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ESTABLISHMENT OF MATCH FACTORY IN WESTERN SAMOA.

SI/WES/77/801 UF/SAM/78/169

SAMOA

Technical Report: Quality Control in a Match Factory

Prepared for the Government of Samoa by the
United Nations Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Ali Zaki El-Azabawi
chemist in match production

United Nations Industrial Development Organization
Vienna

Summary

As part of its technical assistance in the establishment of a match factory in Western Samoa UNIDO provided the services of a chemist for the period of 8 man-months (14 May 1978 to 13 September 1978; from 14 September 1978 to 13 October 1978; and from 14 October 1978 to 13 January 1979) under project numbers SI/WES/77/801 and UF/SAM/78/169.

This technical report on Quality Control in a Match Factory and covers aspects of safety instructions, prevention of fire, general safety regulations, fire fighting methods for various types of fires and indentifies the equipment needed. The report includes standard specifications for matches, quality control, and recommends quality control procedures for both splints and boxes; as well as the quality control and laboratory testing of the composition of the matches.

The report also outlines the procedure of preparing the composition for both the match heads and the friction (on the side of the box) and recommends formulae for application in Samoa.

Methods for testing animal glue are given in addition.

Introduction

In 1976 the Government of Western Samoa sought the assistance of UNIDO to examine the feasibility of setting up a match manufacturing industry in the country in view of the plentiful timber resources available. UNIDO assigned a consultant (Mr. S. Ramachandran) for a month to make the study. 1/ The recommendations were positive.

The Government decided to go ahead with setting up a match manufacturing plant and requested further assistance from UNIDO for the implementation. This follow-up project was approved 2/ and executed in three separate missions as listed on the following page.

1/ Project No.: SI/WES/75/003
2/ Project No.: SI/WES/76/806

1. A 3-months' mission for a consultant to plan and design tha factory, prepare specifications for building, machinery and raw materials and send out enquiries for the equipment (from 27 February 1977 to 2 June 1977).

2. A second mission of one and a half months for the same consultant to assist the Government in the selection of the factory site, analyse quotations received for machinery, prefabricated steel structure and materials and place the necessary orders.

3. A final mission of a team of 4 spacialists, including:

   - the same consultant for 16 months (team leader) from 21 April 1978 to 20 September 1979;

   - a chemist (Mr. Ali Zaki El-Azabawi) for 8 months from 14 May 1978 to 13 January 1979;

   - two mechanical technicians (Messrs. A. Thandavamurth and Gopal M. Dakshanamoothy) for 14 months, each from 31 May 1978 to 31 July 1979,

   to build the factory, install machinery, train local workers and commission the plant.

The factory has been built and is now functioning. About 60 workers are employed in the match factory. The fact that the factory is run entirely by local personnel is clear evidence of their enthusiasm, energy, work aptitude and capacity.

This technical report has been prepared by the UNIDO consultant based on the work of Mr. Ali Zaki El-Azabawi, the chemist attached to the project.

Safety Instructions

Employees contravening the following instructions are liable for dismissal without notice.

These regulations apply to all employees irrespective of their positions and place of work.

1. All departments must be kept tidy. A clean plant stands a good chance of being both efficient and safe. A dirty plant can never be either.

2. Oily rags and liquid spill must not be left lying around and rubbish should not be left or thrown about. These must be removed immediately to the receptacles that are provided for the purpose.

3. Materials, tools and equipment, not in use, must be stored in racks provided.

Prevention of Fire

There is considerable fire risk in the production of matches. The following must be scrupulously observed:

1. The use of fire, naked light, spark producing tools or portable machines are not allowed outside the engineering workshops. If work involving use of such tools requires to be undertaken, this should be executed under the direct responsibility and instructions of the technicians concerned.

2. Smoking is allowed only in canteen area and offices.

3. Any fires discovered in the area must be reported immediately to any member of the fire fighting unit. This unit will be fully trained.

4. Employees assigned to the fire fighting unit should know the locations and correct use of the plant's fire fighting equipment.

5. Fire blankets, First aid boxes etc. must be opened only in an emergency. Use of any fire equipment, extinguishers etc. must be reported immediately to the factory manager.

6. Fire fighting equipment, such as extinguishers, shovels, buckets, hoses etc. must not be used for any other purpose.

7. Passageways to locations of fire fighting equipment must not be blocked or obstructed at any time.

8. All labour other than members of the fire fighting unit must remain at their work positions in the event of a localised fire.

9. Only non-sparking tools should be used for opening the chemical vessels and drums used.

10. Oil soaked waste or rags should not be left on or under work benches and lockers.

11. Employees should always guard themselves from fire hazards arising during their work.

II. General Safety Regulations

1. Reporting of accidents:

All injuries must be reported and recorded by the factory's management section. An ambulance should be summoned and hospital authorities notified immediately if an accident of serious nature occurs.

2. Materials, tools and equipment:

(a) These must be in good condition when in use. (e.g. tools should not be burred, with split handles or spread jaws). They should be repaired only by employees permitted to do so.

(b) Tools and equipment for special purposes should not be used for any other purpose. They must be correct for the job and used correctly. Substitutes for correct tools should not be used.

(c) Tools must be

- handled carefully
- passed from one person to another, not thrown
- laid in a safe place without possible danger to others
- hoisted and lowered in a canvas bag when used at high levels or well secured

(d) Materials, tools and equipment should be protected from falling objects.

3. Nails must be pulled from timber or bent over flat surfaces on scrap wood.

4. Men handling heavy materials, tools or equipment should take great care to avoid injuries from careless handling.

5. In workshops passageways should never be obstructed and benches should always be kept clean.

6. Clothing

(a) Sufficient clothing must be worn to afford some protection from burns or other sources of irritation.

(b) Proper footwear must be worn.

(c) Celluloid sunvisors or hats with celluloid brims must never be worn.

(d) Clothing with oil or grease on it should not be worn.

(e) Employees working near moving shafts, belts, pulleys, etc. should not wear loose clothing.

(f) Protective hats should be worn by personnel over whose head others are working or who may be in danger from flying objects.

7. Welding and Lead burning:

(a) Goggles and/or helmets should be worn.

(b) Regulators, valves, gauges or fittings of oxygen, acetylene or hydrogen cylinders should never be greased or lubricated. They should not be handled with greasy hands or gloves.

(c) Except at high elevations all arc welding operations in open air or close to other workers must be properly shielded.

(d) Acetylene, oxygen or hydrogen cylinders should not be placed inside other vessels.

(e) Cylinder valves should not be tampered with.

(f) 220 volt cables on welding machines should not exceed 75 feet in length except for specially approved equipment.

(g) Cables must not be handled until plugs are pulled out or gloves tested for 30 000 volts worn.

(h) Slings must not be used for transporting cylinders by crane or derrick. Cradles must be used.

(i) Regulators must be attached to cylinders in use, but they should be removed when cylinders are transported any distance.

(j) Cylinder valves must be opened slowly.

(k) Cylinders must be placed far enough away from operation so that sparks or flames will not reach them.

(l) Welding outfits must be placed at a safe distance from operating units and removed immediately the mob is finished.

(m) Brass, bronze, or galvanised iron should be welded only in well ventilated locations and men on the job should wear respirators.

(n) If an acetylene or oxygen hose catches fire, the gas should be shut off at the cylinder only.

8. Electrical work:

(a) Rubber gloves must be worn by men working on or about live or dead lines regardless of voltage.

(b) Rubber mats or other non-conducting material must be placed in front and behind switch and control panels.

(c) The handles of all electrical tools should be insulated.

(d) Cables should be protected from high temperatures.

(e) Electric wires should not be handled by men sitting or standing in wet places.

(f) Electrical equipment should be only handled by electicians or other authorized personnel.

(g) Carbon tetra chloride (CTC) fire extinguishers should never be used in confined places when an electrical fire occurs.

9. Chemical composition room:

Men working in this room should:

- be certified medically fit by a Medical Officer
- be over 20 and under 50 years of age.
- change into uniforms supplied, use rubber boots and gloves.
- after completion of a day's work should take a shower and change to own clothes.
- wash their hands carefully before meals.
- wash skin in contact with composition using soap and water.
- clean composition vessels with water and dungaree cloth at the end of the day's work.

10. Roads and transport:

(a) Speed inside the factory area should never exceed 15 Kms per hour (10 m.p.h.).

(b) Employees should never run except in case of emergency and use only roads and paths, not short cuts through plant and workshops.

11. Machinery

(a) Guards should not be removed from machinery except for authorized inspection.

(b) Workshop machines should not be oiled or greased while in motion.

(c) Switches and starters of powered machines must be turned off when machines are not run.

(d) Machines must be operated only by authorized personnel.

12. Laboratory:

(a) Only a minimum amount of flammable liquids necessary for testing must be kept on work benches. Volatile liquids should be kept refigerated. These liquids must only be used in special benches in the laboratory. They should be drained only into sinks.

(b) Naked flames are prohibited in or near these special benches.

(c) Hot liquids or heavy oils should never be poured into a sink or drain.

(d) The use of Phosphorus should be under the direct control of a qualified chemist.

(e) Rubber gloves should be worn when handling strong alkalies, bromine or other corrosive liquids and solids. They should not be worn while handling Benzine or other hydrocarbons.

13. Storage of chemicals:

(a) Potassium Chlorate store:

(i) This store should be isolated from the stores for other chemicals and should be kept clean and free of organic materials.

(ii) The store should be well insulated from heat.

(iii) Drums of Chlorate should always be opened outside the store.

(iv) The area around the store should be well provided with a water supply for fire fighting purposes.

(b) Red Phosphorus store:

(i) Red Phosphorus should be stored well away from Potassium Chlorate and other chemicals.

(ii) The store must be kept well insulated from heat.

(iii) The Phosphorus tins should only be opened outside the store.

(iv) Plenty of fire buckets filled with sand should be provided in and around the store for use in case a tin catches fire. Some CO_2 fire extinguishers should also be provided.

(c) Paraffin wax store:

(i) Paraffin wax drums or bags should be stored in a cool place.

(ii) An adequate number of CO_2 gas cylinders should be provided in and around the store to contain any fire.

(d) Store for all other chemicals:

(i) Sulphur should be stored well insulated from high temperatures.

(ii) All chemicals should be stored neatly, separated from each other to enable identification and assist in inventory control.

(iii) Foam type fire extinguishers should be provided in the stores.

Important Note:

1. While entering the Chlorate store, the operators should remove their shoes and and wear safety shoes provided by the Company for use in Chlorate store only.

2. Opening of Chlorate and Phosphorus drums should be done very carefully. No steel hammers should be used.

3. Metallic spoons or ladles should never be used to remove phosphcrus from tins.

Fire fighting in the match factory

Timber, splints, board and paper

Water in buckets or from fire hydrants, depending on the area of fire should be used to extinguish the fire.

Matches, packets, sulphur and other chemicals

Foam type extinguishers of 10, 40, or 140 litres capacity should be used to contain these fires. If the fires occur in match machinery, CO_2 gas extinguishers are recommended.

Paraffin wax and other hydrocarbons

Only Foam, Dry Chemical or CO_2 gas type fire extinguishers should be used. Water should on no account be used.

Electrical fires

Only Dry Chemical or CO_2 gas type extinguishers should be used. The first thing to do is to switch off the power source.

Caution:

Carbon Tetra Chloride (CCL_4) extinguishers can be used to contain hydrocarbon and electrical fires, but great care should be taken to provide adequate ventilation for the area, since the inhalation of CCL_4 gas is extremely hazardous.

Maintenance

Used cylinders should be sent to the local gas company for replenishment. They take the responsibility for cleaning and refilling.

Water supply

To ensure adequate water pressure, it would be ideal to have a separate fire water tank of capacity 10,000 gallons and a fire pump that could be started from 2 or 3 points in the factory. Separate fire water mains are to be provided with 3 outlets inside the factory. Fire hoses are provided at these outlets for use in the event of a serious fire.

Other equipment

1. Industrial first-aid kit. This should contain an assortment of first-aid supplies, adequate for at least 10 injured persons at any time.

2. Asbestos fire blankets. 10 pieces should always be available for smothering clothing fires by wrapping the victims in the blankets.

3. Safety respirators. 5 pieces should always be available to protect from sulphur dioxide fumes and other hazards.

4. A generous supply of PVC gloves and PVC coats should be available.

Standard specifications for safety matches in Western Samoa

The matches produced in the Western Samoa factory should conform to the following specifications:

1. The overall dimensions of the match box should be 53.5 mm x 37.2 mm x 13.2 mm.

2. Each box should contain 50 ± 2 match sticks (48 to 52 sticks).

3. Splint size should be 42 mm x 1.85 mm x 1.85 mm.

4. The application of Friction composition should be no less than 35 gms/m^2 to ensure that all match sticks in the box could be fired.

5. Paraffin absorption must be adequate to provide a flame height of no less than 25 mm, 2 seconds after firing the match head.

6. The match head should not come off when pulled by hand.

7. The match head should not ignite at temperatures below 170 degrees C.

8. The match head should not explode when a weight of 165 gms drops from a height of 30 cm.

9. Impregnation must be adequate to produce an ash weight of 12 per cent after combustion.

10. The match should:

- burn well and smoothly.
- not explode on firing.
- not throw sparks on ignition.
- not have any "after-glow" after the flame is extinguished.

11. The match stick should be straight grained and have good breaking strength. It should be made out of an appropriate specie of timber.

Quality control in a match factory

1. Splints

Quality control in the production of splints invloves examining every stage of the process, from delivery of timber at the factory, storage through processing to the loading of the splints into frames. Quality

control is responsible for the production of splints consistent with optimum use of timber. It also includes determination and specification of quality standards.

The following processes are involved in production of splints:

1. Handling timber from log ponds to debarking.
2. Debarking.
3. Cross cutting.
4. Peeling to veneer.
5. Chopping to splints.
6. Impregnating with Phosphate salts.
7. Drying.
8. Polishing.
9. Cleaning.
10. Sieving.
11. Loading frames.

Random samples of 100 splints are tested thrice in 8 hours for the following and percentages of defective splints are logged:

Test	Defective %	Permissible variation, (± %)
Peeling thickness	-	± 3
Chopping thickness	-	± 3
Discoloured	-	1
Broken	-	2
Crooked	-	2
Impregnation	-	1
Cross grained	-	2

2. Outer and Inner Boxes

The following processes are involved in production of boxes:

1. Peeling for outer, inner and bottom veneers.
2. Chopping for outer, inner and bottom skillets.
3. Outer and inner box making.
4. Drying.
5. Labelling.

Ramdom samples of outer and inner boxes are checked twice daily in 8 hours and percentages of defective splints are logged.

Test	Defective %	Permissible variation, (%)
Deformed boxes	-	2
Outer box length, 53.5 mm	-	below 52.5 mm not permissible
Inner box length, 52.0 mm	-	Nil
Labelling	-	1 % defectively labelled possible

3. Frame dipping and frictioning

In frame dipping two dipping operations are involved, dipping in hot Paraffin and then in the match head composition. In frictioning, coating is done on both sides of the box, the thickness and end margins to be controlled. Random samples of 10 boxes are taken twice in 8 hours and examined for the following:

Test	Defective, %	Permissible (%)
Deformed heads	-	Nil
Brittle heads	-	Nil
Loose heads	-	Nil
Small and large heads	-	5
Flame height, min. 25 mm	-	5
Frictioning, min. 35 gms/m^2	-	5
Margin both sides, 5 mm	-	5

4. Filling and packing

Both these operations are done by hand. So no defective boxes or packets are permissible. Stick contents should be ± 4 per cent of 50 sticks. Packets should be packed tightly.

Quality control - Laboratory testing

1. Chemical composition batches:

Specific gravity - - - - - - - - must be between 1.33 and 1.35 for dipping.

Viscosity - - - - - - - - must be 80 poises ± 10 per cent.

Temperature - - - - - - - - must be between 32 and 35 degrees C.

Each batch is tested for the above.

Paraffin dipping - - - - - - - - temperature of the Paraffin must be between 130 and 140 degrees C.

2. Friction Composition batches

Viscosity must be 90 to 100 seconds suing a 1 litre container with a 3 mm hole at the centre of the base of the cup. Volume tested is 250 mls. Each batch is tested.

Composition must be ground fine and homogenous.

Application on box surface should be 35 gms/m^2.

3. Impregnation

The ash content should be maximum 12 per cent. This is tested by burning 100 gms splints on a piece of steel mesh wire over Bunsen burner and weighing the charred splints.

After-glow of splints, taken in random samples should be nil.

4. Matches

Random samples of matches are tested. They should fire on striking without throwing sparks.

Friction composition should be sensitive for striking and not produce sparks. Only stabilized Red Phosphorus should be used for making the friction composition.

One packet of matches should be placed daily in an air oven controlled at a temperature of 30 degrees C and humidity of 90 per cent, for 48 hours. The packet is taken out and all matches fired. The percentage that do not fire is recorded.

Process control in the match factory

The various elements of process control in match production are:

1. Conforming to established formulations in weighing out the chemicals.
2. Ensuring dry mixing of chemicals to a homogenous mix.
3. Regulating addition of water to glue and chemicals.
4. Check temperature of glue during melting.
5. Ensuring mixing of chemicals with water to get a homogenous mass.
6. Final mixing with Chlorate and glue solution to good homogenity.
7. Checking grinding and making necessary adjustments to the FRYMA grinder to ensure firn grinding.
8. Checking specific gravity and viscosity of each batch, make necessary addition of water to get the composition within permissible limits.
9. Checking temperature of Paraffin dipping and head composition dipping.
10. Check production through the various stages of manufacture and report to factory manager any changes in chemical formulation or raw materials specifications that are called for.
11. Check viscosity of friction composition.
12. Check application of friction composition to box surface.

Production of Chemical compositions

1. Head composition

The different component chemicals are stored in separate containers in the chemical making room. Chlorate is stored in special rooms and the

day's requirements are weighed out for the different batches and brought into the chemical room. After weighing out, the different batches of dry chemicals are kept ready in the room.

Glue is weighed out, separately mixed with cold water and allowed to soak overnight. At the beginning of day's work, the chemicals are dry mixed thoroughly, water is added and then mixed again. Chlorate and glue solution are added separately, all lumps broken up properly and well mixed. Both the masses are now mixed together in a mechanical mixer and transferred to the FRYMA grinder where it is well ground. The composition coming out of the grinder should have temperature not exceeding 35 degrees C. The FRYMA grinder is equipped with cooling water circulation. A certain amount of homogenisation and aeration takes place in the grinder. After checking the specific gravity, if it is found necessary, the composition can be put through a homogeniser to increase its bulk. The specific gravity should be between 1.33 and 1.35. The composition is now ready for dipping.

2. Friction composition

Gum Arabic: If used in making composition, it should be well powdered, soaked in water for 24 hours, the weight of water being twice the weight of powder used. It can be used also with Polyvinylacerate (PVA) glue to improve moisture resistance of the striking surface.

Grinding: First grinding - Potassium Bichromate, glass powder, Antimony Trisulphide are placed in the ball mill, one third of their weight of water is added and ground for 5 hours.

Second grinding - Red Phosphorus with a little over half its weight of water is now added to the ball mill and ground further for 10 hours.

Third grinding - Gum Arabic solution and/or synthetic glue are now added to the ball mill and grinding continued for 20 minutes.

The composition is now ready for use. Total water will be roughly four fifths of the total weight of dry chemicals. Again this should be finally adjusted depending on viscosity of the composition.

Technical details of match making

Impregnation of splints

1.6 Kgms of mono- and di-Ammonium Phosphate are dissolved in 1oo litres hot water at approximately 70 degrees C. This temperature should be maintained during impregnation. Consumption will be about 20 litres solution for 1 million splints corresponding to about 0.16 Kgm per 10,000 boxes of 50 sticks each.

Match tip compound

General - Only best quality animal hide glue can be used. The necessary glue must be soaked in cold water for about 12 hours. After soaking the glue containers are placed in hot water tank with temperature of water regulated at 55 degrees C.

Temperatures above this will reduce the adhesive properties of the glue.

It is advisable to dissolve the Potassium Bichromate in hot water and then add the solution to the glue just before other chemicals are mixed.

Potassium Chlorate is added to the glue solution and mixed well, removing and crushing all lumps; the rest of the chemicals are then added. The entire mix is then placed in a mechanical mixer for 10 to 15 minutes before grinding. If quantities of water are controlled carefully the specific gravity will be correct.

Chemicals used: Binder: glue
Ignition materials: Potassium Chlorate and Sulphur
Fillers: Manganese Dioxide, Iron oxide, glass powder, Kiesulghur, asbestos powder, etc.
Flame speed controller: Zinc oxide

The following Formulation Table appears as recommended by Mr. S. Ramachandran, Team Leader of the project.

Formulations

Chemical	Black and Brown heads (%)	Colour heads (%)
Potassium chlorate	52.5	53.5
Manganese dioxide	3.5	-
Iron oxide	4.5	-
Potassium bichromate	1.0	1.0
Glue	10.0	10.0
Zinc oxide	3.5	4.5
Sulphur	3.0	4.5
Glass powder	17.97	21.92
Kiesulghur	3.5	4.5
Gum Tragacanth	0.03	0.03
Lamp black	0.5	0.05
TOTAL	100.0	100.0

Friction composition formulation

Chemical	General (%)	Humid areas	
		% (a)	% (b)
Antimony trisulphide	30.0	34.39	17.0
Zinc oxide	-	-	5.0
Potassium bichromate	0.5	0.54	-
Glass powder	6.3	2.16	6.0
Red Phosphorus	54.0	53.74	54.0
Ammonium acrylate	-	-	4.0
PVA glue	-	9.17	14.0
Gum Arabic	9.0	-	-
Gum Tragacanth	0.2	-	-

Paste for Box making

Flour	93.1 %	Corn starch	10 Kgm
Zinc oxide	0.69 %	Caustic Soda	150 mls of 35 % solution
Sodium hydroxide	6.21 %	Water	35 to 40 litres

(Solution of specific gravity 1.22)

Boil the paste. Storage for 24 hours before use preferable. Grind in conical mill immediately before use.

Solution for protection of logs from Algae and Fungal attack

Spray logs with mixture of Zinc Chloride, Sodium Bicarbonate and Boric acid in the proportion of 3:4:1. After 48 hours, the logs are dumped into water tanks dosed with 5 ppm Copper Sulphate.

The importance of animal hide glue in match production

Production of good quality matches depends on choosing good, high grade glue. The grading is based mainly on the jelly strength and viscosity, which are interrelated.

Jelly strength is really an empirical measurment of the modulus of rigidity of a standard 12.5 per cent glue gel matured for 16 hours at 10 degrees C. It is measured in grams, being the weight required to force a standard plunger 0.4 mm into the gel at a fixed rate of loading, using a Gelometer. The jelly strength should normally lie between 350 and 450 Bloom grams for match-grade glue.

Viscosity is measured on the same 12.5 per cent solution at 60 degrees C in a suitable viscometer and should normally be in the range of 120 to 150 millipoises.

It is also necessary to specify and control various other properties of the glue delivered such as Ph, foam, odour, chloride content, and compatibility with other materials used in match making.

Standard methods of glue testing

1. Moisture content

It is defined as the percentage loss in weight of the sample after drying at 105 degrees C to a constant weight.

A certain weight (approximately one gram) of glue is placed in a crucible which is placed in an oven regulated thermostatically at 105 $\pm$ 0.2 degrees C and heated for two hours. The crucible is then cooled and weighed. It is reheated, cooled and weighed; this is repeated till a constant weight is reached.

$$\text{Moisture content} = \frac{\text{loss of weight}}{\text{Original weight}} \times 100$$

2. Jelly strength

This is an arbitrary test when Gelometer is not available for use. The standard sample that is used for comparison is also prepared under identical conditions to the sample test hereunder:

(a) 10 grams of powdered glue are weighed cut into a 150 mls beaker. 50 mls water are added and well stirred.

(b) The beaker is heated in a water bath for 10 minutes at temperature not exceeding 60 degrees C, with constant stirring.

(c) The solution is now poured into a porcelain cup and the cup kept closed.

(d) The cup is left for 16 hours in a thermostatically controlled bath at 15 degrees C.

(e) The lid is removed and the comparison is effected with the standard sample by pressing with the forefinger.

With experience a fair comparison can be made.

3. Viscosity

(a) 15 grams of powdered sample are added to 105 mls water, cold distilled, in a flask fitted with a cork.

(b) This is allowed to stand for 2 hours and then placed in a water bath maintained at 65 degrees C for 10 minutes.

(c) This is now allowed to cool to 40 degrees C. and placed in a thermostatically controlled bath for 15 minutes, the temperature of the bath being 40 $\pm$ 0.1 degrees C.

(d) The solution is poured into a viscometer, allowed to stand 15 minutes and the viscosity measured.

4. Foam test

(a) A glue solution of 5 gms powder in 50 mls water is prepared by heating in a water bath at 60 degrees C.

(b) The solution is poured into a 100 mls stoppered cylinder. The internal height of the cylinder up to the graduation mark is usually 15 cms $\pm$ 0.5 cms and to the shoulder of the vessel is 23 $\pm$ 0.5 cms. The cylinder is kept in a water bath at 45 degrees C for half an hour.

(c) At the end of the period the cylinder is shaken well for a minute.

(d) The cylinder is now placed again in the water bath kept at 45 degrees C and allowed to remain until the geight of the liquor corresponds to 45 ml. The time taken for this is recorded and the volume of foam above the liquid level measured.

In the absence of grease in glue, the glue solution usually forms a stable foam which gels on cooling. This is a useful property for match making.

5. Water absorption

This test measures the proportion of water that can be absorbed

by glue powder of standard particle size under specified conditions of time and temperature.

(a) 10 grams of powder are added to 100 mls of water and left in a thermostatically controlled bath maintained at 15 degrees C for 16 hours.

(b) The supernatant water is strained through a funnel fitted with fine muslin cloth.

(c) The quantity of water passing through the strainer is measured.

(d) Straining time of 5 minutes is permissible. The difference between 100 mls and the measured quantity gives the water absorption.

6. Ph determination

1 gram of powdered glue is placed in a small quantity of distilled water in a stoppered flask and a solution is prepared. The volume is made up to 100 mls with cooled distilled water. The Ph of this solution is determined with a Ph meter. Match grade glue should be slightly acidic.

7. Ash content

5 grams of powdered glue are incinerated in a platinum crucible over a low flame till all the organic matter is burnt off. The crucible is cooled in a dessicator and the ash is weighed. The loss of weight is observed. The balance remaining in the crucible is expressed as a percentage of the original quantity used. This gives the percentage of the ash.

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