SEAM Project

Guidance Manual
Cleaner Production for Textiles
Combining Preparatory Processes

Ministry of State for Environmental Affairs
Egyptian Environmental Affairs Agency
Technical Cooperation Office for the Environment

***En*tec UK Ltd**
UK Department for International Development

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Cleaner Production for Textiles
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SEAM Project
Implemented by:

Egyptian Environmental Affairs Agency
Technical Cooperation Office for the Environment
and
Entec UK Limited

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The SEAM Project - An Introduction

Support for Environmental Assessment and Management (SEAM), is a multi-disciplinary environmental project being funded by Britain Department for International Development (DFID). This Project is being implemented by the Egyptian Environmental Affairs Agency (EEAA) through the Technical Cooperation Office for the Environment (TCOE) and *En*tec, a UK based engineering and environmental consultancy.

The SEAM Project is made up of 5 components, focusing on environmental management issues. These include Industrial Pollution Prevention/Cleaner Production, Environmental Impact Assessment, Solid Waste Management, Environmental Action Plans and development of an Environmental Database.

The main goal of the Industrial Pollution Prevention/Cleaner Production component is to show that significant financial savings and environmental improvements can be made by relatively low-cost and straightforward interventions. These consist of pollution prevention through good housekeeping, waste minimisation, process modification and technology changes. This approach has two benefits - valuable materials are recovered rather than wasted and factories are moved towards legislative compliance. This work is being undertaken in support of the National Industrial Pollution Prevention Programme (NIPPP) and has focused on three sectors: textiles, food and oil & soap.

Industrial auditing of 32 factories identified in excess of 200 low cost/no cost pollution prevention measures. Commonly occurring issues were then developed as demonstration projects for each sector, whose aims were to show the financial and environmental benefits of the pollution prevention approach.

Thirteen demonstration projects have been implemented in 21 sites as follows:

Textile Sector

- Eco-friendly Processing for Securing International Eco-label.
- Water and Energy Conservation.
- Combined Processing: Desize, Scour and Bleach.
- Bleach Clean-Up using Enzymes.
- Sulphide Reduction in Sulphur Dyeing.

Food Sector

- Installation of Milk Tank Level Controls and Valves.
- Water Conservation in Food Factories.
- Energy Conservation in Food Factories.
- Reducing Waste by Improved Quality Control.
- Recovery and Use of Whey as Animal Feed.

Oil and Soap Sector

- Waste Minimisation in an Edible Oil Factory.
- Oil and Fat Recovery.
- Improving Raw Water Quality to Reduce In-Plant Losses.

Outputs from these projects include industry workshops and seminars, demonstration projects with supporting Guidance Notes and Manuals (to enable other factories to implement similar projects themselves), case studies incorporating cost-benefit analyses to demonstrate project feasibility, detailed Sector Reports and Guidelines describing how to carry out industrial audits.

SEAM Demonstration Project ,Combining Preparatory Processes,

The demonstration project shows what savings can be made by adopting a single stage desize-scour or scour-bleach process. Savings result from reduced water and energy consumption, reduced pollution load, faster processing time and increased cost efficiency. The project was implemented in two factories in Egypt; Giza Spinning, Weaving, Dyeing and Garments Company, Kafr El-Hakeim, Giza and Misr Beida Dyers Company, Kafr El-Dawar, Alexandria.

Using the information gained during project implementation in these factories, this Guidance Manual gives a step-by-step description of how other factories can make similar improvements. It also quantifies the benefits that were achieved at each factory as a result of project implementation.

Factories Participating in the SEAM Demonstration Project

This demonstration project was implemented in two factories, as follows:

1. Misr Beida Dyers Company (Misr Beida Dyers)

Misr Beida Dyers is a public sector company located at Kafr El-Dawar, Alexandria. It was established in 1938 and occupies a 264 feddan site.

The factory pre-treats, dyes, prints and finishes cotton fabrics and cotton/synthetic blends; processes yarns (pre-treatment, mercerising and dyeing); scours and dyes wool ,tops, and produces absorbent cotton. During 1997/8, Misr Beida Dyers pre-treated about 1,182 tons of woven fabric on jiggers, of which about half were pre-treated using the separate processes (kamilase desizing, scouring and half bleaching). The remaining fabric was pre-treated using the combined process consisting of desizing/scouring, using Leonil EB, followed by half bleaching.

Processes combined: Desize and scour.

2. Giza Spinning, Weaving, Dyeing and Garments Company, Giza (Giza Spinning and Weaving)

Giza Spinning and Weaving is a private company located at Kafr El-Hakeim in the Giza Governorate. The factory, established in 1984, covers 25 feddans and employs 2,400 staff.

The factory processes (wet and dry) and manufactures cotton and polyester/cotton garments. During 1996, a total of 5 tons of fabric were processed daily, of which 0.5ton was full bleached and 4.5 tons half bleached and dyed. The factory carries out full bleaching using hypochlorite, followed by a hydrogen peroxide bleaching step and then finishing with acetic acid, optical brightener and softener. Half bleaching is carried out using hydrogen peroxide only, with no finishing. 90% of the fabric produced by Giza Spinning and Weaving is knitted, the remainder being woven.

Processes combined: Scour and bleach.

Part A

1. Conventional Preparatory Processing of Cotton

1.1 The Sizing and Desizing Processes

Sizing consists of coating the warp threads with a ‚sizing, agent, to increase their tensile strength and reduce fibre breakages during weaving. Once woven, the size then has to be removed from the fabric by ‚desizing„ so that chemical penetration of the fabric in later stages is not inhibited. The desizing process is normally carried out with acid (hydrochloric or sulphuric acid) or with enzymes.

1.2 The Scouring Process

Cotton contains 2 to 3% natural impurities, such as waxes, fatty acids, proteins, pectins, and mineral matter. Processing impurities, such as size, dirt and oil may also be present. Scouring is carried out to remove these impurities.

The scouring process is carried out in highly alkaline conditions, at temperatures of 100C or more. The liquor contains an alkali (generally caustic soda); a wetting agent and a sequestering agent. Sometimes sodium carbonate, sodium bi-carbonate, or sodium silicate may also be added to improve the efficiency of the process.

During scouring, the fatty acids present in the fibre are saponified by the alkali to form soluble soaps. These soluble soaps act as emulsifiers for unsaponified oils and cotton wax and help in their removal. Proteins are hydrolysed into water soluble amino acids, whereas, pectic substances present as calcium, magnesium and iron salts are solubilised in the presence of alkali. Hemi cellulose also becomes soluble in alkaline solution and is thus removed.

1.3 The Bleaching Process

Bleaching is a chemical process that destroys natural colouring matters present in cotton. Bleaching decolorises coloured impurities that are not removed by scouring and prepares the cloth for further finishing processes such as dyeing or printing. Several different types of chemicals are used as bleaching agents, and selection depends on the type of fibre present in the yarn, cloth, or finished product and the subsequent finishing that the product will receive.

The two most common methods used for cotton bleaching are sodium hypochlorite bleaching (‚chemicking,) and hydrogen peroxide bleaching. If white or pale shades are required, hydrogen peroxide bleaching is preferred, as it gives a permanent whiteness, whereas sodium hypochlorite bleaching gives a better, but non-permanent whiteness. Due to its toxicity though, it is becoming less widely used.

2. Preparatory Processing in Egypt

Many cotton processing factories in Egypt use sodium hypochlorite in the bleaching process as it is less expensive than hydrogen peroxide. However export oriented textile factories are shifting to hydrogen peroxide bleaching, mainly due to the preference shown by the foreign buyers.

Research on the combined scouring and bleaching process with hydrogen peroxide has been carried out at the National Research Centre, Cairo, but the technique has not been widely adopted in Egypt. Some limited work has also been carried out on the

combination of desize-scour-bleach for woven fabrics and combined scour-bleach for knitted fabrics using proprietary chemicals. Due to high costs and fabric quality limitations, these techniques are not widely used.

3. Environmental Problems from Conventional Preparatory Processing

The purpose of desizing is to remove sizing ingredients, mainly starches, gums, PVA etc. Desizing operations are typically large contributors (of between 40-50%) to the pollution load arising out of the preparatory processes. During desizing, size materials leach out of fabrics. In addition, commonly used assistants used in the size mix (such as glycerine, waxes, urea and surfactants) are released.

Scouring produces effluents which are strongly alkaline (around pH 12.5), and have high organic loads. They tend to be dark in colour and also have high concentrations of Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and oil and grease.

The bleaching process contributes the lowest organic load (BOD <5%) of the total plant load, but relatively high TDS. It also has strongly alkaline characteristics (pH 9-12). In addition, chlorine-containing bleaching agents are regarded as highly toxic and several countries have prescribed strict limits or banned their use in preparatory processing. Chemicals such as sodium hypochlorite are the main source of absorbable organohalogen compounds (AOX).

Typically desizing, scouring and bleaching of 100% cotton leads to pollution loads as indicated in the Table below (expressed in terms of kg/1000 kg product). It must be noted however that the data presented in the table is empirical and should be considered only as a guideline rather than as absolute.

Indicative Pollution Loads for Desizing, Scouring and Bleaching (100% Cotton)

(Source: UNEP Cleaner Production in Textile Wet Processing)

Process	pH	BOD	COD	TSS	TDS	O&G
Desizing						
Enzyme starch	6-8	45.5	91.0	89.0	5.0	5.0
Acid starch	6-8	45.5	91.0	89.5	7.5	5.0
Polyvinyl alcohol (PVA)	6-8	2.5	5.0	5.0	48.0	2.5
Carboxylmethyl cellulose (CMC)	6-8	4.0	8.0	5.0	45.0	9.5
Scouring						
Unmercerised, Grey Fabric	12.5	21.5	64.5	5.0	50.0	40.0
Mercerised, Grey Fabric	12.5	16.5	49.5	5.0	50.0	30.0
Bleaching						
Hydrogen Peroxide (woven goods)	9-12	0.5	2.0	4.0	22.0	Nil
Sodium Hypochlorite (woven goods)	9-12	1.0	4.0	4.0	5.0	Nil

4. Combining the Preparatory Processing Steps

Cutting down stages of preparatory processing from three to two can be financially and environmentally attractive, as it reduces water and energy use as well as processing time.

Combined Desize and Scour

In combining desizing and scouring, hydrogen peroxide or a persulphate is added to the scouring liquor, forming an unstable bleaching system. This unstable system favours desizing and hence the fabric needs to be separately bleached in order to achieve the optimum degree of whiteness. Combined desize-scour, which can be carried out hot or cold, with or without the addition of stabilisers such as silicates or phosphates has been quite successful overseas.

During 1997/98, Misr Beida Dyers pre-treated around 1,182 tons of woven fabric on jiggers of which half were pre-treated using separate processes (desizing, scouring and bleaching). As separate processes were lengthy, the company moved to combined processing, using expensive chemicals, for the remaining 591 tons. This was proving costly and as a consequence the company was considering reverting back to the original three step process for all pre-treatment. As part of the demonstration project SEAM addressed the problems of attaining beneficial combined desize-scour processing.

Combined Scour and Bleach

Normally, scouring and bleaching are carried out as two distinct steps, using either hydrogen peroxide or sodium hypochlorite.

Combined or simultaneous scour and bleach is possible only when bleaching is practised with the help of hydrogen peroxide. Much research has been done, world-wide as well as in Egypt [1] to understand the behaviour of hydrogen peroxide in strongly alkaline solutions, especially on the degradation of sizing agents such as starch and polyvinyl alcohol. Information gained from these studies forms a basis for developing a combined scouring and bleaching process for starch sized cotton fabric and polyvinyl alcohol sized polyester/cotton fabric.

In these experiments it has been found that the critical properties of the fabric, such as whiteness index, loss in weight, wettability, tensile strength, copper number and carboxyl groups could remain comparable with the separate scouring and bleaching processes. Care needs to be taken however in following a correct sequence of chemical addition and exercise a proper control on the process, if optimum results are to be obtained.

At Giza Spinning and Weaving full bleaching was being done in separate scouring, hypochlorite bleaching, optical brightening and softening steps. The half bleaching process that had been recently introduced combined scour and bleach through the use of expensive chemicals.

[1] Hebeish, A., Development in Textile Chemistry and Chemical Technology, Academy of Scientific Research and Technology, Arab Republic of Egypt, 1994.

5. Benefits of Combining Preparatory Processes

Combining the preparatory processes (desize-scour or scour-bleach) provides the following benefits:

- Reduction in processing time thereby increasing the productivity.
- Reduction in water consumption.
- Reduction in energy consumption.
- Minimisation of the generation of effluents/emissions.

Additional benefits of moving from sodium hypochlorite bleaching to combined scouring and bleaching are:

- Elimination of hazard due to handling of sodium hypochlorite.
- Elimination of AOX laden effluents that are toxic to the receiving water bodies.
- Permanency and more uniformity in the whiteness of the fabric.

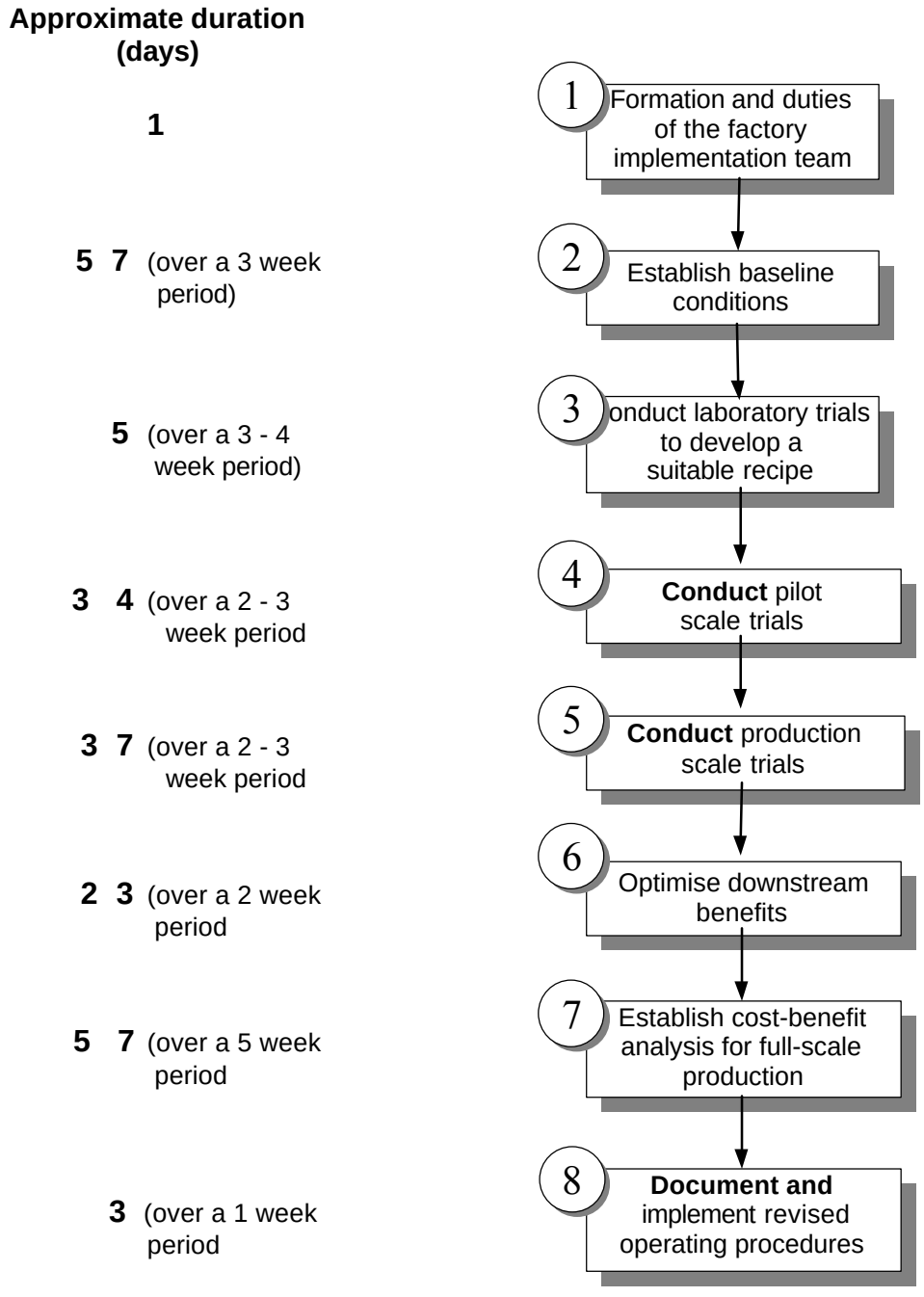
Part B

How to Combine Preparatory Processes - A Step by Step Guide

Figure 1

Step-by-Step Flow Diagram for Combined Preparatory Processes

As implemented by Misr Beida Dyers and Giza Spinning and Weaving



Combining Preparatory Processes - A Step by Step Guide

Introduction

Cutting down the stages of preparatory processing from three to two, or even to a single stage, has both financial and environmental benefits. As part of the SEAM demonstration project, combined desize-scour was implemented at Misr Beida Dyers and combined scour-bleach was introduced at Giza Spinning and Weaving.

The steps for implementing combined processing in a textile manufacturing factory are summarised in Figure 1. Details on each step are outlined below together with information on the experience gained as a result of implementation at Giza Spinning and Weaving and Misr Beida Dyers.

Step 1 - Formation and Duties of Factory Implementation Team

To implement the substitution, a factory team should be formed with senior members ideally being drawn from the following departments:

- Relevant production, environment and service departments to identify, test, implement and optimise required changes to the process. Inclusion of relevant production heads will ensure changes are made in a timely manner without undue interference with production schedules.
- The quality control department to ensure quality control procedures are addressed and maintained.
- The purchase department to ensure that purchase of sodium hypochlorite is discontinued and replaced with hydrogen peroxide.
- The finance department to provide information on costs of current operations and to fully evaluate the costs and benefits of any proposed changes.

A team co-ordinator should be nominated to co-ordinate the different responsibilities and tasks, possibly the Bleaching Master of the Preparation Department.

Factory Team Members	
Giza Spinning and Weaving	**Misr Beida Dyers**
Process Manager (Co-ordinator)	Production Manager (Co-ordinator)
Dyehouse Manager	General Manager of Dyehouse.
Vice Manager and Dyehouse	General Manager of Dyeing
Laboratory Manager	Manager of Dyeing
Quality Control Manager	Manager of Storehouse
	Machine operator in the scouring stage
	Machine operator in the bleaching stage

The use of an external consultant, experienced with modifying the preparatory processes, should also be considered. This will overcome any lack of experience in factory teams as well as being a source of advice on process optimisation.

Step 2 - Establish Baseline Conditions

It is important that the baseline operating and environmental conditions are established to enable later quantification of the incremental costs as well as benefits. The assessment should cover the following:

Fabric Quality

If regular records do not exist then the following parameters should be assessed (see Step 3) for both half bleached and full bleached fabrics:

- Tensile strength.
- Whiteness index.
- Wettability.

Cost Issues

Develop working tables on the costs for processing 1 ton of fabric for both half bleach and full bleach conditions (see Part C). These should include:

- Processing time.
- Water consumption.
- Process chemicals consumption.
- Electricity and/or fuel consumption.
- Steam consumption.
- Amount of labour used.

Some of the above items may have to be estimated if actual records are not available.

Environmental Measurements

The environmental measurements should include:

- Measurement of the wastewater discharge from scouring and bleaching, including the pollutant concentrations in terms of Biochemical Oxygen Demand (BOD), AOX, chlorides and TDS.
- Measurement of the work-space air quality in terms of chlorine.

Worker Health Issues

Other benefits of introducing a combined scour and bleach process are that workplace safety is improved and the smell of chlorine is eliminated. In order to quantify this improvement, it is important to check on the accident record of workers while handling chlorine compounds such as sodium hypochlorite.

Step 3 - Conduct Laboratory Trials to develop a Suitable Recipe

Laboratory trials are important to develop working recipes of the substitutes before proceeding to the pilot trials. The laboratory trials should be carried out on a laboratory jigger for woven fabrics and a laboratory winch for knitted fabrics.

For the laboratory trials it is important to:

- ***Design*** recipes which can be tested for suitability.
- ***Assess*** the suitability of each recipe and its effects on fabric quality particularly tensile strength, whiteness index and wettability. For each trial it is essential that all inputs, outputs and operating conditions are recorded so that a full evaluation, including cost analysis of alternatives, can be made. These results can be compared to the baseline conditions.
- ***Recommend*** which recipe(s) should be implemented at the pilot scale, once all trials have been completed.

To eliminate sodium hypochlorite at Giza Spinning and Weaving and to effect combined processing, the following sequences of processes were recommended:

1. **Scouring and Half Bleaching** (at 90 °C / 60 min.)
   - Non-ionic wetting agent 1 g/l
   - NaOH (47%) 7.5 g/l
   - Organic stabiliser 1 g/l
   - H_2O_2 (50%) 3 g/l
2. **Scouring and Full Bleaching**

   Carry out scouring and half bleaching (as shown in 1. above), then use the following recipe for full bleaching (95 °C / 60 min.):
   - H_2O_2 (50%) 7.5 g/l
   - NaOH (47%) 3 g/l
   - Organic stabiliser 2 g/l
3. **Optical Brightening/Softening** (at 60-70°C / 14-20 min.)
   - Uvitex 2B 0.5 % (owf)

   Followed by cooling and addition of softening (at 45-55°C / 15-20 min.)
   - Acetic acid 5 g/l
   - Net soft 3% (owf)

Four 9 kg trial samples of knitted fabric of different structures (namely rib, rib-lycra, single jersey and interlock) were full bleached. The trials were carried out on a small winch using the above recipes. Fabric quality was analysed after each trial and compared with the conventional separate process method. It can be seen from the table below that properties of the fabric processed by the suggested modified method are very similar to those processed by the conventional methods.

Comparison of Results Obtained from the Conventional and Modified Scouring and Bleaching Methods at Giza Spinning and Weaving
(each sample 9kg, work carried out on a small winch)

Fabric Type (knitted)	Process Type	Conventional Method		Modified Method	
		Whiteness Index	Wettability (seconds)	Whiteness Index	Wettability (seconds)
Rib	raw	27.9	> 120	27.9	> 120
	half bleached	55.2	1.5	53.4	0.75
	full bleached	98.1	1	96.7	0.75
Rib Lycra	raw	58.4	> 120	58.4	> 120
	half bleached	69.8	2	68.1	2.25
	full bleached	112	1.5	108.3	2.25
Single jersey	raw	53.6	> 120	53.6	> 120
	half bleached	67.1	2.5	66.1	1.5
	full bleached	103	2	104.5	1.5
Interlock	raw	58.6	> 120	58.6	> 120
	half bleached	63.8	3	62.8	1.5
	full bleached	107	2	106	1.5

Note: Conventional half bleaching was done using proprietary products Invatex and Invadine. Full bleaching was done using the hypochlorite method.

Significant reduction in water usage and processing time was also recorded in the trials.

Once bleaching has been completed it is important to check the uniformity of subsequent dyeing. In Giza Spinning and Weaving, uniformity of dyeing was assessed by conducting dyeing on 5kg of half-bleached single jersey fabric, in 6 sets of company standard shades. These were Sun Yellow (KM), Turquoise (KM), Turquoise (CF), Yellow/ Turquoise (KM), Orange (KM), and R-Yellow MERL (KM).

The depth of shade of all samples was comparable to those bleached conventionally.

Step 4 - Conduct Pilot Scale Trials

Pilot scale tests are done using the preferred laboratory scale recipes to assess the reproducibility of the tests under conditions resembling production scale.

At Giza Spinning and Weaving, a pilot scale test using the recipe described in Step 3, was carried out on 95 kg of single jersey, the most common processed fabric. The whiteness index and wettability were 65.1 and 1.5 seconds for half bleached and 103 and 1.5 seconds for full bleached fabrics. These are similar to the results achieved at the laboratory scale.

A second half bleach pilot scale test was undertaken on 129 kg of single Jersey fabric on a winch machine. Whiteness index and wettability again were comparable at 65 and 1.5 seconds respectively. The fabric was then dyed and softened in turquoise according to the conventional standard method at the company. The dyed fabric showed a colour depth consistent with the standard requirement.

Step 5 - Conduct Production Scale Trials

The purpose of the production trials is to assess the reproducibility of the laboratory and pilot tests at the production scale. This work must be planned to cause minimal disruption to production schedules.

Pilot trials are carried out in 3 steps:

- ***Conduct*** production scale trials on the optimum recipe developed at the pilot scale level.
- ***Assess*** the results, testing all parameters as indicated for the laboratory trials.
- ***Refine*** the recipe for full scale production.

Combined Desize and Scour - Misr Beida Dyers

At Misr Beida Dyers seven production trials were conducted to improve the efficiency of the combined desizing and scouring process. Four samples of 250-313 kg size were treated on the normal wide jiggers and three samples of 750-850 kg were processed on the Van Henriksen jiggers.

Expensive proprietary chemicals were phased out and replaced with ammonium persulphate and Egyptol. Trials varied the concentrations and rates at which chemicals were added as well as the temperature and number and timing of washes. Initial problems of attaining acceptable wettability and whiteness index were eventually overcome.

All inputs and outputs were recorded for each step. Savings in chemicals, water, energy and processing time are covered in more detail in Part C. Fabric quality was analysed for each trial and a comparison of results for the modified and conventional separate processing methods were conducted.

The final acceptable recipe for pretreating 1 ton of woven fabric (combined desizing/ scouring, followed by half bleaching) was as follows:

Ingredient	Combined (desize/ scour)	Followed by half bleaching
NaOH (38°Be) (l)	133	75
Espycon 1030 (kg)	4.8	1.5
Egyptol PLM (kg)	2.4	-
Ammonium persulphate (kg)	1.2	-
Na_2SiO_3 (kg)	-	16
H_2O_2 (35%) (kg)	-	13.3

A comparison of fabric quality when pretreated with the conventional and modified methods are summarised in the following table.

Production Scale Trials, Misr Beida Dyers

Fabric Quality Comparison

	Pre-treatment Method					
	Modified (Combined)			Conventional (Separate)		
	BB	AB	AD	BB	AB	AD
Handle	soft	soft	soft	harsh	harsh	harsh
Absorbency (sec.)	2	2	2	12	6	5
Whiteness Index	35.1	70.1	-	29.2	68.3	-
Tensile Strength[1] (kg)	53	52	52	52	50	50
Residual Strength[2] (%)	73.6	72.2	72.2	72.2	69.4	69.4
Iodine test	- ve	- ve	-	- ve	-ve	-
Shade (%)	-	-	0.08	-	-	0.08
Uniformity			uniform			uniform
Colour Fastness:						
a) Perspiration: Alkaline	-	-	4	-	-	4
Acidic	-	-	4	-	-	4
b) Washing	-	-	4	-	-	4

Note: 1 - warp direction; 2 - compared to grey sample; BB - before bleaching; AB - after bleaching; AD after dyeing.

The wettability and whiteness index of fabric using the combined modified are higher than those treated by the conventional separate method. The tensile strength of the conventional method is slightly lower and both methods give uniform dyeing with the same colour strength and colour fastness.

Combined Scour and Bleach - Giza Spinning and Weaving

At Giza Spinning and Weaving pilot trials were initially carried out for the full bleaching process as this comprises both the half and full bleaching steps. These tests were done to assess reproducibility and efficiency of the recipe and to enhance the capacity of production staff to implement the new method themselves.

Production-Scale Trials at Giza Spinning and Weaving

(a) Summary of the Successful Recipe

Three production scale trials were conducted on winches using 445kg, 351kg and 452kg of fabric, respectively. The conditions were as follows:

Fabric type: Knitted fabric ,single jersey,.

Recipe (for processing 1 ton of fabric at a liquor ratio of 10:1)

1) **Scouring and Half Bleaching Step** (at 90-95C for 45-60 minutes)

- Non-ionic wetting agent 10 kg
- NaOH (47%) 75 kg
- Organic stabiliser 10 kg
- H_2O_2 (50%) 30 kg

2) **Scouring and Full Bleaching:** First conduct scouring/half bleaching, then conduct full bleaching at 95°C / 60 min. using the following ingredients:

- H_2O_2 (50%) 75 kg
- Organic stabiliser 20 kg
- NaOH (47%) 30 kg

3) **Optical Brightening and Softening** (at 60-70C for 15-20 minutes)

- Uvitex 2B 5 kg
- Softening agent knit soft 30 kg
- Acetic Acid 50 kg

(b) Summary of Fabric Quality Results

Fabric	Whiteness Index	Wettability (sec)
Raw	53.6	> 120
Half bleached	65.0-66.2	1.5
Full bleached	103-104	1.5

Note: The results for each of the three trials show that both the whiteness index and wettability are very similar, showing that the suggested method is both reproducible and efficient. These were also very similar to the fabric quality achieved for the conventional, two-step process. As such, the method was accepted by the factory and implemented at full scale.

Step 6 - Optimise Downstream Benefits

In many cases, substitution can lead to an increase in the operating costs. Optimisation of the sequence is therefore required to achieve economical operations and can typically include interventions such as:

- Elimination of a washing stage.
- Recycle and reuse of liquor.
- Recovery of process chemicals.

In Giza Spinning and Weaving, it was found that the optical brightening could be done in the bleaching bath, once bleaching was complete. Instead of discharging the bath, it was retained for 20 minutes at 90°C before discharging. This modification led to savings in energy and water as well as time.

Appendix 1 includes the process flow diagrams at Giza Spinning and Weaving for the conventional processes as they were (Figures 1 and 2) and after modification to the combined scour-bleach process (Figure 3) for the knitted textiles.

Appendix 2 includes the process flow diagrams as they were for the conventional separate desizing, scouring and bleaching (Figure 1) using Kamilase enzyme and combined desize-scour (Figure 2) using Leonil EB, on Vald Henriksen jiggers at Misr Beida Dyers for woven fabrics. Figure 3 shows the process flow diagram after modification for the combined desizing/scouring method on the same jiggers.

Step 7 - Establish Cost-benefit Analysis for Full Scale Production

Once substitution has been successfully achieved, the overall benefits need to be determined. The parameters initially assessed in Step 2 (fabric quality, production costs and environmental benefits) will need to be reassessed and the two sets of results compared.

Part C of the Manual describes the benefits realised in each factory.

Step 8 - Document and Implement Revised Operating Procedures

Any changes that have been made must be formalised by:

- Issuing revised instructions (manufacturing as well as purchasing).
- Carrying out re-training for staff in areas where modifications have been made.
- Updating the existing quality assurance programme where necessary.

These actions will ensure that the substitution is fully incorporated into the manufacturing process.

Guidance instructions for the modified combined processes at Giza Spinning and Weaving and Misr Beida Dyers are included in Appendix 3.

Part C

Costs and Benefits

1 Introduction

No capital expenditure is necessary for implementation, as the benefits have been achieved through substitution and process optimis. A summary of benefits for the factories is:

	Misr Beida Dyers	Giza Spinning and Weaving	
	Half Bleach	Half Bleach	Full Bleach
Increased cost of chemicals:	1%	25%	14%
Reduction in electricity consumption:	19%	53%	27%
Reduction in steam consumption:	27%	40%	15%
Reduction in water consumption:	30%	59%	61%
Reduction in processing time:	2 hours	4 hours	5 hours

Other benefits included:

- Improved production efficiency by decreasing processing time.
- Improved in fabric quality.
- Reduced levels of pollution with the phasing out of toxic and hazardous substances.
- Improved working conditions.

2 Chemical Substitution and Process Optimisation

2.1 Costs and Benefits at Misr Beida Dyers

A comparison of requirements and costs between the conventional separate (Kamilase) and combined (Leonil EB) processes with the suggested modified method for pre-treating 1 ton of woven fabric on jiggers follows.

Comparison of Processes for Pre-treating 1 ton of Fabric at Misr Beida Dyers

Item	Conventional				Modified		Savings	
	Separate (Kamilase)		Combined (Leonil EB)		Persulphate (combined)		Modified method and	
Chemicals (kg)	Require-ment	Cost (LE)	Require-ment	Cost (LE)	Require-ment	Cost (LE)	Conv. (sep.)	Conv. (comb.)
Kamilase	8	30.8	-	-	-	-	30.8	-
Espycon 1030	6.67	15.8	4	9.5	6.3	15	0.8	(5.5)
Egyptol	-	-	-	-	2.4	15.8	(15.8)	(15.8)
NaOH (38Be-)	140	158.2	140	158.2	140	158.2	0.0	0
Leonil EB	-	-	6.67	145.3	-	-	-	145.3
Ammonium persulphate	-	-	-	-	1.2	17	(17)	(17)
Na_2SiO_3	16	6.1	16	6.1	16	6.1	0.0	0
H_2O_2 (35%)	13.3	23.3	13.3	23.3	13.3	23.3	0.0	0
Cost of chemicals		**234.2**		**342.4**		**235.4**	**(1.2)**	**107**
Water (m^3)	27.2	12.2	18.8	8.5	18.8	8.5	3.7	0
Steam (ton)	4.1	61.5	3	45	3	45	16.5	0
Electricity (k w/h)	94	17.9	76.4	14.5	76.4	14.5	3.4	0
Cost of Utilities		**91.6**		**68**		**68**	**23.6**	**0**
Time (h)	10.67	-	8.67	-	8.67	-	2 hours	0 hours
Labour		48		39		39	9	0
Total cost (LE)		**373.8**		**449.4**		**342.4**	**31.4**	**107**

Note: Figures in brackets indicate an increase in cost.

The cost of chemicals of the modified method is comparable to that of the conventional separate method. Costs of both are much lower than those of the conventional combined method. Water, steam, electricity, time and labour requirements of the combined processes (conventional and modified) are the same as each other but lower than those of the conventional separate processes.

The overall cost of modified combined processes is the least, followed by the conventional separate method, with the conventional combined method being the most expensive.

Based on present production levels the annual savings for the modified process is:

Annual savings on conventional separate process: 591tpa @ LE31.4 per ton	18,557 LE
Annual savings on conventional combined process: 591tpa @ LE107 per ton	63,237 LE
Total annual savings	**81,794 LE**

2.2 Costs and Benefits at Giza Spinning and Weaving

A comparison of the conventional and modified methods for half bleaching of 1 ton of knitted fabric on a winch machine are tabulated below.

Comparison for Half Bleaching of 1 ton of Fabric at Giza Spinning and Weaving

Parameter		Conventional Method		Modified Method		Savings (LE)
		Require-ment	Cost (LE)	Require-ment	Cost (LE)	
A.	Chemicals (kg):					
	Nionil N	10	25.6	10	25.6	0.0
	NaOH (47%)	-	-	75	45	(45)
	Na_2CO_3	30	24	-	-	24
	H_2O_2 (50%)	30	66	30	66	0
	Organic stabiliser	5	11	10	22	(11)
	Cost of chemicals		**126.6**		**158.6**	**(32)**
B.	Water (m^3)	70	35.4	28.96	14.5	20.9
C.	Steam (t)	4.5	109.6	2.7	65.8	43.8
D.	Electricity (kWh)	30	5.9	13.1	2.8	3.1
	Costs of Utilities		**150.9**		**83.1**	**67.8**
E.	Time (h)	7.45	-	3.5	-	3.95 hours
F.	Labour	-	37.2	-	17.5	19.7
	Total cost		**314.7**		**259.2**	**55.5**

A comparison of the conventional and modified methods for full bleaching of 1 ton of knitted fabric on a winch machine are tabulated in the following table.

Comparison for Full Bleaching of 1 ton of Fabric, Giza Spinning and Weaving

Parameter		Conventional Method		Modified Method		Savings (LE)
		Require-ment	Cost (LE)	Require-ment	Cost (LE)	
A.	Chemicals (kg):					
	Nionil N	12	30.8	10	25.6	5.2
	NaOH (47%)	80.5	48.3	105	63	(14.7)
	NaOCl	300	105	-	-	105
	$NaHSO_3$	2	10	-	-	10
	H_2O_2 (50%)	60	132	105	231	(99)
	Organic stabiliser	10	22	30	66	(44)
	Uvitex 2B	5	57	5	57	0
	Knit Soft	30	100.3	30	100.3	0
	Acetic acid (11%)	50	37	50	37	0
	Cost of chemicals		**542.4**		**579.9**	**(37.5)**
B.	Water (m^3)	151.7	75.8	58.96	29.4	46.4
C.	Steam (t)	7.8	190.3	6.65	162.1	28.2
D.	Electricity (kWh)	69.2	14.5	50.44	10.6	3.9
	Cost of Utilities		**280.6**		**202.1**	**78.5**
E.	Time (h)	18.45	-	13.45	-	5 hours
F.	Labour		92.2	-	67.3	24.9
	Total cost		**915.2**		**849.3**	**65.9**

Note: Figures in brackets indicate an increase in costs

Overall savings in the half bleaching process were LE55.5 per ton of fabric. In the full bleaching process, savings totalled LE65.9 per ton of fabric.

In half bleaching, the biggest savings came from a 40% reduction in steam consumption, corresponding to LE44 and a 21% reduction in water consumption, corresponding to LE21. A small saving of LE3 in electricity consumption was also made. The LE32 increase in cost of the process chemicals was completely offset by these savings.

In full bleaching, the biggest savings came from an 87% decrease in the cost of water, corresponding to LE46 per ton of fabric. Smaller savings were also made in steam and electricity. As with the half bleaching process, these savings completely offset the increase in cost of process chemicals.

The greatest benefit has been in the processing time for the half bleaching process which has been more than halved. This has allowed production to be increased from a previous maximum of 4.5 tons per day to a current 9 tons per day.

Based on present production levels the annual savings for the modified process is:

Annual savings on half bleach: 1200 tpa @ LE55.5 per ton	66,600 LE
Annual savings on full bleach : 240 ton @ LE 65.9 per ton	15,816 LE
Total annual savings	**82,416 LE**

3 Improved Productivity and Fabric Quality

3.1 Increased Productivity

In both factories, the modified processes significantly reduced processing time, thereby increasing production capacity. This was most pronounced at Giza Spinning and Weaving where the processing time for half bleach has been more than halved from 7.45 hours to 3.5 hours. With scheduling around shifts this has enabled capacity to be increased by 480 ton per annum. Reduced process cycle time of 5 hours on full bleach has increased production capacity by 25% or 48 tons per annum. Annual benefits for the increased production have been estimated on the basis of a net margin of LE130 per ton plus the savings per ton on the modified bleaching process.

At Misr Beida Dyers production capacity has been increased by 18% by reducing the cycle time by 2 hours.

Net benefits as a result of increased production capacity are:

Giza Spinning and Weaving:	**(LE)**
■ Net gain per year on increased half bleach production: 480 tpa @ LE130 margin per ton	62,400
■ Annual savings on the increased production for half bleach 480 tpa @ LE55.5 per ton	26,640
■ Annual savings on the increased production for full bleach 48 tpa @ LE65.9 per ton	3,163
Total annual savings	**92,203 LE**

3.2 Fabric Whiteness and Wettability

Misr Beida Dyers

In Misr Beida Dyers, the modified process improved both whiteness and wettability of the fabric. It was also noted that tensile and residual strength were also improved.

Comparison of Production-Scale Results obtained from the Conventional and Modified Methods at Misr Beida Dyers

Fabric Type	Process Type	Whiteness Index		Wettability (seconds)	
		Conventional Method	Modified Method	Conventional Method	Modified Method
Woven	Half bleached	68.3	70.1	6	2

Giza Spinning and Weaving

In Giza Spinning and Weaving, the modified method gave slightly better results for full bleached fabric in terms of whiteness and wettability. The increased whiteness was very well received, as whiteness is particularly important in full bleached fabrics; the wettability was within an acceptable range. In half bleaching, a slight decrease in quality was observed - this was insignificant, as the fabric has to undergo further processing.

Comparison of Production-Scale Results Obtained from the Conventional and Modified Methods at Giza Spinning and Weaving

Fabric Type (knitted)	Process Type	Whiteness Index		Wettability (seconds)	
		Conventional Method	Modified Method	Conventional Method	Modified Method
Single jersey	raw	53.6	53.6	> 120	> 120
	half bleached	67.1	65-66.2	2.5	1.5
	full bleached	103	103-104	2	1.5

4 Environmental Benefits and Improved Working Conditions

Sodium hypochlorite is both toxic and hazardous and its elimination from the bleaching process means that workers will not be handling, or coming into contact with it. The smell of chloride gas in the bleaching section has also been eliminated, resulting in more comfortable working conditions. Its elimination form the process will also minimise the amount of halogenated organic hydrocarbons (AOX) in the final effluent leaving the factory.

5 Summary of Financial Savings

No capital expenditure was required; the benefits have been gained from chemical substitution and process optimisation alone. Net annual savings are:

Misr Beida:	**(LE)**
Chemical substitution and process optimisation	81,794
Sub total, Misr Beida Dyers	**81,794**
Giza Spinning and Weaving:	
Chemical substitution and process optimisation, half bleach	66,600
Chemical substitution and process optimisation, full bleach	15,816
Increased production capacity, half bleach	89,040
Increased production capacity, full bleach	3,163
Sub total,Giza Spinning and Weaving	**174,619 LE**
Total annual savings	**256,413 LE**

Most of the fabrics used in trials were sold. The cost for local consultants and expenses was LE56,000 giving a payback period of just over 2 months. Additional costs for international expertise was borne by SEAM and fabric analyses were undertaken in the factories.

Part D

Helpful Hints

Do s and Donts

Do s and Dont s

Do . . .

- ☺ Carry out trials of the conventional and modified process at the same time, so that the results are directly comparable.
- ☺ Note down recipe, water consumption and time taken for each of the processes at each step.
- ☺ Attempt to arrive at an estimation of steam, electricity and labour utilised.
- ☺ Collect full width fabric samples from each of the two processes after bleaching and compare the results for appearance, absorbency, whiteness and strength and the absence of residual starch.
- ☺ Collect full width fabric samples from each of the two processes after dyeing and compare the results for shade, uniformity of colour and colour fastness.
- ☺ Note down the details of the fabric which are being used in the trials. This will help in modifying the recipe for other types of fabric in future trials.
- ☺ Check reproducibility by repeating the successful experiment and rechecking the results.

Dont . . .

- ☹ Do not attempt combination of desizing, scouring and bleaching if results of desizing and scouring combination trial are not highly encouraging.
- ☹ Do not perform chlorine bleaching.

Appendices

1. **Process Flow Diagrams for Misr Beida Dyers**
2. **Process Flow Diagrams for Giza Spinning and Weaving**
3. **Guidance Instructions for Giza Spinning and Weaving and Misr Beida Dyers**

Appendix 1

Process Flow Diagrams
Misr Beida Dyers

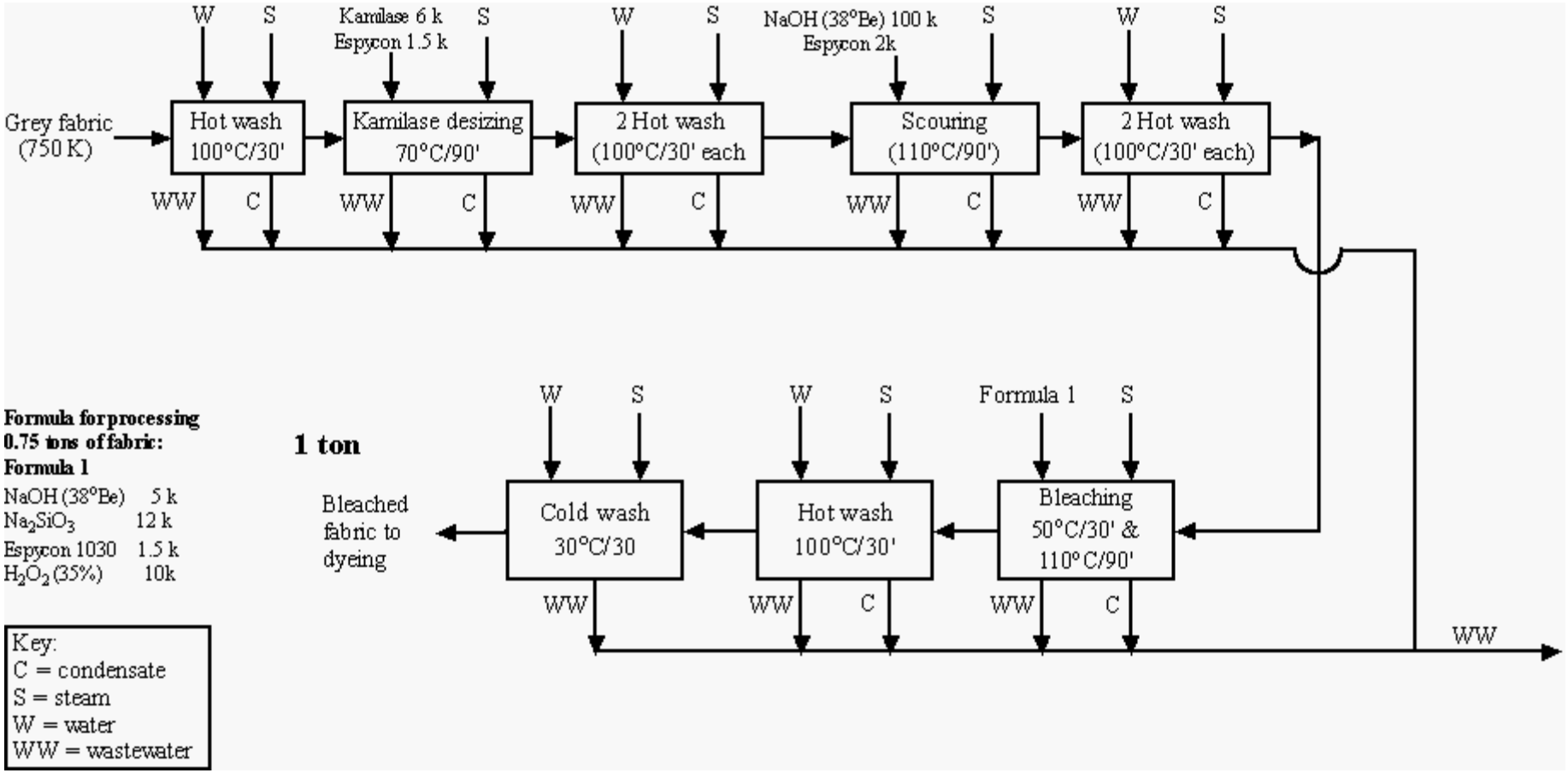


Figure 1
Process Flow Diagram of Conventational Separate Desizing/Scouring Processes Using Kamilase Enzyme on Valid Henriksen Jigger at Misr Beida Dyers For Processing 0.75 tons of Fabric

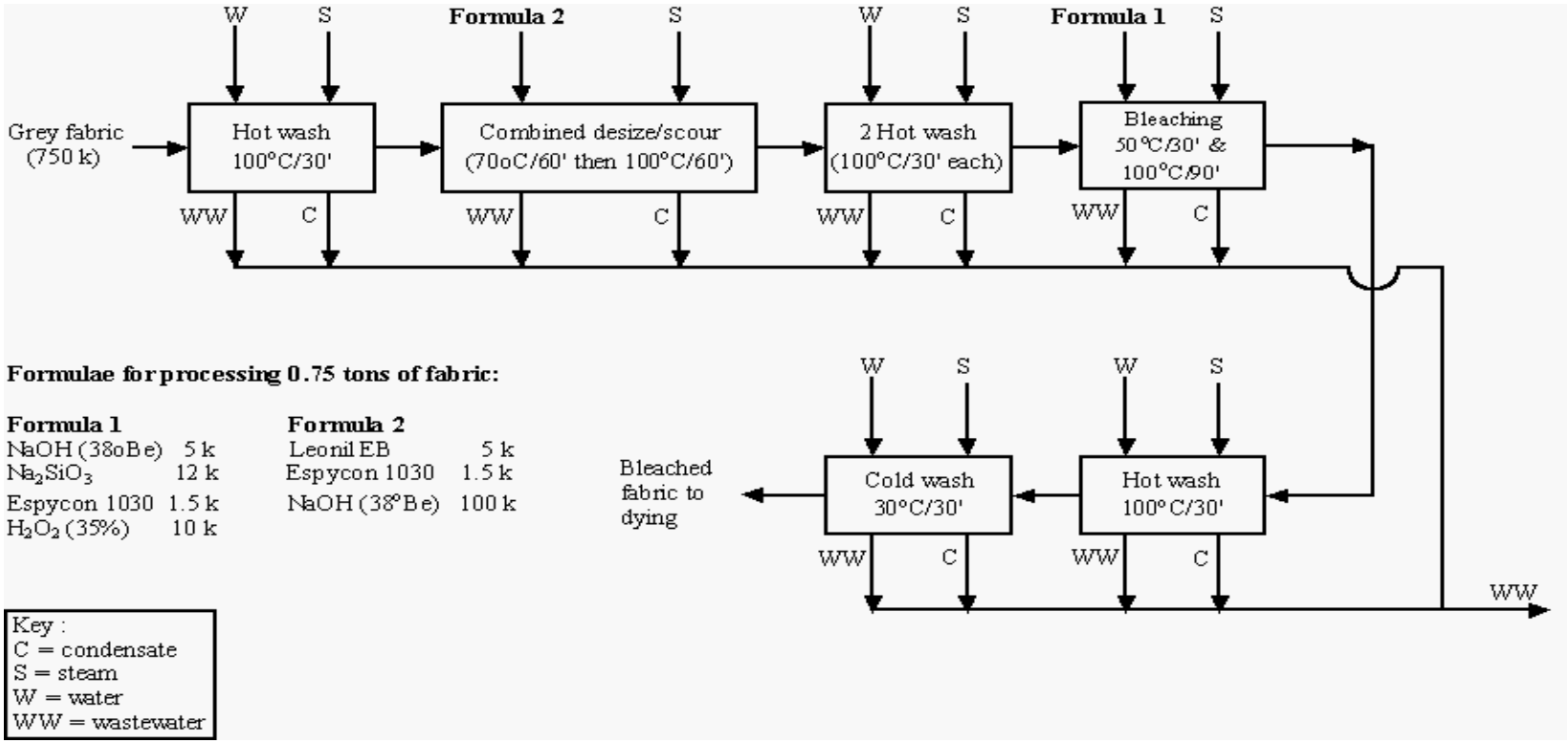
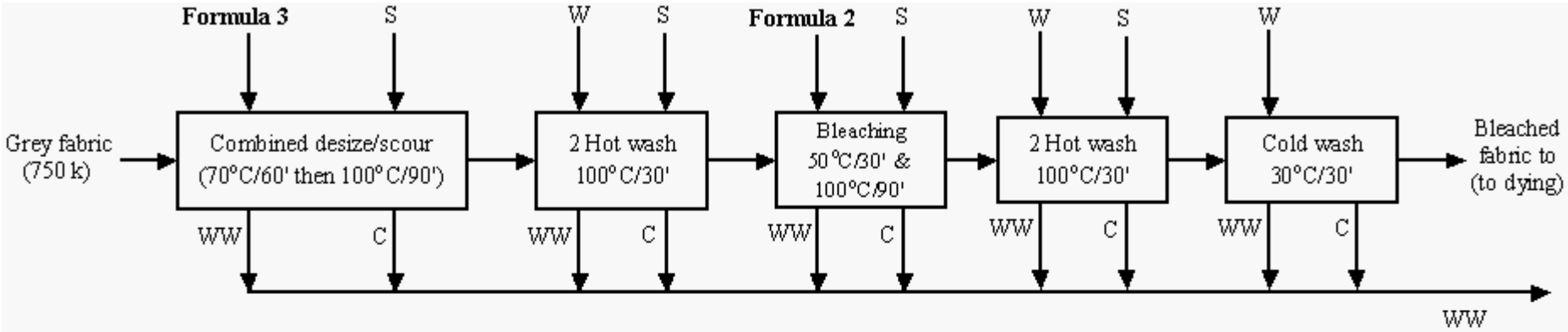


Figure 2
Process Flow Diagram of Conventional Combined Desizing/Scouring Process Using Leonil EB on Vlad Henriksen Jigger at Misr Beida Dyers For Processing 0.75 tons of Fabrics



Formulae for processing 0.75 tons of fabric:

Formula 1		**Formula 2**	
Leonil EB	5 k	NaOH (38°Be)	100 k
Espycon 1030	1.5 k	Egyptol	1.8 k
NaOH (38°Be)	100 k	Espycon 1030	3.6 k
		Ammonium persulphate	900 g

Key :
C = condensate
S = steam
W = water
WW = wastewater

Figure 3
Process Flow Diagram of Modified Combined Desizing/Scouring Process
Using Ammonium Persulphate on Vald Henriksen Jigger at Misr Beida Dyers
For Processing 0.75 tons of Fabric

Appendix 2

Process Flow Diagrams
Giza Spinning and Weaving

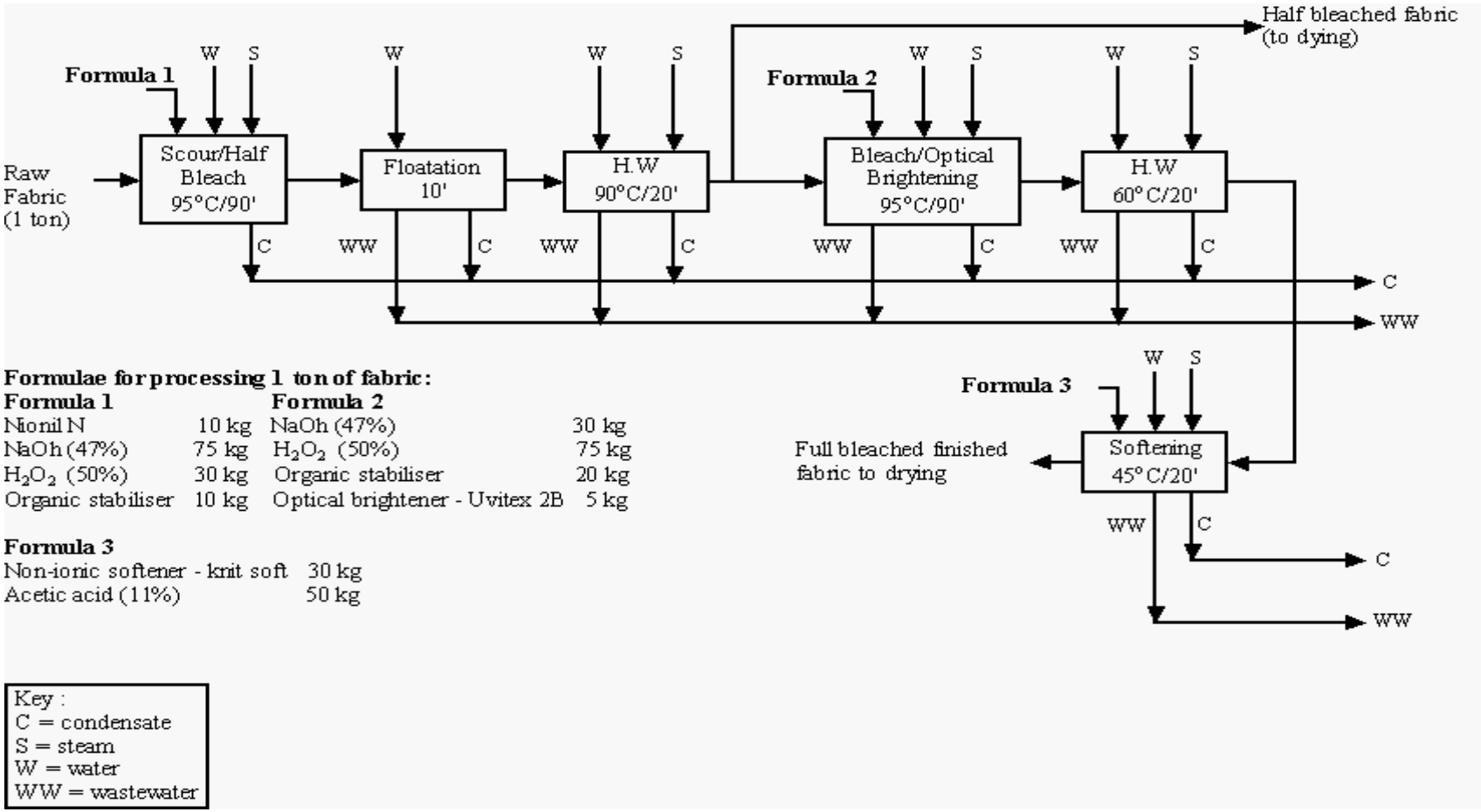
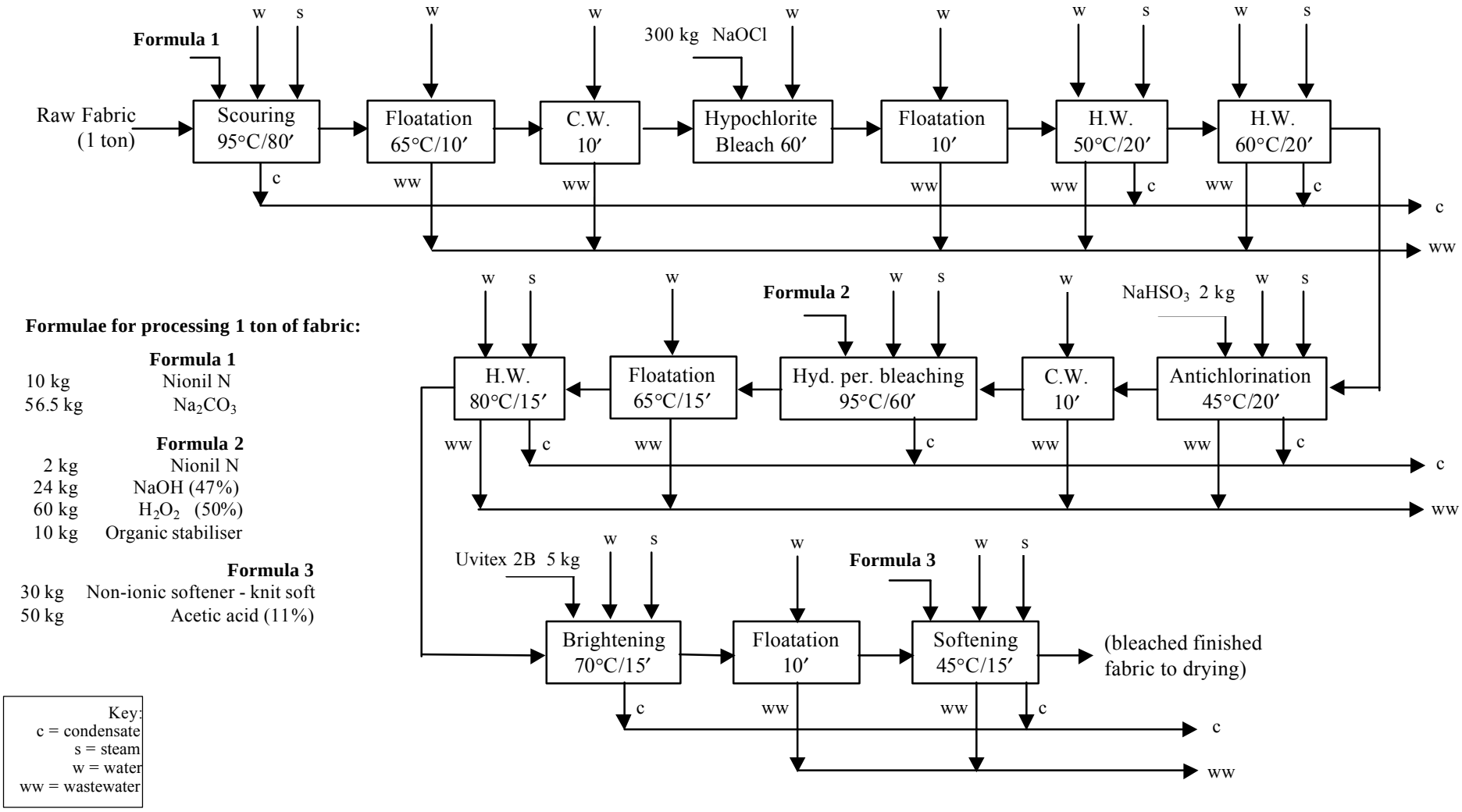


Figure 1
Process Flow Diagram of the Suggested Method of Bleaching and Finishing
1 ton of Knitted Fabric at Giza Spinnig and Weaving



Formulae for processing 1 ton of fabric:

Formula 1

10 kg	Nionil N
56.5 kg	Na_2CO_3

Formula 2

2 kg	Nionil N
24 kg	NaOH (47%)
60 kg	H_2O_2 (50%)
10 kg	Organic stabiliser

Formula 3

30 kg	Non-ionic softener - knit soft
50 kg	Acetic acid (11%)

Key:
c = condensate
s = steam
w = water
ww = wastewater

Figure 2
Process Flow Diagram of Conventional Full Bleaching and Finishing
1 ton of Knitted Fabric at Giza Spinning and Weaving

Appendix 3

Guidance Instructions Misr Beida Dyers and Giza Spinning & Weaving

Misr Beida Dyers - Guidance Instructions for Combined Pre-Treatment of Woven Fabrics

Combined Desize and Scour Followed by Bleaching

To pre-treat a batch of 750-850 kg grey woven fabric on Vald Henriksen jiggers or a batch of 300-350 kg of the same fabric on the normal wide jiggers, at a liquor ratio (LR) of 3, proceed as follows.

1 Desizing/Scouring step

1.1 Recipe

	Vald Henriksen jigger	Wide jigger
■ NaOH (38Be$^-$) (l)	100	75
■ Espycon 1030 (kg)	3.6	2
■ Egyptol PLM (kg)	1.8	1
■ Ammonium persulfate (g)	900	1,000

1.2 Technique

Step 1: After loading the fabric, fill the machine with water, and while raising the temperature to 70C, add the chemicals (either through the dosing tank of Vald Henriksen jiggers, or by uniform distribution in the wide jiggers) in the order shown in the recipe.

- In Vald Henriksen jiggers, addition is carried out by withdrawing about 50l of liquor from the machine in the dosing tank, and mixing the chemicals in it and then feeding it back to the machine.
- In wide jiggers, addition can be carried out by direct addition to the machine (as is the case with NaOH) or by dissolving the chemicals in about 20l of machine liquor.

Step 2: Run the fabric for 4 ends for 1 hr at 70C, then raise the temperature to 100C, where the fabric is run for extra 6 ends (90 min).

Step 3: Discharge the liquor from the machine and then refill with water to the maximum level. The steam should be allowed in at this time to raise the temperature to boiling point. Then perform a hot wash (at the boil) for two ends. Discharge and repeat once more.

2 Bleaching step

2.1 Recipe

.	Vald Henriksen jigger	Wide jigger
■ NaOH (38Be¯) (l)	5	2.5
■ Na_2SiO_3 (kg)	12	8
■ Espycon 1030 (kg)	1.5	0.5
■ H_2O_2 (35%) (kg)	10	6

2.2 Technique

Step 1: Fill the machine and add the chemicals (in the order shown in the recipe) while raising the temperature to 50C, where the fabric is given 2 ends. Then raise the temperature to 100C and give the fabric 6 ends. Discharge.

Step 2: Give the fabric a hot wash (100C/2 ends) as previously described in the desizing/scouring step.

Step 3: Give the fabric a cold wash (room temperature/2 ends). The fabric is now ready for dyeing.

Giza Spinning and Weaving - Guidance Instructions for Combined Pre-treatment of Knitted Fabrics

Scouring/Half Bleaching, Full Bleaching, Optical Brightening and Softening

1 Scouring/Half Bleaching

Prepare the actual amount of chemicals according to the weight of fabric and the Material to Liquor Ratio (MLR). Follow the base recipe as follows:

- Non-ionic wetting agent 1 g/l
- NaOH (47%) 7.5 g/l
- Organic stabiliser 1 g/l
- H_2O_2 (50%) 3 g/l

(at 95 °C / 60 min)

- Add about 75% of the total water volume to the machine, and add the wetting agent.
- Load the fabric and operate the machine
- Add water to the required volume (i.e. as per the MLR)
- Add the rest of scouring/half bleaching chemicals according to the sequence:
  1. NaOH
  2. organic stabiliser and
  3. hydrogen peroxide.

The sequence of addition is critical if optimum scour/bleach is to be obtained.

- Distribute the chemicals evenly along the bath over a 10 minute period. After this, raise the temperature of the bath to 95°C over 20 - 25 minutes. Keep the temperature at 95°C for another hour to achieve scouring/half bleaching.
- Overflow with water for 5 min (while the steam is still open) and then discharge.
- Refill with water, raise to 95°C and wash for another 5 minutes at 95°C and then discharge the bath.

The fabric is then ready for dyeing or full bleaching.

2 Full bleaching, Optical Brightening and Softening

Complete scouring/half bleaching as described previously.

Prepare the actual amounts of chemicals needed for full bleaching, optical brightening and softening using the base recipes as below.

- Full Bleaching

H_2O_2 (50%)	7.5 g/l
NaOH (47%)	3 g/l
Organic stabiliser	2 g/l
(at 95 °C / 60 min)	

- Optical Brightening

Optical brightener	0.5% (owf)
(at 95 °C / 20 min)	

- Softening

Non-ionic softener	3% (owf)
Acetic acid	0.5 ml/l
(at 45 - 50°C / 30 min)	

- Fill the bath with water and add the full bleaching chemicals in the following order :
  1. Sodium Hydroxide.
  2. Organic stabiliser .
  3. Hydrogen peroxide.
- Distribute the chemicals evenly along the bath over a 10 minute period. After this, raise the temperature to 95°C within 20 - 25 minutes. Continue bleaching at 95°C for another hour.
- Add the optical brightener to the bleaching bath, and continue rotating of the fabric for further 20 minutes.
- Discharge the bath.
- Fill with water and heat to 60°C in about 10 minutes, continue washing for about 10 minutes, then discharge.
- Fill with water, add the softening chemicals, heat to 45 - 50°C and keep at that temperature for another 30 minutes.
- Discharge and unload the fabric.
- Centrifuge and dry.