Guide to the Preparation of Plantation Rubber in Ceylon.

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ISSUED BY THE
RUBBER RESEARCH SCHEME (Ceylon).

PREFACE.

IT was originally proposed that a Guide to the Preparation of Plantation Rubber should be prepared jointly by the Rubber Research Institute of Malaya and the Rubber Research Scheme (Ceylon) to bring up-to-date the handbook published by the Rubber Growers' Association in 1917.

A draft was prepared by Major B. J. Eaton, O.B.E., F.I.C., F.I.R.I., F.C.S. (Head of Chemical Division, Rubber Research Institute of Malaya) but owing to differences in details of preparation of Rubber in Malaya and Ceylon it was considered advisable to publish separate handbooks for the two countries.

Major Eaton's draft has been taken as a basis for the following "Guide to the Preparation of Plantation Rubber in Ceylon," and in many cases when applicable to Ceylon conditions his text has been adopted. The writer wishes to express his thanks to Major Eaton and the Rubber Research Institute of Malaya for permission to make use of their handbook, which has greatly facilitated the preparation of this publication.

Guide to the Preparation of Plantation Rubber in Ceylon.

LIST OF SECTIONS.

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GUIDE TO THE PREPARATION OF PLANTATION RUBBER IN CEYLON.

SECTION A.—LATEX IN THE FIELD.

THE most important factor in successful manufacture of plantation rubber is cleanliness at all stages of preparation, and this is no less important in field operations than in the factory. There is more than a superficial resemblance between latex and milk, and many of the troubles which arise in preparation of rubber can be avoided by adopting a standard of cleanliness comparable with that which is essential in a dairy.

1. **Tapping.**—The tapping system which is usually adopted in Ceylon is one spiral cut on half the circumference of the tree on alternate days. The more conservative system of tapping on one third circumference on alternate days, or one half circumference every three days, is met with occasionally.

In Malaya a V cut is more common than a spiral cut, as it is claimed that this reduces the percentage of scrap. Periodic tapping systems which have been largely adopted in other countries but have not up to the present made any progress in Ceylon.

Tapping operations should be started at daybreak, and the tapper's task should be such that all the trees are tapped before 9 a.m.

2. **Latex Cups.**—Coconut shells ("sheraties") are used almost universally in Ceylon for collecting latex. There is much to be said against their use, but they have the advantage of being exceedingly cheap (Rs. 3—4 per 1000) and it is not likely that they will be superseded.

Considering the cheapness of "sheraties" there is no excuse for keeping them in use after they have become encrusted round the edges and outsides with sticky scrap. New cups should be provided every year. Dirty cups are a source of infection, leading to lump formation in the field, and to bubbles and spot disease in the factory.

Cups should not be allowed to lie about on the ground, otherwise the latex is bound to become contaminated with grit. Some of the patented spouts have hooks by which the cups may be hung when not in use, or alternatively they should be inverted on pegs placed in the ground near to each tree.

In order to avoid contamination with bark shavings, cups should not be placed in position until the tapping operation is completed. In the case of a large tree it may be necessary to tap the lower half of the cut first.

3. Spouts.—Various patented spouts are in use as well as the ordinary type. All scrap should be removed daily and the spouts kept clean. Galvanised iron is preferable to tinned iron.

4. Water in Cups.—Water should not be poured on to the tapping cut or into the cups. Latex should be collected undiluted as it flows from the tapping cut.

5. Collection of Latex.—Latex should be collected as soon as possible after the flow has ceased, viz: 3—4 hours after the first tree is tapped.

The latex is poured from the cup into the collecting bucket, and as much as possible removed from the cup with the finger. The use of lumps of rubber for cleaning out the cups should not be allowed, nor is it advisable to allow the cups to be rinsed out with water.

6. Buckets.—Collecting buckets should be of galvanised or enamelled iron, or aluminium, and preferably provided with a cover. Kerosene tins (tinned iron) corrode rapidly and are not recommended.

Buckets should be carefully washed after use, and inspected before the tappers leave the factory. There is no difficulty in cleaning utensils used for holding latex if this is done immediately after use. It is when the latex has been allowed to dry and tackiness to develop that difficulties occur.

Careful attention should be paid to the "kottu" or small receptacles which most tappers carry for collecting latex in steep places. All such vessels should be brought to the factory daily and cleaned with the same care as the official pails.

As the use of a "kottu" is usually necessary, it would be more satisfactory if small buckets were provided by the estate for this purpose.

7. Scrap.—Methods of collecting scrap rubber vary on different estates, this being done either by the tapper, or by another cooly on the day following tapping.

Tree scrap and cup scrap should be collected in separate receptacles, any dark coloured pieces of tree scrap being put with the cup scrap.

Removal of scrap from the cups should be thorough, and it is to be noted that this is more easily done if the cups are kept hung up. If the cups have been left exposed to the sun the film of rubber becomes sticky and difficult to remove.

During the restriction period earth scrap rubber has not usually been collected. If this grade of rubber is prepared it should be collected at frequent intervals in order to avoid excessive tackiness.

8. Transport of Latex—In order to avoid premature coagulation latex should be brought in to the factory as rapidly as possible after collection. On large estates or outlying divisions subsidiary coagulating stations are recommended.

If first grade crepe is manufactured the coagulum can be transported to the main factory by lorry or bullock cart on the morning after coagulation. If sheet is manufactured the machining of the rubber should be carried out at the subsidiary station.

Alternatively, the latex can be brought to the main factory in tanks mounted on lorries or carts. If this is done the tanks must be designed so that they can be thoroughly cleaned out daily, and it will be necessary in most cases to add an anti-coagulant to the latex to prevent premature coagulation.

9. Dry rubber content of latex.—If the trees are tapped on alternate days the dry rubber content of latex from mature trees is usually between 3½ and 4 lbs. per gallon. In dry districts it may be as high as 4½ lbs. per gallon, and in the case of young trees as low as 2½ lbs. per gallon.

On many estates the rubber content of the latex when it reaches the factory is less than 3 lbs. per gallon, but this can usually be traced to addition of water by the tappers.

10. Anti-Coagulants.—The use of anti-coagulants in the field or factory is uncommon in Ceylon and is a complication which should be avoided if possible. There are, however, a number of estates, particularly in the dry districts, where premature clotting of latex in the field or factory is a constant source of difficulty. On such estates the percentage of first grade rubber could be increased by the use of anti-coagulants.

Sodium Sulphite.—Sodium sulphite is the most commonly used anti-coagulant. The amount required varies according to circumstances but should not exceed 1 lb. of anhydrous (powdered) sodium sulphite to 600 lbs. dry rubber.

A stock solution is made by dissolving 1 lb. of powdered sodium sulphite in 8 gallons of water. This is placed in the tappers' buckets before they go to the field, at the rate of 1—2 fluid ounces for each

pound of dry rubber which the tapper is expected to bring in. The tapper should be instructed to stir the latex occasionally during collection. If desired, a stronger stock solution can be prepared and used in proportionate quantity.

If premature coagulation tends to take place in the cups, a few drops of the solution should be shaken from a bottle into each cup. A bottle with a cork provided with two slits may be used for this purpose.

If sodium sulphite is added to the latex a slightly larger quantity of acid is required for coagulation.

Sodium sulphite tends to retard the drying of rubber and the absorption of smoke, so care should be taken to use the minimum amount which gives satisfactory results.

Formalin.—Formalin is in some cases found to be more effective as an anti-coagulant than sodium sulphite and it does not retard drying or absorption of smoke. If added to the latex in excess, formalin has an adverse effect on the quality of the rubber and great care must therefore be taken that the specified amount is not exceeded.

A stock solution of 1 lb. formalin in 8 gallons of water is prepared, and placed in the collecting pails at the rate of 2 fluid ounces per lb. of rubber.

Ammonia.—Ammonia may also be used as an anti-coagulant. A stock solution of 1 lb. strong ammonia (25%) to 8 gallons of water is prepared, and used in the proportion of 2 fluid ounces per lb. of rubber. In this case the solution should be placed in the latex cups.

SECTION B. 1—SMOKED SHEET. (Factory Operations).

Field operations are the same, whether the latex is to be converted to smoked sheet or to pale crepe, except that the prevention of premature clotting is of greater importance if smoked sheet is being manufactured.

1. The Factory.—The factory should be as light and airy as possible. An open building with dwarf walls of stone and the upper part of expanded metal is the most suitable type. The floors should slope slightly so that they can be washed daily. If wooden tables are used they should be covered with aluminium sheeting. Cement tables with tiled tops are also suitable. (See appendix D). Everything should be planned so that the factory can be kept scrupulously clean.

2. Water Supply.—A plentiful supply of pure clean water should be provided for the dilution of the latex and for washing the rubber during and after machining. It is a mistake to suppose that the quality of the water supply is unimportant in sheet manufacture.

3. Receiving and "Weighing up" latex.—In Ceylon the tappers are almost invariably paid by results. On some estates payment is made according to the volume of latex brought in. In other cases each bucket of latex is tested by a Metrolac or hydrometer, and payment is made according to the calculated dry weight of rubber. The latter method is fairer and does not occupy much time if properly organised. If no Metrolac test is made the tapper who adds most water to his latex gains at the expense of others. The latex is nearly always diluted by the coolies on estates where payment is made according to the volume of latex brought in.

4. Metrolacs & Hydrometers.—The Metrolac is an instrument which measures the specific gravity of latex. This is largely dependent upon the amount of dry rubber present, and the instrument is graduated to give a direct reading of the rubber content of the latex in pounds per gallon.

The latex should be diluted with an equal bulk of water before making the test, as the Metrolac does not move freely in undiluted latex.

The composition of latex varies on different estates and at different seasons, and it is impossible for a single instrument to give correct readings in all samples of latex. In order to obtain satisfactory results with the Metrolac or similar instrument it is necessary to determine from time to time the error on each estate and make an allowance accordingly.

The brass Metrolac has the disadvantage that it gradually becomes worn and the reading changes. In order to minimise wear, the Metrolac should be carefully dried with a soft cloth after use.

The Rubber Research Scheme has designed a glass hydrometer which is used in the same way as the Metrolac, but does not become worn as a brass instrument does. The scale is different from that of the Metrolac and is considered to be more suitable for Ceylon latex. (For further details of glass hydrometers see R. R. S. 1st Quarterly Circular for 1926 p. 2).

5. Straining Latex—In order to remove lump etc., the latex should be strained through a coarse sieve before being "weighed up." Much of the grit which inevitably finds its way into latex during collection,

sinks to the bottom of the tapper's bucket. The last of the latex therefore, say ¼ pint should not be poured into the sieve, but should be collected separately and should not be made into first grade rubber.

After being "weighed up" the latex should again be carefully strained through two sieves. Brass wire gauze sieves of 40 and 50 mesh per linear inch are suitable for this purpose. Straining latex through fine sieves is slow but is very necessary if a reputation for clean rubber is to be maintained.

Two sets of sieves should be in use so that when straining in one set becomes difficult it can be replaced by a clean set.

Gentle dabbing of the sieve with a piece of lump rubber is permissible as the rubber removes particles of lump and grit. Hard rubbing, which is a favourite occupation of factory coolies, defeats the object of straining by pushing the dirt through the sieve.

Straining is considerably easier if the latex is previously diluted with water, and this should be done if practicable (see Section B I para 7).

Tests are being made with several improved types of sieve and information on these will be available shortly.

6. Pans and Tanks for Coagulation.—Sheet coagulation in Ceylon is usually carried out in pans or flat troughs. The pans may be of enamelled iron or aluminium. The latter is more satisfactory as enamelled pans soon become chipped and then rapidly corrode. Ebonite pans are also marketed but have not yet been introduced into Ceylon.

Many of the aluminium pans now on the market are too thin and are easily dented. It would be an economy to insist on a minimum thickness of 1.2—1.5 millimetres, although the first cost would be higher.

The most suitable size for a pan to hold 1 gallon of latex, giving a 1½ lb. sheet, is 11½″ × 16″. By suitable manipulation of the coagulum during rolling, sheets can be made which just fit the packing chest. In order to avoid a thick ridge at the edge of the sheet the sides and ends of the pan should be well sloped.

Long troughs, usually holding 5 gallons of latex, are also in use and save a lot of handling. The troughs, may be of hard wood or aluminium. Wooden troughs are satisfactory provided that they are painted with bituminous solution when new, the painting been repeated about once a year. Old troughs cannot be treated in this way as the bituminous solution does not adhere well to wood which has become saturated with serum.

Coagulating tanks, in which the sheet is coagulated on edge, are largely used in other countries but have not been adopted to any great extent in Ceylon. This is probably due to a few unfortunate experiences in the past with wooden tanks of unsuitable design. Modern tanks made of hard wood lined with aluminium and with aluminium partitions are very satisfactory, although it is admitted that there is a tendency for anaerobic fermentation to occur at the bottom of the tank.

Where large volumes of latex are handled the use of tanks or troughs is to be recommended in preference to pans. The cost of a tank lined with aluminium is approximately the same as an equivalent number of dishes.

A suitably sized tank is 10 feet long, 3 feet wide and 12 inches deep, with vertical grooves for the partitions spaced 1½ inches apart along the sides of the tank.

When the partitions are inserted the depth of the latex will be about 11 inches. Such a tank holds 170 gallons of latex, equivalent to 255 lbs. dry rubber. Smaller subsidiary tanks of varying lengths, but similar width and depth are necessary to take "overflow" latex.

7. **Bulking of Latex.**—Latex from as large an area as possible should be bulked together in order to secure uniformity in appearance and in the inner properties of the rubber. This can be achieved by receiving and mixing the latex in a large tank before distributing to Shanghai jars (or coagulating tanks) for addition of acid.

In addition to improving the uniformity of the rubber, bulking of latex has the following advantages:—

1. The bulking tank can be placed on the factory verandah so that there is no need for tapping coolies to enter the factory.
2. If the same tank is used for diluting the latex, careful attention can be given to correct dilution which is not easy when a number of jars of latex are dealt with separately.
3. The final straining can be carried out after dilution which is quicker and more efficient. (See Section B. I para 5).
4. A considerable amount of grit will settle out in the mixing tank. If two outlet taps are provided, one slightly above the bottom and one at the bottom, the residue of the latex, containing the grit, can be run off and worked up separately

Latex which arrives late at the factory should be dealt with separately.

8. Standardisation of Latex.—In order to obtain sheets of even size and shape, which will dry and smoke uniformly, and also to promote uniformity in inner properties of the rubber, the latex should be diluted to a standard dry rubber content. The standardisation recommended is 1½ lbs. dry rubber per gallon of latex, dilution being controlled by means of the Metrolac or hydrometer (See Section B. I para. 4).

The latex should first be diluted to a rubber content of 1 lb. 10 ounces per gallon. This gives a final rubber content of 1½ lbs. per gallon when the standard amount of acid is added.

9. Anti-Coagulants.—If the latex tends to clot during factory operations a small quantity of sodium sulphite or formalin may be added (See Section A. para. 10). In this case only the minimum amount should be required. Addition of sodium sulphite also tends to reduce or prevent fermentation during coagulation but it somewhat retards drying and smoking.

10. Coagulants.—Acetic and formic acids are recommended as coagulants, but the use of sodium silicofluoride as a coagulant may be advisable under certain circumstances.

Formic acid is considerably cheaper than acetic acid but it coagulates the latex slightly more rapidly than acetic acid. It is not advisable to use it therefore for sheet manufacture on estates where difficulty is experienced owing to rapid clotting of the latex after addition of acid.

The acid should be clear and colourless. The slightest trace of blue colour indicates the presence of copper salts. Such acid should be rejected and a sample sent to the Research Laboratories for examination.

The amount of acid required for coagulation varies on different estates and the figures given below only represent an average. The amount required should be adjusted so that a clear or only slightly cloudy serum remains. A milky serum indicates loss of rubber and should not be allowed.

Acetic Acid.—Pure acetic acid should have a strength of 98—100%. The average amount required for coagulation of latex diluted to 1½ lbs. per gallon, where rolling is carried out on the day following coagulation, is 1 lb. of strong acid to 180 lbs. dry rubber. The acid should be added in the form of a 1% solution.

For a Shanghai jar containing 46 gallons of latex at 1 lb. 10 oz. dry rubber per gallon, the average amount required is 6½ ounces strong acid well mixed with 4 gallons of water.

Alternatively the acid can be prepared in the form of a stock solution by mixing 1 part of strong acid with 99 parts of water. The average amount required is 1 part of stock solution to 12 parts of diluted latex.

Stock solutions must be carefully stored in labelled bottles otherwise mistakes will occur. On the whole it is considered more satisfactory to dilute the acid as required.

If the sheets are to be rolled the same afternoon the amount required is approximately 1 lb. of strong acid to 120 lbs. dry rubber.

Formic Acid.—Formic acid is imported in 2 grades containing 90% and 85% formic acid. A glass hydrometer for testing the strength of strong formic acid has been designed by the Rubber Research Scheme and is now on the market. The hydrometer gives a direct reading as percentage formic acid and is accurate to 1% provided that the test is made at the correct temperature.

When a new consignment of acid is received the strength should be compared with that of the old stock so that an alteration can be made in the amount required should this be necessary. It is of interest to note that the strength of acetic acid cannot be tested by hydrometer as the specific gravity does not vary directly with the concentration.

One part by *volume* of 90% formic acid has approximately twice the coagulating power of an equal volume of acetic acid. The word volume is emphasised because formic acid, having a specific gravity of 1.20 is considerably heavier than an equal volume of acetic acid which has a specific gravity of 1.05.

Formic acid should be diluted to twice the extent of acetic acid. For a Shanghai jar containing 46 gallons of latex at 1 lb. 10 oz. rubber per gallon, the average amount required is 3¼ ounces strong acid (90%) in 4 gallons of water.

When formic acid is adopted on an estate, it is advisable to start by using slightly more than half the amount of acetic acid which has been found satisfactory, as an underdose of formic acid leaves a more milky serum than an underdose of acetic acid. Afterwards the amount can be adjusted as required.

Undiluted formic acid is more corrosive to the skin than acetic acid and should be handled with great care. It blisters the skin unless washed off immediately.

Suggestions have been made that formic acid causes excessive corrosion of machinery but up to the present no confirmatory evidence is available. It is considered unlikely that corrosion will be serious if machines are provided with water sprays and are thoroughly washed each day after use. The washing of machinery is also of importance when acetic acid is used as coagulant.

Sodium Silicofluoride.—Sodium silicofluoride (S. S. F.) is an effective coagulant when used in conjunction with a small quantity of acetic or formic acid. It has a marked influence in preventing the type of bubbles caused by premature clotting of the latex. Its use should be considered on estates which have continued trouble with this type of bubbles in sheet.

S. S. F. has the drawback that it corrodes aluminium, and therefore cannot be used with aluminium dishes.

S. S. F. is a white powder which has a low solubility in water, but it "wets" readily and can be added to the latex in the form of a suspension in water.

The amount required is 1 lb. of S. S. F. plus 4 ounces of acetic acid to 200 lbs. rubber. For a Shanghai jar containing 46 gallons of latex at 1 lb. 10 oz. rubber per gallon the average amount required is:—

S. S. F.	6 ounces.
Water	4 gallons.
Acetic acid	1½ ounces (or equivalent amount of formic acid)

The S. S. F. is first mixed with a little water to wet it thoroughly, and is then diluted with the remainder of the water. The acid is added and the mixture thoroughly stirred and poured into the latex before it settles.

If it is desired to use the S. S. F. in the form of a solution, a stock solution can be made up overnight in the proportion of 1 lb. S. S. F. and 4 ounces acetic acid to 16½ gallons of water. This is used in the proportion of 1 pint to each gallon of diluted latex.

The proportion of acid should be increased if the coagulum is too soft or the serum milky.

11. **Mixing Latex and Coagulant.**—If coagulation is carried out in pans, the coagulant and latex should be mixed in Shanghai jars or other suitable vessels of a capacity not exceeding 50 gallons. After thorough stirring with aluminium or wooden paddles, the latex should be distributed to the pans as quickly as possible, in order to avoid premature coagulation in the jars. With good organisation distribution of the latex should be completed within 6—7 minutes after adding the acid.

It is not necessary to continue to stir the latex in the jar while it is being distributed. This tends to make the latex clot more rapidly. It is preferable to have the pans arranged on shelves and to carry the latex to the pans in buckets, rather than to bring each pan to be filled.

In some districts clotting sets in before distribution of 50 gallons of latex is complete. In such cases smaller quantities of latex should be dealt with, or it may even be necessary to distribute the latex to pans before the addition of the acid. The use of an anti-coagulant should be considered.

If coagulating tanks are used they may be of larger capacity than 50 gallons. (See Section B. I. para 6). There is sufficient time to stir thoroughly and place the division plates in position before coagulation sets in. A suitable stirrer consists of a piece of smooth wood, nearly the width of the tank, in which one inch holes are bored. The wood is attached to a long handle and is drawn up and down the length of the tank.

12. **Skimming.**—The mixing of coagulant and latex, and distribution to pans produces a considerable amount of froth. If not removed this causes pitting of the surface of the sheet when the coagulum is rolled. The froth is therefore skimmed off by means of a suitable skimmer such as a piece of smooth board, aluminium, or galvanised iron extending the width of the tank or pan.

13. **Machining.**—Sheet rolling in Ceylon is usually carried out in hand operated rollers, the equipment consisting of one or more smooth rollers and marking rollers. The coagulum is rolled in the smooth rollers 3 or 4 times, the space between the rollers being altered after each rolling, and is then passed through the marking roller.

This is reasonably satisfactory where small crops are being dealt with, although the frequent adjustment of the rollers causes the parts to wear quickly, and there are often differences in thickness of the sheets which lead to uneven drying and smoking.

These difficulties can be overcome to a large extent if the sheets are put through the machine in batches, so that the setting of the rollers is altered as infrequently as possible.

The rollers should be fitted with a water spray so that the serum is washed off the sheets as it is squeezed out. This is also of importance for preventing corrosion of the rollers.

The width of the rollers should be 24 inches. This permits the sheets to be made to the full width of the packing chests (18½ inches for a plywood chest). If necessary the sheets may be put once through the machine sideways in order to increase the width.

When large crops are being handled it is very desirable to instal a proper battery of rollers, the spacing of each being set and the sheets passed from one machine to another for successive rollings. It is reported from Malaya that good results are obtained with two smooth rollers with fixed spacings, the coagulum being passed twice through each roller before going to the marking roller. The success of this probably depends on careful preliminary hand rolling of the coagulum. It is considered preferable to have 3 or 4 smooth rollers.

The cost of manual labour is steadily increasing and the installation of power driven rollers should be regarded as an economy. Modern sheet rollers are comparatively light in construction, and a battery of 3 or 4 smooth and 1 grooved roller can be operated by a 7 h.p. engine.

Hoare's patent multiple roller, consisting of 3 smooth rollers and one marking roller, gives excellent results when properly adjusted and reduces manual labour to a minimum.

In most industries an efficient factory is one in which the machinery is operated for the greatest number of hours per day. This is not the case in the preparation of rubber, and more particularly in sheet manufacture. The coagulum hardens on standing, and delay in rolling also leads to trouble due to fermentation. The equipment should therefore be such that rolling is completed within a few hours. The same coolies are then available for dealing with the latex on arrival, and for sorting sheets in the smokehouse.

14. Care of Machinery.—Rollers should be thoroughly washed each day after use. It is also desirable to wipe the rollers with a cloth soaked in a dilute solution of washing soda (1 lb. to 5 gallons water) in order to remove any acid which remains. The rollers should then be thoroughly rinsed to remove all traces of soda solution, and dried as far as practicable.

Grease or oil for bearings should not be used in excess, since contact with oil or grease causes deterioration of the rubber.

Worn parts of machines should be replaced. Bad machinery makes a rubber of inferior appearance.

15. Speed of Rollers and Output.—The speed of power driven sheeting rollers (6" diameter) should not exceed 15—17 revs. per minute. If driven too rapidly any inequalities in the coagulum are likely to produce ridges in the finished sheet. The marking roller grips the rubber better than the smooth rollers and is run at a slightly lower speed.

The output from Hoare's multiple roller or from a battery of 3 smooth and one marking roller (power driven) is approximately 300 lbs. dry rubber per hour. The output from one smooth roller and one marking roller (hand operated) is 80—100 lbs. per hour.

16. Grooving of Marking Rollers.—A suitable pattern for the rolls of the marking machine consists of spiral grooves cut in the same direction on each roll, at 45° across the face of the rollers. The grooves should be ¼ inch in width and depth and square cut, with ¼ or 3/16 inch between the grooves.

This type of marking is superior to that produced by a diamond pattern roller.

17. Preliminary Rolling or Pressing of Coagulum.—Preliminary hand rolling produces a firm coagulum which is easier to work on the machines but it is not an essential operation. The coagulum should be placed on a table between 2 reapers which are nailed down leaving a space slightly wider than the coagulum. The height of the reaper depends on the extent to which it is desired to press the coagulum.

If the coagulum is pressed by hand, this should be done carefully and uniformly. Suitable manipulation assists in preventing thick edges in the finished sheet. Heavy kneading is not recommended.

18. Size and Shape of Sheet.—The final size and shape of the sheet can be influenced considerably by pressing together the ends or sides of the coagulum. The sheet can also be made wider by rolling sideways through the smooth roller.

In general the aim should be to make a sheet which exactly fits the packing chest *i.e.*, 23″ × 18″ for a momi chest. A 1½ lb. sheet of these dimensions is somewhat thinner than normal, and it may be found advisable to make a slightly heavier sheet by putting more than 1 gallon of latex in each pan.

If owing to the use of narrow rollers or unsuitable reaper spacing in the smokehouse, a sheet of this width cannot be made, care should be taken that the sheets are the correct length.

19. Thickness of Sheet.—The rate of drying is largely determined by the thickness of the sheet. In the case of latex diluted to 1½ lbs. per gallon, a suitable thickness of coagulum is 1¼—1½ inches. This should be rolled to a sheet approximately ¼ inch thick. Such a sheet takes a good pattern on the marking roller and can be dried in a suitable smokehouse in 8—10 days.

20. Washing of Sheet.—After rolling, the sheets should be washed for half an hour in running water. A shorter washing period is permissible if the rollers are fitted with water sprays.

Each sheet should be placed in the washing tank separately. If a pile of sheets is placed in the tank the sheets in the middle of the pile do not come into contact with the water.

As the sheets are removed from the water they should be well brushed on both sides to assist in removing serum substances from the surface.

21. Draining of Sheet.—After washing, the wet sheets should be hung on racks in an open shed to drain. Under favourable conditions a certain amount of surface drying takes place as well as draining. On wet days, or if the sheets are hung in a damp shed, no surface drying can be expected to occur and nothing is gained by prolonged hanging after draining is completed.

22. Use of Para-Nitrophenol.—"Rust" and mould in smoked sheet can be prevented by treating the rubber with para-nitrophenol (P. N. P.). Details of the treatment are given in Appendix B.

"Rust" is caused by the fermentation of serum substances on the surface of the wet sheet when surface drying of the sheet is delayed. If the sheets are well drained and the smokehouse suitably ventilated it should not be necessary to use a disinfectant to prevent its occurrence.

SECTION B. II.—SMOKING AND SMOKEHOUSES.

(For further information on smoking and smokehouses see R. R. S. Bulletins. No. 42. "On the smoking of sheet rubber in relation to mould prevention," and No. 44 "The construction of smokehouses for small rubber estates.").

1. Smoking.—Smoke curing of sheet rubber is a method of rapid drying combined with absorption by the sheet of creosotic and other antiseptic substances from the smoke, which prevent or retard development of moulds or other micro-organisms. The presence of the smoke also enables drying to be carried out at a higher temperature than would otherwise be the case.

The antiseptic value of the smoke depends largely on the way the wood is burnt. A brightly burning fire produces a light pungent smoke deficient in antiseptic substances, whereas a smouldering fire produces a smoke with a high disinfectant value.

Theoretically it would be preferable to supply the heat and smoke separately, *i.e.*, to have a well ventilated fire or furnace to provide the necessary heat, and to produce smoke separately by slow

combustion of wood in a small drum. The ordinary smokehouse fire is a compromise which produces neither heat nor smoke in the most efficient manner, but gives comparatively satisfactory results if a suitable balance of ventilation is maintained.

2. Smokehouses.—Smokehouses are preferably of two storeys, the lower of which contains the fires or furnaces and the upper in which the sheets are hung on racks. Adapted single storey buildings are in many cases giving satisfactory service, but uniform distribution of smoke and heat is difficult.

The smokehouse should be made up of a serious of rooms, each of the maximum size which can conveniently be heated by one fire. A suitable size for a room is 20′ × 20′ and such a room has a capacity of 3,500—4,000 lbs. dry rubber.

Smokehouses in Ceylon are usually built of stone or brick and this material is most satisfactory as heat losses are minimised. Wooden buildings are suitable provided that good joints are made to prevent side draughts interfering with the upward air current in the smoke-house.

The upper storey containing the racks on which the sheets are hung, should have suitable gangways and be provided with large shuttered windows. It is important to have plenty of light to facilitate inspection and turning of the sheets.

The sheets should be hung at right angles to the gangways as they can then be removed or turned more easily. If round reapers are provided which fit into slots and project a few inches into the gangway it is not necessary to turn the sheets over each day. It is sufficient to rotate the reaper thus moving the sheets to a new position. This considerably reduces the time required for turning, and increases the output of the smokehouse.

Reapers should be about 1 inch in diameter and spaced 3—3½ inches apart (centre to centre). 20 inches of reaper space should be allowed for each sheet so that they can be made sufficiently wide to fit the packing chest. A vertical distance of 18 inches should be allowed between reapers so that the sheets can be moved about in order to avoid reaper marks.

Gangways should be floorboarded so that the smoke is forced to pass up through the racks on which the sheets are hung. The space under the racks should be protected with expanded metal to prevent sheets falling through, or preferably covered with a frame of wire gauze to filter the smoke from dust. If gauze is fitted it is necessary to clean it at intervals, otherwise it becomes choked.

The roof may be of tiles or corrugated iron. Top ventilation can be controlled more easily with an iron roof but it is essential that a ceiling should be provided underneath, (ceiling boards or hessian) otherwise condensation occurs on the underside of the roof and tarry drops fall on to the rubber. Roofing iron should be tarred on the inside to prevent corrosion. Corrugated asbestos sheeting and ruberoid are also satisfactory for roofing purposes.

In order to avoid risk of overheating, the distance from the fire to the nearest sheet should be approximately 10 feet. To assist in spreading the heat and smoke a large baffle plate should be suspended over each fire. If the baffle plate is made of heavy gauge metal supported on H irons it may prevent a fire in the event of a collapse of the hanging racks.

3. Ventilation.—The smoke house should be adequately ventilated by means of ventilating boxes in the roof, the opening of which can be regulated, and also by holes in the wall near the floor of the furnace room which can also be regulated. If ventilation is inadequate the atmosphere of the smokehouse will be damp and stagnant and drying will be delayed.

At the same time it must be remembered that the fire causes a strong upward draught and that large volumes of air are drawn in through comparatively small holes. If ventilation is excessive it means that hot air is passing through the smokehouse too quickly and fuel is being wasted in maintaining the correct temperature.

It is impossible to lay down any rule for the number or size of ventilation holes required as this depends on many variable factors. The adequacy of ventilation should be mainly judged by results. If rubber of normal thickness dries in 8—10 days and fuel consumption is economical it can be concluded that the ventilation is satisfactory.

4. Separate Room for Wet Rubber.—It is very desirable to have a small separate smokehouse in which to place sheets for the first 24 hours after rolling. This should be well ventilated as most of the moisture in the sheet is removed in the first day of smoking. Ventilation in the main smokehouse can then be reduced, with consequent economy in fuel consumption.

5. Furnaces.—The furnace should be inside the smokehouse and may consist of a fire in a pit, a fire at ground level in a properly constructed fireplace, or a fire in an iron drum or trolley. An open fire on the ground is not satisfactory. Exterior furnaces with a long flue allow loss of heat and condensation of the creosotic products in the flue.

The main point to remember is that ventilation of the fire should be distinct from the main ventilation of the smokehouse, *i.e.*, it should be possible to increase or decrease the amount of air passing through the smokehouse without influencing the burning of the fire.

A pit fire is the most common type in Ceylon and gives a good balance between heat and smoke if the dimensions of the pit are suitable (usually 4 ft. × 4 ft. × 4 ft.). It has the objection of being difficult to clean out and to stoke. Equally good results without the inconvenience and dirt can be obtained from other types of fire.

Arrangements may be made to stoke the furnace from outside by means of a tunnel, but care must be taken to regulate the draught through the tunnel.

6.—**Fuel.**—Well dried wood should be used as wet or green wood causes the sheet to have a glossy or greasy surface, and also reduces the drying capacity of the air. Rubber wood and most mixed jungle woods are suitable for smoking. It is permissible to add a small proportion of coconut husks or rubber seed pods to the fuel provided that the appearance of the sheet does not suffer.

7. **Temperature and Temperature Control.**—The temperature of the smokehouse should be maintained at 110—120°. It is important that the temperature should not be too low, as the rate of drying probably depends as much on temperature as it does on ventilation.

Every smokehouse should be provided with a maximum and minimum thermometer, which should be enclosed in some sort of a cage so that it can be seen by the cooly but cannot be tampered with.

A more efficient method of temperature control is provided by a recording thermometer, with the dial placed outside the smoke-chamber. This instrument provides a continuous temperature record, and thus indicates whether the smokehouse is being operated at maximum efficiency.

8.—**Sorting Smoked Sheet.**—In order to meet dealers' prejudices in respect of variation in colour and appearance, all sheets after removal from the smokehouse must be inspected for defects and sorted according to colour.

If the method of coagulation, machining and general treatment has been uniform the smoked sheet should be uniform in appearance and colour.

9. **Packing Smoked Sheet.**—When smoked sheet is first removed from the smokehouse it is very resistant to mould growth. If hung up or left lying about before being packed, it gradually absorbs moisture, loses volatile smoke constituents, and is also exposed to mould infection. Smoked sheet should be packed as soon as possible after removal from the smokehouse, preferably on the same day after allowing an interval for the sheets to cool. This is one of the best safeguards against mould in smoked sheet.

SECTION B. III.—DEFECTS IN SMOKED SHEET.

The following are the principal defects which occur in the preparation and production of smoked sheet. Methods of prevention are given except where obvious. Some of these defects, such as bubbles and "rust" have no influence on the intrinsic quality of the rubber from the Manufacturers' point of view, but must be avoided on account of market prejudices.

1. **Curdling of Latex.**—This may be due to,

   (a) Presence of lime (calcium hydroxide) in the water. The influence of this factor on Ceylon Estates has not yet been investigated.

   (b) Fermentation, owing to delay between collection and coagulation of latex. It occurs most commonly in the drier districts of Ceylon, and can be remedied by more rapid transport to the factory, or by the use of an anti-coagulant in the field. (See Section A. para 10.).

   (c) Too much or too strong acid for coagulation.

2. **Milky or Cloudy Serum.**—This is usually due to the use of insufficient coagulant or unsatisfactory mixing of coagulant with the latex. Under special conditions, such as when tapping is resumed after resting, more than the normal quantity of acid may be required.

3. **Soft or Spongy Coagulum.**—This may be due to a deficiency of coagulant, to bad mixing of the coagulant and latex, to overdilution of the latex, or to anærobic fermentation occurring during coagulation. The latter occurs more frequently when the latex is coagulated in tanks.

4. **Pitted Surface of Coagulum.**—Due to unsatisfactory skimming of the latex in the pans, or to fermentation.

5. Violet or Pink patches on surface of Coagulum.—Such patches are caused by oxidising enzymes in the latex, and are most common during the wintering season. If the marks spoil the appearance of the finished sheets they can be prevented by the addition of a small quantity of sodium bisulphite or formalin to the latex (1—2 oz. of sodium bisulphite or formalin to 100 lbs. rubber.).

6. Flat or indefinite marking of Sheets.—(a). Coagulum too hard due to insufficient dilution of latex or excess of coagulant. (b). Coagulum rolled too thin in smooth rollers. (c). Worn marking rollers or too shallow grooves on rollers.

7. Variations in size and weight of Sheet.—This may be due to non-uniform standardisation of different jars of latex, or to careless distribution of the latex to the pans.

8. Variations in Colour.—This may be due to non-uniform standardisation of latex, to oxidation of the surface of the coagulum, to irregular smoking, to excess of sodium sulphite, or to irregular mixing of sodium sulphite in the latex.

9. Rough or irregular suface.—Due to the coagulum being soft or flaky on the underside or to worn rollers. The former may be due to insufficient mixing of acid and latex, to an insufficient amount of acid, to over dilution of latex, or to dirty or rough coagulating pans.

It is advisable to wet the pans before pouring in the latex.

10. Oil Streaks.—Due to excess of grease or oil from the bearings of the machines, or to worn bearings. Oil from bearings frequently contains traces of copper which is very deleterious.

11. Cotton Waste.—Bits of fluff or cotton are occasionally found in sheets owing to cotton waste being used for cleaning the rollers or utensils. This material is not suitable for the purpose and should not be used in a rubber factory. A cloth with a smooth surface should always be used.

12. "Reaper" Marks.—A light mark across the centre of the sheet is caused when the sheet has not been moved daily during smoking. If reapers of round section are used the sheets can be moved easily by rotating the reapers.

A dark mark or stain is usually due to dirty reapers. Frequently the upper side of the reaper is kept clean, but the underside is neglected and the sheet becomes stained where it touches the lower edge of the reaper.

Narrow light and dark markings across the sheet are due to worn rollers or bearings.

13. Glossy surface.—Due to the use of damp (green) fuel or a fuel producing too much creosote such as coconut shells or husks. It may also be due to the addition of an excess of sodium sulphite to the latex.

14. Greasy Surface.—This is due to the exudation of serum substances and evaporation or fermentation of these on the surface of the sheet. It usually points to insufficient washing during and after rolling, or to insufficient dilution of the latex.

15. Tackiness.—This may be due to contact with copper salts in the coagulant, to oil from the bearings of the machines, or to exposure of the rubber to sunlight.

16. Specky Sheets.—The presence of specks of dirt in the rubber is usually due to bad straining of the latex. Masses of minute bubbles are sometimes mistaken for specks of dirt.

17. Thick Edges.—May be due to (a) irregularly shaped pans (b) pans of latex being placed on shelves which are not level (c) unskilful handling of coagulum (d) coagulum becoming doubled up during rolling.

In the case of tank coagulation it may be due to displacement of partitions in the tank.

18. Tar Deposits.—Due to tarry drops of water falling on to the sheet, especially from corrugated iron roofs. A wooden ceiling should be provided, or jute hessian hung under a corrugated iron roof.

19. White or Virgin Streak.—When sheet rubber becomes slightly damp it frequently shows a white streak in the middle. In extreme cases this may show when the sheet is apparently quite dry. This defect is usually due to :—

(a) Insufficient dilution of latex.
(b) Insufficient washing during and after rolling.
(c) Excessive thickness of the sheet.

20 Mould. -Any smoked sheet is liable to develop mould if allowed to become damp, even with an absorption of less than 1% of moisture.

Trouble with mould can usually be prevented by attention to the following points during manufacture :—

1. Thorough washing during and after rolling.
2. Thorough smoking with smoke from a slow burning fire (See Section B. II para 1.).
3. Packing in dry chests on the day of removal from the smokehouse.

Mould can be prevented by the addition of paranitrophenol to the latex, or by soaking the freshly rolled sheet in paranitrophenol. This treatment is recommended if the rubber shows a strong tendency to become mouldy, or if conditions of transport or storage are such that the rubber is likely to become damp. Paranitrophenol is recommended in all cases where sheet is to be stored for long periods.

For methods of using paranitrophenol see Appendix B.

21. "Shortness." —The cause of "shortness" or brittleness in sheet is not fully known, but it is usually connected with sheet manufactured from latex from young or backward trees. The addition of an excess of formalin to latex is also a cause of shortness.

22 "Rust."—"Rust" is caused by the fermentation of serum substances on the surface of the wet sheet. It develops during the period between rolling and completion of surface drying of the sheet.

Rust can be prevented by ensuring that surface drying of the sheet takes place rapidly. Its occurrence can usually be traced to one of the following causes:—

1. Hanging sheets to drain in a damp shed or leaving them hanging for too long a time. (See Section B. I. para 21.).
2. Delay in transfer of sheets to the smokehouse or in starting up the fires.
3. Lack of ventilation in the smokehouse.

Rust can also be prevented by treating the sheets with paranitrophenol, but it should not be necessary to use it for this purpose. (See Section B. I. para 22.).

23. Bubbles.—Bubbles in sheet are usually due to fermentation, but air bubbles may be trapped in the coagulum if an excess of acid, or insufficiently diluted acid is added to the latex.

Broadly speaking there are two classes of bubbles. The first consists of groups of small bubbles centred round small specks in the rubber. These are due to premature clotting of the latex before addition of acid, or to insufficient mixing of acid and latex. The small clots ferment during the night and form bubbles. The occurrence in the rubber of specks or flocks is due to premature clotting of the latex without subsequent fermentation.

The second class consists of single bubbles scattered about the sheet, frequently at the sides or corners. These (unless air bubbles) are due to general or local fermentation setting in after mixing the acid and latex.

Among the causes of bubbles are the following:

1. *Bubbles due to premature clotting, etc.*
   - (a) Dirty cups, spouts or buckets.
   - (b) Addition of dirty water to latex.
   - (c) Rainwater in latex.
   - (d) Delay in collecting latex, transporting to factory, or treatment in factory.
   - (e) Insufficient mixing of acid and latex, or insufficient amount of acid.

2. *Specks or flocks in rubber with or without bubbles.*
   - (a) Presence of lime in the water.
   - (b) Addition of paranitrophenol with the coagulant. (See Appendix B. p. 74). 50
   - (c) Delay in distribution of latex to the dishes after the addition of acid.
   - (d) Addition of certain adulterants such as rice "cunjee."

3. *Air Bubbles.*
   - (a) Use of an excess of acid, or of acid insufficiently diluted.
   - (b) Delay in distribution of latex to dishes after the addition of acid.

4. *Bubbles due to general fermentation.*
   - (a) Insufficient acid.
   - (b) Inadequate stirring of acid and coagulant.
   - (c) Dirty dishes or general lack of cleanliness in the factory.
   - (d) Lack of ventilation in the coagulating shed.
   - (e) Delay in rolling or transport to the smokehouse.
   - (f) Retarded drying in the smokehouse.

If premature clotting of the latex cannot be prevented in any other way the use of an anti-coagulant in the field or factory should be considered. (See Section B. I. para 9.). Sodium sulphite also tends to prevent bubbles due to general fermentation.

If bubbles are traceable to general fermentation special attention should be given to cleanliness in the factory. Dishes or troughs should be rinsed out twice a week with a 2% solution of formalin (1 gallon formalin to 50 gallons water). Racks should be washed down with formalin, disinfectant fluid, or paranitrophenol (1 lb. to 50 gallons water). Floors should be washed with disinfectant daily.

Note.—The precise cause of various types of bubble has not been fully investigated, but it is hoped that work on the subject will shortly be started in Ceylon. The information given above is based on factory experience, but it may be necessary to make some modifications when the subject has been studied further.

24. Blisters.—Blisters are large bubbles caused by overheating in the smokehouse, especially in the early stages of smoking.

Note.—If any of the above defects occur, the sheets containing them should be sorted and packed separately.

It may be stated here that the standard method of preparation recommended in this Guide is that usually adopted in Malaya and Ceylon. In the Netherland East Indies a sheet from more concentrated latex (2 lbs. per gallon), machined on the day of coagulation is the standard method of preparation.

SECTION C.—PALE CREPE RUBBER. ("First latex" crepe)

Pale crepe or "first latex" crepe is the alternative form of first grade rubber prepared on estates at the present time.

All operations in connection with the collection of latex and transport from the field to the factory, which were dealt with in Section A apply to latex which is to be converted to pale crepe.

SECTION C. I.—FACTORY OPERATIONS. (Pale Crepe.)

Operations connected with receiving, "weighing up" and straining the latex are the same as described in smoked sheet manufacture. (See Section B. I. para 1-5.).

1. Bulking of Latex.—As described in Section B. I. para 7 it is very desirable to have a large tiled receiving tank so that latex from large areas is mixed together, thus ensuring uniformity in appearance and inner properties of the rubber.

This tank may also be used for coagulation, but in order to allow grit to settle out and also in order that the final straining may be done after dilution, it is preferable to dilute the latex in the receiving tank and afterwards run it off into another tank for coagulation.

2. **Standardisation of Latex.**—In order to maintain uniformity in the appearance and quality of the prepared crepe, it is recommended that the latex should be diluted to a standard dry rubber content of 2 lbs. per gallon. This can be controlled by means of a brass Metrolac or Rubber Research Scheme hydrometer.

3. **Sodium Bisulphite.**—Addition of sodium bisulphite to the latex is essential in order to obtain a pale coloured crepe. This prevents the darkening due to oxidation by enzymes present in the latex, which would otherwise occur and which would lead to the production of streaky crepe. Sodium bisulphite does not remove the yellow colour which is normally present in latex.

The maximum amount of sodium bisulphite which should be necessary is 1 lb. to 200 lbs. dry rubber, but on most estates a smaller quantity is found to be sufficient to prevent oxidation. The average amount used on estates at present is 1 lb. sodium bisulphite to 265 lbs. rubber (6 ozs. per Shanghai jar of latex at 2 lbs. per gallon.)

The sodium bisulphite should be dissolved in 20 parts of water and added to the latex after dilution. The latex should then be well stirred before the addition of the coagulant.

4. **Deterioration of Sodium Bisulphite.**—Sodium bisulphite rapidly decomposes when exposed to air, particularly at tropical temperatures. It changes to sodium sulphite which in turn deteriorates giving a product which is useless for bleaching purposes. Sodium sulphite is recommended as an anti-coagulant (See Section A. para 10.), and the use of deteriorated bisulphite probably explains cases in which a milky serum remains after coagulation, in spite of using a full amount of acid.

When a new drum of sodium bisulphite is opened the contents should immediately be transferred to small air-tight earthenware jars (holding about 14 lbs. each.). The small expenditure on jars will be amply repaid by the saving in bisulphite and acid.

5. **Coagulants.**—(See Section B. 1. para 10).

Acetic and formic acids are suitable coagulants. It has recently been claimed that sodium silicofluoride produces crepe of better colour than acetic or formic acid, but its use for crepe manufacture is not yet recommended in Ceylon.

Acetic Acid.—The normal amount of acetic acid for latex diluted to 2 lbs. per gallon is 1 lb. of acid (16 fluid ounces) to 200 lbs. dry rubber. The amount should be adjusted so that a clear or only slightly cloudy serum remain after coagulation. The acid should be diluted with 19 parts of water before addition to the latex.

For a Shanghai jar containing 50 gallons of latex at 2 lbs. per gallon the amount is 8 oz. of acetic acid diluted to not less than 1 gallon.

If it is desired to use the acid in the form of a stock solution this is prepared by mixing 1 part of acid with 19 parts of water, and adding this to the latex in the proportion of 1 part stock solution to 50 parts standardised latex.

Formic Acid.—The normal amount of formic acid (90%) is 16 fluid ounces to 400 lbs. dry rubber. The acid should be diluted to twice the extent which is necessary with acetic acid.

For a Shanghai jar containing 50 gallons of latex at 2 lbs. per gallon the amount is 4 oz. of formic acid diluted to not less than 1 gallon.

A stock solution may be prepared by mixing 1 part of formic acid with 39 parts water. This is added to the latex in the proportion of 1 part of stock solution to 50 parts latex.

6. Mixing Coagulant and Removal of Froth.—After the addition of the acid the latex should be thoroughly stirred. A broad paddle of hard wood, having a blade perforated with one inch holes is suitable for Shanghai jars. For tank coagulation a form of rake, having a blade slightly shorter than the width of the tank, perforated with one inch holes and attached to a long handle, is suitable.

After thorough mixing the froth is removed, as this tends to cause streakiness of the crepe. Many Rubber-makers favour a second stirring and removal of froth, and it is likely that this slightly improves the colour of the crepe by removal of further oxidisable material. The jar or tank should then be covered up and left to stand overnight.

7. Machinery.—The type of machines used for the preparation of Ceylon blanket crepe are:—

1. Horizontally grooved rollers for maceration.
2. Smooth rollers for rolling thin crepe.
3. Horizontally grooved rollers for blanketing.

Rollers 15—18 inches in width and 12 inches in diameter are in general use, but machines with rollers up to 30 inches in width have been introduced recently and are more economical in power consumption and labour than smaller machines.

Care should be exercised in the selection of rollers as they differ materially in efficiency. This applies more particularly to smooth rollers.

The rollers are adjusted by means of large screws set at each side of the machine. This is simpler and more satisfactory than devices which set the two sides simultaneously. In many modern machines the screws are of stainless steel, and this should be specified when ordering.

The machines should be set up a few inches below the general floor level of the factory. A space round the machines should be tiled with good smooth (not glazed) tiles, set in acid proof cement. The floor should slope slightly so that water flows towards suitably placed drains.

Machines should never be allowed to run "idle" *i.e.*, without rubber between the rolls, unless the rolls are well separated.

8. Grooving of Rollers.—Horizontal grooves are preferable as they can be more easily re-cut than other types. The grooves should be $\frac{1}{8}$ wide and $\frac{1}{8}$ deep, and $\frac{1}{4}$ inch apart. A groove of V section is preferable to a square cut or U groove as it has less tendency to cut the rubber.

9. Gear Ratio.—

Macerating Rollers.—If only one macerating machine is used a gear ratio of 18:21 is suitable. If two machines are used one should be geared 17:32 and be used for breaking down the coagulum. The other should be geared 18:21 and be used for completion of maceration.

Smooth Rollers.—A gear ratio of 17:32 is recommended. This produces crepe of smoother texture than is obtainable with even speed rollers.

Blanketing Rollers.—If a separate machine is reserved for blanketing, the rolls should run at equal speed. A macerating roller geared 18:21 is also suitable.

10. Speed of Operation.—For rollers of 12 inch diameter the speed of operation should not exceed 22 revs. per minute for macerating and smooth rollers and 20 revs. per minute for blanketing rollers. This speed refers to the faster moving roller.

11. Care of Machinery.—Rollers should be thoroughly washed each day after use. It is also desirable to wipe the rollers with a cloth soaked in a dilute solution of washing soda (1 lb. to 5 gallons water) in orderto remove any acid which remains. The rollers should then be thoroughly rinsed to remove all traces of soda solution, and dried as far as practicable.

Grease or oil for bearings should not be used in excess, since contact with oil or grease causes deterioration of the rubber.

Worn parts of machines should be replaced. Bad machinery makes a rubber of inferior appearance.

MACHINING.

12. Maceration.— The coagulum should be cut into slices not exceeding 3 inches in thickness. Five rollings in the grooved roller under a good water spray, is sufficient to wash out serum substances and bring the rubber to a suitable form for passing through the smooth roller, provided that the machine is in good mechanical condition. Less than 5 rollings is not recommended.

The output of the machine depends largely on the thickness at which the rubber is rolled. The thickness should be such that the blanket can be fed in to the smooth roller without tearing.

Thickness is most conveniently expressed as the weight (dry rubber) per square foot of blanket. This should be between 8 and 12 ounces per square foot, depending on the gripping power of the smooth roller.

13. Smooth Rolling.—The rubber should be passed once through the smooth roller. The smoothness of the finished rubber and freedom from holes depends partly on the texture of the roller surface, partly on the gear ratio and partly on speed of operation of the machine.

The thickness of the crepe must be regulated according to the efficiency of the drying accommodation available. It should be such that the crepe dries completely in 10 days even in wet weather. Thicker crepe may be prepared when drying conditions are favourable. An average thickness for crepe in Ceylon is 2 ounces (dry rubber) per square foot.

In order to obtain the maximum output from the machine the full width of the rollers should be utilised. The hoppers for a 15 inch roller should be 12 inches apart. If the rolls are worn so that the full width cannot be utilised it is an economy to have them re-machined.

Any tendency for the edges of the crepe to "ball up" (due to slip at the sides of the roller) can be reduced by rolling a small quantity of earth scrap in the machine occasionally. This practice is beneficial if carried out occasionally, but the practice should not be abused as the improvement is due to the abrasive action of the grit in the scrap rubber.

"Hairline" grooving has not been found to improve the output of smooth rollers to any considerable extent.

14. Blanketing.—Preferably a separate machine situated in a dry part of the factory should be reserved for blanketing. If one of the

macerating rollers is used it must be dried thoroughly before blanketing is started. Blanket of even width and good texture can be produced in 3 rollings. The rubber should be allowed to cool down before the final rolling.

The rollers gradually become heated up when dry rubber is being rolled and intervals for cooling must be allowed, otherwise the blanket will not be uniform in appearance. Rollers with internal water cooling are preferable.

After blanketing the rubber should be hung up for a day before packing.

15. Output per hour, and size of Battery.—The output per hour which should be obtained under normal conditions is approximately as follows:—

15 inch Rollers.

Maceration (5 rollings)	...	225 lbs. per hour
Smooth rolling (1 rolling)	...	80-100 lbs. per hour
Blanketing (3 rollings)	...	400 lbs. per hour

22 inch Rollers.

Maceration (5 rollings)	...	350 lbs. per hour
Smooth rolling (1 rolling)	..	130—150 lbs. per hour
Blanketing (3 rollings)	...	700—800 lbs. per hour

It will be seen that 4 or 5 smooth rollers are required to keep pace with 2 macerating rollers if a separate machine is reserved for blanketing.

For further information *re* crepe rolling see Rubber Research Scheme Bulletin No. 50.

DRYING.

16. Air Drying.—Owing to the increased cost of machine drying Crepe is now usually dried at ordinary air temperature.

The drying rooms are usually situated over the machine rooms but this is by no means an ideal arrangement owing to the danger of moist air from the rolling shed delaying drying. In designing new factories the drying shed and packing room should be separated from the coagulating and rolling shed.

Successful air drying depends on adequate ventilation of the drying room. Top ventilation should be provided by means of a "jack" or ridge roof and provision should be made for air to enter the room at floor level. The heat of the sun then creates an upward draught through the rubber.

If the drying room is situated over a dry part of the factory the floor should be opened up by removal of floor boards or insertion of gratings. Otherwise, if practicable, ventilation holes should be made in the walls at floor level and these should be provided on the outside with hinged shutters. Window ventilation is also of importance in order to obtain the benefit of any breeze, but on a windless day the upward draught is the chief factor.

Whether it is necessary to close up the room at night depends on local conditions. If mists or heavy dews occur in the district it is desirable to close windows and ventilators, but otherwise no great advantage is gained as the air in the room will in any case become saturated with moisture from the wet crepe which is hanging there.

If adequate ventilation is provided the reapers need not be widely spaced, but for an average drying room they should be at least 6 inches apart, (centre to centre). The crepe should be hung so that there is a space of 12 to 18 inches between the floor and the rubber. This improves the circulation of air.

The rate of drying depends on the thickness of the rubber, but crepe of average thickness should dry in 5—6 days in good weather and 8—10 days in wet weather.

The crepe should not be considered dry until all opaque spots have disappeared. Small moisture spots dry out to a certain extent during the blanketing process, but there is a danger that they may remain and cause fungal spots to develop in the rubber after packing.

The dry crepe should be taken down in the afternoon ready for rolling to blanket the following day. The moisture content of the crepe is then lower than it is in the early morning.

Crepe which is exposed to sunlight or direct window light during drying becomes discoloured. Such crepe should be taken down and rolled separately. If mixed with the other crepe it is likely to cause streaks in the finished blanket. Preferably the windows of the drying sheds should be provided with shades so that only diffused light enters the room.

For further information *re* ventilation of air drying sheds see Rubber Research Scheme Third Quarterly Circular for 1927. p. 7.

17. **Assisted Air Drying.**—Drying can be improved to some extent by the use of fans in the drying lofts. Unfortunately the effect is least when most required *i.e.*, during wet weather.

Excellent results have been obtained in some cases by utilising the waste heat from the engine exhaust to raise the temperature of the

drying room. The exhaust gases are led through a large diameter pipe at one end of the drying room. An exhaust fan at the other end of the room draws air over the hot pipe and through the rubber. The efficiency of this system depends largely on the type of engine.

Radiation from steam or hot water pipes would probably prove the most suitable method of heating, if the engine exhaust heat cannot be used. No fan is required and heating could be continued during the night, when little drying takes place at ordinary temperatures.

18. Machine Drying.—The C. C. C. type of drier is generally used. The air temperature should not exceed 150° and the thickness of crepe and the amount spread on each tray should be adjusted so that drying is complete in 1—1½ hours. It is usual to put 2½—3 lbs. of rubber (dry weight) on each tray, and the output from each compartment of the drier is thus 30—36 lbs. per hour. The crepe should not be blanketed until the day after drying.

The standard thermometers fitted to the driers do not record the full temperature as they are not in the direct air current. It is very desirable to have a recording thermometer fitted to the main air inlet so that the temperature of the air can be carefully controlled.

Vacuum driers are rarely used at the present time.

SECTION C.II.—DEFECTS IN PALE CREPE RUBBER

The following are the principal defects which occur in pale crepe. Where the remedies are not obvious suggestions are made.

1. Yellow Crepe.—A deep yellow crepe is obtained during the early stages of opening a new tapping cut. An increase in the amount of sodium bisulphite added to the latex will not reduce the depth of colour.

The yellow tint is due to a natural colouring matter present in the latex. Fractional coagulation (See Section F. I. para 2.) may be adopted to obtain a pale crepe, and this results in a proportion (10—12%) of deep yellow crepe as the first fraction and a very pale crepe as the second fraction.

2. Brown Discoloration.—This may be due to the use of impure water for diluting the latex. The purity of the water used during the rolling is of less importance but it should naturally be as pure and clean as possible.

3. Dull Colour.—This may be due to the addition of too little sodium bisulphite, to the use of an inferior quality of sodium bisulphite, or of sodium bisulphite which has deteriorated during storage.

Pale crepe becomes dull and darker in colour during storage.

Blanket crepe prepared from latex coagulated without dilution has an opaque appearance instead of the translucent amber colour which the market prefers.

4. **Streaky or Mottled Crepe.**—Streakiness in blanket crepe is frequently due to pieces of crepe of slightly different colour being blanketed together. This may be due to variation in the latex from different fields, or to differences in the treatment of different jars of latex. The best remedy is to coagulate in large tanks which ensures that the crepe is uniform in colour.

During wet weather surface mould may develop on the rubber hung in parts of a badly ventilated drying shed, or the crepe may darken slightly owing to oxidation. This also causes a streaky or mottled appearance in the finished blanket crepe.

Direct sunlight or bright light shining on portions of crepe in the drying room causes discoloration and may lead to streaks in the blanket crepe.

Streaks in the thin crepe may be due to premature local clotting of the latex, to bad mixing of bisulphite or coagulant with the latex, or to insufficient skimming. Discoloration of the froth occurs particularly during and just after wintering owing to the greater tendency of the latex to become oxidised when exposed to the air.

5. **Grey or Dark Colour.**—A grey or dark colour may be caused by particles of soft steel or carbon from the rolls of the machines getting into the rubber. A piece of waste crepe should be passed through the rollers several times before the fresh coagulum is rolled. The rollers should not be allowed to run "idle."

6. **Greenish Tacky Streaks.**—These streaks are due to contamination with oil from the bearings of the machines. Such oil frequently contains copper from the bearings which causes the rubber to become tacky.

7. **White or Yellow Streaks or Patches.**—Such patches in the thin crepe are usually due to bad mixing of the sodium bisulphite with the latex.

8. **Cotton Waste.**—Bits of cotton or fluff may be found in the crepe if cotton waste is used for cleaning rollers or utensils. The use of cotton waste should not be permitted in a rubber factory. Cloth with a smooth surface should always be used.

9. **White Spots.**—These may be due to the thicker portions of the crepe being incompletely dry. Dry crepe should be of an even translucent colour.

White spots in perfectly dry pale crepe and lower grade crepes have been found (in Malaya) to be due to adulteration with tapioca or other starchy materials.

10. Coloured Spots.—Spots or patches which may be black, blue, violet, red, orange, yellow, or green are caused by various micro-organisms, and may develop during manufacture or during subsequent transport or storage if the rubber becomes damp. All raw rubber contains the spores of these organisms which in the presence of moisture may develop and produce the discoloration.

The appearance of "spot disease" during manufacture is due to slow drying of the rubber, the most frequent causes of which are :—

1. Badly ventilated drying rooms.
2. The use of an excess of sodium bisulphite.
3. Too thick a crepe.

An insufficient amount of sodium bisulphite may also be responsible for the appearance of spot disease, as sodium bisulphite acts as a mild disinfectant during drying.

The usual causes of development of spots after packing are :—

1. Blanketing the crepe on wet rollers.
2. Packing in damp chests.
3. Storage of packed rubber in a damp place.
4. Accidental contamination of the chests of rubber with sea or rain water.

"Spot" disease and surface mould can be prevented by the addition of a small proportion of paranitrophenol to the latex with the coagulant (see Appendix B. para. 2.).

Crepe containing P. N. P. is more liable than ordinary crepe to become discoloured if exposed to bright light in the drying room, but any discoloration due to this cause is preferable to serious trouble with spots or surface mould.

11. Tackiness.—Tackiness may be caused by (a) contamination with salts of copper (b) exposure to sunlight (c) exposure to heat.

SECTION D.—LOWER GRADE CREPES.

The lower grades of crepe usually prepared in Ceylon are as follows :—

1. Mottled Crepe.—Consisting of lump, bucket washings, froth, and off colour rubber, and trimmings from first grade rubber. On some estates this rubber is mixed in with tree scrap.

2. **Light Scrap.**—(Tree Scrap). This consists of the dried layer of latex removed from the tapping cut. Any badly discoloured (oxidised) pieces should be sorted out during collection and added to the cup scrap.

In order to avoid unnecessary darkening in colour, the scrap on arrival at the factory should be soaked overnight in a solution of sodium bisulphite (8 ozs. sodium bisulphite to 40 gallons water) and machined on the following day.

3. **Dark Scrap.**—(Cup Scrap). Cup scrap consists of the film of latex which dries in the collecting cup, after the latex has been transferred to the collecting pail. When coconut shells are used, the scrap is frequently dark grey or black in colour. Cup scrap should be worked up together with discoloured pieces of tree scrap.

4. **Earth Scrap.**—During the Restriction period this grade of rubber has not been prepared to any great extent. It consists of rubber which has overflowed from the tapping cut or latex cup owing to rain or accidental causes, and coagulated on the bark or on the ground at the foot of the tree.

It is usually black in colour and may be sticky or tacky. If this grade of rubber is prepared it should be collected at frequent intervals, in order to prevent unnecessary deterioration.

5. **Machining of Scrap Rubber.**—Tests made in Sumatra indicate that the amount of power used in machining scrap rubber is about 2½—3 times that required for making first grade crepe. Thus, if payment is made for collection of scrap the total cost of production may be greater than that of pale crepe. This point is worth remembering when the price of rubber leaves only a small margin between profit and loss.

In order to make a uniform grade of rubber, and to remove dirt and grit successfully, scrap rubber should be macerated in the type of machine known as a "Scrap washer." This may consist of deeply grooved rollers rotating under water, or else of a single roller with pointed projections which force the rubber against similar projections or ridges on the main body of the machine.

Maceration in ordinary grooved rollers leads to rapid wear of the rollers, and does not completely remove sand and bark from the rubber.

The rubber emerges from the scrap washer in the form of irregular sausages or lumps which are subsequently converted to crepe on the ordinary machines. After drying, the crepe may be packed in the form of thin crepe or made up into blanket. Any tacky portions should be cut out before blanketing.

SECTION E.—PACKING OF RUBBER.

1. Chests.—Two types of packing chest are in general use, namely the "Momi" or plank chest imported from Japan, and the plywood chest of which the "Venesta" is probably the best known.

Both chests have the same external dimensions namely 19″ × 19″ × 24″, equivalent to 5 cubic feet or 1/10 of a shipping ton. The plywood chest being made of thinner wood has a greater internal capacity, giving an advantage of 7—8% over the Momi chest. The plywood chest is stronger than the Momi so the potential advantage in capacity is greater than 7%.

The plywood chest is semi water-tight so the rubber is less likely to develop mould or spot disease if the chest accidentally becomes damp in transit. The wood has a smooth surface and the rubber is less liable to damage by splinters.

The Momi chest is considerably cheaper, and for rubber which is sold on the local market is probably the most economical, unless the Buyer is prepared to pay a premium for packing in plywood chests.

For export, on the other hand, the plywood chest has an appreciable advantage. Shipping charges are made according to volume (1 ton=50 cubic feet) so there is a saving proportional to the greater capacity of the chest. In addition a rebate of 25% is allowed on London dock charges when plywood chests are used, as only a proportion of the chests are opened for sampling.

2. Packing.—Whichever type of chest is used it is important that as much rubber as possible should be packed in the chest in order to minimise packing and transport charges.

The amount of rubber which can be packed in a chest naturally depends on the size, thickness and texture of the sheets or pieces of crepe, but the amounts to be aimed at are as follows:—

	Blanket Crepe	Smoked Sheet.
Momi chest	140—150 lbs.	190—200 lbs.
Plywood chest	150—160 lbs.	224 lbs.

In order to pack these quantities, pressure of some sort must be applied, either by means of a light screw press, or by placing weights on the rubber overnight. Tight packing is an advantage as the rubber otherwise sinks down gradually by its own weight, and being loose in the chest, is more liable to be damaged by splinters.

The chests should be thoroughly dried before packing the rubber. Momi chests may be put out in the sun to dry but this is not advisable with plywood chests.

Packing should not be carried out before 11 a.m. since rubber in the store room absorbs moisture during the damp nights and early mornings.

Before packing, the sides of the chest should be lined with pieces of rubber of the same quality which is to be packed. This prevents dirt and splinters penetrating between the sheets of rubber, and is now insisted on by the Rubber Association of America for consignments of contract quality rubber.

3. **Assembling Plywood Chests.**—In assembling the chest, the battens for the upper edges should be nailed to the lower edges of the cover and not to the sides of the chest, so that they are removed with the cover when the chests are opened, thus facilitating removal of the rubber.

All projecting nails must be clinched so that the rubber can be easily slipped from the chest.

4. **Assembling Momi Chests.**—Plank Chests must be strengthened externally with hoop iron strapped round the edges. The hoop iron should be nailed on previous to packing and all projecting nails must be clinched.

5. **Marking.**—All chests should be marked "stow away from boilers."

SECTION F.—SOLE CREPE.

Two distinct methods are used for the preparation of sole crepe, and may be referred to as the "Ceylon" method and the "Malayan" method. The essential difference is that in the Ceylon method the rubber is worked up into smooth uniform sheets after drying, whereas in the Malayan method this is done before the rubber is dried, and after drying, the thin plies of crepe are pressed together to give the required thickness of sole crepe.

Sole crepe prepared by the Malayan method is smoother in texture than Ceylon sole rubber. It contains more plies and the plies are not visible when the edge of the sheet is examined. There is a wider market for the Malayan type of sole crepe and at present the selling price is higher.

SECTION F. I.—PREPARATION OF SOLE CREPE BY THE CEYLON METHOD.

Procedure varies considerably on different estates and the following summary is only an outline of the usual procedure adopted. Success depends mainly on careful organisation and supervision.

1. **Coagulation.**—The present demand is for a very pale sole crepe and, in order to obtain this, the method of fractional coagulation of latex is usually adopted. By this method the natural yellow colouring matter, which is present to a greater or less extent in all latex, is removed in the first clot, which is converted into ordinary blanket crepe of a yellow colour. The method of fractional coagulation is described below. If fractional coagulation is not practised, the ordinary method of coagulation is adopted (See Section C. I.).

2. **Fractional Coagulation.**—Two coagulating tanks should be provided, one at a higher level than the other so that after coagulation of the first fraction, the latex can be run from the upper to the lower tank for completion of coagulation.

The latex is diluted to 2 lbs. per gallon in the upper tank and sodium bisulphite is added in the proportion of 1 lb. to 200 lbs. dry rubber.

According to the usual practice acetic acid, (diluted to 5% strength) is then added to the latex in the proportion of 1 lb. of strong acid to 1,600 pounds dry rubber. The correct amount of acid depends on the latex and must be adjusted according to results. In many cases, however, it is not necessary to add any acid at this stage, and this is preferable as the first fraction is then smaller.

The latex, either with or without acid, is then allowed to stand for 12—18 hours. The time of standing must be adjusted according to results. The latex is then thoroughly stirred until clots of rubber collect on the paddles. These are removed and the latex is run in to the lower tank through a fine mesh sieve. The latex is then coagulated by addition of diluted acid in the proportion of 1 lb. strong acetic acid to 200 lbs. dry rubber. It may be found necessary to increase the amount of acid in order to obtain a clear serum. The latex coagulates rapidly and should be ready for machining in 2—3 hours. Coagulation may be assisted by stirring.

The proportion of first fraction to second fraction rubber varies on different estates, and according to weather conditions. The treatment should be adjusted so that the first fraction does not exceed 8—10%.

Formic acid may be used in place of acetic acid the quantities being approximately half those mentioned for acetic acid.

3. **Machining.**—The coagulum is macerated and rolled to thin crepe as in the preparation of ordinary crepe (See Section C. I.) and hung to air dry.

4. Machinery for preparing Sole Crepe.—The most suitable type of machine for preparing sole crepe is one with (superimposed) smooth rollers 22 or 24 inches wide by 12 inch diameter, provided with an internal water cooling system. The two rollers must run at equal speed and the operating speed should not exceed 12 revs. per minute.

5. Milling the Sole Crepe.—Dry lace crepe is fed evenly into the machine with the rollers set so that the rubber emerges as a fairly uniform sheet about ⅛ inch thick.

The rubber is then carefully examined (usually by women) and any dirty pieces cut out. This is a very important operation as a whole sheet of finished sole crepe may be spoiled by the presence of one dirty mark.

Three or four layers of this rubber are then placed together and passed three times through the machine. The rollers are tightened at each rolling and are finally set so that a uniform sheet of rubber slightly over 1/16 inch thick emerges from the machine. The width of the rubber at this stage should be 17—18 inches.

These sheets form the plies from which the sole crepe is built up to the required thickness. Two plies are used for ⅛ inch sole crepe, three for 3/16 inch sole crepe and so on.

6. Building up the Plies.—The procedure for building up the plies is as follows:—A sheet of the rubber is laid out on a table which may be thirty feet or more in length. The rubber is stretched slightly and held in position at each end of the table. Another sheet of rubber is carefully placed on top of the first sheet and secured at the ends in the same way. A heavy hand roller (a roll from an old smooth crepe machine is suitable) is passed once over the rubber to bind the plies together. The required number of plies are built up in this way, and the rough edges are then cut off with scissors leaving the rubber with a width of 15—16 inches. The rubber is then ready for the final rolling.

The long sheet of rubber is passed once through the machine with the rolls set so that it emerges at the exact thickness required.

The output of sole crepe from a machine of the type described should approximate to 100 lbs. per hour.

7. Trimming.—Sole crepe is always marketed in the form of sheets 36 × 13 inches and must be cut to this exact size.

Cutting may be done by means of knives, guided by a straight edge, but this is not very satisfactory as it is difficult to avoid making jagged edges, which detract from the appearance of the rubber. A special

cutting machine with two rotating knives, working on the principle of the circular saw, is available in Ceylon and gives excellent results. This machine cuts the rubber to the correct width and the ends are afterwards cut by hand.

A wet knife must be used for cutting the rubber, and the surface of the rubber thus becomes damp so it must be hung up for 24 hours to dry thoroughly before packing.

8. Uniformity of Thickness.—Great care must be taken to ensure that the rubber is made to the exact thickness specified by the Buyer. A small difference in thickness which may be imperceptible to the eye and hardly measurable with calipers will make a considerable difference in the number of sheets of sole crepe per ton. The rubber is sold by weight, but the Manufacturer buys it in expectation of finding a definite number of sheets per ton.

The most satisfactory method of controlling thickness is by the weight of the sheets. The standard number of sheets of sole crepe (Ceylon type) per ton are as follows :—

	Number of pieces per ton.	Number of pieces per chest (140 lbs.)
1/8 inch sole crepe ...	1,152	72
3/16 „ sole crepe ...	864	54
1/4 „ sole crepe ...	576	36

This should be regarded as the basis for controlling thickness, but at the same time calipers or gauges should be provided for checking the thickness during manufacture.

The correct setting of the machine for the various rollings should be determined by tests and these should be clearly marked on the adjusting screws. There should then be no difficulty in securing uniformity in thickness.

9. Grading and Sorting.—Grading and sorting are essential and all pieces showing streaks, non uniformity in colour, bad finish, or varying thickness must be discarded.

Preferably the weight of each piece of sole crepe should be checked and a rough balance for this purpose can easily be improvised.

10. Packing.—Plywood chests 38″ × 11″ × 15″ are in general use for packing sole crepe and are preferable to Momi chests. 140 lbs. of sole crepe is packed in each chest.

The chest should be lined with grease proof paper and it is also customary in Ceylon to place a sheet of grease proof paper between each sheet of rubber. This is not done in other countries and is probably unnecessary.

SECTION F. II—PREPARATION OF SOLE CREPE BY THE MALAYAN METHOD.

(Reprinted from "Guide to the Preparation of Plantation Rubber" issued by the Rubber Research Institute of Malaya.)

On account of the popularity of a thick raw crepe rubber as a sole for footwear, sole crepe has appeared as a new development in the preparation of rubber on estates. This type of rubber is now prepared on a number of estates in Malaya and fetches a considerable premium over the ordinary first latex grades (smoked sheet and pale crepe). It costs more to prepare, however, owing to the extra labour and supervision required.

1. FIELD OPERATIONS.

1. Sole crepe is prepared from thin pale crepe. The methods of collection and transport of latex in the field are similar to those described in Section A.

2. A closely knit and well finished crepe of uniform thickness, free from holes and laciness is, however, desirable, so that considerable care has to be taken in the machining operations in the estate factory.

2. FACTORY OPERATIONS.

3. **Coagulation.**—The present demand is for a very pale sole crepe and, in order to obtain this, the method of fractional coagulation of latex has been adopted on some estates. By this method the natural yellow colouring matter, which is present to a greater or less extent in all latex, is removed in the first clot, which is converted into ordinary thin crepe of a yellow colour. The method of fractional coagulation is described below. If fractional coagulation is not practised the ordinary method of coagulation of latex for the preparation of thin pale crepe is adopted.

4. **Fractional Coagulation.**—No anti-coagulant such as sodium sulphite should be added to the latex in the field or in the factory, since this inhibits the formation of the first fraction, after the acid coagulant is added.

Sodium bisulphite should be added to the strained latex in the proportion of 1 lb. in 10 gallons of water to 100 gallons of diluted latex ($2\frac{1}{2}$ lbs. of dry rubber per gallon). Acetic acid should then be added in

cutting machine with two rotating knives, working on the principle of the circular saw, is available in Ceylon and gives excellent results. This machine cuts the rubber to the correct width and the ends are afterwards cut by hand.

A wet knife must be used for cutting the rubber, and the surface of the rubber thus becomes damp so it must be hung up for 24 hours to dry thoroughly before packing.

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4. **Fractional Coagulation.**—No anti-coagulant such as sodium sulphite should be added to the latex in the field or in the factory, since this inhibits the formation of the first fraction, after the acid coagulant is added.

Sodium bisulphite should be added to the strained latex in the proportion of 1 lb. in 10 gallons of water to 100 gallons of diluted latex (2½ lbs. of dry rubber per gallon). Acetic acid should then be added in

the proportion of 1 gallon of 1 per cent. acid to 36 gallons of the diluted latex. This is a suitable quantity, if the first fraction or clot is removed on the following day. If the first fraction or clot is removed on the same day, the amount of acid will require to be increased slightly.

The latex and acid should be well stirred and after the first clot is formed, the residual latex should be run off and strained through a fine sieve (60 mesh).

This residual latex is then coagulated by the addition of 1 part of acetic acid per 1000—1200 parts of latex as for coagulation of normal standard latex. A satisfactory clot is usually formed in less than one hour. No additional sodium bisulphite is required. The second clot or fraction should amount to 80—90 per cent. of the total dry rubber content of the original latex. This second, very pale fraction, is converted into thin crepe for the manufacture of a pale sole crepe. During the wintering season, acid in the proportion of 1 part to 3000 parts of latex should be used to coagulate the first clot.

5. Machinery.—In many estate factories sole crepe is manufactured by using the ordinary creping and finishing machines with rolls 16 inches to 18 inches wide.

The width of sole crepe required by the market is 13 inches and on ordinary estate factory machines, it is not possible to prepare a satisfactory thin crepe of sufficient width without joining.

A finely grooved creping machine, with grooves of $1/32 \times 1/64$ inch and a large gear ratio on the rollers of about 2 : 1 is essential.

Unless wide roller machines are available, there is no necessity on the ordinary 16—18 inch rolls to make the thin crepe more than 9 inches in width, since joining is necessary in any case. It should be possible to prepare about 250 lbs. of such thin crepe per hour with two finishing machines.

A good thin crepe can be prepared by passing the coagulum through the machines as below :—

Macerating machine (Ratio of pinion teeth 21/27	... 5 times
Creping machine (Ratio of pinion teeth 24/26	... 2 times
Finishing (smooth roll) machine (pinion teeth 17/32)	2 times

If the rolls are run at slower speeds, there is not such a decrease in width of the coagulum after successive machining, but the output is naturally reduced considerably. Owing to the crinkling of the edges, it is essential to prepare a thin crepe of 16 inch width, in order to obtain a 13 inch width after trimming the edges.

6. Treatment of thin crepe. –The thin crepe is dried in the usual manner.

If the dried crepe is of sufficient width (13 inches) after the edges have been trimmed, it is cut into lengths of 42 inches.

If the dried crepe is not of sufficient width, it is joined by placing freshly cut edges together. Care must be taken to cut evenly, since this facilitates the joining of the edges.

For building up the sole crepe, which is done by laminating the necessary number of lengths of the thin crepe, small tables 36 inches high with tops about 48″ × 20″ are convenient.

The pieces of thin crepe are superimposed and each piece is pressed on the layer below by hand, all wrinkles being carefully flattened. The pieces of crepe should only be stretched lightly, sufficiently to give a flat surface.

A number of pieces of the thin crepe are used to give the required thickness. A preferable method is to weigh the pieces of crepe, after trials have been made to determine the weight of the final piece of thick sole crepe. This ensures greater uniformity in the final thickness, owing to the slight variations in the thickness of the pieces of thin crepe.

In the manufacture of ¼ inch sole crepe, the weight of thin crepe (not joined) required is about 4½ lbs. and the finished sole crepe will weigh 3½ lbs. In the finished sole crepe (13″ × 36″) 7 ozs. in weight corresponds to 1/32 inch thickness, so that the number of pieces of thin crepe required can be determined, when the thickness is known.

In the case of thin crepe which has had to be joined, about 25 per cent. excess is required for clippings or trimmings cut from the edges.

No detailed instructions can be given on the method of building up the sole crepe by hand, except that great cleanliness must be observed and the hand pressing must be even. Success depends on the training and experience of the labour employed. Before pressing the built-up crepe between rolls, it is advisable to warm the rubber slightly. This can be done on a table, heated by means of a steam coil or by warm water contained in a suitable receptacle below.

The thick layer of crepe is then passed between the rolls of a laminating machine. This machine has two even-speed, smooth, polished rolls set obliquely, horizontally or vertically. Water cooled or steam-heated hollow rolls are not necessary. Rolls of 6 inches diameter and 20 inches long are sufficiently heavy for the purpose.

As a rule, the thick layer of crepe can be passed once between the open rolls and twice between the "closed" rolls. After this treatment, perfect cohesion between the layers of thin crepe should be obtained.

The length of the sole crepe is allowed to cool for 24 hours and is then cut into lengths exactly 13 inches wide by 36 inches long. This may be done by means of knives guided by a straight edge or preferably in a special cutting-press of the exact dimensions required.

7. Grading and Sorting.—Grading and sorting are essential and all pieces showing streaks, non-uniformity in colour, finish or thickness must be discarded.

The best method of determining thickness is to weigh each piece of sole crepe, after it has been cut to the requisite dimensions.

8. Packing.—Special Venesta (three ply) cases of the requisite size for packing the sole crepe flat are the most suitable. It is advisable to wrap the sole crepe in paper in order to avoid contamination with dirt, small splinters, etc. from the cases. Packed sole crepe should be despatched as soon as possible, since it is liable to become damp if stored and to develop "spot" disease.

The cases should be dry, the rubber should be packed in the afternoon and the cases should be stored in a well ventilated dry room till despatched.

9. Remarks.—No detailed instructions can be issued, other than those given above, since the manufacture of sole crepe is essentially a specialized operation and the labour force has to be trained for the work, while much is learnt only by actual experience.

10. Coloured Sole Crepe.—Laboratory and factory experiments have been carried out on the preparation of coloured sole crepe. Although such coloured crepes open up possibilities, their manufacture is liable to lead to the use of inferior grades of rubber, since the colours in some cases obscure defects. The manufacture of coloured crepes has developed from the use of such crepe in making artistic mats of raw rubber. Such mats, however, are no longer made in estate factories.

For the manufacture of coloured sole crepes, three shades have been adopted to match black and brown leather and red vulcanised rubber.

The following colours, which are mixed with the latex before coagulation, have been found effective when used in the proportions given below:—

Blacks.	Fine Carbon Black	... 0. 1	per cent. on weight of standard latex.
	Nigrosine (Aniline Black)	... 0. 02	" " "

Browns.	Chrome Brown	... 0. 2	per cent. on weight of standard latex.
	Bismark Brown (Aniline Brown)	0.025	" " "
Reds.	Oxide of Iron (Red Brown)	... 0. 2	" " "
	Aniline Red (Eosine)	... 0. 02	" " "

It may be stated here that no special purpose is served by the manufacture of these sole crepes, since dyes and pigments may be obtained for colouring the edges of ordinary raw rubber sole crepe, to match the leather of the footwear.

SECTION G.—PRESERVED (Ammoniated) LATEX.

1. Latex preserved with Ammonia has been exported to some extent from Ceylon but this trade has not developed to the extent which it has in other producing countries.

When latex is exported on a large scale it is shipped in bulk in tank steamers. Latex from a group of estates is collected at a central receiving station and transported by lorry or railway tank wagon to the port, where it is pumped into the tank steamer. Estates in Ceylon are comparatively widely scattered (except in the Kalutara district), and therefore not well adapted for bulk export of latex. There are now various processes for concentrating latex, either by centrifuging or evaporation and it is likely that in the future latex will largely be exported in a concentrated form (60—70% rubber).

Small quantities of latex can conveniently be shipped in ordinary 4 gallon kerosene tins, two of which are packed together in an open wooden crate. It may also be shipped in special nesting barrels such as the Kenward barrel. These barrels can be used a number of times, being returned to the estate nested together (10 nested barrels are said to occupy the same space as 2 ordinary barrels).

2. **Handling Ammonia.**—Great care should be taken in opening drums of ammonia. "Liquid ammonia" consists of a solution of ammonia gas in water. As exported from England it contains more gas than it can hold at tropical temperatures. A pressure is generated in the drum and when the stopper is removed a fountain of liquid may rise several feet from the drum. This not only causes a loss of part or all of the contents of the drum but is dangerous to the operator. For use in the tropics a strength of not more than 29% (by weight) should be specified.

Drums of ammonia should be stored in the coolest place available and immersed in water overnight before being opened. The stopper should be loosened slowly and any pressure allowed to escape before removing it completely.

Liquid ammonia bought locally usually contains about 25% of ammonia gas, but it is advisable to take the same precautions in opening the drums.

Ammonia evaporates rapidly if not kept tightly corked and consignments vary in strength, so it should be tested by means of a hydrometer before use. Suitable hydrometers may be obtained from the Rubber Research Scheme, and a table showing the relation between specific gravity and strength at tropical temperatures is given in Appendix C.

3. The following recommendations are suitable for preparing preserved latex on a comparatively small scale:—

Dilution.—The latex should not be diluted, and precautions should be taken to see that water is not added by coolies. The rubber content of the latex should be not less than 3½ lbs. per gallon.

Proportion of Ammonia.—Undiluted ammonia should be added in the proportion of 3 gallons of strong liquid ammonia (25% strength) to 100 gallons of undiluted latex (3½ lbs. per gallon).

If the strength of the ammonia is less than 25%, or if the rubber content of the latex exceeds 3½ lbs. per gallon a correspondingly larger quantity of ammonia should be used.

Delay.—The latex should be as fresh as possible. Not more than 5—6 hours should elapse between tapping and the addition of the ammonia.

Straining.—The latex should be strained twice through a 40 or 50 mesh sieve before the addition of the ammonia. Clots or thickened latex which collect in the sieve should not be rubbed through but should be rejected.

Containers.—Clean kerosene tins, or Kenward collapsible barrels are recommended. One inch air space should be allowed in a kerosene tin, and 5% space in a barrel.

Mixing.—A Shanghai jar or tank with a well fitting wooden cover and a bottom outlet tap is suitable. The latex and ammonia should be well mixed together, the cover placed in

position and the latex run off without delay into the containers. This is more satisfactory than placing latex and preservative separately in each container.

Soldering Kerosene tins.—The caps should be soldered in position as soon as possible after filling the tins. If a liquid flux is used care must be taken that drops of it do not fall into the latex.

Packing.—Kerosene tins should be packed in cases or open wooden crates made just sufficiently large to hold two tins. The tins must fit tightly in the crate, otherwise shaking during transit may cause the tins to split at the seams.

For further information on preservation of latex see Rubber Research Scheme Bulletin No. 32.

SECTION H.—NOTES ON CHEMICALS.

1. **Coagulants. Acetic Acid and Formic Acid.**—These acids should be clear, colourless, and free from sediment and should be supplied in glass carboys. The usual specified strength of acetic acid is 98—100%. Formic acid is supplied in 2 grades 90% and 85%.

One gallon of acetic acid weighs 10½ lbs. One gallon of 90% formic acid weighs approximately 12 lbs. Acetic acid and formic acids evaporate on exposure to air and also absorb moisture so they should be stored in well stoppered bottles.

Stock solutions may be made up and stored in glass or earthenware vessels closed with a stopper or good cork.

Sodium Silicofluoride.—Sodium silicofluoride is sold in the form of a fine white powder. It is soluble in water to the extent of about 0.85%. It does not deteriorate on storage but should not be kept in iron receptacles.

2. **Sodium Sulphite.**—Sodium sulphite is usually supplied in the anhydrous (water free) form and this should be specified when ordering.

Pure anhydrous sodium sulphite is a dry white powder and contains 50.8% of sulphur dioxide. On exposure to air it oxidises and loses its anti-coagulant properties. It should therefore be stored in air-tight containers. When a drum is opened the contents should immediately be transferred to screw stoppered earthenware jars.

Alternatively a stock solution of 10 or 20% may be made and stored in well closed glass bottles. The bottles must be completely filled otherwise deterioration occurs. Stock solution of chemicals should always be carefully labelled.

3. **Sodium Bisulphite.**—Pure sodium bisulphite is a white powder usually specified to contain 60—62% sulphur dioxide.

It deteriorates rapidly on exposure to air, and is then useless as an anti-oxidising agent for the preparation of pale crepe.

If it becomes necessary, owing to deterioration, to use large quantities of the bisulphite the rate of drying of the rubber is much retarded.

Sodium bisulphite is usually imported in sealed drums. When a new drum is opened the contents should immediately be transferred to small screw stoppered earthenware jars.

The powder frequently has a strong odour of sulphur dioxide, but this is no criterion of its quality. It usually indicates that rapid decomposition is taking place.

4. **Formalin.**—Formalin is a clear colourless liquid usually containing 40 per cent. of formaldehyde.

It evaporates on exposure to the air and should be stored in closely stoppered bottles.

5. **Ammonia.**—Ammonia is usually sold in the form of a clear colourless solution of the gas in water, having a specific gravity of 0.88 and containing 35.6% by weight of ammonia gas, but for use in the tropics the strength should not exceed 29%. Precautions to be observed in opening drums of ammonia are given in Section G. para II.

Ammonia purchased locally is usually in the form of a 25% solution. Ammonia evaporates on exposure to air and the drums should be kept tightly stoppered.

Ammonia is also used in the form of the liquefied gas contained in steel cylinders.

6. **Paranitrophenol.**—The commercial product is a brownish yellow crystalline powder. It should be free from smell but most of the material available in Ceylon at the present time has a slight almond like odour.

It is soluble in water to the extent of about 2% at ordinary temperatures, and is readily soluble in boiling water. It is also soluble in undiluted acetic or formic acid.

In order to comply with shipping regulations it contains 20% of moisture. On exposure to air the moisture evaporates and the powder frequently becomes lumpy. When a new drum is opened the contents should be spread out to dry, and then crushed. It should be stored in earthenware jars as it corrodes iron. It does not deteriorate on storage, either in the solid state or in solution.

SECTION J.—SAMPLES FOR INVESTIGATION.

All samples sent to the Laboratories should be packed in the quantities and in the manner prescribed below:—

Samples should be labelled with a description of the contents and the name of the estate.

Liquids should be sent in clean glass bottles fitted with a good cork.

Solids should be sent in a glass bottle with a wide mouth, so that the contents can be easily removed.

The bottles should be fitted with good corks and should be completely filled, since some chemicals deteriorate if an air space is left in, the bottle.

Bottles must be dried before being filled, or in the case of liquids, should be washed a few times with the liquid to be examined and then drained.

Bottles should be packed in wooden boxes filled with sawdust or other suitable material, so that the contents are not shaken about.

Latex.—The quantity sent should be about one pint. If not already preserved with ammonia or other anti-coagulant, ammonia should be added in the proportion of ½ oz. of strong liquid ammonia to one pint of latex.

Serum.—The quantity sent should be about one pint. A few drops of formalin should be added as a preservative.

Raw Rubber.—A whole smoked sheet or a piece of crepe weighing about 1½ lbs. should be sent for testing purposes or for report on defects.

The sample should be packed in glazed brown paper and should not be wrapped in soft paper which will adhere to the rubber.

In the case of rubber samples, full information as a reply to the questionnaire in Appendix A. should be sent with the sample or under separate cover.

Water.—The quantity sent should be about one quart. If a filtration plant is in use, samples of the water before and after filtration should be sent, in order to test the efficiency of the filtration.

NOTE.—Complete water analyses cannot be undertaken, but a report of the probable suitability of waters for rubber manufacture will be given.

Acetic Acid.—A quantity of about 4 ozs. should be sent. The cork should be sealed, preferably with paraffin wax.

Formic Acid.—As for acetic acid.

Sodium Sulphite.—An average sample should be taken, since a portion from a partially filled drum, which has been in contact with the air, will probably have deteriorated. The sample should be packed immediately after sampling and the cork of the bottle be sealed with paraffin wax or sealing wax.

The quantity to be sent should be about 4 ozs.

Sodium Bisulphite.—The same precautions must be taken as in the case of sodium sulphite.

The quantity to be sent should be about 4 ozs.

Ammonia.—About 4 fluid ounces should be sent. The sample should be taken rapidly and the bottle be well corked, since ammonia solutions are very volatile.

Chemicals-Various.—The quantity sent should be about 4 ozs. and the same precautions should be taken as in the case of the other solids or liquids mentioned above.

Corrosive liquids, such as sulphuric acid, should be sent in glass stoppered bottles.

APPENDIX A.

INFORMATION REQUIRED ON METHOD OF PREPARATION OF RUBBER.

When samples are forwarded for examination it is requested that full information should be supplied under the headings given below. The information is very valuable for reference and comparison, apart from its bearing on the actual samples forwarded.

SMOKED SHEET.

1. Method of transport of latex to factory. Distance of furthest fields from factory.
2. Water supply, including any observations on the water.
3. Straining of latex. Type of sieves used and sizes of mesh.
4. Dry rubber content of diluted latex.
5. Method of determining the dilution of latex.
6. Coagulant used, strength of solution and amount used.
7. Whether an anti-coagulant is used. State strength and proportion.
8. What type of pans are used? State material, size, shape and capacity.
9. Type of machines used for rolling. Hand or power driven. Number of times sheet is rolled. Are machines provided with a water spray?
10. Is the coagulum machined on the day of coagulation or on the following day?
11. Is the sheet (a) soaked in water after machining, (b) hung to drain, inside or outside the factory, before being placed in the smokehouse?
12. Is a solution of paranitrophenol or any other antiseptic added to the latex, or is the sheet soaked in a solution of such antiseptic after machining? If so, state method of application and amount and strength of solution.
13. Period of smoking. Whether continuous—day and night. Temperature in smokehouse and method of recording temperature.
14. Type of fuel used.
15. Type of smokehouse, including type of furnace, ventilation, etc. Materials of which smokehouse is constructed.
16. Type and size of packing chests and amount of rubber packed in each chest.
17. Type of packing and storage rooms. Nature of floor and whether on ground level or raised.

CREPE RUBBER.

1. As for smoked sheet.
2. do do
3. do do
4. do do
5. do do
6. do do
7. do do
8. Amount and strength of sodium bisulphite used.
9. Number and type of creping machines used, including gearing and speed, and number of times coagulum is treated in each machine.
10. Is the coagulum machined on the day of coagulation or on the following day?
11. Period of drying.
12. Type of drying shed, ventilation, etc. Materials of which drying shed is constructed.
13. If machine dried, type of drier, time of drying and temperature.
14. Type and size of packing chest, and amount of rubber packed per chest.
15. Type of packing and storage room, and nature of floor; whether on ground level or raised.

APPENDIX B.

PARA-NITROPHENOL (P. N. P.).

1. PREVENTION OF MOULD (AND RUST) IN SMOKED SHEET.

Para-nitrophenol can be used in two ways for prevention of mould and rust in smoked sheet.

A. An appropriate quantity is added to the latex before coagulation, or alternatively is dissolved in the acid used for coagulation.

B. The sheets after rolling and washing are soaked in a dilute solution of the chemical.

The simplest method is obviously to add the disinfectant with the coagulant, but P. N. P. has a slight clotting influence on latex which may lead to trouble with bubbles under certain conditions. On estates where coagulation takes place slowly P. N. P. can safely be added with the coagulant and this method of treatment is recommended. On other estates (especially in the Kegalle, Matale and Uva districts) where the latex has a tendency to rapid clotting, it is not likely to be satisfactory. It is suggested that estates should experiment with this method of treatment and adopt it if satisfactory.

A.—Incorporation of P. N. P. with Latex.

When acetic acid is used as coagulant the P. N. P. can conveniently be dissolved in the undiluted acid in the proportion of 1 lb. P. N. P. to 5½ lbs. strong acid. The P. N. P. dissolves freely but it is advisable to crush it thoroughly before mixing. The mixture does not deteriorate on keeping.

A carboy of acid (45 lbs.) should be divided into 2 equal portions, half being poured into an empty carboy. 4 lbs. of P. N. P. is added to each carboy, and shaken or stirred at intervals until the P. N. P. is dissolved.

Addition of the P. N. P. has the effect of "diluting" the acid, its strength being approximately 85%. Thus if the dose of acid required for coagulation was previously 6 ozs. per Shanghai jar the dose of mixture will be 7 ozs.

Alternatively a 1% solution of P. N. P. in water (1 lb. P. N. P. to 10 gallons water) may be prepared and added to the diluted latex or acid in the proportion of 1 gallon of stock solution to 100 lbs. dry rubber (equivalent to 1 lb. P. N. P. to 1,000 lbs. rubber).

When formic acid is used as coagulant the latter procedure should be adopted, as it is difficult to dissolve sufficient P. N. P. in the strong acid. It should be remembered that formic acid is a faster coagulant than acetic acid, so trouble with clotting of the latex may arise with formic acid and P. N. P. which would not occur with acetic acid and P. N. P.

P. N. P. should not be added to the latex if sodium silicofluoride is used as coagulant. In this case the soaking method is recommended.

If it is found that the dose of P. N. P. recommended above causes clotting of the latex, it may be possible to combine the two methods of treatment, adding a small amount of P. N. P. to the latex and afterwards soaking the sheets in a solution of P. N. P. In this case P. N. P. should be dissolved in the undiluted acid in the proportion of 2 lbs. to a carboy of 45 lbs. This corresponds to 1 part P. N. P. to 4,000 lbs. rubber, and assists in protecting against mould, sheets which are not efficiently soaked.

B.—Soaking Sheets in a solution of Para-Nitrophenol.

In this method of treatment the freshly rolled sheets are soaked in a 0.1% solution of para-nitrophenol for half an hour.

The solution is made up by dissolving 6½ ounces of P. N. P. in 40 gallons of water in a Shanghai jar or tank. It dissolves slowly in cold water but is readily soluble in boiling water. Half a gallon of boiling

water is sufficient for 6½ ounces. The hot solution is poured into the jar containing the bulk of the water, being strained through muslin to remove the black sediment which remains undissolved.

The sheets do not require washing before soaking provided that the sheeting rollers are fitted with water sprays. If no water spray is fitted the sheets should first receive the ordinary washing.

The sheets should be placed in the jar of solution singly, each sheet being pushed well under the surface of the liquid before the next sheet is placed on top of it. The object of this is to ensure that the whole surface of each sheet comes in contact with the chemical. If a mass of sheets is placed in the solution, the solution will not be absorbed by the sheets in the centre of the pile.

The sheets are allowed to soak for half an hour and are then removed and hung to drain before removal to the smokehouse.

Another method of treatment which ensures better soaking but involves more labour is to have 2 jars of solution. The sheets are placed one by one into the first jar. When the jar is full (60—70 sheets) the sheets are transferred one by one to the second jar. This is repeated 5 times and occupies about half an hour.

Soaking in P. N. P. gives complete immunity against mould if carried out efficiently but this is not always done on estates. It is for this reason that, if possible, a small proportion of P. N. P. should be incorporated in the latex.

40 gallons of P. N. P. solution is sufficient for treatment of approximately 400 lbs. of rubber.

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2. PREVENTION OF SURFACE MOULD AND FUNGAL SPOTS IN CREPE.

P. N. P. may also be used in crepe manufacture for the prevention of surface mould and fungal spots during drying and storage.

For this purpose it should be incorporated in the latex in the proportion of 1 lb. P. N. P. to 4,000 lbs. dry rubber. This amount is considered sufficient to prevent mould and spotting under ordinary conditions of manufacture and storage, although it is not entirely effective under stringent laboratory tests.

It is most convenient to dissolve the P. N. P. in the strong acid used for coagulation, the proportion being 1 lb. of P. N. P. to 20 lbs. acetic acid or 12 lbs. formic acid. The acid is afterwards diluted and used in the ordinary way. The P. N. P. should be well crushed before being added to the acid, so that it dissolves more readily.

Crepe containing even this small amount of P. N. P. becomes discoloured if exposed to *direct* window light during drying. If the rubber is effectively protected from direct light no discoloration occurs and the blanket crepe is indistinguishable in appearance from the ordinary product.

Discoloration can be prevented by fitting shades to the drying room windows so that only diffused light enters the room, but in many factories this would entail a considerable expenditure. In recent tests it has been found that equally good results are obtained if the rubber is hung to dry in the form of "mats," such as are usually prepared when crepe rubber is to be dried artificially.

The "mats" (for which a suitable size is 3′ × 4′ 6″) contain several layers of crepe and occupy approximately the same reaper space as an equal weight of crepe hung in the usual way. When the "mats" are hung on the reapers, the crepe is high up from the floor and *direct* light from the windows does not fall on the rubber. Under these conditions the crepe does not become discoloured even when hung close to the windows.

It is found that the "mats" of crepe dry approximately as rapidly as crepe hung in the ordinary way, which is probably attributable to the improved circulation of air through the room.

The use of P. N. P. in crepe manufacture can be recommended, provided that precautions are taken to protect the rubber from *direct* light during drying.

APPENDIX C.

SPECIFIC GRAVITY AND CONCENTRATION OF AMMONIA SOLUTIONS.

Temperature 28°c (82.4°F).

Strength of Ammonia (per cent. by weight)	Specific Gravity (Hydrometer Reading)
29	·891
28	·894
27	·898
26	·901
25	·904
24	·907
23	·911
22	·914
21	·917
20	·921
19	·924
18	·927
17	·931
16	·934
15	·937
14	·941

APPENDIX D.

ACID PROOF JOINTS FOR TILED TANKS.

The following method for making acid proof joints for tiled tanks and drains is in use in the Nederlands East Indies and has been tried out with success in Ceylon. The description is taken from a publication of the Proefstation voor Rubber, Java.

"Tanks and drains should be cemented with a lime-free mixture in the proportion of one part Portland cement and three parts sand. While the cement is still soft the tiles are carefully impressed into it so as to form a level surface; it is best to leave seams of $\frac{1}{16}$—$\frac{1}{8}$ inch as narrower ones are difficult to close up. After all the tiles are in, the cement is allowed to harden, whereupon the seams and joints are closed up with a mixture of dry Portland cement and water-glass (1 part fine Portland cement to 1½ or 2 parts water-glass). The mixture should be freshly prepared immediately before use (small quantities of about ½ lb. at a time are best); it should be so mixed as to produce a paste of the proper consistency. The paste is laid in the seams with a thin spatula, the surface is smoothed, the surplus paste removed, and a little more plain water-glass laid on in a thin, level layer over the now closed seams.

A tank treated in this way should not be used for a little time (at least two or three days) until the cement and the water-glass are quite dry and hard. The surface of the seams becomes glassy and as hard as stone and it is practically impossible for any acid to work into the cement."

The quality of water-glass required for a 500 gallon tank is approximately 10 lbs.

APPENDIX E.

EXPLANATORY NOTES ON VULCANISATION TESTING OF RUBBER.

(Reprinted from R. R. S. 2nd Quarterly Circular for 1927.)

Revised by G. MARTIN, B.Sc., A.I.C., F.I.R.I.,
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Estate Superintendents and others have frequently asked for a simple explanation of the meaning of figures given in reports dealing with the vulcanising properties of rubber samples. It is thought that the following notes may increase the value of such reports to non-technical readers.

With the exception of crepe soles and one or two minor products rubber is always used in the vulcanised form, and it has not been found possible by examination of raw rubber to predict what its properties will be after vulcanisation. Consequently in order to test the quality of a sample of rubber, it is necessary to vulcanise it under suitable conditions and then submit it to tests for strength, elasticity, etc.

From the point of view of the layman it is fairly accurate to say that "vulcanisation" or "curing" consists of causing rubber to combine with a certain proportion of sulphur, whereby the rubber becomes stronger, more elastic and less easily affected by heat and cold. The combination of rubber and sulphur is usually effected by heating a mixture of the two at a temperature of 140—150°C. If certain substances known as "accelerators" are also added to the rubber the process takes place more rapidly, or alternatively can be carried out at a lower temperature.

For commercial purposes, before vulcanisation rubber is almost invariably "compounded" with various ingredients in addition to sulphur. These have the effect of modifying the properties of the vulcanised rubber to make it suitable for various uses. For testing purposes it was usual until recently to make the tests on rubber vulcanised with sulphur only, as this brings out differences between various samples of rubber. Since the introduction of organic accelerators, however, it has been found advisable in many cases to make an additional test by vulcanising in the presence of an accelerator. Most accelerators only function in the presence of compounding ingredients, so it is necessary for a suitable substance (usually zinc oxide) to be added to the accelerator mix. Thus in a report from the Imperial Institute we sometimes find the tests given under the two headings.

A. Rubber sulphur mixing (consisting of rubber and sulphur only.)

B. Accelerator mixing (consisting of rubber, sulphur, zinc oxide and accelerator.)

Mastication and Mixing.

Preparation of the raw rubber for vulcanisation involves repeated rolling through heated, differentially-geared rollers until the rubber becomes extremely soft and tacky and in a condition to absorb sulphur and compounding ingredients and to be moulded easily to the required

shape. This process is known as "mastication." The sulphur and any other compounding ingredients are then added gradually and rolling is continued until they are thoroughly mixed with the rubber.

Samples of plantation rubber vary in the amount of working required to soften the rubber, or in other words they vary in plasticity. This variability causes great inconvenience in manufacturing processes. For many purposes, such as in the manufacture of tubing, solid tyres, etc., the rubber after being mixed is "extruded" or forced through dies of the required shape, and if not sufficiently plastic it emerges from the machine with a rough and uneven surface. It has then to be sent back and reworked.

Plasticity Tests.

The plasticity of rubber is determined by the Rubber Research Scheme staff in London by passing it for fixed numbers of times through the masticating rolls under carefully controlled conditions. Samples are removed and submitted to tests, from the results of which it is possible to calculate the number of times it would be necessary to pass the rubber through the rolls to reach a fixed plasticity. Some samples require much more masticating than others. A detailed study of the factors affecting plasticity is therefore being made with a view to producing rubber as uniform as possible in this respect.

Time of Vulcanisation and Tensile Strength.

To turn from plasticity to vulcanisation tests, the first factor on which information is required is the rate of vulcanisation of the sample, *i.e.*, the length of time which the rubber must be heated with a fixed amount of sulphur at a fixed temperature in order to develop its maximum strength. Variability in rate of vulcanisation is a feature of plantation rubber and previously caused great inconvenience to the manufacturer, but since the introduction of organic accelerators it has lost some of its significance as suitable accelerators tend to equalise the rate of vulcanisation of different samples. It is very desirable, however, to supply rubber which is as uniform as possible, and lack of uniformity generally displays itself in different rates of vulcanisation.

Under the present conditions of testing most samples require slightly more than two hours vulcanisation to reach their maximum tensile strength. It is desirable to produce a rubber which does not

vary in time of vulcanisation by more than five per cent. on either side of the mean. With an average time of vulcanisation of 120 minutes, the lower limit would be 114 minutes and the higher limit 126 minutes. Such a degree of uniformity can only be achieved by careful standardisation of all processes and the bulking of the latex from as large an area as possible. At present the time of vulcanisation of sheet and crepe from Ceylon varies from about 110 to 140 minutes.

When vulcanisation is completed the sheets of rubber are allowed to stand for 24 hours, after which ring test pieces of accurately measured diameter and thickness are cut by means of a special knife. The ring is placed in a machine known as the "Schopper" testing machine, and is stretched by applying a gradually increasing load. While the ring is being stretched the Schopper machine automatically draws a graph representing the amount that the rubber stretches as the load is gradually increased, and a typical curve given by a rubber-sulphur mix is shown in diagram I. The end of the curve represents the point at which the ring broke.

In table I. are given the results of tests on three samples after vulcanisation for 100 minutes. Two sets of figures separated by a vertical line are shewn in the table. The two columns (3) and (4) are results actually obtained after vulcanisation for 100 minutes. It is not easy to compare the samples on the basis of these figures, however, on account of their different rates of vulcanisation. As vulcanisation proceeds there is a continuous alteration in properties. The rubber becomes tougher *i.e.*, it does not stretch so much when supporting a given load (see column 4). It also becomes stronger until a maximum is reached, after which it quickly becomes weak and brittle. The results given in columns (3) and (4) are therefore recalculated in columns (5) and (6) to represent the same state of vulcanisation for all samples. This is selected to correspond with the development of maximum tensile strength.

In general the tensile strength of a sample vulcanised to give its maximum in the rubber sulphur mix exceeds 2,000 lbs. /sq. ins. It is not often that a markedly weak rubber is obtained.

Tensile strength depends upon so many factors that it is unwise when comparing samples to draw conclusions as regards quality from differences of less than 20 per cent.

Ageing Tests.

Another heading given in reports is "Ageing Tests." It is common knowledge to every user that rubber gradually perishes, particularly when exposed to light and air, and it will be appreciated that it is of importance to compare the properties of different samples of rubber in this respect. Perishing of rubber takes place slowly and it would be a great handicap if the investigator had to wait several years to observe the effects of keeping the rubber. It has been found that if the sample is heated in an oven at 70°C in a current of air, a change in tensile strength and elasticity takes place similar to that which occurs during ordinary storage or use, and this is known as "artificial ageing." Heating in the oven for 24 hours has approximately the same effect as six months natural ageing. From Table 2 it will be seen that tests are made after 48, 96 and 144 hours artificial ageing. The latter period therefore corresponds to three or four years natural ageing.

It will be noticed that the tensile strengths of the samples 24 hours after vulcanisation (*i.e.* ageing period nil) range from 1,780 to 2,120 lbs. per square inch. Two of the samples are weaker than the 2,000 lbs. per square inch which was stated to be the lower limit of strength for good quality rubber. The reason for this is that in commercial practice it is not customary to vulcanise samples to give their maximum tensile strength soon after vulcanisation or they would perish very quickly. These samples were therefore purposely under-vulcanised and the tensile strengths are satisfactory for the degree of vulcanisation. It will be seen that after ageing for 48 hours all the samples have become stronger and in each case the tensile strength exceeds 2,000 lbs. per square inch. After 96 hours, however, they all shew signs of weakening and after 144 hours are extremely brittle *i.e.*, "perished." These changes in strength are normal for crepe. If any sample had failed to reach a maximum strength of 2,000 lbs. per square inch it would have been regarded with suspicion and if one of them had become brittle in 96 hours instead of 144 hours it would have been regarded as of inferior quality.

It is hoped that the above notes will be of assistance in explaining in a general way the meaning of the figures given in reports of vulcanisation tests. In certain respects the explanations are necessarily incomplete, as full explanation would involve technical discussion which would not be of interest to the reader for whom these notes are intended.

TABLE I.

Sample No. (1)	Form of Rubber. (2)	Tensile Strength (3)	Elongation load 1.04 kgs. sq. mm. (4)	Estimated	
				Maximum tensile strength (5)	Time of vulcanisation (6)
		(lbs sq. ins.	(per cent.	(lbs sq. ins.	(mins.)
1207	Air-dried crepe	2,050	824	2,230	112
1208	Smoked sheet	2,240	810	2,340	109
1209	Air-dried crepe	1,940	885	2,340	128

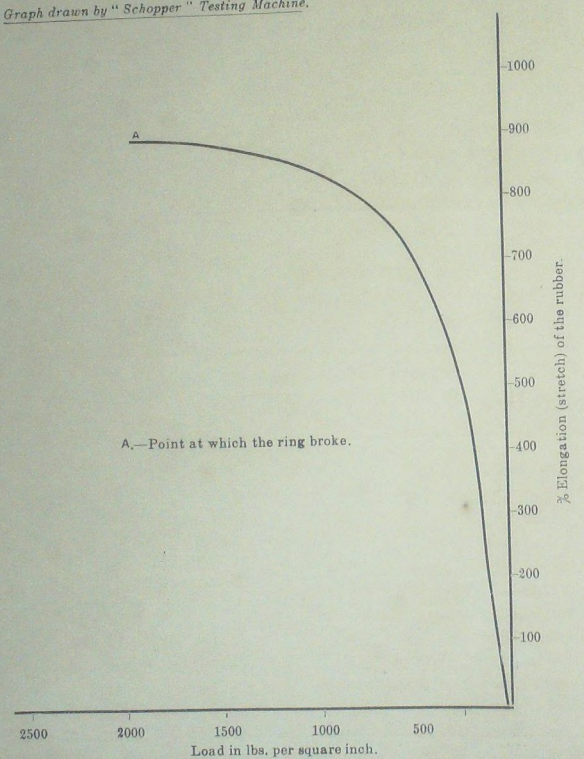
TABLE II.

VULCANISING AND AGEING TESTS.

Sample No.	Form of Rubber.	Time of vulcanisation.	Period of ageing at 70°c	Tensile strength	Elongation at load of 1.04 kgs. sq. mm.
		(mins.)	(hours.)	(lbs. /sq. in.)	(per cent.)
1261	Blanket crepe (control)	120	nil	1,780	890
			48	2,240	793
			96	1,880	749
			144	280	—
1262	Blanket crepe soaked in 0.1% para-nitrophenol for 30 minutes.	120	nil	1,910	887
			48	2,080	786
			96	1,790	744
			144	340	—
1263	Blanket crepe from latex coagulated with acetic acid and 0.1% para-nitrophenol (Calculated on dry rubber.)	120	nil	2,120	860
			48	2,390	768
			96	1,680	726
			144	330	—

DIAGRAM I.

Graph drawn by "Schopper" Testing Machine.



A.—Point at which the ring broke.

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