British Standards:

- B.S. 265. Cold rolled brass sheet, strip and foil. Common brass.
- B.S. 334. Chemical lead (types A and B).
- B.S. 410. Test sieves.
- B.S. 580. Trichloroethylene.
- B.S. 805. Toluenes.
- B.S. 903. Methods of testing vulcanized rubber.
- B.S. 907. Dial gauges for linear measurement (excluding lever type).
- B.S. 1004. Zinc alloys for die casting and zinc alloy die castings.
- B.S. 1432. Copper for electrical purposes. Strip with drawn or rolled edges.
- B.S. 1449. Steel plate, sheet and strip.
- B.S. 1470. Wrought aluminium and aluminium alloys for general engineering purposes. Sheet and strip.
- B.S. 1673. Methods of testing raw rubber and unvulcanized compounded rubber. Part 3. Methods of physical testing.
- B.S. 1763. Thin PVC sheeting (flexible, unsupported).
- B.S. 2782. Methods of testing plastics.
- B.S. 3189. Phosphate treatment of iron and steel for protection against corrosion.
- B.S. 3370. Wrought magnesium alloys for general engineering purposes. Sheet and strip.
- B.S. 3442. Determination of flash point of petroleum products by means of the Abel apparatus.

The following B.S.I. references relate to the work on this standard:

Committee reference P/139

Draft for comment D 64/3989

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CO-OPERATING ORGANIZATIONS

The Packaging Standards Committee, under whose supervision this Packaging Code was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

- *Association of British Chemical Manufacturers
- Association of Steel Drum Manufacturers
- Board of Trade
- British Carton Association
- British Jute Trade Federal Council
- British Paper Bag Federation
- British Paper and Board Makers' Association (Incorporated)
- British Paper Box Federation
- British Plastics Federation
- British Railways Board
- *British Tin Box Manufacturers' Federation
- Collapsible Tube Manufacturers' Association
- Crown Agents for Oversea Governments and Administrations
- Envelope Makers' and Manufacturing Stationers' Association
- Fibreboard Packing Case Manufacturers Association
- Food Manufacturers' Federation Incorporated
- Glass Manufacturers' Federation
- *Institute of Packaging
- *Institution of Production Engineers
- Ministry of Transport
- Packaging Films Manufacturers' Association
- Paintmakers Association of Great Britain
- *Printing, Packaging and Allied Trades Research Association
- Society of British Soap Makers
- *Society of Motor Manufacturers and Traders Limited
- Timber Container Confederation

The industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this section of the Packaging Code:

British Iron & Steel Federation
British Iron & Steel Research Association
British Refrigeration Association
British Scientific Instrument Research Association
Chamber of Shipping of the United Kingdom
Council of British Manufacturers of Petroleum Equipment
Institute of Marine Engineers
Institute of Petroleum
Institution of Mechanical Engineers
Machine Tool Trades Association
Ministry of Aviation
Ministry of Defence, Army Department
Ministry of Defence, Air Force Department
Ministry of Defence, Navy Department
National Physical Laboratory (Ministry of Technology)
Office of the High Commissioner for Australia
Oil Companies Materials Association
Post Office

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FOREWORD

B.S. 1133, 'Packaging Code', was originally issued in 1943 to give guidance on the packaging of Service and other Government supplies. The Code was, however, in practice used also by civilian packers and it is accordingly being kept up to date.

This Section was first issued (as Section 3) in 1944 and first revised in 1953 and the current edition, while following the same general layout, incorporates some additional material. The order of describing the basic cleaning process has been changed so that all non-aqueous precede all aqueous processes; this conforms to the order in which a two-stage cleaning process may be used. The principal changes in substance are the expansion of the former Subsection E dealing with petroleum solvent cleaning to cover also the similar process of cold cleaning with non-flammable halogenated solvents; and the removal of the spray emulsion cleaning process (now relatively unimportant) into an expanded sub-section covering the use of aqueous solutions and emulsions containing alkaline cleaners, organic materials or both. This leaves under the heading 'Emulsifiable solvent cleaning' the quite distinct processes in which an emulsion is formed after the cleaning stage. A description of the principles of ultrasonic cleaning has been included under the heading of 'Special methods of application', and a reference is made to the use of ultrasonic techniques in connection with the processes to which they can be applied.

Subsection B has been substantially expanded to give more specific descriptions of methods using heat and to incorporate the newly developed process of drying by immersion in hot chlorinated solvent compositions.

In the present edition the range of materials still remains similar to that of the Government specifications, but it has been extended to incorporate two additional types of protective, not included in the 1953 edition, TP 8—Strippable coating, cold applied, and TP 10—Contact inhibitors.

The Institute of Petroleum methods referred to in this Section are those given in 'Standard Methods for the Testing of Petroleum Products'. They are subject to revision at any time and the current versions should always be used. The volume may be obtained from the Institute of Petroleum, 61 New Cavendish St., London, W.1.

The Packaging Code now consists of the following Sections all of which are published separately with the exception of Sections 1–3 which are published in one volume. It may be convenient for readers to know that a binder is available so that any two or more sections can be brought together under one cover.

Sections 1-3 : Introduction to packaging

Section One gives general guidance on the choice of containers, precautions to be taken in the packaging and choice of packaging methods, and notes relating to physical and statutory limitations and packing bay conditions. An appendix describes the categories of methods of packaging recommended by the Services.

Section Two gives recommendations in regard to the storage of packaging materials and deals with covered and open storage, weight limitations, fire hazards, dangerous goods and inspection. Section Three gives guidance on the addressing, marking and labelling of containers.

Section 4 : Mechanical aids in package handling.

Describes briefly the many types of mechanical handling equipment suitable for the moving of packaging materials and filled packages in factories and warehouses. Also gives notes to assist users in selecting equipment and using it to the best advantage.

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

Gives guidance on the avoidance of damage to packages and their contents from attack from moulds, bacteria, insects, mites and rodents.

Section 6 : Temporary protection of metal surfaces against corrosion (during transportation and storage).

Gives guidance on the cleaning and drying of metal surfaces prior to the application of temporary (i.e. easily removable) protectives against corrosion and on the selection and application of these. Performance specifications are included for ten types of protective together with methods of test.

Section 7 : Paper and board wrappers, bags and containers.

Gives general guidance on the use of paper and board in the following forms:

Wrapping papers, waxed paper, greaseproof paper, glassine, vegetable parchment, waterproof paper, wet strength paper, cellulose and other films, foils, laminates, bags, envelopes, multiwall sacks, liners and linings, paperboard cartons and boxes, moulded pulp, and fibre-board cases and drums. Methods of test are also given.

Section 8 : Wooden containers.

Gives general information regarding the styles, design and construction of large framed wooden cases, nailed wooden cases, wirebound wooden boxes, plywood cases of battened and metal edged construction, plywood postal type boxes, wooden casks, plywood barrels, veneer casks, wooden crates, metal-lined cases and closures for returnable cases.

Section 9 : Textile bags, sacks and wrappings.

Describes and defines materials and methods of stitching and closing jute bags. Cotton bags are also dealt with. Methods of baling and the jute materials to be used are described, and typical specifications are given.

Section 10 : Metal containers.

Gives descriptions of the materials and construction for tins and cans, drums, crates, hampers and trays, collapsible tubes and composites. Includes many illustrations of types of containers and their closures. For tins and cans also describes decoration, testing, filling and closing. For collapsible tubes, covers sizes, weights, decoration, filling, and packaging for transport.

Section 11 : Packaging felt.

Covers pressed felts and needle-loom felts for cushioning against shock. It describes 5 types of felt, and methods of proofing. Chemical requirements are specified, together with methods of test.

Section 12 : Cushioning materials and suspension packing (excluding packaging felt).

Gives general information on cushioning, and describes cushioning materials in the form of cellular rubber, cellulose wadding, cotton waste, cork, corrugated and embossed papers, fibreboard, moulded pulp, paper shavings, plastics, rubberized hair, wood wool and miscellaneous cushioning materials. Methods of suspension packing with springs and rubber are described.

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Section 13 : Twines and cords for packaging.

Gives guidance on the types of twine and cords available for packaging and the purposes for which they may be used.

Section 14 : Adhesive closing and sealing tapes.

Gives general guidance, with illustrations, on the uses and various properties of gummed tape and self adhesive tape available for packaging purposes.

Section 15 : Tensional steel strapping.

Gives guidance on the use of tensional steel strapping for packaging purposes. It covers flat band and wire strapping and the machines used for applying both kinds of strapping.

Section 16 : Adhesives for packaging.

Describes the characteristics and use of nine broad groups of adhesives used in packaging, namely:

Animal and fish glues.	Rubber and latex adhesives.
Bituminous adhesives.	Silicates and silicate mixtures.
Natural resins and gums.	Synthetic resin adhesives.
Protein adhesives.	Vegetable adhesives.

Waxes (microcrystalline).

Section 17 : Wicker and veneer baskets.

Gives general descriptions and definitions relating to wicker baskets and hampers and veneer baskets (chips) and punnets.

Section 18 : Glass containers.

Gives general guidance on the types of glass containers available for packaging and describes the factors to be considered when ordering or using them. Details of various forms of closures are also given.

Section 19 : Use of desiccants in packaging.

Gives guidance on the use of desiccated packages, the factors governing the choice of desiccant, determination of quantity of desiccant and general considerations affecting this method of packaging.

Section 20 : Packaging for air freight (excluding livestock).

Gives general guidance on the special problems of packaging for air freight in relation to different types of containers; also includes clauses on the general precautions to be taken in the carriage of machinery, fragile items, restricted articles, obnoxious cargo, and cargo susceptible to variations in temperature. Prohibited packaging materials, labelling and marking are also discussed.

Section 21 : Transparent cellulose films, plastics films, metal foil and flexible laminates.

Gives general information and guidance on the manufacture, properties and uses of various forms of these four types of material.

Section 22 : Plastics containers (in preparation).

NOTE 1. Where metric equivalents are stated the figures in British units are to be regarded as the standard. The metric conversions are approximate; more accurate conversions should be based on the tables in B.S. 350, 'Conversion factors and tables'.

NOTE 2. In place of the customary, but incorrect, use of the pound and kilogramme as units of force, the units called pound-force (abbreviation lbf) and kilogramme-force (abbreviation kgf) have been used in this standard. These are forces which, when acting on a body of mass one pound or one kilogramme respectively, give it an acceleration equal to that of standard gravity.

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SECTION 6

TEMPORARY PROTECTION OF
METAL SURFACES AGAINST CORROSION
(DURING TRANSPORT AND STORAGE)

1. SCOPE

Many metal articles have to be transported and stored, sometimes for long periods, and are then used with their working surfaces in the bare state. Unless these surfaces are protected between manufacture and use, most of them will rust and corrode owing to the effect of humidity or polluted atmospheres. The materials used for such protection are called temporary protectives as they provide protection primarily for the transportation and storage period; the significance of the term 'temporary' lies not in the duration of the efficacy of the protective but in the fact that it can easily be removed so that the protected surfaces can if necessary be restored to their original state. If on the other hand there are corrodible non-working surfaces that must be safeguarded against corrosion during use, they must be covered with longer lasting and more durable materials like paints and varnishes. This Section of the Code deals only with temporary protection against corrosion.

It is very important that the coatings should be applied only to clean and moisture-free surfaces, otherwise their effectiveness may be reduced or even nullified, and the first part of this document, therefore, deals with cleaning methods. The same methods can be used for surfaces that are to be painted, and this is convenient when, as sometimes happens, some parts of an article are to be painted and others coated with a temporary protective.

Corrosion prevention and subsequent packaging must necessarily be considered together. The policy advocated in this Code is to choose the protective to suit the article and provide an adequate standard of protection thereby. Sometimes the nature of the article precludes the required standard of protection being obtained with any of the recommended materials and the subsequent packaging should then be specially chosen to supplement the protective. Apart from these instances, however, the purpose of a package is to prevent mechanical disturbance of the protective coating and to exclude abnormal influences (such as free water and salt spray) in addition to the general functions of preventing mechanical damage, facilitating handling, etc. The temporary protective should not be chosen to suit the package.

If severe conditions in transport or in storage, either at home or overseas, are expected, it may be necessary to use coatings of increased thickness and to provide extra packaging.

New and improved temporary protectives are continually being developed and it has been necessary to restrict the descriptions herein to established and proved methods and materials; newer materials will be incorporated in future editions when they have been given sufficiently wide trial and practice may anticipate such revision of the text.

A. CLEANING

2. GENERAL INFORMATION ON CLEANING

a. 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, which may be defined as any unwanted deposits on the surface of an article, are usually present on items unless definite 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.

b. Choice and application of cleaner. 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 must be carefully selected and properly carried out. In this Section of the Packaging Code, information is given about the most common cleaning problems and the most widely used cleaning methods. It would be impossible to give complete details of all applications, and complex problems should be referred to specialists in the particular fields. The following factors have to be considered:

- (i) Nature of contaminants to be removed.
- (ii) Nature of the materials of which the articles to be cleaned are constructed.
- (iii) Complexity of construction.
- (iv) Nature of the surface.
- (v) Availability of cleaning materials and equipment and hazards involved.
- (vi) Stage at which cleaning is done.
- (vii) Number of articles to be treated.

These points are amplified in the following paragraphs, and a detailed description of cleaning methods is given in later clauses. The principal features are summarized in Table 1 (page 44), which should not be acted on without having consulted this text.

(i) *Nature of contaminants to be removed.* Residues to be removed are frequently present in association with oil or grease. Cleaning with grease-solvents, such as 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 have to 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.

(ii) *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 its detriment and whether it will leave residues which will cause corrosion later. These questions apply particularly to certain degreasing methods.

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 it is necessary to ensure that they are not used where they can cause attack, e.g. on aluminium and its alloys, tin, zinc and brass.

All assemblies incorporating non-ferrous parts therefore require careful consideration and it may be preferable to clean the 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 eventual corrosion may be promoted. 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, trichloroethylene and alkali solutions are not generally suitable. Certain emulsifiable solvent cleaners or petroleum solvents may be used.

There is in general a greater possibility of causing chemical attack and rust or corrosion on metal surfaces by the use of water-soluble cleaners than by the use of trichloroethylene or other solvent cleaners.

(iii) *Complexity of construction.* Only unit parts or very simple assemblies should be cleaned in aqueous cleaners. Parts or assemblies of complex construction should not be so cleaned owing to the risk of trapping cleaning solution that would not be removed by subsequent rinsing and drying. If such assemblies are to be coated with protective and it is impracticable to clean the parts and apply the protective before assembling, trichloroethylene or another solvent cleaner should be chosen, 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 and the like. After cleaning it may sometimes be necessary to handle and store parts in an air-conditioned room having controlled low humidity.

(iv) *Nature of the surface.* The degree of finish or polish and of dimensional accuracy must be considered. Thus, with a casting the light rust stain from fingerprints might be tolerated, but it would spoil a highly finished surface. Again, with highly finished surfaces made to fine dimensional limits, great care must be taken in degreasing to avoid any deposit or staining. Such deposits may be caused by incorrect operation of the particular cleaning method and are more likely to occur with alkaline cleaners than with the others. Articles rough machined, stamped or drawn, may be cleaned by any easily applicable method.

(v) *Availability of cleaning materials and equipment and hazards involved.* 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 part, etc. as detailed above, have been allowed full weight. If the availability of materials and equipment were to be allowed to over-rule these primary considerations, an unsuitable method might be selected. (Corrosion can actually be caused by the application of inappropriate methods of cleaning.) Tables 1 and 2 on pages 44-49 indicate the materials, equipment and services required for each method. The fact that certain industrial hazards accompany the use of cleaning materials should not be a determining factor in the choice of a cleaning method; all materials present certain hazards, but they can easily be overcome. Thus, trichloroethylene, although non-flammable, is narcotic and it is not desirable to breathe the vapour in any high concentration; petroleum solvents present fire hazards, and all organic solvents, if in contact with the skin, have a degreasing effect which may make the skin liable to infection from dirt or germs; alkalis, dry or in solution, have a similar effect on the skin and may cause burns, or damage to eyes, etc. Hot aqueous solutions and hot solvent baths may also cause burns. Nevertheless, all the materials and methods, both chemical and mechanical, described in this Code, have had wide industrial application over a long period and, if suppliers' recommendations and precautions and the relevant statutory regulations are carefully observed, no ill effects to personnel will occur.

(vi) *Stage at which cleaning is done.* 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 at every stage in manufacture if this is 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.

(vii) *Number of articles to be treated.* Most of the recommendations in this Section relate to the treatment of relatively large numbers of parts. Where

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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.

c. Special methods of application. Many of the cleaning processes described in the following Clauses 3 to 20 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 some kind of mechanical means which may be 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.

(i) *Electrolytic cleaning.* This is applicable to solutions that are electrolytes, such as alkaline cleaners and acid pickles. The articles to be cleaned are attached to suitable fixtures and immersed in a solution kept at room temperature. A low voltage current is then passed through the articles and solution, liberating gas bubbles at the surfaces being cleaned: in forming and escaping to the surface of the solution, these bubbles exert a 'throwing off' and scrubbing action which aids cleaning.

(ii) *Ultrasonic cleaning.* This makes use of vibrations in the cleaning liquid, usually at frequencies between 18 kilocycles and 1 megacycle per second, produced by exciting a magnetostrictive or ceramic transducer at its resonant frequency by means of 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 Subclause 4a(iv)) or aqueous detergents (Subclause 12a(iii)) or rust and scale removal by acids (Subclause 17b(ii)).

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

Group I. Removal of Oil, Grease, Dirt and Swarf

A. Trichloroethylene Cleaning

3. GENERAL INFORMATION ON TRICHLOROETHYLENE CLEANING

These clauses relate to 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; choice of 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 harm 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 processes and in equipment similar to those used with trichloroethylene.

4. PROCEDURE FOR TRICHLOROETHYLENE CLEANING

a. 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.

(i) *Trichloroethylene vapour process.* To remove simple films of oil and grease, articles may be subjected to the vapour process, in which the parts are immersed 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 the maximum condensation, the articles should be as near as possible to room temperature (or below) at the time of immersion; they should be passed through or suspended in the solvent vapour until no further condensation occurs, after which point 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.

(ii) *Trichloroethylene liquor process.* Loosely bound contamination that is too great for vapour treatment, such as swarf and 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 the solvent vapour until no further condensation occurs.

(iii) *Trichloroethylene jetting process.* Articles with obstinate dirt deposits that cannot be removed by 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.

(iv) *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.

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

c. Handling precautions. During processing the articles should be placed on hooks or racks or in suitable containers. They should be so arranged that there is adequate opportunity for the solvent to drain from holes, crevices and other irregularities. Parts or assemblies that would trap solvent should be rotated or tilted during the degreasing process to prevent 'drag-out' of trichloroethylene. 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 kept to the 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 degC above room temperature before applying the protective. Cooling to room temperature may cause microscopic condensation on bare metal surfaces.

d. Safety precautions. Since trichloroethylene is narcotic, adequate ventilation should be provided and care taken to avoid breathing the vapour unnecessarily; 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.

No person should enter a pit or vessel which contains trichloroethylene or in which the solvent vapour may be present.

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.

5. MATERIALS AND EQUIPMENT FOR TRICHLOROETHYLENE CLEANING

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

b. 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 generally 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.

* B.S. 580, 'Trichloroethylene'.

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.

c. **Maintenance.** Apart from correct operation during processing, satisfactory trichloroethylene cleaning also depends upon attention being paid to the following points:

(i) *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.

(ii) *Distillation of the trichloroethylene 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 about 50 per cent; this may be determined sufficiently accurately and very simply from the specific gravity. Plants are designed to enable distillation to be carried out easily, or a separate still may be employed for large plants or for a number of smaller units.

(iii) *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 (B.S. 580*, Type 2) is being used.

(iv) *Keeping all internal surfaces clean,* and free from deposits, particularly surfaces through which the liquid is heated.

(v) *Exclusion of water from the degreasing plant.* If there is a possibility of water being introduced, e.g. with oil-water cutting emulsions, a water separator should be fitted.

(vi) *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 may be carried out by shaking vigorously about 25 ml of solvent (condensed

* B.S. 580, 'Trichloroethylene'.

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 check should be carried out by the appropriate one of the following methods:

A. For alkaline stabilized solvent (B.S. 580*, Type 1): To 100 ml of solvent (condensed from the vapour) add 50 ml of distilled water and 4–6 drops of bromophenol blue indicator. Titrate slowly with 0.1N hydrochloric acid, 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 seconds. The total quantity of 0.1N 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, take corrective action by mixing the contaminated solvent with an aqueous solution of sodium carbonate and distilling.

B. For neutral stabilized solvent (B.S. 580*, Type 2): It is necessary to carry out a titration in alcoholic solution. The reagents required are (1) an approximately 0.1N solution of sodium hydroxide in A.R. methanol, standardized against potassium hydrogen phthalate, (2) 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 (the mixture must not be cloudy), and (3) neutral ethanol obtained by titrating A.R. ethanol or industrial methylated spirit with methanolic NaOH in presence of cresol-red indicator until the solution just turns violet.

A 25 ml portion of the dioxan-HCl is measured by pipette into a 250 ml ground neck conical flask, and 10 ml of the trichloroethylene sample is added. A glass stopper is inserted, the liquid is swirled to ensure mixing, and the flask is left to stand 15 minutes at room temperature. Then 25 ml of the neutral ethanol is added and the unreacted HCl is titrated with the 0.1N methanolic alkali, until a violet colour is obtained and persists for 30 seconds (the change of the cresol-red indicator from pink to yellow is ignored). A blank run, with the trichloroethylene sample omitted, is carried out at the same time. If b is the titre (in ml) of the blank, and c that with the sample present, and f is the normality of the methanolic NaOH, then with the above quantities of dioxan-HCl and sample taken, and taking 1.46 as the specific gravity of stabilized trichloroethylene:

$$\begin{aligned}\text{Acid acceptance value} &= (b - c)f \times \frac{40.0}{1000} \times \frac{100}{10 \times 1.46} \\ &= (b - c)f \times 0.274\% \text{ NaOH}\end{aligned}$$

* B.S. 580, 'Trichloroethylene'.

The acid acceptance value of new solvent is normally approaching 0.17 per cent NaOH. Solvent recovered by distillation may show a lower figure but this is normally used in a mixture with new solvent, and in practice it can be safely used in this way if it has any positive acid acceptance value.

B. Cold Solvent Cleaning

6. GENERAL INFORMATION ON COLD SOLVENT CLEANING

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

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

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

7. PROCEDURE FOR COLD SOLVENT CLEANING

a. Processes. The three main methods are outlined below; precise details depend upon the quantity and characteristics of the parts or assemblies to be cleaned.

(i) *Immersion cleaning.* This method may be used for unit parts or assemblies when contamination is light and where the highest degree of cleanness is not essential; it is particularly suitable for hand cleaning 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 one minute. Agitation is desirable, and brushing or scrubbing will aid and speed cleaning. Articles with cavities that may hold the 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 not usually desirable to use ultrasonic techniques with flammable solvents but if such procedure is intended the manufacturer of the generating equipment should be consulted. The energy dissipated in the liquid can be quite high (depending on the type of generator used) and it is possible that intense local heating may be caused, 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 one minute 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.

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

Solvent 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.

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

b. 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 may be dried by wiping. Further reference to these methods is made in Clauses 22, 26 and 27 relating to the removal of water but the methods described in Subclauses 22a and b 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.

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

d. Safety precautions. Petroleum solvents are flammable and suitable fire precautions should be taken when they are used (see Subclause 8a).

The vapour of most halogenated solvents is narcotic. Adequate ventilation should be provided where these are used.

Oil-resisting 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.

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

8. MATERIALS AND EQUIPMENT FOR COLD SOLVENT CLEANING

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

The halogenated hydrocarbons have the advantages of being non-flammable and free from high boiling constituents. Articles cleaned with these solvents dry completely in air and any residual solids can be readily dusted off. These solvents have varying degrees of toxicity, the least toxic being the chlorofluoro-hydrocarbons which, because of their low solvency properties on certain insulating materials are particularly useful for the cleaning of electrical components. Of the chlorinated hydrocarbons 1,1,1-trichloroethane (methyl chloroform) is most commonly used owing to its relatively low toxicity.

b. Equipment. Cold solvent immersion cleaning can be carried out in a simple steel tank when non-flammable solvents are used. Ultrasonic cleaning may be carried out by fitting suitable transducers.

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. Proprietary equipment is also available for spray or jet cleaning in which small articles are placed in a cabinet provided with a transparent hood and solvent is directed on them through a nozzle held in a gloved hand.

c. Maintenance. The solvent should be checked periodically for dirt and moisture and replaced when contamination causes unsatisfactory cleaning, when the dirt (determined by evaporating a measured volume of solvent until only the oily and solid residues remain, and then weighing those residues) reaches 2 per cent 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 and loss by evaporation.

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 see 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.

C. Emulsifiable Solvent Cleaning

9. GENERAL INFORMATION ON EMULSIFIABLE SOLVENT CLEANING

a. Applicability. These clauses relate to 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 degree of cleanliness less than that obtained by trichloroethylene or aqueous cleaning methods but may be employed if a residual trace of the cleaning medium may 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 should not be used on assemblies containing fabrics, rubber or other organic material, unless it has been reliably ascertained that no harm will result.

b. Material. The cleaning agent consists of a solvent, such as kerosine or white spirit, and an emulsifying agent capable of producing an oil-in-water emulsion. Proprietary materials requiring dilution with solvent, and others in ready-for-use form, are available, and should be made up according to the manufacturer's recommendation. In either case no water is added to the cleaning solution, the emulsion being formed during the subsequent water washing stage. (References to the use of cleaning emulsions containing a small proportion of a solvent/emulsifier mixture in water are made in Subclause 13a as the techniques used are similar to those applying to other aqueous detergent solutions.)

10. PROCEDURE FOR EMULSIFIABLE SOLVENT CLEANING

a. Processes. The choice of process will depend on the size and portability of the articles.

(i) Immersion process. This method is used for the general purpose cleaning of small articles with accessible surfaces. The articles should first be immersed in a bath of the concentrated emulsifier/solvent mixture for 1-10 minutes or longer, depending upon the degree of contamination. After the necessary soaking time, the articles should be removed from the mixture and all excess liquid allowed to drain back into the tank. This may require up to 30 seconds. 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 there is no further milky mixture on the surface and should

be followed by a dip in clean running water. If the articles have to be dried, they may finally be immersed in hot water (80–95°C) for 30–60 seconds.

(ii) '*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 does not cause trouble.

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 contact period dependent upon the degree of contamination. After the necessary time to loosen the dirt, the applied mixture should be removed by water, until no further milky mixture remains on the surface.

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

b. Drying. Immediately after final rinsing the parts should be dried in accordance with Clauses 21–27, unless further cleaning in accordance with Clauses 16–20 (removal of rust and miscellaneous residues) is to be undertaken.

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; it is usually desirable to allow the article to cool to 5 degC above room temperature before applying the protective. Cooling to room temperature may cause microscopic condensation on bare metal surfaces.

c. 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 the minimum.

d. Safety precautions. The mixture may contain a flammable solvent and as it is first used without water all the necessary precautions against fire risk should be taken. Emulsifiable solvent mixtures will quickly degrease the skin and any contact should be immediately followed 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 this should be avoided by adequate ventilation or the wearing of a respirator.

D. Aqueous Alkaline and Detergent Cleaning

11. GENERAL INFORMATION ON AQUEOUS ALKALINE AND DETERGENT CLEANING

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

Several methods of processing are available; 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.

12. PROCEDURE FOR AQUEOUS ALKALINE AND DETERGENT CLEANING

a. Processes. The four main methods are described below, but 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.

(i) *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 1–10 minutes 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.

(ii) *Electro-cleaning process.* Electro-cleaning in an alkaline solution (see Subclause 2c(i)) 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 1–5 minutes, and then as the anode for 15–30 seconds. If only one tank without current reversing switches is available the articles should be cleaned for 1–5 minutes as the anode only.

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

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 Clause 16) 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.

(iii) *Ultrasonic cleaning process.* Ultrasonic vibrations (see Subclause 2c(ii)) 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.

(iv) *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 jiggled, suspended or placed in baskets, in such a position that the jets or sprays can reach all surfaces that require cleaning.

b. 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 conveyORIZED jetting and spraying machines the rinsing is usually with water jets; otherwise the articles should be transferred from the cleaning tank to a cold running water rinse tank. 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 much reduces the amount of water needed to give effective rinsing.

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

c. Drying. Immediately after final rinsing the parts should be dried in accordance with Clauses 21–27, unless further cleaning in accordance with Clauses 16–20 (removal of rust and miscellaneous residues) is to be undertaken.

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; it is usually desirable to allow the article to cool to 5 degC above room temperature before applying the protective. Cooling to room temperature may cause microscopic condensation on bare metal surfaces.

d. 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 the minimum.

e. 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.

13. MATERIALS AND EQUIPMENT FOR AQUEOUS ALKALINE AND DETERGENT CLEANING

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

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

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 avoiding 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 per cent 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 only in very small proportion.

Where hard water only is available this may be softened. The addition of a small proportion of sodium hexametaphosphate is useful; usually 1 g/l, about 1½ oz in 10 gal, will be adequate.

Solutions of organic surfactants alone are usually harmless to any metal, but as they have a less vigorous action they require a longer period of contact than alkaline cleaners and are unsuitable for dealing with very greasy surfaces. Such solutions are an effective means of cleaning tinplate without damage but

not all surfactants are suitable for this purpose and a 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 30–60 g/l (3–6 lb in 10 gal) of water of an alkaline mixture is necessary for immersion cleaning, and of 5–30 g/l ($\frac{1}{2}$ –3 lb in 10 gal) water for jet cleaning. An operating temperature of 80–95°C is generally recommended. If surfactants are used alone then concentrations of the order of 1–10 g/l (2 oz–1 lb in 10 gal) of water are normally used at room temperature though should jet cleaning be 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.

b. Equipment. All apparatus for cleaning with aqueous detergent solutions or emulsions needs to be provided with heating arrangements unless one of the cold processes specified in Subclause 12a 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; preferably, agitating may be provided by 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 furnish direct current of density 270–540 amp/m² (25–50 amp/ft²) of surface being cleaned. The voltage will normally be between 4 and 8 volts, but will depend upon the electrical resistance of the cleaning solution, the articles, the suspension racks, etc.

Proprietary 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, electrocleaning and ultrasonic cleaning may also be provided with conveyors for continuous or automatic operation.

c. Maintenance. Regular concentration checks should be made on alkaline solutions at an interval determined by experience. The solutions should be completely renewed when the oil and sludge content prevent satisfactory cleaning.

Accumulation of sludge should be prevented by periodical 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.

E. Steam Cleaning

14. GENERAL INFORMATION ON STEAM CLEANING

These clauses relate to the use of a jet of high pressure steam for the 'in situ' cleaning of large unit parts, assemblies and machinery that cannot be accommodated in a cleaning apparatus. Steam cleaning should not be used where delicate mechanisms are found. The cleaning may be carried out with pure steam or with aqueous detergent solution/steam mixtures.

After cleaning, the parts may have traces of the original contamination and of water or cleaning solution on their surfaces.

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

15. PROCEDURE FOR STEAM CLEANING

a. Processes. Where a steam supply is available it can be used in conjunction with a simple 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. Straight 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, as described in Subclause 13a; the mechanical action of the steam usually permits the use of lower concentrations of detergent than are required for immersion cleaning. Special steam cleaning equipments are available which produce steam at pressures up to 10 kgf/cm² (150 lbf/in²) within a few minutes of starting from cold; they permit an immediate change-over from detergent solution/steam to straight steam or vice versa.

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

c. Drying. The raised temperature of the surfaces subjected to high pressure steam helps the drying, but parts retaining moisture should immediately be

dried by blowing with compressed air (see Clauses 21–27), unless further cleaning in accordance with Clauses 16–20 (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 should be applied without delay otherwise corrosion may occur very quickly; it is usually desirable to allow the article to cool to 5 degC above room temperature before applying the protective. Cooling to room temperature may cause microscopic condensation on bare metal surfaces.

d. 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.

e. 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. Due care should be taken to avoid steam burns.

Group II. Removal of Rust and Scale

16. GENERAL INFORMATION ON REMOVAL OF RUST AND SCALE FROM STEEL PARTS

a. General. Rust may be present after degreasing owing to exposure to corrosive conditions during manufacture. Owing to its hygroscopic nature, rust retains a certain amount of water, and further corrosion may thus occur underneath a deposit of rust. It is therefore necessary that rust be removed before application of protectives.

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

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

- (i) mechanical (e.g. shot-blasting, sand-blasting, 'barrelling', abrasive treatment);
- (ii) chemical (e.g. acid pickling or electro-chemical treatment).

b. 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.

It should be noted that special methods of pickling may be required for high alloy steels. Owing to the wide diversity of composition and requirements, no detailed recommendations can be made; specialists should be consulted.

c. 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 is preferably not used on steel having an ultimate tensile strength greater than 102 kgf/mm² (65 tonf/in²). If this cannot be avoided the pickling must be followed immediately with a low temperature heat treatment. Much of the absorbed hydrogen is gradually released during storage or more rapidly at elevated temperatures, e.g. after an hour either in boiling water or in an oven up to 250°C.

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

d. Safety precautions. Safety precautions and statutory regulations should be observed where appropriate with both mechanical and chemical methods. Thus, 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.

17. METHODS OF REMOVAL OF RUST AND SCALE

a. Mechanical methods. Shot or sand 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.

Shot blasting produces a coarser finish than sand blasting, but involves less hazard to the health of the operator. 'Barrelling' with various types of abrasives

is effective, but has the disadvantage that corners may become rounded in the process. The method chosen depends on the finish required.

It should be noted that scratch brushing will remove only loosely adherent scale or rust; the closely adherent underlying layers, though burnished, are not removed.

b. Chemical methods: sulphuric or hydrochloric acid pickling. (i) 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 may thus be unsuitable for parts of complicated shape, particularly those containing narrow channels or blind holes that cannot be properly washed out, or parts with porous surface layers. The following types of components should, therefore, not normally be treated with these acids:

Parts built up by riveting, spot welding, or similar methods. Cast-iron parts owing to the possibility of occlusion of pickling acid in porous surface layers.

Ferrous articles with associated non-ferrous or non-metallic parts should not be pickled because of the risk of attack or of electrolytic effects, and because acid may be trapped at the join.

(ii) For the operation of sulphuric or hydrochloric acid pickling, various types of acid-resistant tanks are available, e.g. lead (for sulphuric acid), glass or glazed earthenware; wood, steel or concrete lined with rubber or other acid-resisting materials may also be used.

Several efficient inhibitors to reduce acid attack on the base metal are available commercially and one of these should be employed; it is necessary to adhere strictly to the manufacturer's instructions regarding suitability, concentration and method of addition.

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

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

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

Pickling may be accelerated to some extent by mechanical agitation of the parts or of the solution, and sometimes by lightly scrubbing off deposits that have loosened in the acid bath. Alternatively, the pickling action may be facilitated by the use of ultrasonic vibrations (see Subclause 2c(ii)). 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. The limiting iron (Fe) contents are of the order of 35 g/l for hydrochloric acid pickle and 16 g/l for sulphuric acid pickle.

(iii) 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 the washing by a treatment in one of the following alkaline solutions.

- a. Sodium carbonate (soda ash) 10–20 g/l (1–2 lb in 10 gal)
- b. Soda crystals (washing soda) 25–50 g/l ($2\frac{1}{2}$ –5 lb in 10 gal)
- c. Sodium silicate (water-glass) 3–6 per cent solution of 140° Tw.
- d. Caustic soda 5 g (8 oz)
Trisodium phosphate 7.5 g (12 oz)
Water to 1 litre (10 gal)

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 Clauses 21–27, and coated with protective as soon as possible.

c. **Chemical methods: phosphoric acid pickling.** 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 B.S. 3189*.

(i) *Rust removal with phosphoric acid.* Light rust can be removed by immersion in cold phosphoric acid, or in proprietary liquids based on phosphoric acid and substantially free from other mineral acids, diluted for use according

* B.S. 3189, 'Phosphate treatment of iron and steel for protection against corrosion'.