

STORAGE, PRESERVATION & ECONOMIC UTILISATION OF ENGINEERING MATERIALS

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ABSTRACT

The various types of deterioration and damage suffered by the Engineering Stores and their causes are discussed ; some remedial measures to ensure correct storage and proper preservation are indicated.

SECTION I—GENERAL

Introduction

One of the problems which faced the Engineers in recent years is the protection, conservation, preservation and economic utilisation of Engineering stores, machinery and equipment. The subject is vitally important in view of the susceptibility of the engineer materials to deterioration and consequent failure under the tropical conditions prevailing in our country which is subject to diurnal and seasonal variations in temperature and humidity. Apart from the great economic loss involved thereby, operational efficiency will be reduced by unreliable tools, equipment and machinery which may give a false sense of safety in handling. Therefore, work on "tropic proofing" *ie*, protecting materials against deterioration under tropical conditions of storage and use, has been receiving high priority.

2. Large volume of Engineering stores, most of which is imported at high cost, is normally held for use. The industrial potential in this country has not yet reached high enough as to eliminate imports in foreseeable future in respect of engineer plant and machinery. Even in regard to indigenous manufacture, the quality standards are still in the process of rigorous enforcement, and there is no knowing as to when production attains perfection with respect to durability and serviceability. Even if pre-treatment is given to engineer stores during their manufacture to make them resistant to deterioration, still that does not confer permanent protection against agencies which attack after fabrication and during storage and use.

3. It is, therefore, intended to discuss in the following paragraphs (a) the types of deterioration/damage suffered by the engineering materials, (b) the factors responsible for the damage, (c) the control measures against the damaging agencies, and (d) the methods of preserving some specific and typical engineer stores, machinery and equipment.

Types of deterioration suffered by engineer stores

4. Engineer materials are liable to undergo deterioration during storage and use due to (a) activities of living agencies such as moulds (fungi), bacteria, insect pests and rodents, or (b) by unfavourable physical conditions such as moisture, heat and light. Materials like timber (*e.g.* legs, sleepers, squares,

beams, planks, boards and scantlings, ballies, handles, shelves, plywood) bamboos, wall boards/pulp boards textiles and brushware are susceptible to be damaged by biological agencies. On the other hand metallic stores (eg iron mongery like bolts, nuts, screws, spikes, nails and rivets; rolled steel items like angles, bars (flats, rounds), beams, plates, sheets, channels, wire products like flyproof wire netting, mosquito proof wire netting, wire netting galvanised, steel wire rope, expanded metal, barbed wire etc., water supply stores (eg mild steel tubing and fitting, cast iron piping and specials, tubes, bends, elbows, flanges, sockets etc.) tools, plants and machinery; mechanical engineering equipment; and electrical stores are susceptible to be damaged by non-biological agencies which lead to rusting of ferrous items and corrosion of non-ferrous items. In addition chemical deterioration and loss may occur in engineering accessories like rubber, plastics, leather, paints, enamels, varnishes, lacquers and dopes, petrol, fuels and lubricants, acids and chemicals etc. Obviously in view of the wide range of these stores, and the different purposes to which they are utilised, it will not be possible to describe fully the preservation of each and every store, but the cardinal principles in regard to their storage, stacking, packing and turnover will be dealt with, and these are generally applicable to all of them.

Factors responsible for damage

5. (a) *Biological damage*—Organisms like insects and microbes need for their growth (i) food, (ii) oxygen, (iii) moisture and (iv) optimum temperature. In materials like timber the food (*viz.*, starches and sugars) and adequate moisture (unless thoroughly seasoned) are available. Oxygen is abundantly present in the atmosphere in free state and in the timber itself in the combined state. The tropical temperatures in India are quite conducive for growth of insects and moulds. Under these conditions, the pests thrive and destroy susceptible materials.

(b) *Non-biological damage*—Heat, light, humidity, effect of corrosive agencies (acid fumes, alkaline contact *e.g.* marine corrosion, submerged sea water corrosion etc., contamination with foreign impurities etc.) chemical reaction will lead to non-biological damage.

Control measures against damaging agencies

6. (a) *Against biological agencies*—(i) Insect proofing and insecticidal treatments (*e.g.*, treatment of timber by means of insecticides, *e.g.*, creosote, copper naphthenate, ascu etc.) timber should be thoroughly seasoned before acceptance for use. Seasoning means reduction of the excess moisture in unconverted timber to the minimum level. This is achieved by air seasoning (*i.e.*, drying in air), kiln seasoning (*i.e.*, exposing to hot air), electrical seasoning (*i.e.*, passing electricity at high frequency through timber), chemical seasoning (*i.e.*, with such dehydrating materials as calcium chloride) or vapour seasoning (*i.e.*, pickling with volatile solvents like xylene or toluene) and other similar methods. Air seasoning is commonly adopted.

Stacking of timber is also important. This may be either vertical or horizontal. The storage may either be aquatic or terrestrial (for short term storage). Poles and ballies should be crosspiled. Legs should be stacked in a 'solid' manner (*i.e.*, without leaving air spaces between the legs). Thin squares, sleepers and thick scantlings should be stacked 'one by nine' and 'two by nine' methods. Thin scantlings, boards and planks may be 'box-piled'.

Use of 'anti-termite dunnage', 'termite-proofing' of ground, and storage areas are also important. One of the methods of control of termites is to construct buildings in such a way that all timber is made inaccessible to termites, or so that the approach of the latter is readily noticed. The first and foremost obvious precaution is to keep away from contact with the ground all untreated timber. Use of termite barrier is therefore, necessary (*e.g.*, timber-framed buildings on concrete piers with metal termite barrier and metal collar on pipe; continuous concrete termite barrier and concrete floor; filling joints with bitumen), insertion of strip metal in the joints between concrete floor and termite barrier; concrete foundations and plinths etc.

(ii) Rot proofing and fungicidal treatments (*i.e.*, providing dry conditions of storage by means of top covers, ventilation and dunnage, and treatment with chemicals like copper naphthenate, sodium pentachlorophenate etc.).

(iii) Rotproofing of godowns (*i.e.*, provision of pucca floors, walls and roof; tight fitting doors and windows, fitting in plate along the bottom 6" of the outer surface of the doors; provision of 1/2" wire netting to windows; wire netting ends of drain pipes etc., rat trapping and rat destruction by poison baiting).

(b) *Against non-biological agencies.* Protective coatings, dry storage etc., are discussed below.

Preservation of Metal Stores

Metallic stores undergo corrosion.

Types of Corrosion

7. The following are some types of corrosion normally encountered in respect of metallic stores:—

- (a) Direct attack, *i.e.*, uniform damage all over the surface as in pickling. (The loss due to this is by far the greatest).
- (b) Galvanic corrosion, *e.g.*, in galvanised roofing sheets, plated stores.
- (c) Concentration cells, *e.g.*, in sieves (involving metal crossings.)
- (d) Pitting, *e.g.*, in aluminium articles, stainless steel to sea water.
- (e) Intergranular, *e.g.*, in stainless steel (cast) acid pump bodies.
- (f) Dezincification, *e.g.*, in brass articles turning into porous copper mass.
- (g) Stress corrosion, *e.g.*, in extruded metal items.
- (h) Erosion, *e.g.* in elbows of fume ducts, turbine blades, propeller fans.

Methods of Corrosion Prevention

8. A—Applicable at the designing or manufacturing stage

(i) *Modification of design*—Modification of design may take various forms depending on the special circumstances of each case. In general, the underlying principle is the elimination of contact between dissimilar metals thus minimising corrosion due to galvanic action, (*e.g.*, the rapid failure of galvanised iron tanks in hot water systems in which copper pipes are installed or corrosion of a steel propeller shaft in contact with a copper sheath and a gun metal sleeve).

(ii) *Alteration of metal*—Iron in a more or less pure state is much more prone to corrosion than if blended or alloyed with other metals like nickel or chromium, (*e.g.*, addition of chromium, nickel or manganese such as in the stainless steel.)

B—Applicable during storage

Alteration of environments, *e.g.*—

- (i) By leading corrosive smokes from factory chimneys as far away as possible, or by chemical 'trapping' of the corrosive parts of the smoke.
- (ii) Adding materials like sodium benzoate in the water circulating in radiators of IC engines in order to prevent rust formation in the radiators.
- (iii) Vapour phase corrosion inhibitors for wrapping, *e.g.* use of packing paper coated with sodium benzoate or nitrite.

9. *Protective coating*—Coating surfaces of corrodible metals with impervious films so that agencies responsible for corrosion are not allowed to come into contact with the metal surface.

10. Application of even the best preservative loses much of its value unless the metallic surface is thoroughly derusted and cleaned. Consequently, before a preservative is applied, it should be ensured that the parts being preserved are free from (i) dust, sweat from handling, metallic residues from machining, greases, oils (ii) rust and (iii) moisture. The degree of this cleaning is required to be very high if a metallic coating is to be given on the store.

11. Cleaning and degreasing prior to preservation of metal stores with corrosion preventives

An appropriate method of cleaning has to be employed.

The choice of the method will depend upon the following factors:—

(a) *Composition of the part to be cleaned*—The cleaning material should not attack the metal surface chemically, nor should it leave irremovable residues which will cause corrosion later.

(b) *Nature of the parts surfaces*—The degree of finish or polish and the degree of dimensional accuracy must be considered.

(c) *Complexity of construction*—Parts or assemblies of complex construction should not be cleaned by any process which involves the use of water owing to the possibility of trapping portions of the cleaning material which would not be removed in subsequent rinsing and drying operations.

(d) *Nature of contaminants to be removed*—To remove oil or grease either solvent cleaning or alkaline cleaning may be selected, provided the surface finish does not exclude alkaline cleaning. Sweat may be removed by methanol. Inorganic contaminants (*e.g.*, particles or metal or metallic salts) may be removed by alkaline cleaning.

(e) *Degree of cleanliness required*—The degree of cleanliness will vary in direct proportion to the finish, dimension and importance of surface.

(f) *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 when the other primary factors of composition, surface, complexity of construction and contaminant permit.

(g) *Time of cleaning*—Prior to derusting.

12. *Methods of cleaning.*

(a) *Solvent cleaning.*

(i) The solvents generally used are white spirit, oil kerosene superior and trichloroethylene. Stores can either be dipped in them or sprayed with them. Scrubbing the store while it is dipped or sprayed is very helpful.

(ii) This process is used when a high degree of cleanliness is required. It is also used where the cleaner is likely to be trapped in channels or depressions. It should not be used for assemblies containing fabric, rubber or other organic materials likely to be damaged thereby.

(iii) It is then followed by sweat removal in the case of highly finished bright surfaces. Methanol or special solvents, *e.g.* petroleum solvent containing 5-20 per cent of soap and 5-10 per cent of water, are used for removing sweat and similar residues.

(iv) Trichloroethylene may be used in the form of vapour. The liquid in a covered tank is heated to 70-75 °C and the store suspended in the vapour.

(b) *Alkaline cleaning.*

(i) Typical alkaline cleaner for ferrous parts contains:—

6-8 oz of mixture of equal parts of "tridodium phosphate, sodium metasilicate, caustic soda and soda ash" in one gallon of water plus some resin soap (sodium resenate). It is used at 180 °F,

(ii) For aluminium, its alloys and zinc base die castings; 6-8 oz of mixture of trisodium phosphate and sodium silicate per gallon of water at 190 °F,

(iii) Alkaline cleaning is not suitable for porous articles or parts and assemblies that will trap the solution. It may also dull highly finished surfaces.

(iv) Excess of alkaline solution must be quickly drained from the article before washing.

(c) *Emulsion cleaning*

1-10 per cent of kerosene superior or white spirit in water used at 105-180 °F, Degree of cleanliness less than (a) and (b). The emulsion must be quickly drained from the article before it is washed.

'Washing Store', subjected to alkaline or emulsion cleaning, must be thoroughly washed in a tank with running water followed by a minute dip in water at 80-95 °F

Removal of rust

13. Some of the methods of derusting are as follows:—

A-Mechanical

(i) Scratch brushing with rust looseners like kerosene oil or 10 per cent solution of 50 : 50 mixture of lime and caustic soda at 60 °F. Internal surfaces of pipes may be derusted with Flexotube apparatus.

(ii) Sand papering.

(iii) Rumbling for small stores like nails, rivets, washers, *i.e.* stores without threaded parts or complicated construction. The stores are mixed with sand or saw-dust in a drum or other suitable container which is then revolved for necessary duration.

(iv) Derusting of internal surfaces of cans or drums is done by vigorously rumbling them with iron chains inside. The drums or barrels are then flushed with kerosene oil inferior quality.

(v) Sand or shot blasting—Sand or lead shot is 'rained' with considerable force on the surface to be derusted until rust is removed. Suitable only if finely polished smooth surface is not desired.

The loosened rust particles after mechanical derusting, should be removed by cleaning with white spirit or kerosene oil superior.

B—Physical

Oxyacetylene flame cleaning process—The flame cleaning process consists of 'scrubbing' steel surfaces with a series of closely spaced oxyacetylene flames that have an extremely high temperature. As a result all mill scale that is not tightly bonded to the steel is caused to crack off due to the sudden differential expansion between the scale and the base metal. After this treatment the surface is scrubbed clean. The process is not used for steels of thickness less than 3/16".

C—Chemical

(a) Chemical methods of derusting depend on treating the store in either hydrochloric, sulphuric or phosphoric acid of suitable concentration. The following type of components should not be pickled in sulphuric or hydrochloric acid.

(i) Stores having complicated shape, or narrow cavities, channels.

(ii) Rivetted or welded parts, and stores fabricated from these.

(iii) Stores containing non-ferrous attachments, or coatings of paints, or organic materials.

(iv) Cast iron parts—(Cast iron parts can be derusted in hydrochloric acid provided they are subjected to machining operations after derusting).

(v) Steel having tensile strength of more than 65 tons per sq. inch.

(vi) Galvanised or tinned stores.

(b) Derusting by hydrochloric acid

(i) Containers—Glazed earthenware or glass containers can be used where available. The size and capacity of the containers will naturally depend on specific requirements. Leakproof wooden vats or tanks made from acid resisting bricks may also be used.

(ii) Strength of acid bath—a mixture prepared by diluting 1 volume of the concentrated acid with $1\frac{1}{2}$ to 2 volumes of water may be used.

(iii) Addition of glue to the acid mixture—1 lb per 10 gallons of solution.

(iv) Temperature for pickling—Room temperature.

(c) *Derusting by sulphuric acid.*

(i) *Containers*—Glazed earthenware or glass containers or containers lined with thick lead sheet may be used. Tanks made from acid resisting bricks may also be used.

(ii) *Strength of acid*—A mixture prepared by adding gradually 20 parts of concentrated sulphuric acid to 80 parts of water.

(iii) *Addition of glue to the acid mixture*—Same as at (b) (iii) above.

(iv) *Temperature for pickling*—140 to 160° F. This acid is cheaper than hydrochloric acid.

(d) *Derusting by phosphoric acid.*

(i) *Containers*—Steel or iron tanks for cold acid solution. Lead lined tank for hot acid solution.

(ii) *Strength of acid and temperature*—25% phosphoric acid to treat the stores at room temperature when there is light rust.

10—15% phosphoric acid to treat the stores at 185° F. when there is heavy rust.

(iii) *Addition of glue is not necessary.*

Phosphoric acid is costlier than hydrochloric and sulphuric acids.

Phosphoric acid solution in water with 1-2% of a wetting agent may be used in lieu of phosphoric acid. The solution should be diluted with 2—4 parts by volume of water.

(e) Economy in phosphoric acid can be effected by the use of *Footner's process* which consists of (i) pickling in 5% sulphuric acid at 140 to 150° F. for 15 to 20 minutes (or until all scale and rust is removed), in inhibitor like glue should be used, (ii) washing in water at 140 to 150° F. (iii) immersion for 3 to 5 minutes in 2 percent phosphoric acid containing 0.3 to 0.5 per cent of iron phosphate at 185° F.

Removal of corrosion products from non-ferrous metal surfaces

14. (a) *Brass and Copper*

(i) *Bright dip*—Pickle the store at room temperature for not more than 20 seconds in a mixture of sulphuric acid concentrated 80 lbs., nitric acid concentrated 10 lbs., hydrochloric acid concentrated 0.175 lb., water 5 gallons.

(ii) *Scale dip*—Pickle at room temperature for 1-2 minutes in a mixture of sodium dichromate crystals 10 lbs., sulphuric acid concentrated 3.75 lb., water 5 gallons.

(b) *Aluminium*

Pickle at 200—212° F. for 45 minutes in a mixture of 0.75% (wt.) chromic acid., and 0.5% (vol.) phosphoric acid, in water.

(c) Unanodised aluminium alloys

Pickle at 212° F, for not more than 15 minutes in a mixture of phosphoric acid 6 lbs.,

Chromic acid 2 lbs., and Water 10 gallons.

(d) Zinc die-casting alloy and magnesium alloys

Immerse at boiling temperature for not more than 15 minutes in a mixture of chromic acid 1 lb., water 1 gallon.

Washing parts after acid pickling and before applying corrosion preventives

15. As at para 12 above.

Drying after degreasing or removal of corrosion products

16. There are five methods of drying:—

- (a) Blowing with prepared compressed air.
- (b) Drying in an oven.
- (c) Immersion in fluid water displacing.
- (d) Wiping with a cloth.
- (e) Use of boiling water.

Method (d) wiping with a cloth, should only be adopted if facilities are not available for any of the other methods. Method (c) immersion in fluid water displacing is the most efficient and at the same time most nearly 'fool-proof' since it simultaneously provides a thin film of corrosion preventive which generally also possesses some perspiration resistant qualities for protection during subsequent handling. If method (a) blowing with compressed air is used where heavy quantities of water have to be removed, the parts should in addition be dried in an oven. Stores washed in water, if dipped in boiling water will dry quickly.

Selection of preservatives

17. There is no universal corrosion preventive. The use of a wrong preservative may actually ruin the store. Certain factors are given below as a guide to the selection of the proper preservative:—

(a) *Composition of the part to be preserved*—The possible chemical reaction of the preservative (i) with the metal surfaces highly finished copper or brass and similar metals, or parts plated with cadmium or zinc which may be stained by some of these preservatives and become unserviceable, (ii) with rubber, leather, cork, paper, fabric, plastics or other non-metallic parts has to be considered.

(b) *Nature and function of the parts surfaces*—The degree and/or type of finish are the main points to be considered. Preservative for plated items should be selected to fit or add some particular property necessary with the metal treatment being used. On highly finished surfaces which are usually held to extremely close tolerances, the preservatives to be applied should either be easily removable, or be a type which may be left in place without affecting functioning of the assembly. Similarly for small delicate parts, preservatives of the heavy type are usually unsuitable.

(c) *Complexity of construction*—In case of close fits, the heavy types of preservatives or the hard or semi-hard films will not be suitable as they may prevent subsequent assembly.

(d) *Type of exposure and preservation required*—The choice of preservative is affected by such factors as high atmospheric humidity, water immersion (fresh or salt), corrosive atmospheres, high temperatures with consequent run-off of preservative, wide temperature fluctuations with consequent water condensation, mechanical impact conditions, or any combination of these.

(e) *Other functions required of the preservative*—Where the preservative should function also as lubricant (e.g. in respect of ball bearings, pistons), a suitable material with such dual purpose, e.g. mineral Jelly GS may have to be selected.

(f) *Nature of packing to be used over the preservative*—When selecting a particular type of preservative it is important to consider whether and how the treated parts are to be wrapped and packaged, e.g. items preserved with soft film type of preservatives require to be wrapped in Grease Resisting paper or covered with gunny. If the packaged parts are to be exposed to rain, salt water, high temperatures, the method of preservation should be correlated with the packaging.

(g) *Ease of removal or necessity of removing the preservative*—Where it is necessary to remove the preservatives, they must be readily removable by wiping with rags or by petrol.

(h) *Availability of material*—Where correct preservative is not available best possible substitute should be used.

(i) *Difficulty of application*—Only approved means of applying the materials should be adopted. Suitable methods should be devised for this purpose.

Lubricating oils or greases are not necessarily suitable for use as preservatives. Straight mineral oil type compounds are not efficient as preservatives.

Preservatives compounded specially for preventing corrosion, and consisting usually of surface active materials or inhibited oils, provide much better protection, and for this reason only approved preservatives should be used.

Preservative coatings

18. (a) *Metallic Coatings* like lead, tin, zinc, nickel and chromium are given during manufacture.

(b) *Non-metallic coatings*

(i) *Paint*—This is the cheapest and commonest method of preservation of metal stores. The choice of the particular paint is guided by (i) the nature of the pigment and its effect on the corrosion rate, (ii) the permanence and impermeability of the vehicle used in the paint and (iii) the general durability and appearance after long exposure. The surface of the metal store should be thoroughly cleaned before the application of the paint. Some of the paints commonly used are aluminium paints, bituminous black paints, red oxide paints, red lead paints.

(ii) *Lacquer or varnish* is used in coating the internal surfaces of tins and cans for processed food.

(iii) *Oxide coating*—A thin layer of oxide of the metal is formed by heating the iron part in various media.

(iv) *Phosphate film*—A thin layer of iron phosphate is formed by the action of iron part with suitable chemicals.

(v) *Coat of bituminous material*—This consists in coating metal surfaces with coal tar pitch or petroleum pitch in which are incorporated suitable quantities of fabric (e.g. asbestos fibre) and fillers (e.g. kaolin, china clay) to increase its flexibility. Soon after the application of hot bituminous coating, a thin layer of sand is sprayed on the surface to reduce the effect of temperature changes.

(vi) *Temporary corrosion preventives*—These materials accord temporary protection to metal surface on application. The advantages of these preservatives are that they are easily removable, and the store can be taken into use without much difficulty. The disadvantages are due to their limited protection, and in some cases the need for subsequent wrapping. These are broadly divided into 3 groups according to the type of film that these preservatives leave on the surface on which they are applied:

Group I—On application leaves a *thin tough film*; cannot be easily removed by abrasion; contain bitumen, resin and other types of solid ingredients which are soluble in petroleum solvents.

Group II—*Thick soft film*, e.g., Grease, Mineral Jelly.

Thin soft film—e.g., wool fat based preservatives.

Group III—*Oil type film*, e.g., mineral oils.

19. Methods of application of preservatives

(a) *Dipping*—The parts or assemblies should be coated by completely submerging them in a bath of preservative. The period and position of immersion should be such that all trapped air is allowed to escape, thereby permitting a continuous coating to be applied on the piece.

(b) The temperature or solvent content condition of the preservative bath depends on the type of preservative used and the thickness of coating desired.

If the period of dip is too short an excessively thick film will be obtained resulting in waste of preservatives and difficulties in handling.

(c) *Spraying or fogging*—When spraying is necessary and preservatives are viscous or solid, the preservative should be reduced to spraying consistency preferably by heat, or by diluting with a volatile solvent such as white spirit.

Parts coated by spraying with preservative thinned by heating should be near room temperature and parts coated with preservative thinned by solvents, should if possible, be warm in order to accelerate the 'setting' of the coating to the proper consistency.

(d) *Brushing*—When the preservative is too thick for satisfactory application by brushing it should be reduced by heating. If the nature of the material and the desired coating permit, it may be reduced by diluting with a volatile petroleum solvent such as white spirit but such dilution should be avoided if possible.

The brushes should be clean and the parts should not be touched with bare hands or dirty gloves while brushing. Clean canvas gloves or their equivalent should be used. The preservative should be brushed as evenly and continuously as possible over all metallic surfaces. When it is thin enough to be brushed without reduction, it should be applied to parts practically at room temperature.

In order to aid the spreading of preservatives reduced by heating, or to accelerate the drying or setting of coatings reduced with a solvent, reduced preservatives should, whenever possible, be applied to warm parts. In applying solvent reduced preservatives, sufficient material should be applied (repeatedly if necessary) to give the required thickness of preservative coating after evaporation of the solvent.

(e) *Flow coating*—This method consists essentially of pouring the preservative on the parts or assemblies. It is particularly suitable for applying solvent or oil types of preservatives to parts too large to dip, or to limited portions of parts when it is not permissible to coat a part completely.

Sufficient preservative should be 'flowed on' to cover the desired areas completely and to permit any excess to drain off by gravity.

Parts should be so placed before coating to prevent 'pocketing' of the preservative in blind holes and cavities or else drained after coating.

Identification

20. As important as other preservation operations is the necessity of proper identification of all stores prior to their preservation/packaging. Identification labels must be attached at all steps from innermost wrapping paper-carton to facilitate correct issues without having to disturb the original preservation.

Packaging of metal stores

21. (a) *Method O*

This method does not involve application of any preservative for the article and is applied to those items which rely entirely on their immunity from corrosion either by the nature of the protective treatments or finish imparted to them during manufacture. Items, packaged to this standard may require protection against physical damage during transit or storage, e.g., galvanised stores.

(b) *Method I*—(Unsealed wrapping)

This method envisages the use of a preservative which provides the entire protection to the item against corrosion. Since this method does not provide a completely waterproof/moisture vapour proof barrier, it should only be employed where the item is of simple and steady construction without delicate or critical working parts, e.g., Crankshafts preserved with rosin.

(c) *Method I*—A (Sealed water-proof barrier)

Items protected by soft film type preservative adequately wrapped and enclosed in sealed water-proof barrier e.g., greased items.

(d) Method II—(Sealed moisture vapour proof barrier)

Items not fully protected by preservative, enclosed with desiccant in a sealed moisture-vapour proof barrier, *e.g.*, packaging of watches, wireless sets, generating sets and optical instruments with desiccant, *e.g.*, silica gel.

22. Some further details of the above methods of packaging are given below—

(a) Method I

After the application of preservative the item is given a wrapping in non-corrosive paper. Grease resisting paper should be used for soft preserved items; waxed paper for hard preserved items. Where items are coated with hard film preservatives which resist scraping, a wrapping over the whole item may not be necessary to hold the preservative in place. Wrapping operation should follow immediately after proper draining and setting of the preservative. The closing edge or lap of the wrapper should be secured by folding, taping, tying or stapling.

(b) Method IA

(i) The function of Method IA packaging in conjunction with preservation is to provide long term protection. After preservation the item is wrapped in suitable non-corrosive primary wrap (waxed paper for hard preserved items and grease resisting paper for soft preserved items), cushioned with paper corrugated and placed in appropriate sized carton/tin. The carton/tin is then made waterproof by any of the following methods—

Wrapped and sealed by hot wax dip,

or

Placed in grease resisting waterproof bags, approved by the department concerned and sealed by whatever method is suitable, *e.g.*, hot wax dip or waterproof adhesive, or soldering of metallic containers.

(ii) A printed label made waterproof with clear varnish is to be affixed to the item by a grease resisting manilla tie-on tag before it is wrapped. Two more printed labels are to be affixed to the carton/tin after it is made waterproof. The label should be covered with transparent tape self-adhesive.

(c) Method II

This method is used when it has not been possible to provide full preservative protection for an item, the nature of which is such that moisture-proof and moisture vapour-proof pack is required. In all cases of Method II packing, the use of a desiccant is involved. The item is firstly kept in a box or case made of cushioning materials, *e.g.*, corrugated fibre board and the desiccant contained in a dust proof bag is introduced in the box. The box is sealed using waterproof adhesive and an identification label is fixed to the top. The case is now sealed in a moisture vapour-proof barrier which is made of metal foil laminated or other similar materials. The case is sealed by heat seal. Seams are reinforced using waterproof fabric self-adhesive tape. Identification label is fixed to the top. A warning label that "packed with dehydrating agent—Do not open until wanted for use" is also affixed to top surface. The case is now put in another card board box, which is sealed using waterproof adhesive. Identification label is again fixed to the top. This package is finally put in a crate lined with waterproof liner.

Cocooning

23. This is a modern form of spray packaging. The principle is to provide a storage package whereby equipment can be stored in the open without the necessity of erecting permanent covered structures, or providing continual maintenance, or alternatively for export packaging requiring to occupy a minimum of space. The materials used are a plastic liquid mixed from resins, a bitumastic compound and a "Gilsonite" aluminium compound. The equipment required is of the ordinary paint spraying variety, embodying a gun and a pressure shot with a compressed air supply of upto 80 lbs. per sq. inch. Examples of stores which may be cocooned are aircraft spares, aeroplanes and ships.

SECTION II—STORAGE AND PRESERVATION OF CIVIL ENGINEERING STORES

Introduction

From storage and preservation point of view, Civil Engineering stores may be broadly classified as follows—

1. Structural timber and plywood.
2. Constructional steels and non-ferrous stores.
3. Asbestos cement sheets and other asbestos products.
4. Portland cement and concrete.
5. Lime and gypsum products.
6. Bricks, terra-cotta ware, sanitary ware, and other clay products including porcelain ware.
7. Building stones.
8. Glassware.
9. Plastic-ware.
10. Rubber goods.
11. Paints, enamels, varnishes, lacquers, dopes, distempers.
12. Abrasives.
13. Glues and adhesives.
14. Insulating materials.

Structural Timber and Plywood

(a) Timber

Timber is available commercially in the form of logs, sleepers, squares and beams and planks, boards and scantlings. Protective treatments to timber are given below—

- (i) 50:50 mixture of creosote and used mineral oil.
- (ii) Coppernaphthenate solution in kerosene oil or dispersion in ammonia.
- (iii) 8% Ascua solution in water.
- (iv) B-57 borax solution in water.

Details regarding the “seasoning” of timber, stacking of timber, storage of various forms of commercial timber, provision of dunnage (anti-termite) and top cover over timber stacks are already discussed in para 6(a)(i) Section I above.

(b) Plywood

Plywood is a board consisting of 3 or more sheets (“Veneers”) of wood bonded together with a suitable adhesive, usually in such a manner that the grains of adjacent veneers run at right angles to each other, but in plywood with an even number of plies, the grains of the centre pair run in the same direction. Semul, rosewood, mango are some timbers used for manufacturing

the plies or veneers. The adhesives used in plywood are synthetic resins (ureas and phenolics) casein or other protein glues. Veneers are treated with suitable preservatives (*e.g.*, borax, boric acid, or sodium pentachlorophenate). Where necessary, glue is also impregnated with suitable fungicides (*e.g.*, sodium pentachlorophenate).

Plywood sheets should be stacked on level foundations, one above the other, preferably on flat dunnage. A good wooden frame should be constructed with 2"×1" battens which will give support to all form edges of plywood sheet or package the centre being filled in with similar timber 18"×20" apart. Solid stacking should be adopted and the top sheet of plywood should be suitably weighed down to prevent warping. The sides of the stack should be coated with a thick solution of varnish or 5—10% sodium silicate solution (water glass).

Constructional steels and non-ferrous items

(a) Rough heavy structures and machinery should be painted with coal tar base paints (indigenously available at a lesser cost) or in their absence, with bitumen paints (which are mostly imported). Angles, cast iron fittings, joists etc. should be painted with "red oxide of iron" paint.

(b) Mild steel corrugated sheets should be derusted, when necessary with a 10% solution of equal parts by weight of caustic soda and quick-lime preserved with "red oxide of iron" paint.

(c) Structural steels used for re-inforcement should not be painted or oiled for technical reasons. They should, therefore, be preserved with cement wash.

(d) Water supply tubings and fittings (made of mild steel) should be preserved with bitumen paint, and the threads to be greased.

(e) Bolts and nuts should be preserved with grease or hot dip in mineral Jelly.

(f) Non-ferrous items *e.g.*, aluminium, brass etc. do not normally require any preservative treatment. Where needed, they may be treated with preservative oil.

Asbestos cement sheets and other A C Products

Stacking of asbestos cement sheets—

(i) The sheets should be stacked smooten side up so that they rest correctly. In case of corrugated sheets all down laps should be on one side of the stack and all up laps on the opposite.

(ii) Individual stacks should consist of sheets of the same length (*e.g.*, 6 ft. sheets, 10 ft. sheets separately).

(iii) Not more than 100 sheets should be placed in each stack. Stacks to be built solidly to prevent rains driving between the sheets.

(iv) Site for stacking the sheets should be hard ground or standing to avoid the sinking of stacks.

Portland Cement

Cement should be kept under cover on a suitable dunnage away from the walls to prevent slow ingress of ground moisture.

The stacks should normally not exceed 6 bags high but where accommodation is limited, may be up to 10 bags high, but in these cases the bags should be periodically turned over to eliminate chances of setting. Sheds where cement is stacked should be adequately ventilated and a rigid programme of opening them on relatively dry days should be observed.

Moisture should be kept away from Portland cement. The best method of storage is in bulk and bins of loose cement 6' or more in depth can lie for longer than a year with no more damage than the formation of a crust about 2" thick, which must be removed before the cement is taken into use. If prolonged storage of bagged cement is unavoidable, it is better to empty the containers, and stock the cement in deep a heap as possible in a building of which the walls and floor are non-porous.

Bagged cement may also be kept safely for many months if stored in a weather proof shed with a dry-floor well off the ground. For long storage the tops and sides of the piles may be covered with tarpaulins, water-proof paper, or other covering as an extra precaution against moisture.

As far as possible, cement packed in jute bags should not be stored longer than 3 months. An absorption of 1-2 per cent of moisture by cement has no appreciable effect, but further amounts of absorption retard the hardening of cement and reduce the strength. If the absorption exceeds 5 per cent, the cement becomes ruined.

Bags should not be piled more than 15 high. If the piles are greater than 7 or 8 bags high, the bags should be placed in headers and stretchers, alternately lengthwise and crosswise so as to tie the piles together and lessen the danger of piles overturning.

Lime and gypsum products

The reaction between lime and water, which is known as "slaking", produces calcium hydroxide. This reaction is quite rapid when the lime is not in the compact or crystalline state, and since heat is evolved rapidly, high temperatures will result unless care is taken to provide for the escape of heat or to control the speed of the reaction by regulating the conditions of mixing.

Setting of the gypsum plaster results from

- (a) Hydration.
- (b) Crystallisation.
- (c) Evaporation of water.
- (d) Hardening.

Brickware

Because of overfiring or perhaps for some other reason, many bricks come from the kiln discoloured, roughened, or twisted. Such bricks must be cast aside and are known as "Culls".

White incrustation due to efflorescence is produced by the leaching out of soluble salts from the bricks by water. The salts are somewhat hygroscopic and, even when not actually wetted by rains, they dissolve by taking up moisture from the atmosphere and the bricks absorb their solutions. Then when dry weather arrives, they bring about disintegration of bricks by the expansive force of their crystallisation. During damp or wet weather the efflorescence often disappears; it returns, however, with the coming of dry weather.

Building stones

Deterioration of stone may be due to either physical or chemical causes, or to a combination of the two. The agencies may be purely external, or their effects may be supplemented by changes within the rock itself. Soluble salts in stones get leached by water, change in colour or stones occurs due to oxidation. Repeated temperature changes have a weakening effect on stone.

The use of protective coatings on stone is not likely to be of great interest. Some study of the subject has been made, using water-proofing compounds in volatile solvents.

Glassware

Breakage in glass results from—

- (a) Improper packing.
- (b) Rough handling.

1. Sheets of glass during storage should be cleaned and interleaved with clean dry paper.

2. Not more than 6 inter-leaved sheets should be made up into a secure paper packet. The packets should be covered with 1" thick straw or hay or wood wool or double corrugated cardboard. 4 or more such packets should be placed together side by side in a sound timber case. The internal dimensions of the case must allow a padding of 2" of similar packing material or saw dust. The padding should be compressed as tightly as possible. The sheets should be packed vertically in the case. Maximum gross weight of case and contents should not normally exceed 80 lbs. The cases may be provided with battens if necessary to avoid placing them on sides.

Plastic-ware

Plastic-ware should be protected from mechanical breakage during storage and handling and exposure to adverse agencies such as heat, light, moisture, contact with acids, alkalies etc.

Rubber Goods

Rubber goods should be protected against exposure to air and light. These must be preserved by dusting with French Chalk or soap stone powder.

Paints and allied products

These should be kept in sound containers in a cool dry place, preferably on a 3" bed of dry sand, properly sealed/stoppered. Fire precautions should be observed. Sealed paint drums should be rolled and turned about and restacked every 6 months.

Abrasives

Abrasives should be packed in ten numbers in waterproof paper and sealed moisture tight.

Glues and Adhesives

Glues and adhesives should be stored in air-tight containers and kept in cool dry place.

Insulating Materials

Normally insulators are packed with a medium of sawdust around the insulators. But the sawdust packing gives way during handling, with the result that they get damaged due to impact against one another.

A better method of packing the insulators is to provide a cushion of un-serviceable gunny bags around the insulators and then pack them with sawdust inside the packing.

SECTION III—STORAGE AND PRESERVATION OF MECHANICAL ENGINEERING STORES

Introduction

Mechanical engineer stores that require preservation treatment can be broadly classified as follows—

I—Mobile machinery (*e.g.*, vehicles).

II—Plant static machinery (*e.g.*, refrigerators, lathes, drilling-cutting/grinding/buffing machines).

III—General stores (*e.g.*, hand tools, implements, tool accessories *e.g.*, chasers, cutters, etc.).

I—Mobile machinery and plant

(a) *Engines and engine assemblies (Internal combustion engines)—*

Preliminary treatment—

1. Run the engine on unloaded petrol until it attains natural working temperature. Turn off petrol and allow the engine to stand until it cools down to room temperature. Drain the fuel from carburettor and petrol pump and start preservation as soon as possible according to the following schedule—

2. Spray preservative (oil type) through pipe line and carburettor, drain the sump and attach a level showing “No oil”.

3. Introduce preservative (thin soft type) into the engine in such a way that a firm film of this preservative is evenly deposited on the following parts:—

Cylinder walls, combustion chamber, valves, valve seats and stems, valve springs, valve operating mechanism, inlet and exhaust manifolds.

4. Rotate the engine by hand/motor during the introduction of the preservative into manifolds and cylinder bores and as a final operation introduce the preservative into each cylinder with the engine stationary.

Note—When spray gun is used, precautions must be taken to remove all moisture from pipe line before starting the spraying operations. It is essential that sufficient liquid preservative reaches all parts, the actual quantity of the preservative required varying with the type of engine. The time and pressure of spraying shall be determined by experiment for each type of engine.

Interior treatment—

5. Remove sparking plugs, withdraw starter motor and spray flywheel and starter ring with preservative (thin soft film type), while engine is being rotated by hand. Where flywheel is exposed, it shall be covered with primary wrap after treatment.

6. Dip Bendix pinion and sleeve in preservative (oil type) and replace starter.

7. Insert nozzle of spray gun into carburettor intake with throttle open and spray preservative (thin soft film type), until vapour of the preservative escapes through sparking plug orifices—the engine being rotated during this operation.

8. Insert nozzle of spray gun into exhaust manifold and spray as in (7) above.

9. Spray each cylinder bore through sparking plug orifices while engine is being rotated.

10. Remove valve cover and spray preservative over valve operating mechanism, valve springs, stems and interior of chamber. Replace valve cover (fitting new gasket, if necessary).

11. (i) With the engine stationary, spray each cylinder bore in turn through sparking plug orifice. The engine, on completion of this operation, should not again be rotated.

(ii) Fit dummy plugs of approved pattern in sparking plug orifices.

(iii) Preserve sparking plugs with grease, wrap in grease resisting paper and pack in cartons as necessary.

12. When fitted, spray inside of oil filler pipe and cap. Pressure dip stick with grease and seal in place.

Exterior treatment

13. Remove fan belt and paint fan pulleys.

The belt should be well covered with French Chalk (soap stone powder) cartoned and securely fastened inside the case.

14. Blank off all external orifices including petrol and oil unions with metal blanking plates or caps, held in position and seal with adhesive tape.

(ii) Paint all aluminium and right alloy parts (excluding carburettor and petrol pump) with primer and finishing coats.

* **Note**—A minimum period of 4 hours, preferably overnight, should be allowed for drying before applying a second coat of paint.

(iii) Similarly paint all ferrous parts with primer and finishing coats.

(b) Clutch (Vehicles)

15. All splines and moving parts should be well greased during assembly. Clutches also should be treated with suitable preservative. Clutch housings should finally be sealed with a suitable cover, the joint being taped with adhesive tape.

Note—The preservative must be cleaned off pressure surfaces before use.

(c) Distributor—

16. Grease external machined parts and wrap. Carbon brush spring, spindle contact breaker, plates and points, all parts of automatic ignition control gear should be lightly coated with preservative (oil type), care being taken that an excess quantity of preservative is not used.

Fold back wires of distributor and cover the whole with mouldable waxed wrapping.

(d) Dynamo and starter motor—

17. Brush dynamo and starter motor with preservative (oil type) and cover it with mouldable waxed wrapping paper held in position with adhesive tape.

Carbon brush springs (if not plated) should be similarly preserved.

(e) Carburettor—

18. Spray preservative (all type) grease external joints with mouldable waxed wrap and secure in position with adhesive tape.

19. After assembly all nuts and bolts should be brushed with paint or alternatively greased.

When required the whole assembly should be slung and sprayed with preservative (oil type), care being taken to mask rubber or other parts on which oil will be deleterious.

(f) Other major assemblies

(i) *Gears, axles etc.*—Coat open gear with grease ; in case of enclosed gear, fill gear box to normal level with lubricating oil, all orifices blanked with metal banking plates. In other instances gear box should be filled with preservative (oil type). Spraying, gear turned to cover all internal parts, the preservative drained and all orifices blocked. All external non-moving parts to be painted with priming and finishing paints. External moving parts e.g., shafts, pivots of brake shoes and plunger of brake expanders should be greased.

(ii) *Differential assemblies*—Dip in preservative (mottled soft thick film type) and wrap in grease proof paper.

(iii) *Oil pump assemblies*—Dip in preservative (oil type) and wrap in grease proof paper.

(iv) *Propeller shaft assemblies*—Dip splined ends in preservative (mottled soft thick film type) and wrap in grease proof paper.

(v) *Other M. T. stores*—Bearings, ball and roller bearings, bins and stowage parts, joints universal, oil seals, pistons, piston rings, road springs, valves and valve springs, valve tappets should be dipped in preservatives (mottled soft thick film type).

Clutches (not fitted to engines of vehicles), dynamos and magnetoes, flexible pipes (free of rubber), injectors etc. should be greased.

Bins and stowage parts, hull fittings (not mechanical), cylinder heads, radiators and radiator cores, water tanks, water pipe connections, heavy iron structures and machinery should be suitably painted.

II—Plant and static machinery*Plant (e.g., refrigerating plant)*

The compressors charged, and the compressors uncharged should receive appropriate preservative treatments. Engines should be preserved on the general lines indicated in Sec 1. Electric motors should be preserved by greasing the shafts and other parts (springs) followed by wrapping in waxed paper. In condensers, evaporators, receivers and similar closed vessels, all orifices should be hermetically sealed with plates and gaskets, and the exterior carefully secured and painted.

Static machinery (e.g. lathes, drilling machines, grinding machines, shaping machines, welding and cutting machines.)

The following preservative treatments should be carried out—

(a) *Beds and slide ways*—Grease to be applied, round the brass of the saddle and head stocks and tail stocks; remaining exposed bed coated with grease.

(b) *Contact surfaces*—Coated with grease.

(c) *Spindle, quills and handles*—Grease applied round each spindle where it enters its brushing or support, then the exposed spindle and handle coated with grease; main boring spindles and quills coated with grease; traverse and elevating screws also coated with grease.

(d) *Oiling points*—Oiled with preservative oil.

(e) *Enclosed gear*—Where lubricating oil other than hypoid oil is used as lubricant, gear box filled to normal level with lubricating oil and all orifices blanked with metal blanking plates; in other instances gear box filled with preservative oil, gear turned to cover all internal parts, the oil drained and all orifices blanked. All external non-moving parts painted and external moving parts greased.

(f) *Chain*—Coated with grease.

(g) *Driving belts*—Rubber belts treated with soap stone powder.

(h) *Pulleys*—painted.

III—General stores (e.g., hand tools, implements, tool accessories)

(a) All nuts, bolts, springs, hinges, sleeves, vices, chucks, tool post coated with grease.

(b) Rubber accessories treated with soap stone powder.

(c) Leather belting cleaned and treated with a foam of soap.

(d) Hand tools and implements greased on ferrous parts and wrapped suitably.

SECTION IV—STORAGE AND PRESERVATION OF ELECTRICAL ENGINEERING STORES

Introduction

In the following paragraphs are discussed the methods of maintenance, treatment and storage of electrical and electronic (including telecommunication) stores.

Nature of the problem

(a) Humidity

(i) With electrical apparatus and circuits, excessive humidity is the damaging factor; this will also lower insulation resistance by causing surface leakage over insulators, and the absorption of moisture by hygroscopic materials, such as cotton coverings, and the growth of fungi and moulds which either destroy insulation value by actually attacking the insulator and/or bridge insulators due to their content of quantities of liquid in the form of conducting solutions. In the case of many items of electrical equipment, it is fortunate that, in spite of lowered insulation resistance, the apparatus will often continue to function because of its relatively low operating voltage. However to obtain reliable operation and maximum efficiency, special measures have to be taken (see para 3 below).

(ii) *Breathing and sweating*—Accumulation of water due to “Breathing and sweating” occurs on the inside of electrical equipment and partially sealed items e.g. meters, flame proof motors etc.

(b) *Corrosion*—Corrosion on contacts, conductors or metal parts adjustment to them, may result in leakage, bad electrical contact if the corrosion dries or open-circuits if the conducting parts become completely eaten away. It is found, for instance, that vibratory regulators employing tungsten contact often suffer from condensed moisture between the blades and therefore soon suffer damage unless action is taken to exclude moisture or to give special treatment. Where moisture is in contact with dissimilar metals, currents causing corrosion will tend to be set up, the magnitude and subsequent galvanic attack of which, are increased by the humid conditions.

(c) *Mould attack*—Growth of mould often forms an actual leakage path and also deteriorates certain insulating material thereby allowing short circuits, either partial or complete to develop between insulated conductors. Once formed a growth tends to maintain a film of moisture over the surface and, being itself a vegetable contains conducting fluids and thus aggravates any effects of high humidity already present.

Remedial Measures

(a) *Tropic design*—Manufacture of materials so as to resist, in use, attacks of humidity, temperature and biological damage.

(b) *Tropic proofing*—Without alteration in design, reworking to safeguard in use, against biological damage (by application of a water proofing varnish to which a fungicide and insecticide have been added)—particularly on electrical parts such as windings and insulation materials of panels.

It may be applied, in fact, with advantage to all bare metal or conductor surfaces, except on these faces between which electrical continuity must remain assured or where it would introduce a gap in a magnetic circuit, or where clearances are small and/or relative movement between adjacent parts might be impaired. When applied to metal it acts as an anti-corrosion coating on the metal surface.

(c) *Temporary preservation*—Preservative treatment prior to packaging for protection in transit or during storage.

(d) *Tropical packaging*—Packing so as to ensure that when the pack is opened after transit to, and storage in a tropical place, stores will be in a usable condition.

Generators and motors

The process will consist of dismantling, testing, cleaning, drying, masking where necessary, proofing of the windings, preservation of the metal work, removal of masking and testing and reassembly. With smaller machines, baking in an oven is advantageous. The commutator must be kept clear of the varnish and, subsequent to protection should be carefully cleaned with varnish solvent, xylene, polished with dead smooth glass-paper or metal polish, all carbon or copper dust afterwards brushed out and the mica-insulation cleared in the usual manner. Ball bearings should be washed out with kerosine or white spirit, dried and preserved with mineral jelly bees wax mixture (90 : 10).

Switch boards and generating sets and other smaller apparatus

Same remarks apply *i.e.*, drying, cleaning and masking the rear of switch boards and associated apparatus inside H.T. cages should be treated with the varnish. All moving parts and hinges should have the hinge portions carefully masked off as the varnish will prevent relative movement.

Switches—Switch blades etc. should be lightly smeared with grease.

Meters—The outside of the case, particularly if of moulded material should be treated with varnish, paying special attention to the joints between the component parts to any screw holes etc., and to the joints where the back stems come out of the case. The luting of the glass front should be checked by external examination and renewed if doubtful. The zero adjuster must be completely sealed up, either by the application of a piece of adhesive tape while the first coat of varnish or, by the application of a piece of asbestos sealing compound if this is available.

Cables and wiring—Enamelled wire is generally satisfactory as it stands but the addition of a coat of the varnish will be advantageous. Cotton covered wire should have been covered with specially treated cotton for tropical use, but with existing stores of cotton-covered wire, as for completed windings, the tropical varnish will give sufficient protection. Rubber covered cables used in connection with electrical equipment will be reasonably satisfactory, but exposure to

light and heat, excessive dampness and contact by oil must be avoided. The ends of the swaths of rubber-covered cables should be sealed over suitably to prevent the ingress of moisture.

Dissimilar metals—Metals in contact should be so chosen that the contact potential is low (smaller than 0.5V).

Metal rectifier—These all fail at high temperatures; the selenium type will not withstand ambient temperatures much above 75°C and the copper oxide type above 60°C. It is necessary to rate these down to approximately $\frac{1}{2}$ being normal output.

Transformers—In the smaller sizes tropic-designed transformers have a hermetically sealed case and vacuum-impregnated windings. CF with these the "potted" type, with the windings vacuum-impregnated and placed in a bitumen-filled pot or case, is the next best. For an open transformer the only treatment which can be applied is careful drying-out and dipping or spraying with tropic-proofing varnish to seal the windings.

H. T. Insulation on distributor mouldings etc.

The tendency to "tracking" i.e. formation of a conducting path across the surface of the normal moulding materials, causing surface discharge, is particularly prevalent under tropical conditions. Anti-tracing varnish should therefore be used.

Microphones, receiver head gear and loud speakers.

(a) *Diaphragm type*—Dismantle, clean with thinners by brushing, and dry out. Mask all electrical contacts with solutions, metal preservation. Dip or spray the complete assembly in varnish, special with fungicide, diluted to the correct strength. Wipe off excess varnish from the screw threads dry in oven, recoat and dry again. Reassemble and test.

(b) *Reed and moving coil types*—Dismantle, clean with thinners by brushing and dry out. Apply varnish, special, with fungicide, diluted to the correct strength, by brushing, taking care not to set the varnish on the moving points. Apply 2 coats of varnish, reassemble and test.

7. *Instruments*—If the instruments or components are without packing in cup-boards, a high power electric bulb should be kept burning in the cup board for a few hours at a time to drive out the moisture condensing on them. Making and working of the hot boxes is based on this principle.

8. While the instruments are in use or are kept unpacked they should be kept in their cases after initial wrapping in water proof paper and their working parts must be kept free from dirt and dust; exterior surfaces of metal parts should be cleaned with soft rags or chamois leather and must not be coated with oily or greasy substances. Glass surface should be cleaned with soft linen, muslin or tissue paper specially kept for the purpose and maintained in a clean, dry condition.

Telecommunication equipment/components

9. In the case of telecommunication equipment also, failure of the instruments is due essentially to the ingress of moisture. A secondary cause of deterioration and ultimate failure is fungus growth. A third cause is corrosion of metal parts which results from penetration of moisture.

10. Some of the specific defects which develop in tropical areas because of excessive heat, humidity and fungus growth are given below:

- (a) Condensers and resistances fail on account of physical presence of moisture.
- (b) Transformers break down due to moisture penetration.
- (c) Electrolytic action, visible in the form of corrosion, takes place in relay coils, transformers and similar equipment and causes eventual breakdown.
- (d) Cable insulations break down.
- (e) Moisture provides leakage paths between battery terminals.

11. Besides observing the precautions given above, during the monsoon the instruments should be worked from time to time so that any moisture that might have condensed inside could evaporate. Raw ends of cables should be sealed with Chatterton's compound to prevent ingress of moisture.

12 The following additional precautions should be observed during storage of telecommunication equipment/spares:

- (a) Circulation of air should be ensured by avoiding close stacking.
- (b) The equipment should be kept well away from the ground on suitable dunnage.
- (c) Components and small items should be stored in hermetically sealed containers. Some items already packed in such containers, should not be unpacked until they have to be inspected before issue. The present practice is to seal the various components as condensers, trimmers, resistors, small IF transformers and chokes in alkathene bags, and a hermetically sealed tin contains a number of these alkathene bags containing similar stores.
- (d) Crystals should be sealed within alkathene bags.
- (e) Variable air condensers should be greased and kept away from dust.
- (f) Cables should be cleaned free of dirt in soap water, and then dusted with French chalk, and stored in a cool dark room.