



# Guide for Assessment of Effluent Treatment Plants



**Department of Environment**  
**Ministry of Environment and Forest, Bangladesh**

**June, 2008**



**পরিবেশ অধিদপ্তর**  
**Department of Environment**



**Canadian International  
Development Agency**



## Guide for Assessment of Effluent Treatment Plants in EMP/EIA Reports for Textile Industries



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First Edition



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**Khandaker Rashedul Haque, PhD**  
**Director General**  
Department of Environment  
Government of the People's Republic of Bangladesh

## Foreword

I am pleased to write this foreword for the “Guide for Assessment of Effluent Treatment Plants” published by the Department of Environment (DOE) with support from the Bangladesh Environmental Institutional Strengthening Project (BEISP).

Water pollution due to discharge of untreated industrial effluent into water bodies is an alarming environmental crisis of Bangladesh. Most industries do not have effluent treatment facilities and few industries which have these facilities are either not properly designed or operated and monitored regularly. The Environmental Conservation Act 1995 (ECA) provides that all relevant industrial units will install Effluent Treatment Plant (ETP) to treat their waste water to achieve certain standard before releasing it into receiving environment. DOE is mandated to enforce this provision of law. Thus DOE officials are often engaged in reviewing and evaluating the ETP schemes submitted to them for granting permission to new industries, and inspection and monitoring of ETPs in the existing industries. In order to enforce this provision of law DOE officials need to have adequate knowledge on all aspects of effluent treatment technologies and their design, operation and construction. Keeping these needs in view two training programs on ETP were conducted by BEISP in DOE. The training was provided by the experts from Northern India Textile Research Association (NITRA).

This guide book is the outcome of the proceedings of the above mentioned training programs and has been prepared by NITRA and BEISP experts with contribution from the concerned officials of the DOE.

It is expected that this guide book will serve as a practical tool for reviewing ETPs submitted to DOE and for conducting inspection of ETPs and will meet a long felt requirement by DOE.

Khandaker Rashedul Haque, PhD

## ACRONYMS

BEISP	Bangladesh Environmental Institutional Strengthening Project
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
DG	Director General
DO	Dissolved Oxygen
DOE	Department of Environment
ECA	Environment Conservation Act, 1995
ECC	Environmental Clearance Certificate
ECR	Environmental Conservation Rules, 1997
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ETP	Effluent Treatment Plant
HP	Horsepower
HRT	Hydraulic Retention Time
HTHP	High Temperature High Pressure
IEE	Initial Environmental Examination
KWH	Kilowatt-hours
LCC	Location Clearance Certificate
MOEF	Ministry of Environment and Forests
NITRA	Northern India Textile Research Agency
PVA	Polyvinyl Acetate
RFD	Ready for Dyeing
RPH	Revolutions per Hour
RPM	Revolutions per Minute
SOR	Surface Overflow Rate
SRO	Statutory Regulatory Order
SS	Suspended Solids
TDS	Total Dissolved Solids
TSS	Total Suspended Solids

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# 1 Purpose and Objectives of the Guide

## 1.1 Purpose

This *Guide for Assessment of Effluent Treatment Plants* has been prepared as a tool for use by Department of Environment (DOE) staff in the enforcement of environmental legislation relating to industry waste water treatment and discharge. The Guide provides the methodology to be followed when assessing the documentation regarding the effluent treatment plant (ETP), which is submitted by textile industries in the Environmental Management Plan (EMP) and Environmental Impact Assessment (EIA) Report. This *Guide* should be used by existing staff to determine whether the ETP complies with the law and would also be useful for training new staff.

The *Guide* is divided into two main sections. Part 1 of the manual presents the Assessment Guide, which provides step-by-step instructions on the procedure for assessment of ETPs, that DOE staff can use as a quick and concise reference for reviewing ETP designs. Part 2 presents in more detail essential background information on ETP design and effluent standards. There are also 2 annexes: Annex A describing with diagrams the textile processes and Annex B with pictures of ETP components.

## 1.2 Objectives

The objectives of the guide are as follows:

- to provide the user with the tools necessary to evaluate ETPs presented in textile industry EIAs;
- to provide the design and effluent standards required to assess the ETP and determine whether it complies with the law;
- to provide the background information necessary to the user to understand the manufacturing process and the inputs and outputs of that process; and
- to provide the legislative background to the Environmental Clearance Process.

This *Guide for Assessment of Effluent Treatment Plants* was developed with the technical assistance of ETP specialists from the Northern India Textile Research Agency (NITRA) and M. Rahman of BEISP. It was assembled by M. Myles and S.I. Ali from BEISP and further refined with assistance from the many comments from DOE staff familiar with carrying out ETP reviews. The production of the document was facilitated by BEISP, a project supported by the Canadian International Development Agency and the Government of Bangladesh.





**PART 1**  
**ASSESSMENT GUIDE**



## 2 Overview of ETP Assessment Procedure

### 2.1 Introduction to ETP Assessment

Under Section 12 of the Bangladesh Environment Conservation Act 1995 (ECA 1995) no industrial unit or project can be established or undertaken without obtaining an Environmental Clearance Certificate (ECC) from the DOE. The ECC ensures that the industry/project meets all the prescribed standards set by the Bangladesh Government in terms of the quality standards of air, water, noise, odor and other environmental components.

As part of the ECC application, for Orange-B and Red category industries, an Environmental Management Plan (EMP) must be submitted. Fabric dyeing and chemical treatment industries fall under the Red category, and are therefore required to submit an EMP. The purpose of the EMP is to prescribe measures to reduce environmental impacts and risks associated with the industry. The Plan should contain mitigation and contingency plans, expected impacts and risks, impact management and environmental enhancement plans, monitoring plans and impact reporting.

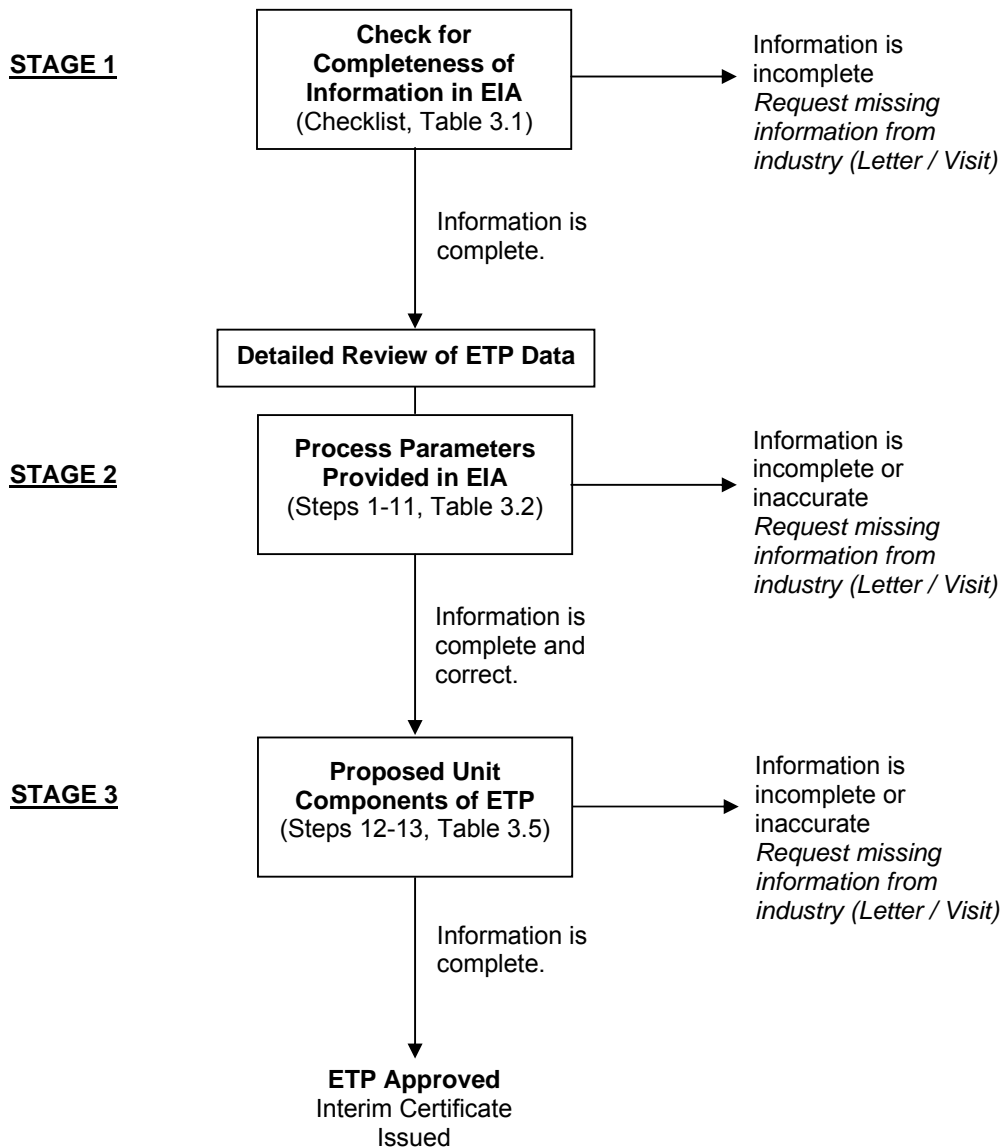
A major environmental hazard present in textile industries is the discharge of untreated effluent to the environment, causing pollution of nearby soil and water. To mitigate the risks from the discharge of untreated water, an effluent treatment plant is required. Effluent must meet the national effluent discharge quality standards. As water passes through the ETP, pollutants are removed and the quality of the water is improved, allowing for final discharge to the environment without significant risk. The EMP should contain the Process Flow Diagram, Layout Plan including the location for the Effluent Disposal System, and the plan and design of the Effluent Treatment Plant with full information about its effectiveness. The EMP should also include a post-project monitoring program.

The purpose of this *ETP Assessment Guide* is to assist DOE staff to review a proposed ETP design and assess its effectiveness. There are many options for the design of an ETP. The type of plant and the various components of the plant will depend on the characteristics of the effluent. In evaluating an ETP design, it is necessary to determine whether the components of the ETP are sized correctly for the flow and to assess whether the effluent is likely to meet the requirements of the national discharge standards.

## 2.2 Overview of Assessment Procedure

Figure 2.1 shows the ETP assessment procedure. There are 3 stages for reviewing an ETP design and checklists are provided for each. As indicated, in any stage if the information provided for the proposed ETP is found to be inadequate, incorrect or outside the guideline values, the industry must be consulted to provide or correct the information.

**Figure 2.1: Overview of Stages in ETP Assessment Procedure**



### 3 ETP Assessment Procedure

#### 3.1 STAGE 1: Preliminary Check for Completeness of Information

The following checklist is to be used to determine if all the required information for the proposed ETP has been provided by the industry in its EIA package. After completing the checklist, request missing information from the industry.

**Table 3.1: Checklist for Completeness of Information Submitted**

S.N.	Contents	Information submitted?	
		Yes	No
1.	<b>Introduction</b>		
	1.1 Name and Address of Industry	<input type="checkbox"/>	<input type="checkbox"/>
	1.2 Installed/Proposed Production Capacity	<input type="checkbox"/>	<input type="checkbox"/>
	1.3 Names of Raw Materials (Cotton, Polyester, Blend, etc.) & Final Products (Bleached, dyed, printed, etc.)	<input type="checkbox"/>	<input type="checkbox"/>
	1.4 Number of Total Employees (Officers & Staff)	<input type="checkbox"/>	<input type="checkbox"/>
	1.5 Operation Hours (hours/day and shifts/day)	<input type="checkbox"/>	<input type="checkbox"/>
	1.6 Source of Water & its Proposed Treatment	<input type="checkbox"/>	<input type="checkbox"/>
	1.7 Boiler Capacity, Make and Pollution Control System	<input type="checkbox"/>	<input type="checkbox"/>
	1.8 Disposal Method for Treated Effluent Discharge (e.g. outlet to river, pond, sewer, etc.)	<input type="checkbox"/>	<input type="checkbox"/>
	1.9 Method of Domestic Wastewater Treatment & Disposal	<input type="checkbox"/>	<input type="checkbox"/>
1.10 Any other information (not covered in the above) e.g. Drain / pipe line for collection / disposal	<input type="checkbox"/>	<input type="checkbox"/>	
2.	<b>Water Requirement &amp; Consumption Pattern: Breakdown of Water Quantity (M<sup>3</sup> or KL/day)</b>		
	2.1 Boiler	<input type="checkbox"/>	<input type="checkbox"/>
	2.2 Process House	<input type="checkbox"/>	<input type="checkbox"/>
	2.3 Domestic (Toilets/Canteen)	<input type="checkbox"/>	<input type="checkbox"/>
	2.4 Softener, Filter Wash, any other Water Treatment	<input type="checkbox"/>	<input type="checkbox"/>
	2.5 Cooling, Humidification	<input type="checkbox"/>	<input type="checkbox"/>
3.	<b>Production Process and Effluent Generation</b>		
	3.1 Details (Numbers and Capacity) of Process Machines	<input type="checkbox"/>	<input type="checkbox"/>
	3.2 Final Product Weights (kg / day)	<input type="checkbox"/>	<input type="checkbox"/>
	3.3 Flow Charts of Wet Processing with Material : Liquor ( M : L ) ratio	<input type="checkbox"/>	<input type="checkbox"/>
	3.4 Names & Approximate Quantity of Daily Consumption of Dyes and Auxiliary Chemicals	<input type="checkbox"/>	<input type="checkbox"/>
3.5 Quantity of Daily Effluent Generation (M <sup>3</sup> /day)	<input type="checkbox"/>	<input type="checkbox"/>	
4.	<b>Characteristics of Untreated Combined Effluent</b> (pH, TSS, COD, BOD, Oil & Grease, TDS and any other)	<input type="checkbox"/>	<input type="checkbox"/>

(continued on p. 3-2)

S.N.	Contents	Information submitted?	
		Yes	No
5.	<b>Effluent Treatment Scheme</b>		
	5.1 Basis for Selection of Treatment Scheme & Components	<input type="checkbox"/>	<input type="checkbox"/>
	5.2 Design Criteria and Treatment Unit Sizes (M3/Day and M3/Hour)	<input type="checkbox"/>	<input type="checkbox"/>
	5.3 Method of Flow Measurement at Final Outlet	<input type="checkbox"/>	<input type="checkbox"/>
	5.4 Scheme Description with Flow Chart / Block Diagram	<input type="checkbox"/>	<input type="checkbox"/>
	5.5 Guaranteed Characteristics of Treated Effluent	<input type="checkbox"/>	<input type="checkbox"/>
6.	<b>Specification of Civil Items</b>		
	6.1 Size, Material of Construction for all Treatment Units	<input type="checkbox"/>	<input type="checkbox"/>
	6.2 Drawings (only General Arrangement for all Treatment Units)	<input type="checkbox"/>	<input type="checkbox"/>
7.	<b>Specification of Mechanical and Electrical Equipment</b>		
	7.1 Numbers, Capacity / Tank Sizes, Motor HP, Material of Construction and Other Details (RPM / RPH ), as applicable	<input type="checkbox"/>	<input type="checkbox"/>
	7.2 General Drawings	<input type="checkbox"/>	<input type="checkbox"/>
8.	<b>Tentative Cost of Treatment Plant</b>		
	8.1 Civil Cost	<input type="checkbox"/>	<input type="checkbox"/>
	a) ETP Cost	<input type="checkbox"/>	<input type="checkbox"/>
	b) Disposal Drain / Pipe Line Cost	<input type="checkbox"/>	<input type="checkbox"/>
	8.2 Electrical & Mechanical Equipment Cost	<input type="checkbox"/>	<input type="checkbox"/>
9.	<b>Details of ETP Recurring Expenditure</b>		
	9.1 Quantity of Chemicals for Treatment & Cost per Day	<input type="checkbox"/>	<input type="checkbox"/>
	9.2 Power (Electricity–KWH) & Cost per Day	<input type="checkbox"/>	<input type="checkbox"/>
	9.3 Manpower Cost per Day	<input type="checkbox"/>	<input type="checkbox"/>
	9.4 Total Treatment Cost (Tk / M <sup>3</sup> )	<input type="checkbox"/>	<input type="checkbox"/>
10.	<b>Enclosures</b>		
	10.1 DOE Prescribed Form (Form -3) duly filled	<input type="checkbox"/>	<input type="checkbox"/>
	10.2 Drawings	<input type="checkbox"/>	<input type="checkbox"/>
	10.3 Layout Plan with Units Sizes	<input type="checkbox"/>	<input type="checkbox"/>
	10.4 Hydraulic Flow Diagram with Levels	<input type="checkbox"/>	<input type="checkbox"/>
	10.5 Undertaking for Providing Separate Electrical Meter for ETP	<input type="checkbox"/>	<input type="checkbox"/>
	10.6 Any other	<input type="checkbox"/>	<input type="checkbox"/>

### 3.2 STAGES 2 and 3: Detailed Revision of ETP Data

#### 3.2.1 STAGE 2: Process Parameters Provided in EIA

Check the parameters provided by the industry in the EIA using the following table (Table 3.2). Fill in the second column with the values required. If the information is not provided or is incorrect, clarify the information with the industry.

**Table 3.2: Process Parameters**

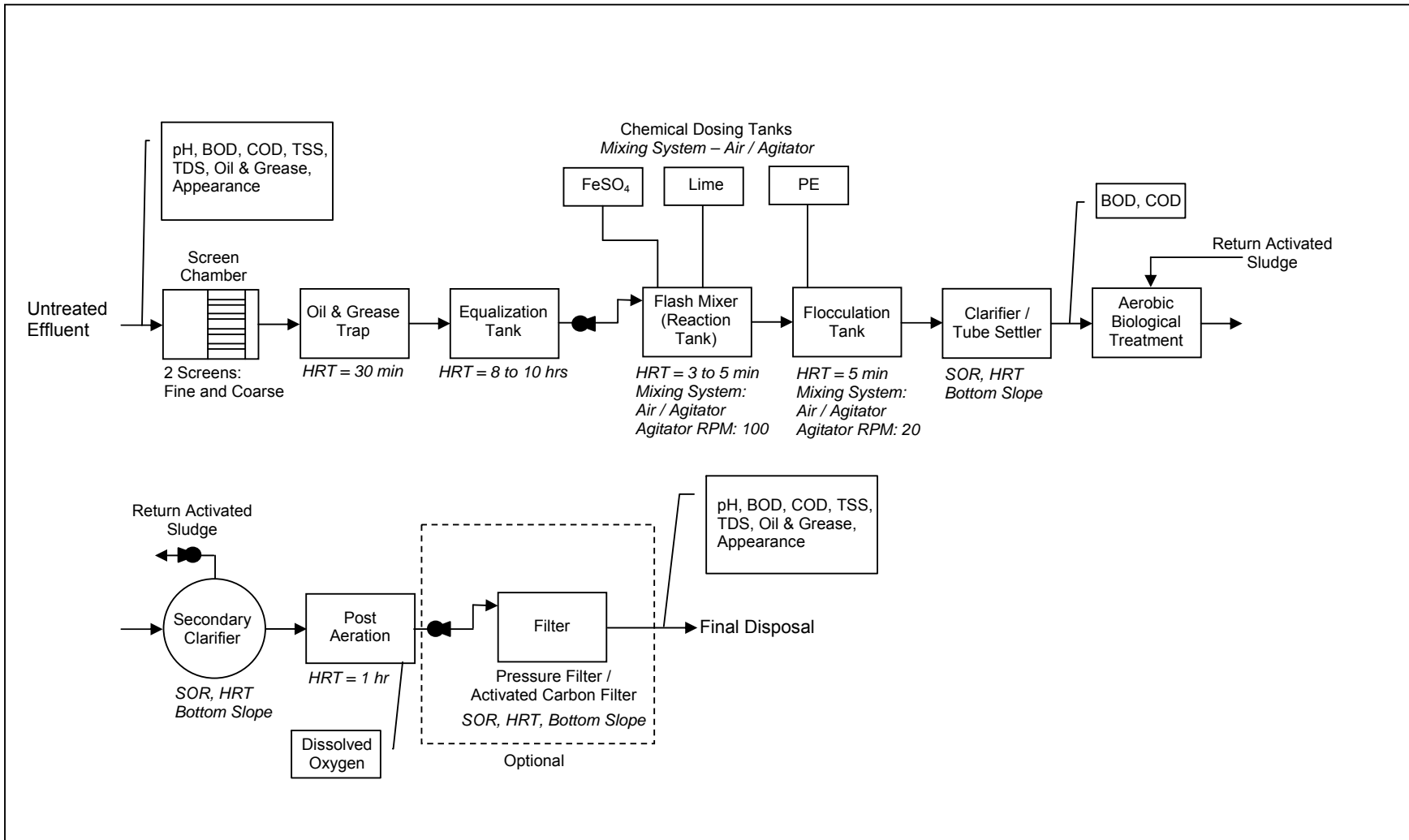
Step	Parameter	Values (To be completed by evaluator)														
1.	<p><b>Production per Day</b> Determine the amount of textile produced per day in kg/day. If the value is given in meters (m/day), convert this number to kg using the conversion factor provided by the industry in GSM or grams per square metre (e.g. 10m = X grams or kg of textile).</p> <p><i>Example conversion calculation:</i> If the conversion factor provided by industry is 10m = 5kg</p> <p>Production (P): 5,000 m/d Conversion Factor: 10 m = 5 kg Therefore, 2 m/kg</p> <p>Production (kg/day) = <math>P \div C</math> = <math>5,000 \text{ m/d} \div 2 \text{ m/kg}</math> = 2,500 kg/d</p>	<p>_____ kg/day</p>														
2.	<p><b>Water Consumption for Processing and Utilities</b> Check that the sum of the water consumed in each process or component is equivalent to the total water consumption provided in the EIA, in m<sup>3</sup>/day. Include all process water consumption and that required for utilities such as boilers, cooling and all domestic uses. Record the total water consumption in the next column.</p> <p>Also check that the water consumption for individual processes (i.e. wet processing, sanitary, etc.) is approximately equal to the typical percentages of total water consumption for textile industries:</p> <table border="1" data-bbox="396 1335 922 1562"> <thead> <tr> <th>Process</th> <th>Percentage of Total Water Consumption (tentative)</th> </tr> </thead> <tbody> <tr> <td>Wet processing</td> <td>72%</td> </tr> <tr> <td>Sanitary*</td> <td>8%</td> </tr> <tr> <td>Water treatment</td> <td>8%</td> </tr> <tr> <td>Cooling water</td> <td>6%</td> </tr> <tr> <td>Steam production</td> <td>5%</td> </tr> <tr> <td>Fire fighting</td> <td>1%</td> </tr> </tbody> </table> <p>* in some cases this is treated separately.</p> <p>(Note: KL/day is equivalent to m<sup>3</sup>/day.)</p>	Process	Percentage of Total Water Consumption (tentative)	Wet processing	72%	Sanitary*	8%	Water treatment	8%	Cooling water	6%	Steam production	5%	Fire fighting	1%	<p>_____ m<sup>3</sup>/day</p>
Process	Percentage of Total Water Consumption (tentative)															
Wet processing	72%															
Sanitary*	8%															
Water treatment	8%															
Cooling water	6%															
Steam production	5%															
Fire fighting	1%															
3.	<p><b>Effluent Generation</b> Check the amount of effluent generated from textile processing (dyeing, printing and finishing), utilities such as boilers, cooling and all domestic uses, as indicated in the EIA, in m<sup>3</sup>/day. This should be approximately equivalent to the water consumption recorded in Step 2.</p> <p>(Continued on following page...)</p>	<p>_____ m<sup>3</sup>/day</p>														



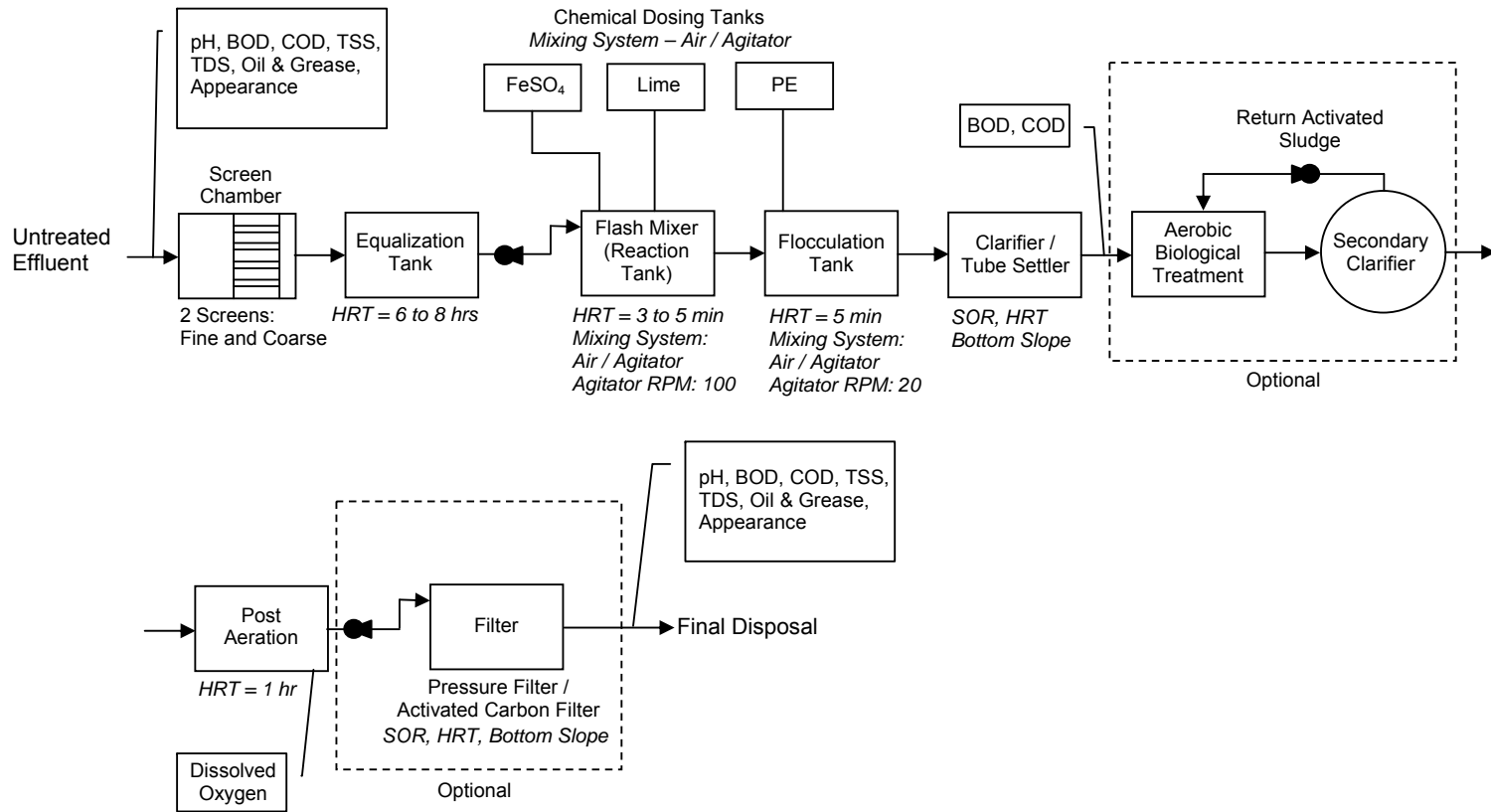
Step	Parameter	Values (To be completed by evaluator)																								
4.	<p><b>Proposed Effluent to be Treated in ETP</b>            Check proposed quantity of effluent to be treated in the ETP, as reported in the EIA. This must be equivalent to or greater than the amount in Step 3.</p>	<p>_____ m<sup>3</sup>/day</p>																								
5.	<p><b>Cross-Check Water Consumption with Typical Values</b>            Cross-check the amount of water consumed with the range of typical values (see list below) for the specific type of fabric being produced. The value for Step 2 should be within the range calculated here.</p> <p>Typical specific water consumption rates (tentative):</p> <table border="0"> <thead> <tr> <th data-bbox="396 590 467 615">Fabric</th> <th data-bbox="781 590 834 615">Rate</th> </tr> </thead> <tbody> <tr> <td data-bbox="396 617 581 642">Cellulosic Fabric</td> <td data-bbox="781 617 927 642">100-120 L/kg</td> </tr> <tr> <td data-bbox="396 644 732 669">Synthetic Fibre, Yarn &amp; Fabric</td> <td data-bbox="781 644 899 669">25-70 L/kg</td> </tr> <tr> <td data-bbox="396 672 626 697">Grey Polyester Fibre</td> <td data-bbox="781 672 899 697">30-40 L/kg</td> </tr> <tr> <td data-bbox="396 699 537 724">Acrylic Fibre</td> <td data-bbox="781 699 899 724">25-30 L/kg</td> </tr> <tr> <td data-bbox="396 726 610 751">Grey Viscose Fibre</td> <td data-bbox="781 726 899 751">70-80 L/kg</td> </tr> <tr> <td data-bbox="396 753 597 779">Grey Cotton Fibre</td> <td data-bbox="781 753 927 779">100-140 L/kg</td> </tr> <tr> <td data-bbox="396 781 509 806">Raw Wool</td> <td data-bbox="781 781 899 806">40-50 L/kg</td> </tr> <tr> <td data-bbox="396 808 618 833">Scoured Wool Fibre</td> <td data-bbox="781 808 915 833">80-100 L/kg</td> </tr> <tr> <td data-bbox="396 835 594 861">Grey Cotton Yarn</td> <td data-bbox="781 835 899 861">70-80 L/kg</td> </tr> <tr> <td data-bbox="396 863 610 888">Grey Cotton Fabric</td> <td data-bbox="781 863 927 888">150-180 L/kg</td> </tr> <tr> <td data-bbox="396 890 740 915">Grey polyester – Cotton Fabric</td> <td data-bbox="781 890 927 915">100-120 L/kg</td> </tr> </tbody> </table> <p>Example calculation:            Textile Production (P): 2,500 kg/day (From Step 1)            Textile Type: Synthetic Fibre            Therefore, water consumption (Q<sub>r</sub>) is 25-70 L/kg</p> <p>Calculate the range of water consumption            Water Consumption (low) = P x Q<sub>Low</sub>              = 2,500 kg/day x 25 L/kg              = 62,500 L/day              = 62.5 m<sup>3</sup>/day</p> <p>Water Consumption (high) = P x Q<sub>High</sub>              = 2,500 kg/day x 70 L/kg              = 175,000 L/day              = 175 m<sup>3</sup>/day</p> <p>Compare that the amount for Step 2 is within the range calculated here.</p>	Fabric	Rate	Cellulosic Fabric	100-120 L/kg	Synthetic Fibre, Yarn & Fabric	25-70 L/kg	Grey Polyester Fibre	30-40 L/kg	Acrylic Fibre	25-30 L/kg	Grey Viscose Fibre	70-80 L/kg	Grey Cotton Fibre	100-140 L/kg	Raw Wool	40-50 L/kg	Scoured Wool Fibre	80-100 L/kg	Grey Cotton Yarn	70-80 L/kg	Grey Cotton Fabric	150-180 L/kg	Grey polyester – Cotton Fabric	100-120 L/kg	<p>_____ m<sup>3</sup>/day            TO            _____ m<sup>3</sup>/day</p>
Fabric	Rate																									
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Grey Cotton Fabric	150-180 L/kg																									
Grey polyester – Cotton Fabric	100-120 L/kg																									
6.	<p><b>Specific Water Consumption</b>            Calculate the specific water consumption (SWC) of the industry, in Litres/kg of fabric, using the formula below.</p> $\text{SWC (L/kg)} = \frac{\text{Water consumption (m}^3\text{/d)} \times 1000}{\text{Daily production (kg/day)}} \quad (\text{A})$ <p>(Note: 1000 is a conversion factor to convert m<sup>3</sup> to L)</p> <p>(Continued on following page...)</p>	<p>_____ L/kg</p>																								

Step	Parameter	Values (To be completed by evaluator)
	<p>Example Calculation:  Medium quality cotton fabric: 6-8 m/Kg (Standard Width 1.2 m)  Daily production: 50,000 m/day  Water Consumption in Process House: 500 KL /Day (equivalent to 500 m<sup>3</sup>/day or 5 lakh liters /day).</p> $\text{Weight (quantity) of fabric} = \frac{50,000 \text{ m/day}}{8 \text{ m/kg}} = 6250 \text{ kg/day}$ $\text{SWC (L/kg)} = \frac{500 \text{ m}^3/\text{day} \times 1000}{6250 \text{ kg/day}} = 80 \text{ L/kg}$	
7.	<p><b>Compare Specific Water Consumption with Guidelines</b>  Compare the value from Step 6 with the guideline values listed in Step 5. Record the guideline value or range in the second column. The value calculated in Step 6 should fall within the typical range.</p>	_____ L/kg
8.	<p><b>Design Flow Rate for ETP</b>  a) Calculate the average flow rate (Q<sub>av</sub>) for the design of the ETP using the following formula. A maximum of 22 hours of operation per day is generally used. However, for smaller plants shorter operating times can be used, e.g. 8 or 16 hours. Use the operating hours as indicated in the application.  b) Then calculate the <u>design</u> flow rate for the ETP. Record this value in the next column.</p> $Q_{av} \text{ (m}^3/\text{hr)} = \frac{\text{Total volume of effluent to be treated (m}^3/\text{day)}}{\text{Total hours of ETP operation (hr/day)}} \text{ (B)}$ <p>ETP Design Flow (Q)* = Q<sub>av</sub> + 10% = Q<sub>av</sub> x 1.10</p>	_____ m <sup>3</sup> /hr
9.	<p><b>Compare Design Flow Rate with Proposed ETP</b>  The design flow rate submitted in the EIA should be equal to or greater than the design flow rate calculated in Step 8. Record the proposed design flow rate from the EIA in the next column.</p>	_____ m <sup>3</sup> /hr
10.	<p><b>Treatment Scheme</b>  Check the flow diagram submitted in the EIA and ensure adequacy of the recommended treatment scheme. For guidance, flow diagrams have been provided on the following pages. Figure 3.1 (p.3-7) shows an example of a flow diagram for an ETP for dyeing / printing cotton and blended textile. Figure 3.2 (p. 3-8) shows the flow diagram for garment washing.</p> <p>Example ETP treatment schemes include:  a) For dyeing, printing and finishing of cotton and other substrates, the treatment scheme should be:  Preliminary treatment → Physico-chemical treatment → Biological treatment → Post aeration for DO increase.  <b>OR</b></p> <p>(Continued on following page...)</p>	<p>Is proposed treatment scheme adequate?</p> <p>_____ YES</p> <p>_____ NO</p>

<b>Step</b>	<b>Parameter</b>	<b>Values</b> (To be completed by evaluator)
	<p>Preliminary treatment → Biological treatment (extended aeration, 48 hours retention time) → Decolonization by physico-chemical or ozonation, etc. → Post aeration for DO increase</p> <p>b) For garment washing (no dyeing), the treatment scheme should be:  Preliminary treatment → Physico-chemical treatment → Biological treatment* → Post aeration for DO increase → Media filtration and activated carbon (Optional) → Post Aeration for DO level increase</p> <p>Other treatment schemes are possible and may be acceptable. Consult other literature if required.</p> <p><i>*Note: Untreated effluent characteristics and prescribed treated effluent characteristics will decide the requirement of biological treatment.</i></p>	
<b>11.</b>	<p><b>Treated Effluent Characteristics</b>  Check that the guaranteed treated effluent characteristics meet the national Waste Discharge Quality Standards for Industrial Units and Projects: Quality at Discharge Point (see Table 3.3 on p. 3-9 and Table 3.4 on p. 3-10).</p>	<p>Do guaranteed effluent characteristics meet standards?</p> <p>_____ YES</p> <p>_____ NO</p>



**Figure 3.2: Flow Diagram for Effluent Treatment Plant and Parameters –  
Garment Washing Unit**



**Table 3.3: National Standards – Waste Discharge Quality Standards for Industrial Units and Projects: Quality at Discharge Point**

Parameter	Unit	Location of Final Disposal		
		Inland Surface Water <sup>1</sup>	Public Sewer <sup>1</sup>	Irrigated Land <sup>1</sup>
Ammonia (free ammonia)	mg/L	5	5	15
Ammoniacal Nitrogen (as N)	mg/L	50	75	75
Arsenic (As)	mg/L	0.2	0.5	0.2
BOD <sub>5</sub> 20°C	mg/L	50	250	100
Boron (B)	mg/L	2	2	2
Cadmium (Cd)	mg/L	0.05	0.5	0.5
Chloride (Cl)	mg/L	600	600	600
Chromium (hexavalent Cr)	mg/L	0.1	1.0	1.0
Chromium (total Cr)	mg/L	0.5	1.0	1.0
COD	mg/L	200	400	400
Copper (Cu)	mg/L	0.5	3.0	3.0
Cyanide (CN)	mg/L	0.1	2.0	0.2
Dissolved Oxygen (DO)	mg/L	4.5-8	4.5-8	4.5-8
Dissolved Phosphorus (P)	mg/L	8	8	10
Electrical Conductivity	µMho/cm	1200	1200	1200
Fluoride (F)	mg/L	7	15	10
Iron (Fe)	mg/L	2	2	2
Lead (Pb)	mg/L	0.1	0.1	0.1
Manganese (Mn)	mg/L	5	5	5
Mercury (Hg)	mg/L	0.01	0.01	0.01
Nickel (Ni)	mg/L	1.0	1.0	1.0
Nitrate (N molecule)	mg/L	10.0	Undetermined	10.0
Oil and Grease	mg/L	10	20	10
pH		6-9	6-9	6-9
Phenol Compounds (C <sub>6</sub> H <sub>5</sub> OH)	mg/L	1.0	5	1
Radioactive Materials	As determined by Bangladesh Atomic Energy Commission			
Selenium (Se)	mg/L	0.05	0.05	0.05
Sulfide (S)	mg/L	1	2	2
Temperature – Summer	°C	40	40	40
Temperature – Winter	°C	45	45	45
Total Dissolved Solids (TDS)	mg/L	2100	2100	2100
Total Kjeldahl Nitrogen (N)	mg/L	100	100	100
Total Suspended Solids (TSS)	mg/L	150	500	200
Zinc (Zn)	mg/L	5.0	10.0	10.0

Notes: (1) *Land Surface Water* refers to any pond, tank, water body, water hole, canal, river, spring or estuary  
*Public Sewer* refers to any sewer connected with fully combined processing plant including primary and secondary treatment  
*Irrigated Land* refers to an appropriately irrigated plantation area of specified crops based on quantity and quality of wastewater

**Table 3.4: Discharge Quality Standard for Classified Industries  
– Composite Textile Plant and Large Processing Units  
(Investment over Tk 30,000,000)**

<b>Parameter</b>	<b>Limit (mg/L)</b>
Total Suspended Solids (TSS)	100
BOD <sub>5</sub> 20°C	150*
Oil & Grease	10
Total Dissolved Solids (TDS)	2100
Wastewater Flow	100 L/kg of fabric processing
pH	6.5-9
<i>Special parameters based on classification of dyes used:</i>	
Total Chromium (as Cr molecule)	2
Sulfide (As S molecule)	2
Phenol Compounds (C <sub>6</sub> H <sub>5</sub> OH)	5

\* BOD limit of 150 mg/L will be applicable only for physico-chemical processing method

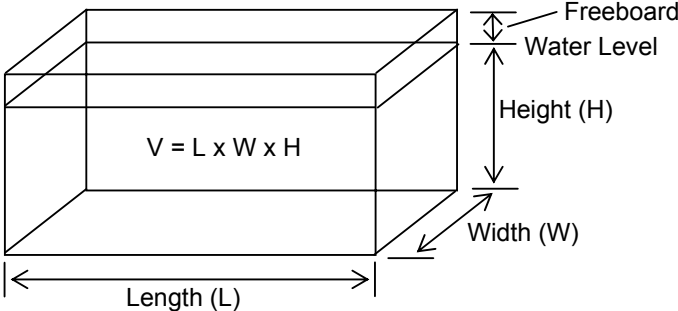
### 3.2.2 STAGE 3: Proposed Unit Components of ETP

Once the general parameters for the ETP have been checked and deemed to be appropriate (Steps 1-11, above), the individual process components must be verified to ensure they have been designed properly. Follow the steps outlined in Table 3.5, below. Where indicated, fill in values and/or Yes/No in the second column of the table. If the information is not provided or is incorrect, clarify the information with the industry.

**Table 3.5: Proposed Unit Components**

Step	Parameter	To be completed by evaluator
<b>12.</b>	<b>Check for Unit Components</b> Check for the unit components below (a-d) of various treatment processes, if applicable. If not applicable, indicate N/A.	<b>Provided?</b> <i>Indicate Yes, No or N/A</i>
	<b>a) Preliminary Treatment</b> i. Bar Screen ii. Oil & Grease Trap (Not required for Garment Washing) iii. Equalization Tank	i. _____ ii. _____ iii. _____
	<b>b) Physico-Chemical Treatment</b> i. Flash mixer / reaction tanks with rapid mixing system like diffused air (for small plant). ii. Chemical dosing tanks (at least three units) with mixers or diffused air mixing system and equipped with dosing pump / gravity dosing along with control valves. iii. Flocculation with slow mixing system. iv. Primary clarifier / Tube settler / Lamellar clarifier, with sludge withdrawal system at bottom, launders at top.	i. _____ ii. _____ iii. _____ iv. _____
	<b>c) Biological Treatment</b> i. Aeration tank fitted with surface aerators or floating aerator or diffuser along with blower for supply of oxygen in aeration tank, suitable system for dosing of urea & di-ammonium phosphate (DAP) for supplementing Nitrogen and Phosphorus. ii. Secondary tube settler / secondary clarifier for separation of bio-sludge fitted with scraper mechanism for sweeping sludge into well, sludge withdrawal valves at the bottom. iii. Sludge recycling system from secondary clarifier to aeration tank comprising of pumps and piping. iv. Treated effluent collection tank fitted with air supply system to meet dissolved oxygen requirement of final treated effluent. This tank should be located after the outlet of secondary clarifier. v. Flow measurement on outlet.	i. _____ ii. _____ iii. _____ iv. _____ v. _____
	<b>d) Sludge Collection and Dewatering</b> i. Preferred system - filter press (Other systems are acceptable). ii. Sludge collection pit and feed pump in case of filter press. iii. Adequate number of sludge drying beds (sludge can be directly discharged into beds from clarifier). iv. Other sludge collection and dewatering system (e.g. brick-making) <i>(Continued on following page...)</i>	i. _____ ii. _____ iii. _____ iv. _____



13.	<p><b>Adequacy of Treatment Units</b>  Check the proposed treatment units as indicated below. Where necessary, calculate the requirements for the proposed treatment units using the equations given and check that the proposed design values for these parameters are correct.</p>	
	<p><b>a) Bar Screen</b>  <b>For Manually Cleaned Screen:</b></p> <ul style="list-style-type: none"> <li>• At least two bar screens should be provided – Coarse Screen &amp; Medium Screen.</li> <li>• Screens should be fitted into drains at an angle of 45-60° from horizontal.</li> </ul> <p><b>For Mechanical Screen:</b></p> <ul style="list-style-type: none"> <li>• Continuous running – one (1) unit is sufficient.</li> <li>• Screens should be fitted into drains at an angle of 45-60° from horizontal.</li> </ul>	<p><i>Indicate Y or N</i></p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>
	<p><b>b) Oil and Grease Trap</b></p> <ul style="list-style-type: none"> <li>• Two to three chambers with entry from the top in first chamber.</li> <li>• Located before equalization tank.</li> </ul> <p>Note: For Textiles Effluent – Oil Skinner is NOT required</p> <ul style="list-style-type: none"> <li>• Calculate Hydraulic Retention Time (HRT) as follows:</li> </ul> $\text{HRT (hours)} = \frac{\text{Total Volume (m}^3\text{)}}{\text{Flow Rate of Effluent (m}^3\text{/hr)}} \quad (\text{C})$ <p>Where:  Total Volume = Total volume of oil and grease trap chambers, excluding freeboard (see diagram)  Flow Rate of Effluent = Proposed flow rate (Step 9).</p>  <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>	<p><i>Indicate Y or N</i></p> <p>_____</p> <p>_____</p> <p>HRT = _____ hrs</p> <p>_____</p> <p>_____</p> <p><i>Indicate Y or N</i></p> <p>_____</p> <p>_____</p>
	<p><b>c) Equalization Tank</b></p> <ul style="list-style-type: none"> <li>• Calculate retention time (HRT) of the tank using equation C from Step 13b, using the volume of the equalization tank, excluding freeboard, and the proposed design flow (Step 9).</li> </ul> <p>(Continued on following page...)</p>	<p>HRT = _____ hrs</p>

	<ul style="list-style-type: none"> <li>• Check that the retention time is within: <ul style="list-style-type: none"> <li>○ Garment Washing: 4 - 6 Hrs</li> <li>○ Fabric Processing: 7 - 12 Hrs</li> </ul> </li> <li>• Check that the HRT calculated matches the one for the proposed ETP.</li> <li>• At least 0.6m of free board height is provided in the tank.</li> <li>• Check whether pH adjustment system, if required, is provided. pH adjustment is required if pH is not between 7 – 8.</li> </ul>	<i>Indicate Y or N</i> _____ _____ _____ _____
	<p><b>d) Reaction Tank / Flash Mixers</b></p> <ul style="list-style-type: none"> <li>• Reaction tank fitted with mixer for rapid mixing OR two / three fitted with diffused air.</li> <li>• Diameter of reaction tank is greater than 600mm.</li> <li>• Calculate retention time (HRT) in reaction tank using equation C from Step 13b, with the volume of the tank excluding freeboard and the proposed design flow (Step 9).</li> <li>• Check that the retention time calculated is approximately 5-8 minutes (0.8-0.13 hrs) for the reaction tank.</li> <li>• Check that the HRT calculated matches the one for the proposed ETP.</li> </ul>	<i>Indicate Y or N</i> _____ _____ HRT = _____ hrs <i>Indicate Y or N</i> _____ _____
	<p><b>e) Flocculation Tank</b></p> <ul style="list-style-type: none"> <li>• Flocculation tank fitted with slow paddle mixer to increase flock size.</li> <li>• Diameter of flocculation tank is greater than 600mm.</li> <li>• Check retention time (HRT) using equation C from Step 13b, using the volume of the flocculation tank excluding freeboard and the proposed design flow (Step 8).</li> <li>• Check that the retention time calculated is 8-10 minutes (0.13- 0.17 hrs).</li> <li>• Check that the HRT calculated matches the one for the proposed ETP.</li> </ul>	<i>Indicate Y or N</i> _____ _____ HRT = _____ hrs <i>Indicate Y or N</i> _____ _____
	<p><b>f) Dosing Tanks</b></p> <ul style="list-style-type: none"> <li>• At least three separate dosing tanks are provided.</li> <li>• Check that the dosing tank size will hold sufficient quantities of solution for at least 8 hours of operation using the following process:</li> </ul> <p style="margin-left: 40px;">Tank Volume (m<sup>3</sup>) = Feed Rate (m<sup>3</sup>/hr) x Time (hrs) (D)</p> <p>Where:  Feed rate = Required flow of chemical (m<sup>3</sup>/hr)  Time = 8 hrs</p> <ul style="list-style-type: none"> <li>• Check mixing system in dosing tank - can be either through diffused air or mechanical agitator.</li> <li>• Check for the dosing pumps. Motor HP &amp; Agitator HP will depend on type of chemical and flow rate.</li> </ul> <p><i>(Continued on following page...)</i></p>	<i>Indicate Y or N</i> _____  V = _____ m <sup>3</sup>  <i>Indicate Y or N</i> _____ _____

	<p><b>g) Primary Clarifier</b></p> <ul style="list-style-type: none"> <li>• Check that a clarifier has been provided (e.g. conventional / lamella clarifier or tube settler).</li> <li>• Check for the retention time (HRT) and surface loading rate (SOR) of the clarifier as given below, depending on the shape.</li> </ul> <p><b>For circular clarifiers:</b></p> <ul style="list-style-type: none"> <li>• Check retention time (HRT) using equation C from Step 13b, using the volume of the clarifier, excluding freeboard (see diagram for volume calculation) and the proposed design flow calculated in (Step 9).</li> </ul> <div data-bbox="451 604 1023 829" data-label="Diagram"> <p style="text-align: center;"><math>V = 0.785 \times D^2 \times H</math></p> <p style="text-align: center;">Diameter (D)</p> <p style="text-align: right;">Freeboard Height (H)</p> </div> <ul style="list-style-type: none"> <li>• Check surface overflow rate (SOR) using the following equation:  <math display="block">\text{SOR (m/h)} = \frac{\text{Flow (m}^3/\text{hr)}}{\text{Surface Area of Clarifier (m}^2\text{)}} \quad \text{(E)}</math> <p>Where:  Flow = Proposed design flow rate (Step 9)  Surface Area = <math>0.785 \times D^2</math></p> </li> </ul> <p><b>For rectangular / square clarifiers</b></p> <ul style="list-style-type: none"> <li>• Check retention time (HRT) using equation C from Step 13b, using the volume of the clarifier, excluding freeboard, and the proposed design flow (Step 9).</li> <li>• Check surface overflow rate (SOR) using equation E above.  Where:  Flow = Proposed flow rate (Step 9)  Surface Area = <math>L \times W</math></li> </ul> <p><b>Check HRT and SOR values</b></p> <ul style="list-style-type: none"> <li>• Check that the HRT and SOR values calculated match the values in the proposed design.</li> <li>• Check that Retention Time (HRT) falls within guidelines: <ul style="list-style-type: none"> <li>○ Plain clarifier: 2 hours</li> <li>○ Lamella clarifier: 1.5 – 2 hours</li> <li>○ Tube settler: 1.5 hours</li> </ul> </li> <li>• Check that a sludge withdrawal valve and associated piping is provided at bottom of the clarifier.</li> <li>• Check for scraper mechanism in plain clarifier.</li> <li>• Note: SOR (Surface Overflow Rate) is the main criteria for calculation of area (size) of clarifier, not retention time.</li> </ul> <p><i>(Continued on following page...)</i></p>	<p style="text-align: right;"><i>Indicate Y or N</i></p> <p style="text-align: center;">_____</p> <p>HRT = _____ hrs</p> <p>SOR = _____ m/h</p> <p style="text-align: right;"><i>Indicate Y or N</i></p> <p style="text-align: center;">_____</p> <p style="text-align: center;">_____</p> <p style="text-align: center;">_____</p> <p style="text-align: center;">_____</p>
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	<ul style="list-style-type: none"> <li>• SOR &amp; settling efficiency depends upon the internal design configuration of the clarifier. Check that the Surface Overflow Rate (SOR) calculated falls within the guidelines: <ul style="list-style-type: none"> <li>○ Plain clarifier: 0.9 - 1.2 m<sup>3</sup>/hr/m<sup>2</sup> (m/h)</li> <li>○ Tube settler: 2.0 - 2.5 m<sup>3</sup>/hr/m<sup>2</sup> (m/h)</li> <li>○ Lamella clarifier: 1.2 - 1.5 m<sup>3</sup>/hr/m<sup>2</sup> (m/h)</li> </ul> </li> </ul>	<p>_____</p>
	<p><b>h) Aeration Tank</b></p> <ul style="list-style-type: none"> <li>• Check retention time (HRT) using equation C from Step 13b, using the volume of the aeration tank, excluding freeboard, and proposed design flow (Step 9).</li> <li>• Check that the HRT calculated matches the HRT for the proposed design.</li> <li>• Check that the HRT falls within the guidelines: <ul style="list-style-type: none"> <li>○ Aerobic biological treatment process: 20 - 25 hours</li> <li>○ Extended aeration: 36 - 48 hours</li> </ul> </li> <li>• Check that oxygen is being supplied through surface aerator or diffusers.</li> <li>• Check that distribution channels for inlet of effluent and launders for outlet of effluent from tank are provided.</li> <li>• Check that a pump and piping for the return activated sludge (RAS) is provided. Check the flow capacity of the RAS pumps using the proposed quantity of sludge to be returned (and not wasted) from the application.</li> </ul>	<p>HRT = _____ hrs</p> <p><i>Indicate Y or N</i></p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>
	<p><b>i) Secondary Clarifier</b></p> <ul style="list-style-type: none"> <li>• Note: The specific gravity of the sludge generated by biological treatment is less compared to inorganic sludge generated by physico-chemical treatment. Therefore, the SOR for the secondary clarifier should be less than the SOR for the primary clarifier. In general, a plain clarifier is used as the secondary clarifier.</li> <li>• Check the surface loading (SOR) and retention time (HRT) as described in Step 13g.</li> <li>• Check that the SOR and HRT calculated match the values for the proposed system.</li> <li>• Check that the retention time (HRT) is between 2 - 2.5 Hrs.</li> <li>• Check that the surface loading rate (SOR) is in the range of 0.75 - 1.0 m<sup>3</sup>/Hr/m<sup>2</sup> (m/h).</li> <li>• Check for the provision of the scraper mechanism.</li> <li>• Check for provision of a sludge withdrawal valve at the bottom of the clarifier.</li> <li>• Check that the outlet of the sludge recycling system is located at the inlet of aeration tank.</li> <li>• Check that the sludge withdrawal system has provision for wasting sludge.</li> </ul> <p><i>(Continued on following page...)</i></p>	<p>HRT = _____ hrs</p> <p>SOR = _____ m/h</p> <p><i>Indicate Y or N</i></p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>

	<p><b>j) Sludge Collection Pit</b></p> <ul style="list-style-type: none"> <li>• Check for the storage capacity of the wet sludge collection pit. It should be sufficient to store the amount of wet sludge likely to be generated in 24 Hrs from physico-chemical treatment.</li> </ul> <p>Pit/Tank Volume (m<sup>3</sup>) = Sludge flow (m<sup>3</sup>/hr) x Time (hrs) (F)</p> <p>Where  Sludge Flow = Sludge flow proposed by industry (m<sup>3</sup>/hr)  Time = 24 hours</p> <ul style="list-style-type: none"> <li>• Check for the sludge withdrawal system from the sludge collection pit. Where sludge is fed into a filter press or centrifuge for dewatering, suitable feed pumps should be provided at the sludge collection pit. Check the flow capacity of the pumps with the capacity of the dewatering technology.</li> </ul>	<p>V= _____ m<sup>3</sup></p> <p><i>Indicate Y or N</i></p> <p>_____</p>
	<p><b>k) Sludge Dewatering System</b></p> <ul style="list-style-type: none"> <li>• Check for adequacy of the capacity of sludge dewatering system like sludge drying beds, filter press or centrifuge with respect to proposed sludge generation.</li> <li>• Check sludge dewatering system: <ul style="list-style-type: none"> <li>○ Filter press is preferred because of its controlled and simple operation, low initial cost and low power requirement compared to centrifuge.</li> <li>○ Sludge drying bed should not be preferred because of high space requirements and operational problems.</li> </ul> </li> </ul>	<p><i>Indicate Y or N</i></p> <p>_____</p> <p>_____</p>
	<p><b>l) Dry Sludge Storage Facility</b></p> <ul style="list-style-type: none"> <li>• Check that the dry sludge storage facility has a capacity to store sludge for the required period before its final disposal at a site as earmarked by the regulatory authority.</li> <li>• Check that the dry sludge storage facility is shaded and is properly lined to stop leachate from seeping during rain.</li> </ul>	<p><i>Indicate Y or N</i></p> <p>_____</p> <p>_____</p>
	<p><b>m) Pumps and Blowers</b></p> <ul style="list-style-type: none"> <li>• Check that all the effluent transfer pumps, sludge recycling pumps, sludge feed pumps to filter press and air blowers are provided in duplicate (i.e. one standby pump is provided for each in order to ensure continuous running).</li> </ul>	<p><i>Indicate Y or N</i></p> <p>_____</p>

**PART 2**  
**TECHNICAL INFORMATION**



## **4 Environmental Clearance Process**

### **4.1 Overall Environmental Clearance Process**

Under Section 12 of the Bangladesh Environment Conservation Act 1995 (ECA 1995) no industrial unit or project can be established or undertaken without obtaining an Environmental Clearance Certificate (ECC) from the DOE. The ECC, together with the Location Clearance Certificate (LCC), aims to maintain ecological balance and overall development through protection and improvement of the environment. The ECC ensures that the industry/project meets all the prescribed standards set by the Bangladesh Government in terms of the quality standards of air, water, noise, odor and other environmental components.

The Environmental Conservation Rules 1997 (ECR 1997) categorize all the projects and industries in Bangladesh into four groups on the basis of degree of anticipated load of pollution causing adverse impacts upon the environment: (i) Green; (ii) Orange-A; (iii) Orange-B, and; (iv) Red. Industrial units and projects under any of these categories are required to obtain an ECC. The validity of an ECC for industries/projects under all categories is one year from the date of issue, and must be renewed 30 days before the expiry date of the certificate.

The DOE, under the Ministry of Environment and Forests (MOEF), is the lead agency of the government responsible for issuing ECCs. The Environment Policy, 1992 and Implementation Program is the key legislation that provides the legal mandate for the process. In addition, the Bangladesh Environment Conservation Act, 1995, the Environment Conservation Rules, 1997, and the Environment Court Act, 2000, are the key acts and rules that govern the process. Also, several Statutory Regulatory Orders (SROs) have been published periodically to complement the legislation in place.

DOE offices in each of the six divisions of the country receive applications and issue ECCs for industries/projects in that particular division. ECC applications have to be submitted in a prescribed application form along with the required supporting documents. If the applicant is a proposed industry/project (Orange-A, Orange-B, and Red), the applicant needs to first apply for a LCC. Once the LCC is approved, the applicant can undertake land and infrastructure development at the proposed site. In special cases, the Director General (DG) may directly issue a LCC if he considers it appropriate to issue such a certificate to the industry/project, upon receiving an application from the entrepreneur.

For Orange-B and Red categories, once the applicant has the Environment Impact Assessment (EIA) approved, the applicant can then open Letters of Credit for import of machinery, including that for the Effluent Treatment Plant (ETP). Once the ETP is installed, the applicant can then apply for the ECC, without which the applicant cannot commence trial production. The maximum processing time allowed under the law once a complete application is submitted is 60 working days for Orange-B and Red Category applications.



## **4.2 EIA Process**

The EIA guidelines set forth by DOE for various types of industries define EIA as a comprehensive process involving study of the probable adverse impacts upon the physical, biological and socio-economic environment due to a proposed industry, development activity or project and formulation of a suitable environment management plan toward offsetting those adverse impacts and enhancing environmental quality. The objectives of EIA, as stipulated in the above guidelines, are:

- to identify sources of impacts that the proposed activity could have upon the various environmental components and to recognize which of those sources are critical;
- to predict the impacts using qualitative and, if possible, quantitative methods;
- to recommend an environmental management plan (EMP) to reduce adverse impacts and enhance positive contributions of the industry, development activity or project by exploring changes needed to be brought about in technology, use of raw materials, fuels, designs, operational practices, or even by evaluating alternative sites for the industry, development activity or project;
- to present results of impact identification, prediction and assessment with suggested mitigation measures; and
- to set the basis for continuous monitoring of the key activities of the industry, development activity or project and that of the environmental conditions.

The EIA process needs to pass through the following three tiers in order to optimize the resources required for conducting EIA studies:

- *Screening*: to decide whether the EIA process needs to be applied to the specific case and, if so, the type (IEE or EIA);
- *Initial Environmental Examination (IEE)*: to help delineate potential adverse impacts upon the environmental components and to find ways to mitigate the impacts or enhance the quality of those environmental components;
- *Full-scale EIA*: to carry out detailed examination of the impacts through conducting surveys and monitoring with the application of rigorous impact prediction tools, where necessary, and ensuring effectiveness of the mitigation and enhancement measures through formulation of Environment Management Plans.

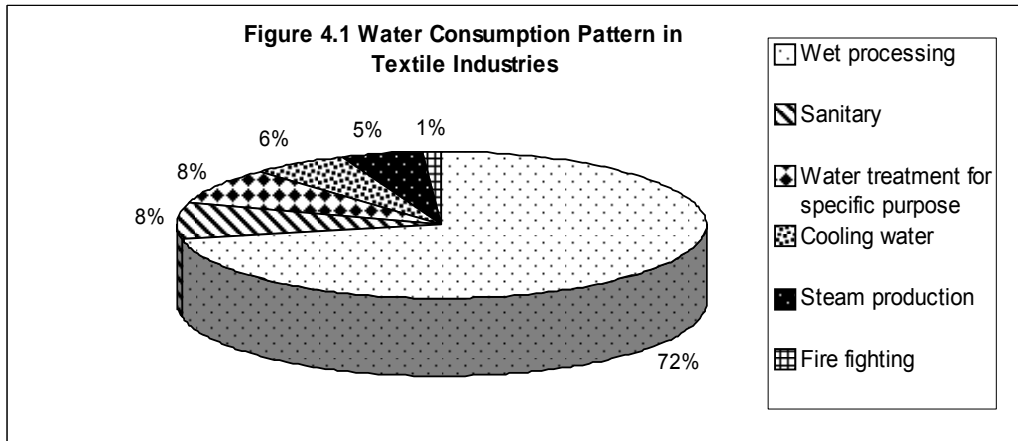
## **4.3 Effluent Treatment Plants**

### ***Water Consumption in Textile Processing***

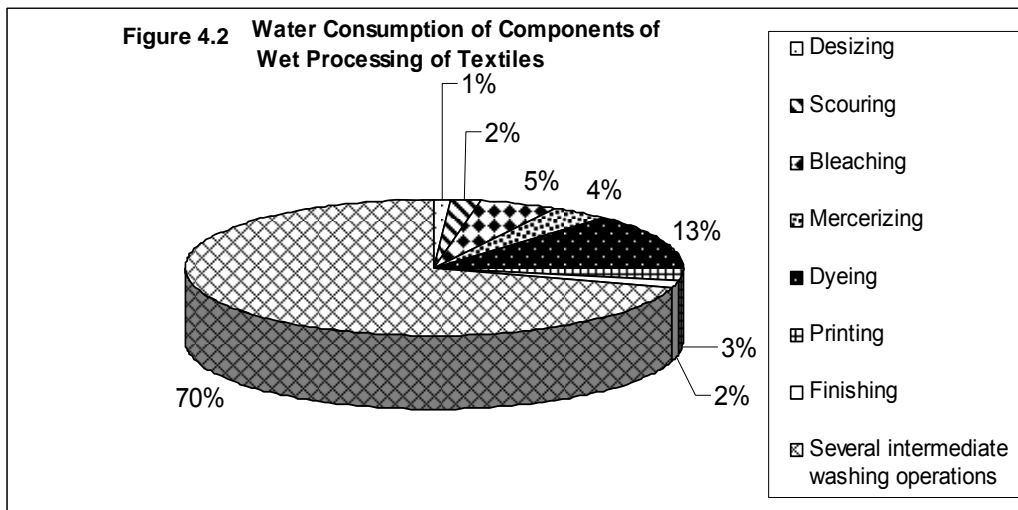
The production of textile goods involves spinning (fibre to yarn), weaving / knitting (yarn to fabric), chemical (wet) processing, and garment manufacturing. The majority of the water consumption (72%) takes place in the chemical (wet) processing of textiles. The water is required for preparing the fabric for dyeing, printing and finishing operations, intermediate washing / rinsing operations and machine cleaning. Other major uses of water in the textile industry, as shown in Figure 4.1, are:

- steam generation (boiler feed water);
- water treatment plant (reject stream, periodic cleaning of reverse osmosis plant, regeneration and washing of demineralization, softener plant, back wash of media filters);
- cooling (processing machines, cooling tower);
- humidification (spinning process); and
- domestic purposes (irrigation of lawn and garden, sanitation, cleaning, drinking and miscellaneous uses).

Process descriptions and process flow diagrams for each category of textile industry, attached in Annex A, illustrate the various textile manufacturing processes and the inputs and outputs of each.



Water consumption is dependent on the type of machines employed, the complexity of processing sequences, the type of dyes used and fabric processed. Many machines require a fixed volume of water regardless of the fabric load. The specific water consumption for cellulosic fabric processing ranges from 100 to 120 liters/kg of fabric processed, whereas for synthetic fiber, yarn and fabric it ranges between 25 to 70 liters / kg of the product processed. Figure 4.2 shows the water consumption of the individual components of the wet processing stage.



As demonstrated in Figure 4.2, 60-70% of the water is consumed in the washing stage. This effluent is light in colour and contains low to moderate loads of pollutants such as biological oxygen demand (BOD), chemical oxygen demand (COD) and suspended solids (SS). The major chemical or dyeing operations use 30-40% of the water. These effluents are intensively coloured and contain a high pollutant load. Throughout the last decade, there has been a focus on decreasing the amount of water required in textile processing by minimizing waste through process control and adopting suitable end-of-pipe technology for recovery of water from the effluent, such as reed beds.

### ***Effluent Generation and Characteristics***

Wet processing of textiles involves, in addition to extensive amounts of water and dyes, a number of inorganic and organic chemicals, detergents, soaps and finishing chemicals to aid in the dyeing process to impart the desired properties to dyed textile products. Residual chemicals often remain in the effluent from these processes. In addition, natural impurities such as waxes, proteins and pigment, and other impurities used in processing such as spinning oils, sizing chemicals and oil stains present in cotton textiles, are removed during desizing, scouring and bleaching operations. This results in an effluent of poor quality, which is high in BOD and COD load. Table 4.1 lists typical values of various water quality parameters in untreated effluent from the processing of fabric using reactive, sulfur and vat dyes and compares these to the DOE effluent standards for discharge into an inland surface water body (e.g. river, lake, etc.). As demonstrated, the effluent from textile industries is heavily polluted.

**Table 4.1: Effluent Characteristics of Untreated Effluent from Processing of Fabric Using Reactive, Sulfur and Vat Dyes and DOE Standards for Waste for Discharge into an Inland Surface Water Body**

Sl. No.	Parameters	Units	Typical Values	DOE Standards For Waste from Industrial Units or Project Waste - For Inland Surface Water Discharge
1.	Appearance	-	Colloidal	-
2.	pH	-	8 – 10	6-9
3.	Color	-	Intensively colored	-
4.	Heavy Metals	mg/l	10 – 15	Varies depending on type of metal
5.	Suspended Solids (SS)	mg/l	200 – 300	150
6.	Total Dissolved Solids (TDS)	mg/l	5000 – 6000	2100
7.	Chemical Oxygen Demand (COD)	mg/l	1500 – 1750	200
8.	Bio-chemical Oxygen Demand (BOD)	mg/l	500 – 600	50
9.	Oil & Grease	mg/l	40 – 60	10
10.	Surfactants	mg/l	10 – 40	-
11.	Sulfide as S	mg/l	50 – 60	1

Table 4.2 shows the effluent characteristics (pH, COD and BOD) from various wet textile processing operations. These can also be compared with the DOE standards listed in Table 4.1, showing the amount of contaminants present in the effluent from these processes.

**Table 4.2: Effluent Characteristics of Various Wet Textile Processing Operations**

Sl. No.	Source of Effluent Generation	Parameters		
		pH	COD (mg/l)	BOD (mg/l)
<b>A</b>	<b>Process Effluent</b>			
1.	Desizing	5.83 - 6.50	10,000 - 15,000	1700 - 5200
2.	Scouring	10.0 - 13.0	1200 - 3300	260 - 400
3.	Bleaching	8.5 - 9.6	150 - 500	50 - 100
4.	Mercerizing	8.0 - 10.0	100 - 200	20 - 50
5.	Dyeing	7.0 - 10.0	1000 - 3000	400 - 1200
<b>B</b>	<b>Wash Effluent</b>			
1.	After bleaching	8.0 - 9.0	50 - 100	10 - 20
2.	After acid rinsing	6.5 - 7.60	120 - 250	25 - 50
3.	After dyeing (hot wash)	7.5 - 8.5	300 - 500	100 - 200
4.	After dyeing (Acid & soap wash)	7.5 - 8.64	50 - 100	25 - 50
5.	After dyeing (Final wash)	7.0 - 7.8	25 - 50	
6.	Printing washing	8.0 - 9.0	250 - 450	115 - 150
7.	Blanket washing of Rotary Printer	7.0 - 8.0	100 - 150	25 - 50

### ***Effluent Treatment Plant Design<sup>1</sup>***

Textile industries (fabric dyeing and chemical treatment industries) are classified according to the Environmental Conservation Rules 1997 as Red category industries, and therefore an ETP must be designed and constructed to treat plant effluent. The effluent from the plant must meet the national effluent discharge quality standards, including the “Quality Standards for Classified Industries”, before discharge to the environment. These quality standards must be ensured at the moment of beginning trial production. The waste discharge standards differ according to the final disposal place of the effluent. The effluent standards are presented in Tables 4.3 and 4.4 (also included in Part 1). It is the DOE’s mandate to enforce this legislation, and this guide provides the tools required to assess the ETPs proposed by textile industries in the EMP/EIA.

<sup>1</sup>Much of this information is from: BCAS and SEI (2005). *Choosing and Effluent Treatment Plant*. BCAS: Dhaka, Bangladesh.

**Table 4.3: National Standards – Waste Discharge Quality Standards for Industrial Units and Projects: Quality at Discharge Point**

Parameter	Unit	Location of Final Disposal		
		Inland Surface Water <sup>1</sup>	Public Sewer <sup>1</sup>	Irrigated Land <sup>1</sup>
Ammonia (free ammonia)	mg/L	5	5	15
Ammoniacal Nitrogen (as N)	mg/L	50	75	75
Arsenic (As)	mg/L	0.2	0.5	0.2
BOD <sub>5</sub> 20°C	mg/L	50	250	100
Boron (B)	mg/L	2	2	2
Cadmium (Cd)	mg/L	0.05	0.5	0.5
Chloride (Cl)	mg/L	600	600	600
Chromium (hexavalent Cr)	mg/L	0.1	1.0	1.0
Chromium (total Cr)	mg/L	0.5	1.0	1.0
COD	mg/L	200	400	400
Copper (Cu)	mg/L	0.5	3.0	3.0
Cyanide (CN)	mg/L	0.1	2.0	0.2
Dissolved Oxygen (DO)	mg/L	4.5-8	4.5-8	4.5-8
Dissolved Phosphorus (P)	mg/L	8	8	10
Electrical Conductivity	µMho/cm	1200	1200	1200
Fluoride (F)	mg/L	7	15	10
Iron (Fe)	mg/L	2	2	2
Lead (Pb)	mg/L	0.1	0.1	0.1
Manganese (Mn)	mg/L	5	5	5
Mercury (Hg)	mg/L	0.01	0.01	0.01
Nickel (Ni)	mg/L	1.0	1.0	1.0
Nitrate (N molecule)	mg/L	10.0	Undetermined	10.0
Oil and Grease	mg/L	10	20	10
pH		6-9	6-9	6-9
Phenol Compounds (C <sub>6</sub> H <sub>5</sub> OH)	mg/L	1.0	5	1
Radioactive Materials	As determined by Bangladesh Atomic Energy Commission			
Selenium (Se)	mg/L	0.05	0.05	0.05
Sulfide (S)	mg/L	1	2	2
Temperature – Summer	°C	40	40	40
Temperature – Winter	°C	45	45	45
Total Dissolved Solids (TDS)	mg/L	2100	2100	2100
Total Kjeldahl Nitrogen (N)	mg/L	100	100	100
Total Suspended Solids (TSS)	mg/L	150	500	200
Zinc (Zn)	mg/L	5.0	10.0	10.0

Notes: (1) *Land Surface Water* refers to any pond, tank, water body, water hole, canal, river, spring or estuary  
*Public Sewer* refers to any sewer connected with fully combined processing plant including primary and secondary treatment  
*Irrigated Land* refers to an appropriately irrigated plantation area of specified crops based on quantity and quality of wastewater

**Table 4.4: Discharge Quality Standard for Classified Industries – Composite Textile Plant and Large Processing Units (Investment over Tk 30,000,000)**

Parameter	Limit (mg/L)
Total Suspended Solids (TSS)	100
BOD <sub>5</sub> 20°C	150*
Oil & Grease	10
Total Dissolved Solids (TDS)	2100
Wastewater Flow	100 L/kg of fabric processing
pH	6.5-9
<i>Special parameters based on classification of dyes used:</i>	
Total Chromium (as Cr molecule)	2
Sulfide (As S molecule)	2
Phenol Compounds (C <sub>6</sub> H <sub>5</sub> OH)	5

\* BOD limit of 150 mg/L will be applicable only for physico-chemical processing method

There are various types of ETPs and their design will vary depending on the quantity and quality of the effluent, amount of money available for construction, operation and maintenance, and the amount of land available. There are three mechanisms for treatment which are: Physical, Chemical and Biological. These mechanisms will often be used together in a single ETP. There are generally four levels of treatment, as described below:

- Preliminary: Removal of large solids such as rags, sticks, grit and grease that may result in damage to equipment or operational problems (Physical);
- Primary: Removal of floating and settleable materials, i.e. suspended solids and organic matter (Physical and Chemical);
- Secondary: Removal of biodegradable organic matter and suspended solids (Biological and Chemical); and
- Tertiary: Removal of residual suspended solids / dissolved solids (Physical, Chemical and Biological)

There are many ways of combining the operations and processes in an ETP:

- A properly designed biological treatment plant, which typically includes screening, equalization, pH control, aeration, and settling, can efficiently satisfy BOD, pH, TSS, oil and grease requirements. However the compounds in industrial effluent may be toxic to the microorganisms so pretreatment may be necessary. Most dyes are complex chemicals and are difficult for microbes to degrade so there is usually very little colour removal.
- Another option is a physico-chemical treatment plant, which typically includes screening, equalization, pH control, chemical storage tanks, mixing unit, flocculation unit, settling unit and sludge dewatering. This type of treatment will remove much of the colour depending on the processes used. It can be difficult to reduce BOD and COD to meet effluent standards and it is not possible to remove TDS.
- Most often, physico-chemical treatment will be combined with biological treatment. The typical components of such a plant are screening, equalization, pH control, chemical storage, mixing, flocculation, primary settling, aeration, and secondary settling. The physico-chemical treatment always comes before the biological treatment units. Using a combination of treatments will generally reduce pollutant levels to below the discharge standards.

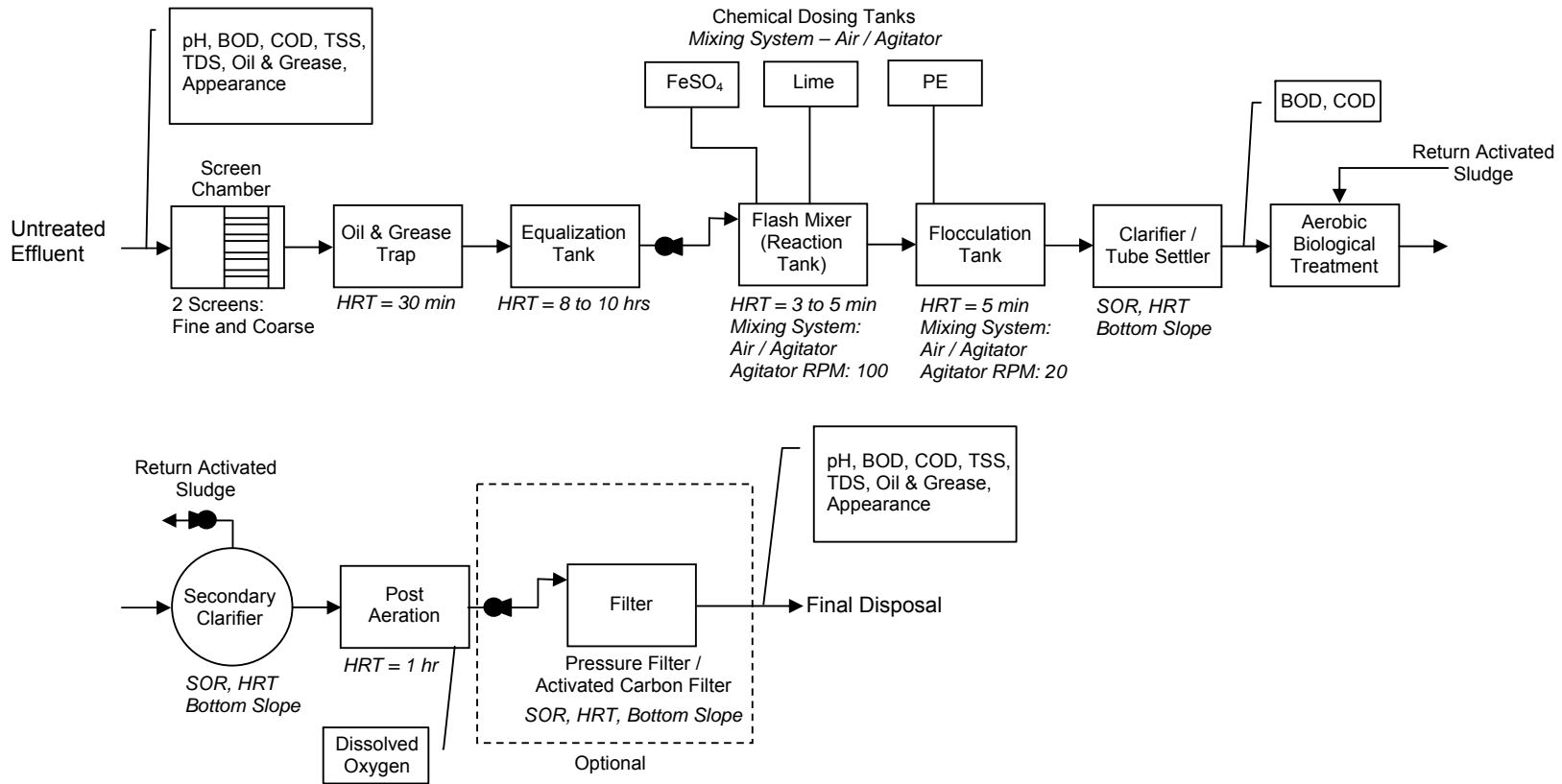
- Another form of biological treatment is the reed bed, which can be used with a settling tank, or in combination with other treatment processes. It presents a natural method of treating effluent which is often lower in capital, operation and maintenance costs. Reed beds can contribute to a reduction in colour, a decrease in COD, an increase dissolved oxygen and a reduction in heavy metals, but function best with some form of pretreatment.

As discussed, there are many options for the design of an ETP. The type of plant and the various components of the plant will depend on the characteristics of the effluent. In evaluating an ETP design in an application for an ECC, it is necessary to determine whether the components of the ETP are sized correctly for the flow and to assess whether the effluent is likely to meet the requirements of the discharge standards.

#### ***Effluent Treatment Plant Flow Diagrams***

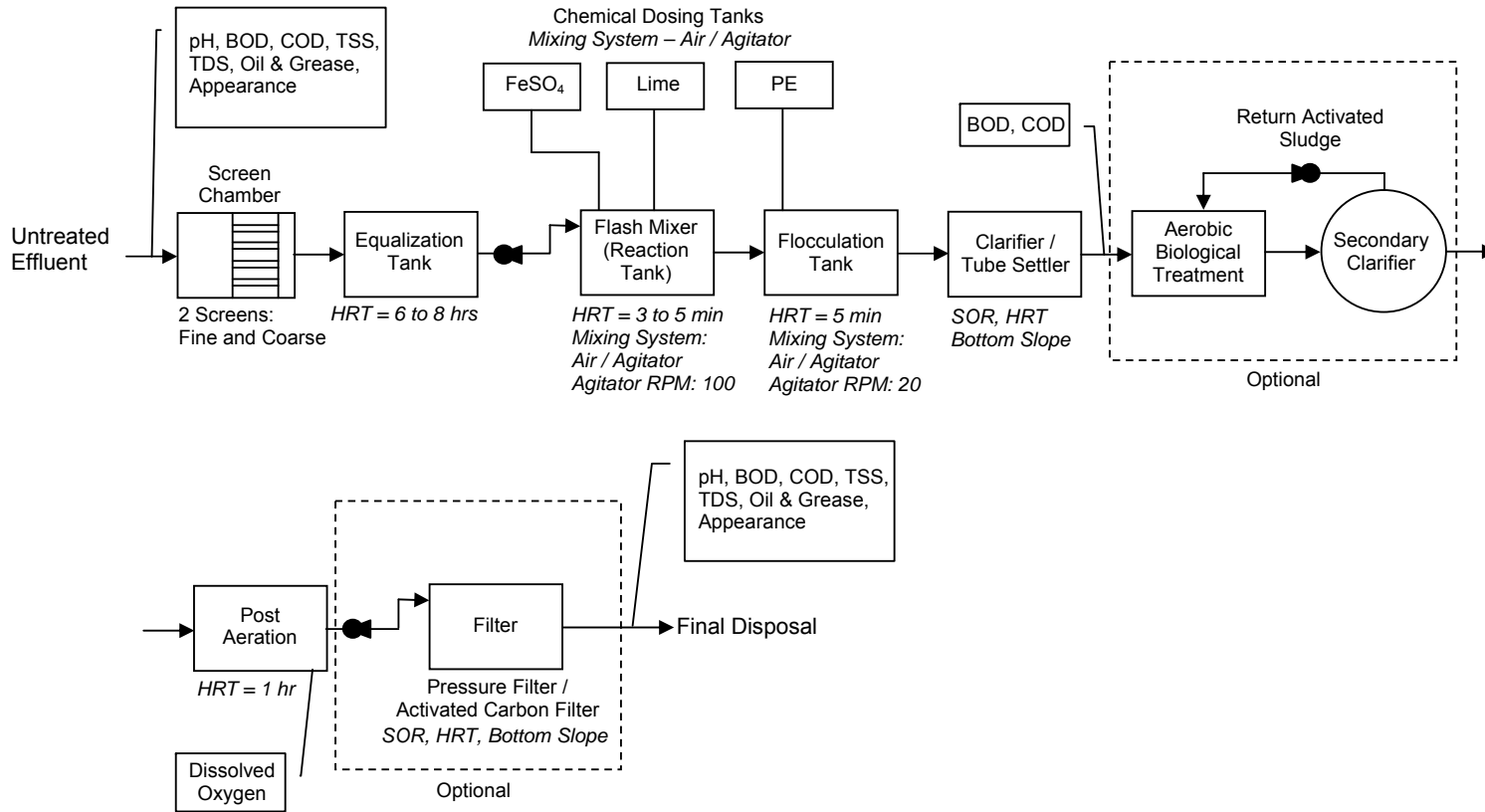
Figures 4.3 and 4.4 illustrate two example flow diagrams for typical ETP designs (these are also shown in Part 1, Figures 3.1 and 3.2). Both include physico-chemical and biological treatment components. The first represents a typical layout for a Dyeing, Printing Cotton and Blended Textile Products Industry and the second is for a Garment Washing Unit. Each diagram also shows the typical design parameters for each process in the ETP. Annex B contains photographs of the various treatment units.

**Figure 4.3: Flow Diagram for Effluent Treatment Plant and Parameters –  
Dyeing, Printing Cotton and Blended Textile Products**





**Figure 4.4: Flow Diagram for Effluent Treatment Plant and Parameters –  
Garment Washing Unit**



## **Annex A**

# **Textile Industry Process Descriptions and Diagrams**

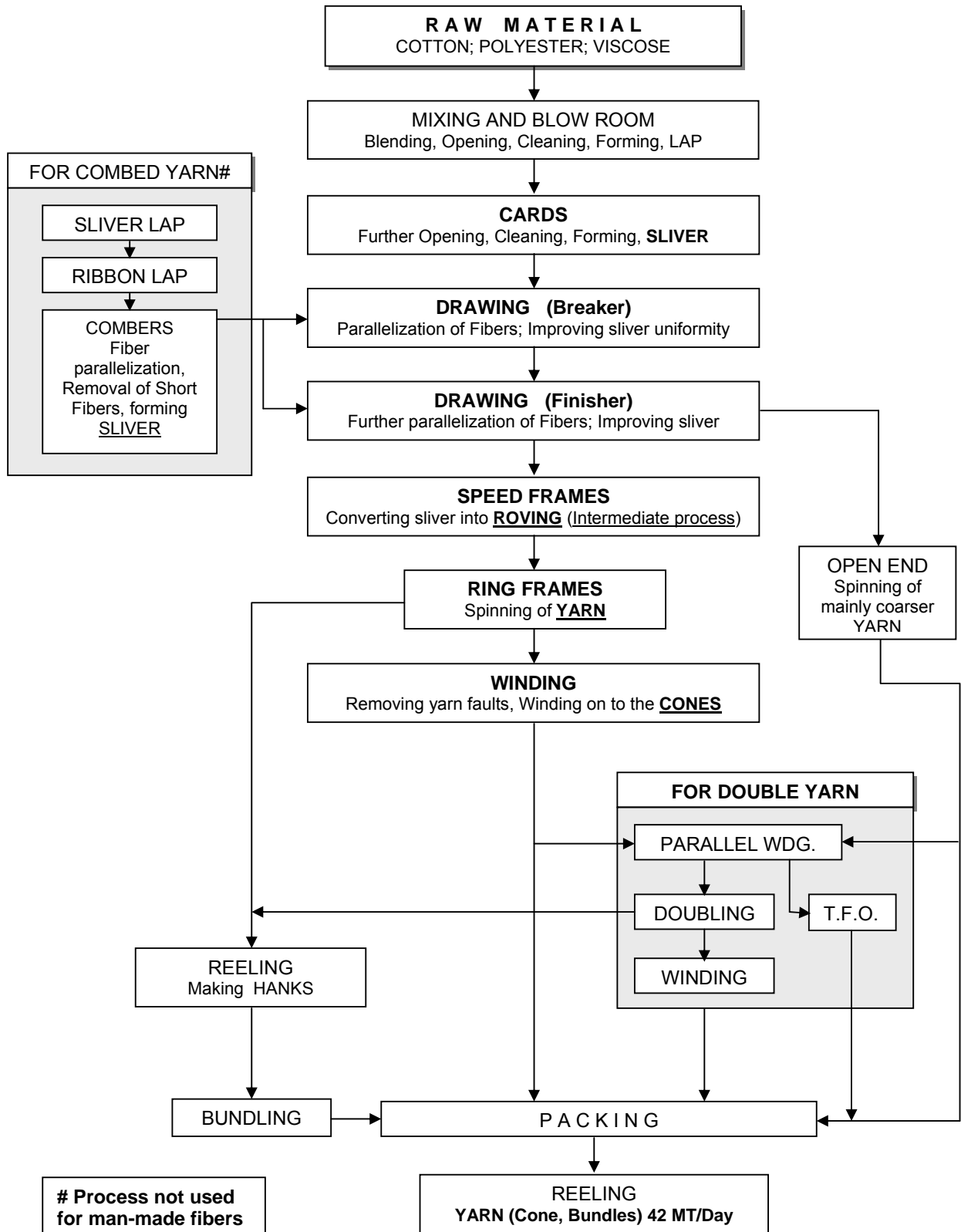


## ***Yarn Manufacturing (Spinning)***

The process of manufacturing of yarns from fibers (grey, dyed and pure white) is known as spinning. All types of fibers undergo a series of mechanical / physical operations as depicted in the schematic flow diagram (Figure A-1). The flow diagram shows the sequence of stages for making yarns and gives the nomenclature and brief function for each of the stages.

The process is entirely a mechanical / physical process with very little water required. The process is carried out under controlled temperature and humidity conditions. Water is used to cool the air and to maintain the ideal humidity level; it evaporates through evaporative cooling and a negligible amount is discharged periodically into the drain.

**Figure A-1: Process Flow Chart for Yarn Manufacturing**



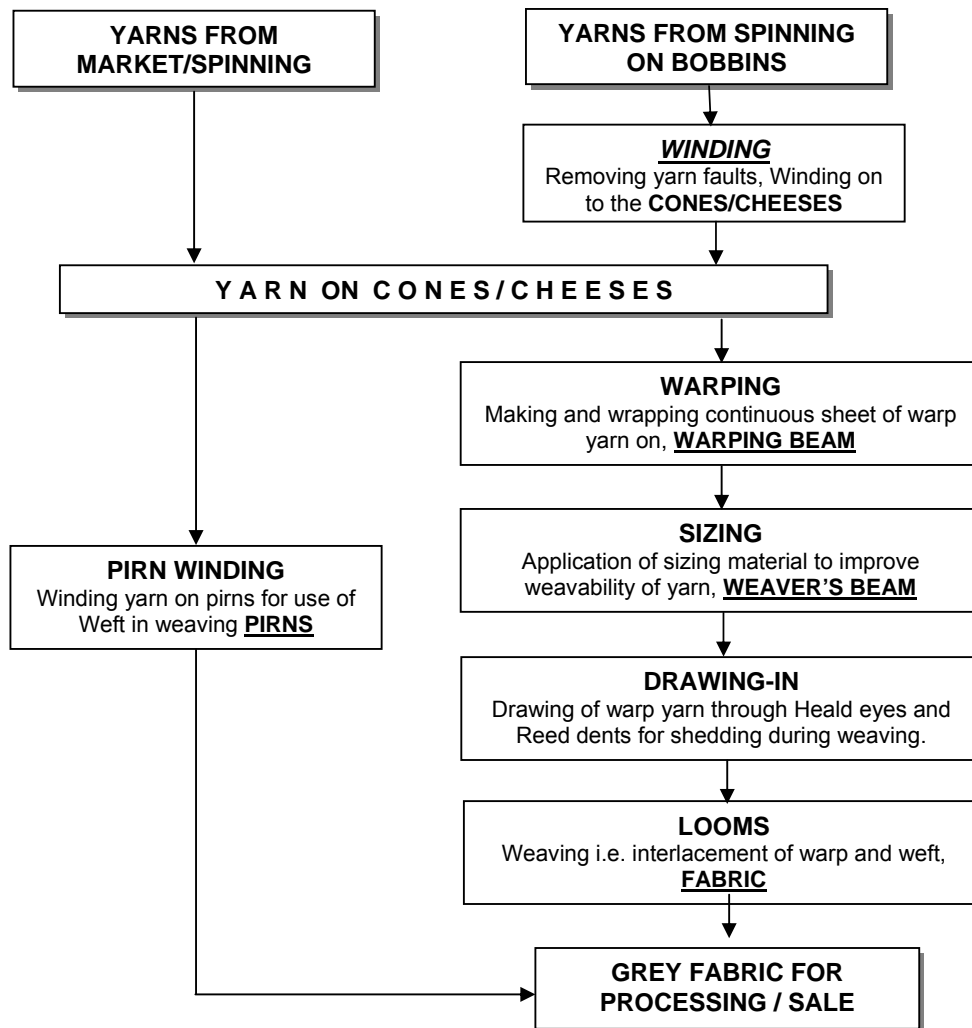
## ***Fabric Manufacturing (Weaving)***

The process of manufacturing grey / finished fabric or other textile products from yarn / waste textiles is called weaving. Both natural as well as synthetic fibers and their blends can be used. The schematic flow diagram of the weaving process for fabric is shown in Figure A-2. The flow diagram shows the sequence, nomenclatures and brief functions of the various stages.

The preparation of warp yarn for weaving involves sizing to improve the weavability of the yarn by improving its strength and frictional properties. The required number of beams from warping are assembled on the creel and then passed through a sow box containing a size mix {starches, gums, softeners, French chalk, etc. for cotton yarn; a small quantity of Polyvinyl Acetate (PVA) for blended yarns}. Yarn is then put on drying cylinders for drying; after separating the ends, it is wound onto a weaver's beam. Pure synthetic yarns do not require sizing; instead oil and wax are applied during spinning to improve their frictional properties. The only water required in weaving is in the sizing operation for preparing the size mix and occasional washing of the sow box. Consequently this process does not lead to significant effluent generation.

The warp yarn obtained from sizing or double count or dyeing is subjected to drawing-in, where individual yarns are drawn through hold eyes and reed dents. For use as weft during weaving, yarn on cones or hanks is wound on bobbins called pirn on pirn winding machines. For production of fabric or other textile products the warp yarn on the beams and the weft yarn on pirns are interlaced (woven) on automatic or semiautomatic power looms, or handlooms.

Figure A-2: Process Flow chart for Fabric Manufacturing



## ***Chemical Processing***

Chemical processing (also called wet processing) of textiles (fiber, yarn, fabric and specialty articles) is carried out to impart the desired qualities, colors, prints and finishing to the final products. All woven fabrics or articles manufactured from grey yarn or fiber contain impurities that have to be removed prior to dyeing or printing. These impurities may be those present in natural cellulosic fibers (e.g. cotton waxes and natural coloring matter) or those added to facilitate spinning, weaving or knitting (e.g. warp sizes or lubricants).

The objectives of removal of these impurities are:

- i. To achieve high and uniform dye uptake;
- ii. To reduce the natural impurities of cotton to very low levels;
- iii. To impart good hydrophilic properties combined with high absorbency and uniform swelling;
- iv. To cause little or no fiber tendering;
- v. To produce an acceptable degree of 'whiteness' for use as un-dyed fabric articles; and
- vi. To give the required brightness of shade to the subsequently dyed fabric.

The chemical processing of various textile substrates comprises of two parts: 1) Ready for Dyeing (RFD) Operations - a substrate preparatory treatment; and 2) Main Dyeing and Finishing Operations. Operations such as singeing, desizing, scouring, bleaching and mercerizing are considered RFD operations. The requirement for these operations is dependent on the type of the substrate and they can be applied either as separate stages or as combined stages, e.g. desizing and scouring or scouring and bleaching. The processing sequence / operation may vary depending upon the desired product quality, the water characteristics and type of dyes and auxiliary chemicals used.

## ***Fiber Dyeing***

The natural fibers cotton, wool, silk and manmade fibers like acrylic, viscose, polyester as well as their blends are the basic raw material for preparation of yarn. These fibers are used either directly (grey) or after chemical processing (dyeing). Some textile products, e.g. carpets, blankets, felts etc., are manufactured by using a substantial amount of processed fiber directly. Chemical processing of fibers is carried out in a high temperature high pressure (HTHP) machine at elevated temperature. However, the class and type of dyestuffs used in fiber dyeing is highly dependant on the type of fiber being processed.

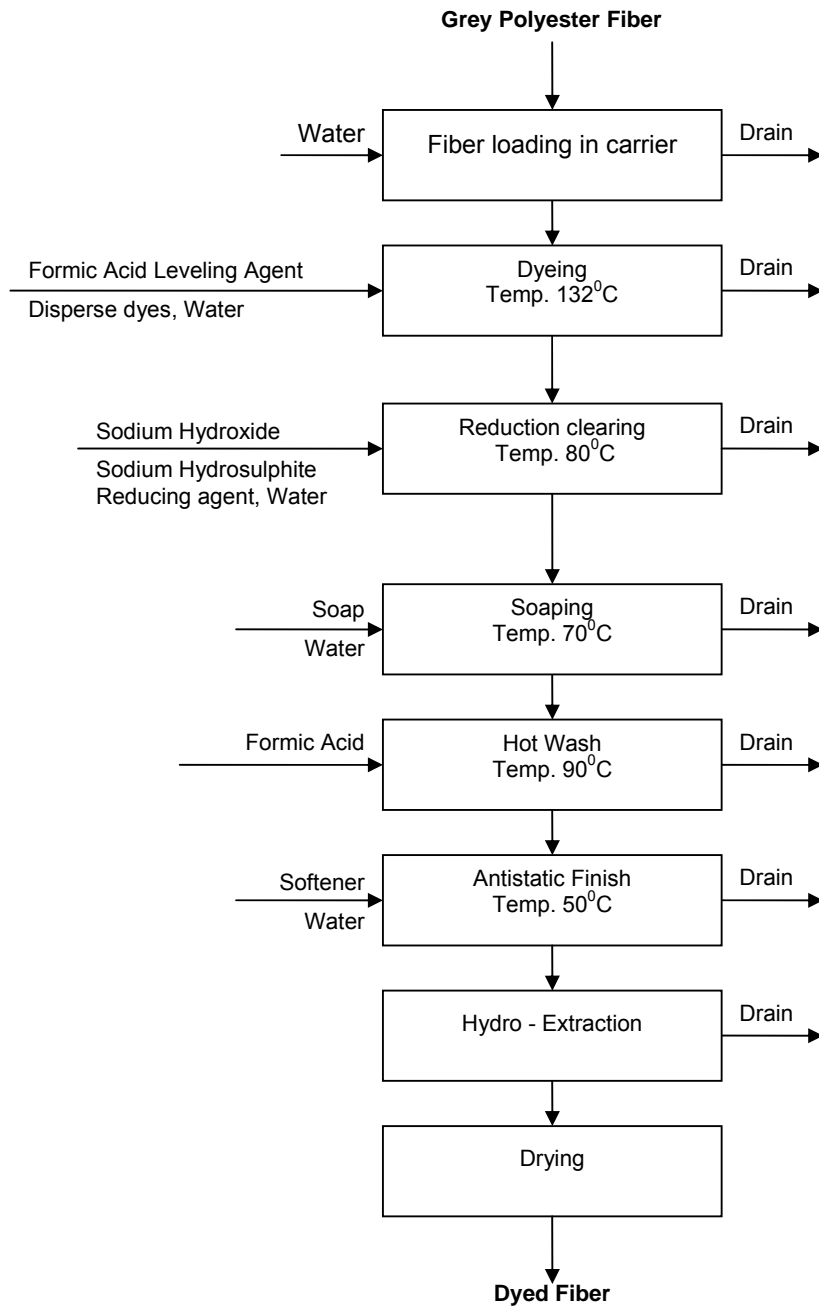
### ***Polyester Fiber Dyeing***

Dispersed dyestuffs are used for dyeing of polyester fiber. The dyeing operation starts with loading a predetermined quantity of fiber into the carrier with the help of water and manual pressing. The loaded carrier is then transferred into the HTHP fiber dyeing machine. The dye bath solution containing the requisite quantities of dispersed dyes, leveling agent, formic/acetic acid to maintain pH at about 4, and water is prepared in a separate vessel and pumped into the machine. The temperature of the dye bath is raised to 132°C with the help of steam and mixing of the solution is achieved by internal recycling. At the end of dyeing, the machine is gradually cooled to 70-80°C and the dye bath solution is drained.



This dyeing operation is followed by other operations such as reduction clearing at 80°C (only in case of heavy dark and dark shade), soaping at 70°C, hot and cold wash, neutralization and anti-static finishing treatment at 50°C. After completion of these operations, dyed fiber is removed from the carrier and subjected to hydro-extraction to remove excess liquid carried by the fiber. Hydro-extracted fiber is dried in a hot air blower to get the final dyed fiber. The schematic process flow diagram is shown in Figure A-3.

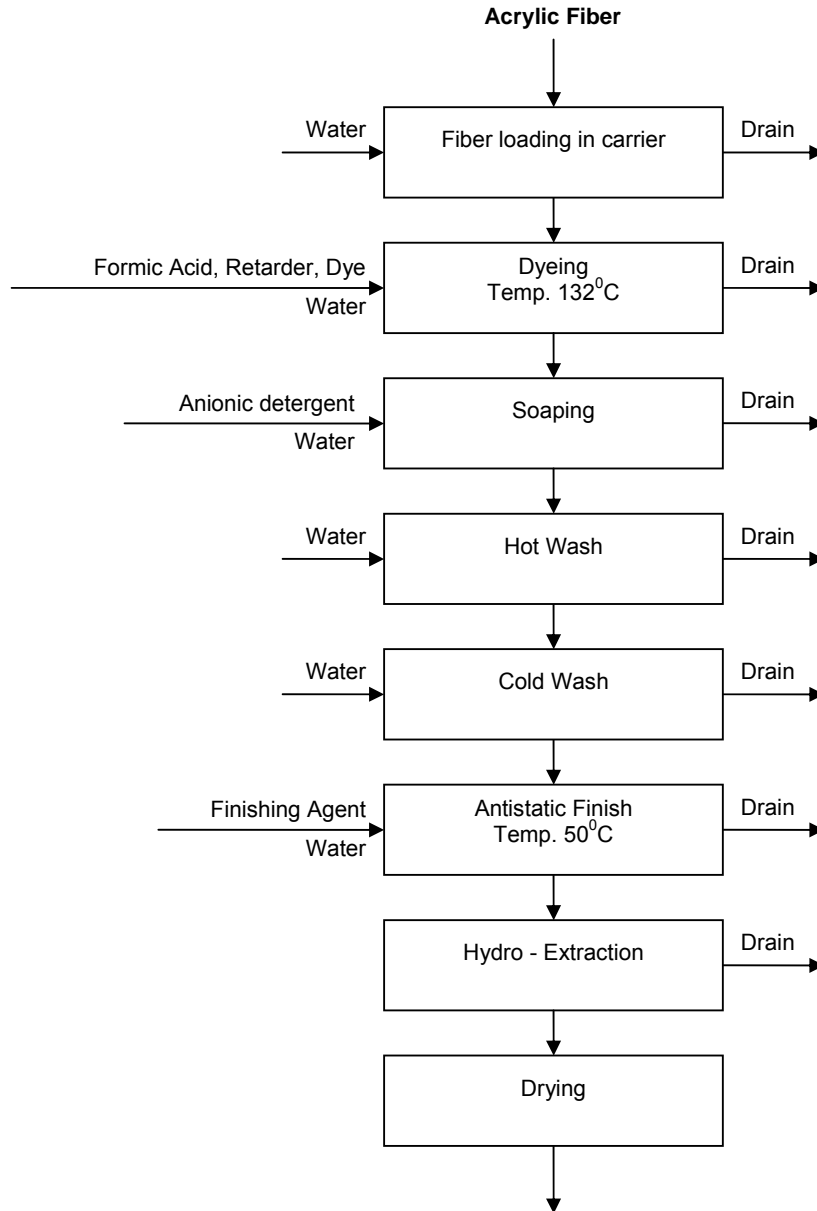
**Figure A-3: Process Flow Chart for Polyester Fiber Dyeing**



### ***Acrylic Fiber Dyeing***

The process of acrylic fiber dyeing is similar to polyester fiber dyeing with the exception that in the dye bath, basic dyestuffs and retarder are used in place of dispersed dyes and leveling agent. Acrylic fiber dyeing does not involve the reduction clearing operation of polyester fiber dyeing. The schematic process flow diagram for acrylic fiber dyeing is shown in Figure A-4.

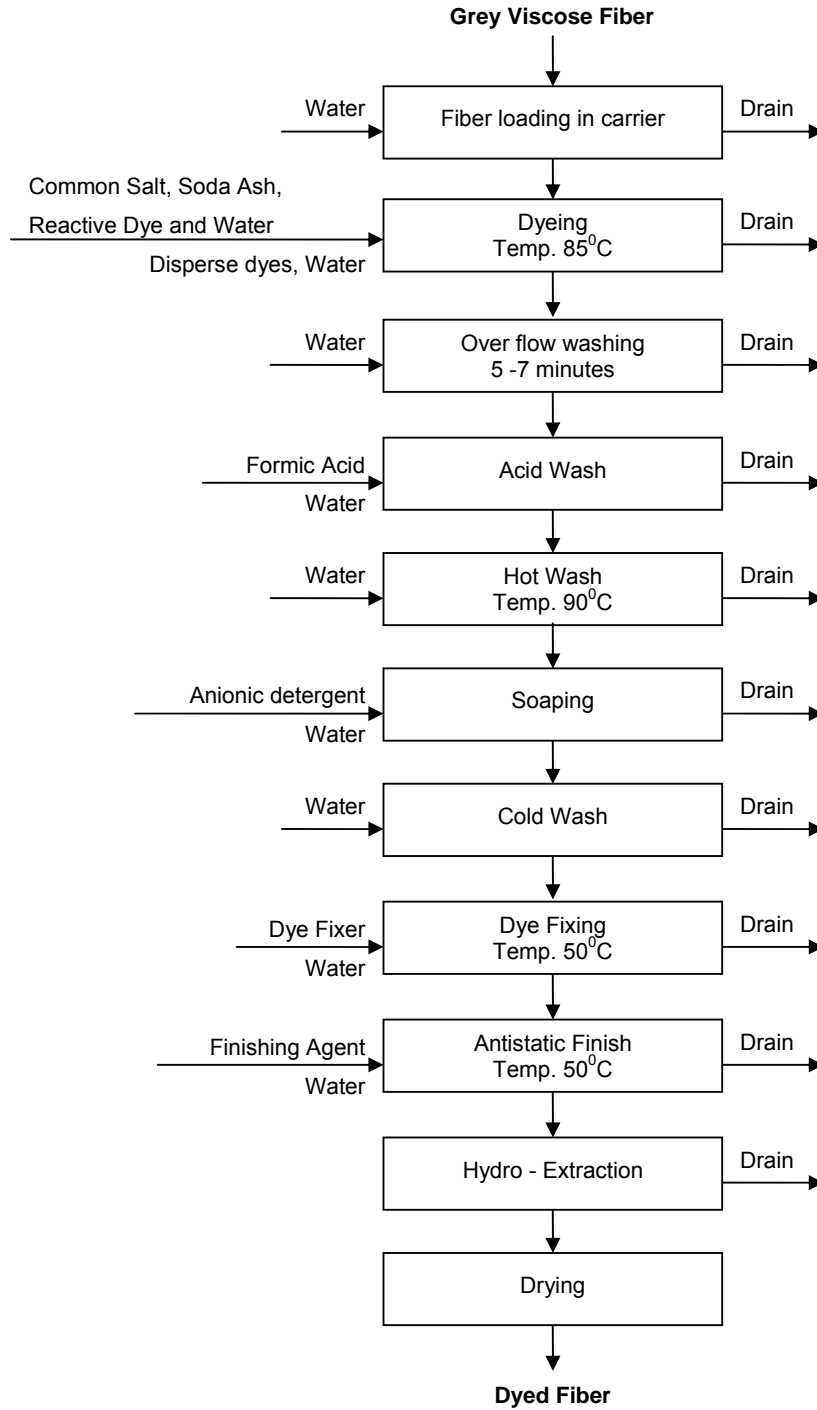
**Figure A-4: Process Flow Chart for Acrylic Fiber Dyeing**



### ***Viscose Fiber Dyeing***

Viscose fiber dyeing involves the use of reactive dyestuffs in the presence of a high concentration of common salt. The dye bath is comprised reactive dyestuff, common salt (20-80 g/L), soda ash (10-20 g/L, depending on percent shade dyed) and water. The procedure for loading viscose fiber, preparation of the dye bath solution and its charging in the HTHP machine is similar to that described for polyester fiber dyeing. Dyeing is carried out at 80°C. The residual dye bath is drained at the end of the dyeing operation and the fiber is given an overflow wash with cold water for 2-5 minutes (depending on shade depth) to remove excess dyes, salt and soda ash. This is followed by acid wash for neutralization, hot wash, soaping, another hot and cold wash, dye fixing and antistatic finishing operations. Dyed fiber is subjected to hydro extraction and drying to get the final dyed viscose fiber. The schematic process flow diagram is furnished in Figure A-5.

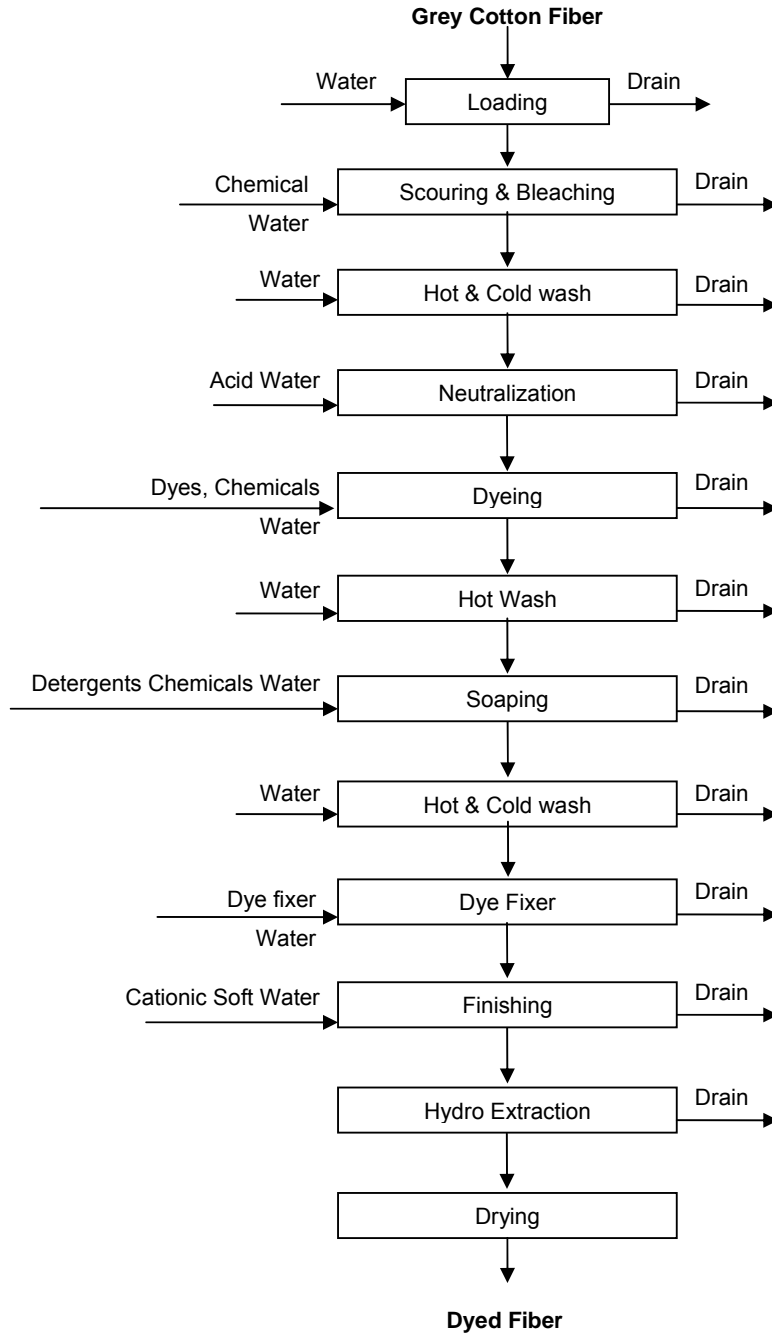
**Figure A-5: Process Flow Chart for Viscose Fiber Dyeing**



### ***Cotton Fiber Dyeing***

Reactive, sulfur and vat dyestuffs are used for dyeing of cotton fiber. The selection of dyestuffs is solely guided by the cost, end use and light fastness requirement of the finished product. However, 95% of cotton fiber dyeing is carried out using reactive dyes. Grey cotton fiber is loaded in a carrier using water, transferred to the HTHP machine and subjected to ready for dyeing operations like scouring and bleaching followed by washing and neutralization operations. Other operations are similar to those described for viscose fiber dyeing. The process flow diagram for cotton dyeing is given Figure A-6.

**Figure A-6: Process Flow Diagram of Cotton Fiber Dyeing**

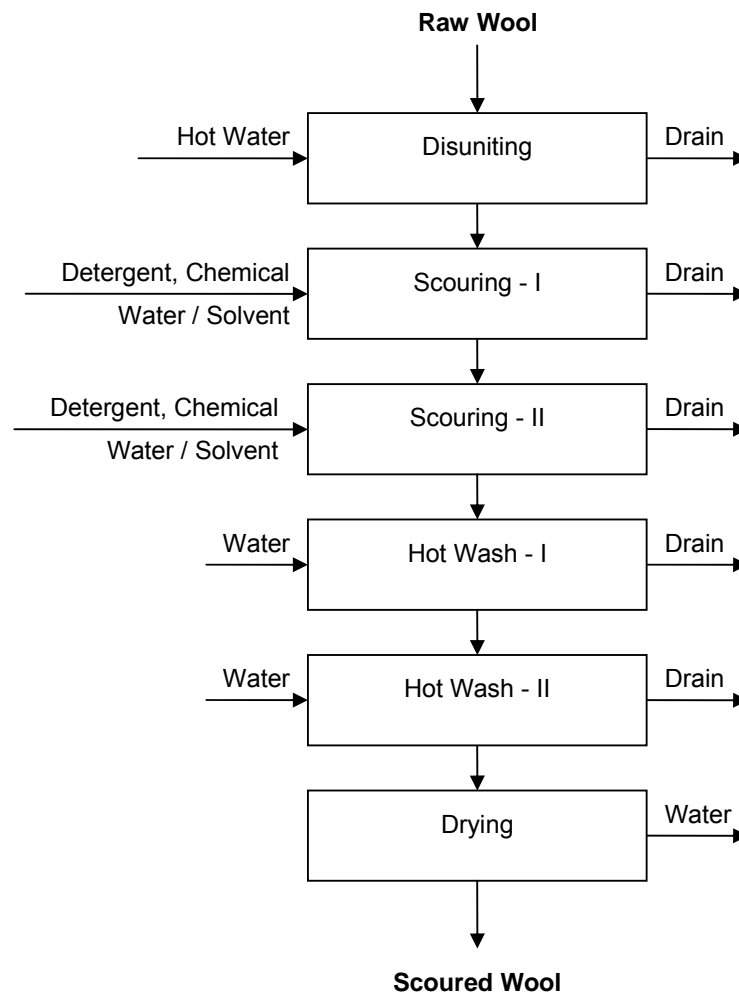


### **Wool Processing**

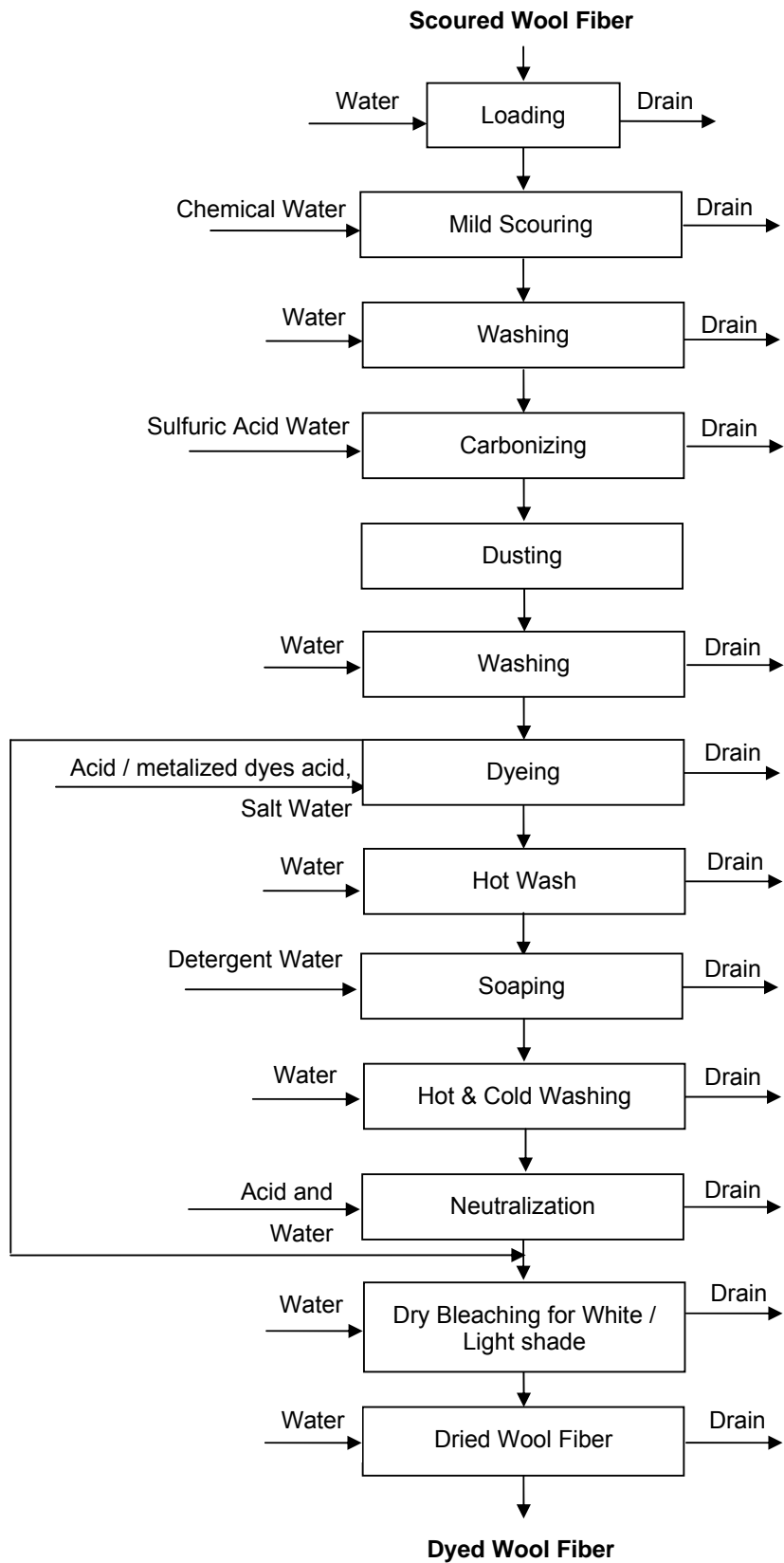
Wet processing of wool comprises scouring (before weaving), stock dyeing (fiber dyeing), carding, fulling, carbonizing, piece dyeing, bleaching and brightening. Wool processing industries are grouped into two categories. The first category consists of those industries that purchase raw wool and carry out scouring. Those of the second category purchase scoured wool and carry out further wet processing.

Wool dyeing is also carried out in an HTHP machine using various classes of dyes. The process flow diagrams for the wet processing and dyeing of wool are given in Figures A-7 and A-8.

**Figure A-7: Process Flow Diagram for Wool Processing**



**Figure A-8: Process Flow Diagram for Wool Fiber Dyeing**



## **Yarn Dyeing**

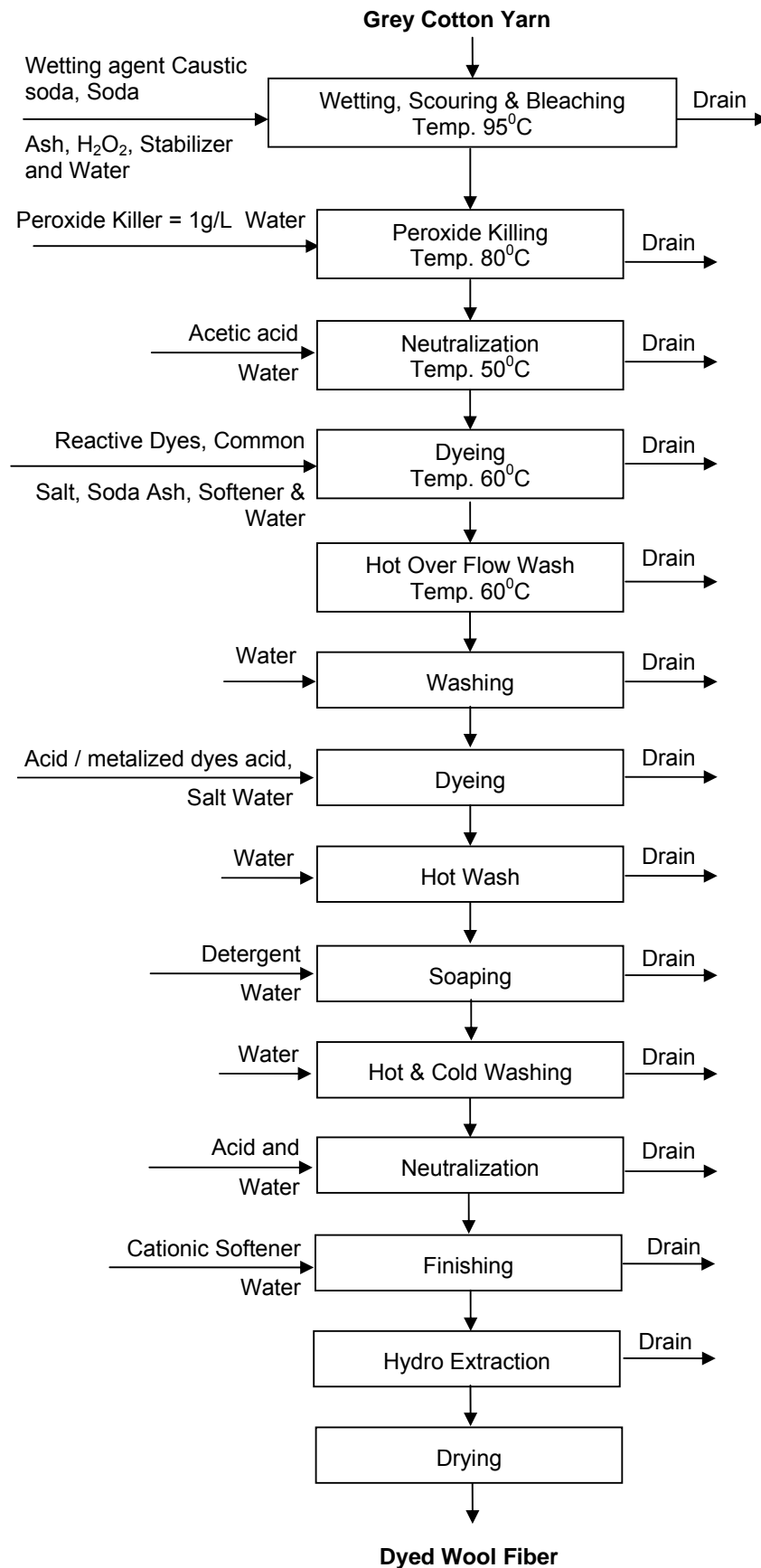
Yarn, which is used for conversion to fabric or other specialty textile products, is spun out of grey as well as dyed fiber. The use of dyed yarn in the weaving stage provides ample opportunity for creating different designs in the fabric or product. Therefore, dyed yarn is extensively used in manufacturing of various textile products. There are two methods of manufacturing dyed yarn. In the first method, dyed fiber is used whereas in the second method grey yarn is subjected to dyeing in package or hank form. Grey yarn is wound on cones/ cheeses/ beams for package dyeing in an HTHP dyeing machine or hanks are prepared for dyeing in a cabinet dyeing machine or manually.

Yarn dyeing starts with loading and wetting of yarn on cheeses / cones / beams in an HTHP machine or in hank form in a cabinet dyeing machine. The wetted yarn is subjected to scouring or scouring / bleaching using a wetting agent, soda ash, caustic soda and a chemical bleaching agent (sodium hypochlorite and hydrogen peroxide) at 70 to 95°C depending on the processing machine used. Cotton yarn, which contains natural impurities, wax and coloring matter, is subjected to strong scouring, whereas synthetic yarn like polyester, acrylic, etc. contains spin finishing and tint which are removed by mild scouring. Polyester blended yarns are preshrunk on paper tubes by steaming for one hour with saturated steam at 100°C or for 20 minutes at 110°C in a vacuum steamer before scouring. The scouring operation is followed by peroxide killer (optional), hot and cold washing and neutralization operation. Scoured/ bleached yarn is dyed in the same machine by using a dye bath comprising of reactive dyes, common salt, soda ash and softener at 60°C. The dyed yarn is given a hot overflow wash to remove adhered chemicals with yarn and excess alkalinity is neutralized by acetic acid. The neutralization operation is followed by soaping, again a hot overflow wash, dye fixing (only in the case of dark and heavy dark shades) and finishing operation. At the end of these operations, yarn is removed from the dyeing machine and transferred into hydro extractor for removing absorbed water from the yarn under centrifugal force. Yarn is finally dried in a yarn drying machine. The process flow diagram for cotton yarn dyeing is furnished in Figure A-9.

In the case of blended yarns like polyester-viscose, polyester-cotton, first the polyester component of the yarn is dyed using dispersed dyes, followed by the cotton/viscose part using reactive dyes. The chemical processing of pure acrylic and polyester yarn is similar to that described in pure fiber dyeing, above, with the exception that a cabinet dyeing machine is used for dyeing of yarn in hank form.



**Figure A-9: Process Flow Diagram for Cotton Yarn Dyeing**



## ***Fabric Dyeing***

Fabric dyeing, printing and finishing form an integral part of the process chain of making a saleable fabric or garment. Most of the fabric and allied textile products produced by textile industries are classified into the following two categories, depending on whether single or multi component fibers are used:

- i. Pure fabric
- ii. Blended fabric

### ***Cotton Fabric Dyeing***

The dyeing of pure cotton fabric starts with a singeing operation. Singeing is the process of removing the protruding fibers from the surface of the fabric by passing the grey fabric over a flame at a very high speed. As a result, the protruding fibers are burnt off leaving a smooth surface. In the singeing machine, petrol and air are used for producing flames from the burner nozzles of the singeing machine. After singeing, the fabric is quenched by passing it through a de-sizing bath.

The purpose of de-sizing is to remove the sizing material (starches, gums, polyvinyl acetate (PVA), etc.) used during sizing for strengthening yarn to withstand the stress in weaving. The presence of such material hinders the efficacy of subsequent processes, hence the importance of its removal. The process is generally carried out by enzymatic and chemical de-sizing. The fabric is padded with a solution containing an enzyme, common salt, a wetting agent, acetic acid (for adjusting the pH) and a sequestering agent at 50-60°C, with a wet pick-up of about 100%, and then stored for about 12 hours. The chemical de-sizing is carried out by using 0.2 to 2.0% hydrochloric acid or oxidizing agents like hydrogen peroxide and sodium hypochlorite. This operation is followed by hot and cold washing to remove chemicals adhered to the fabric.

De-sized fabric is subjected to a scouring operation whereby the natural substances from the grey fabrics (wax, protein, foreign matters present in cotton) are removed. This process is performed by using sodium hydroxide, soda ash, a wetting agent and a sequestering agent above 100°C. The scouring process is carried out in closed Kiers and sometimes in JT – 10. Some processors carry out combined scouring and bleaching with the help of the above mentioned machines or continuous bleaching range.

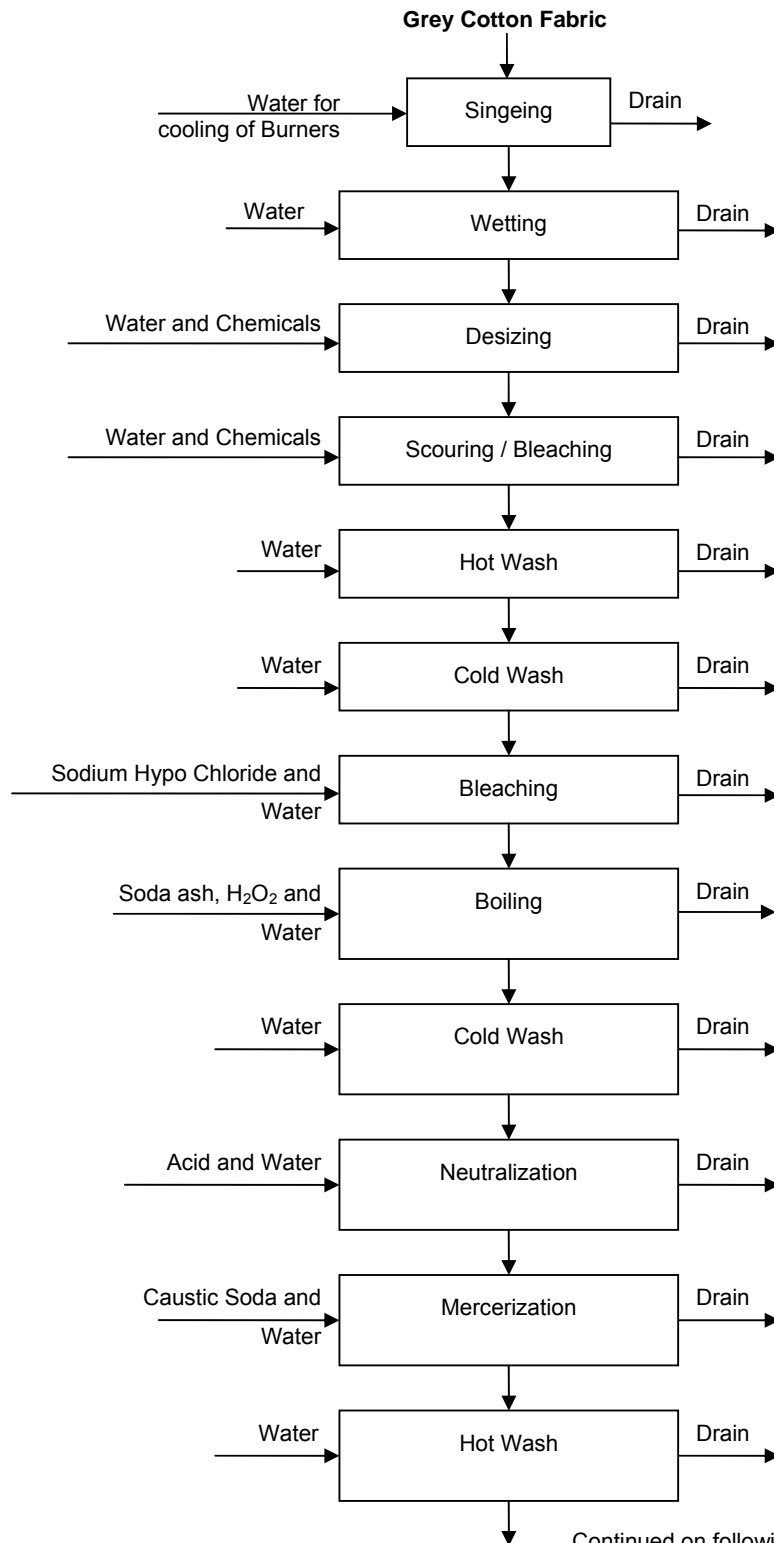
The purpose of bleaching is to remove the natural substances present in cotton which give it a greyish colour. It is carried out by soaking the scoured fabric in a sodium hypochlorite solution or hydrogen peroxide for about 30 minutes followed by washing and neutralization and then it is dried on a cylinder drying range.

Cotton fabric is mercerized in order to improve its luster and enhance its dyeability. Fabric is mercerized in 23% caustic soda in a mercerizer, followed by hot and cold washing. Excess alkali is neutralized by the acid treatment. Thus processed fabric is ready for dyeing.

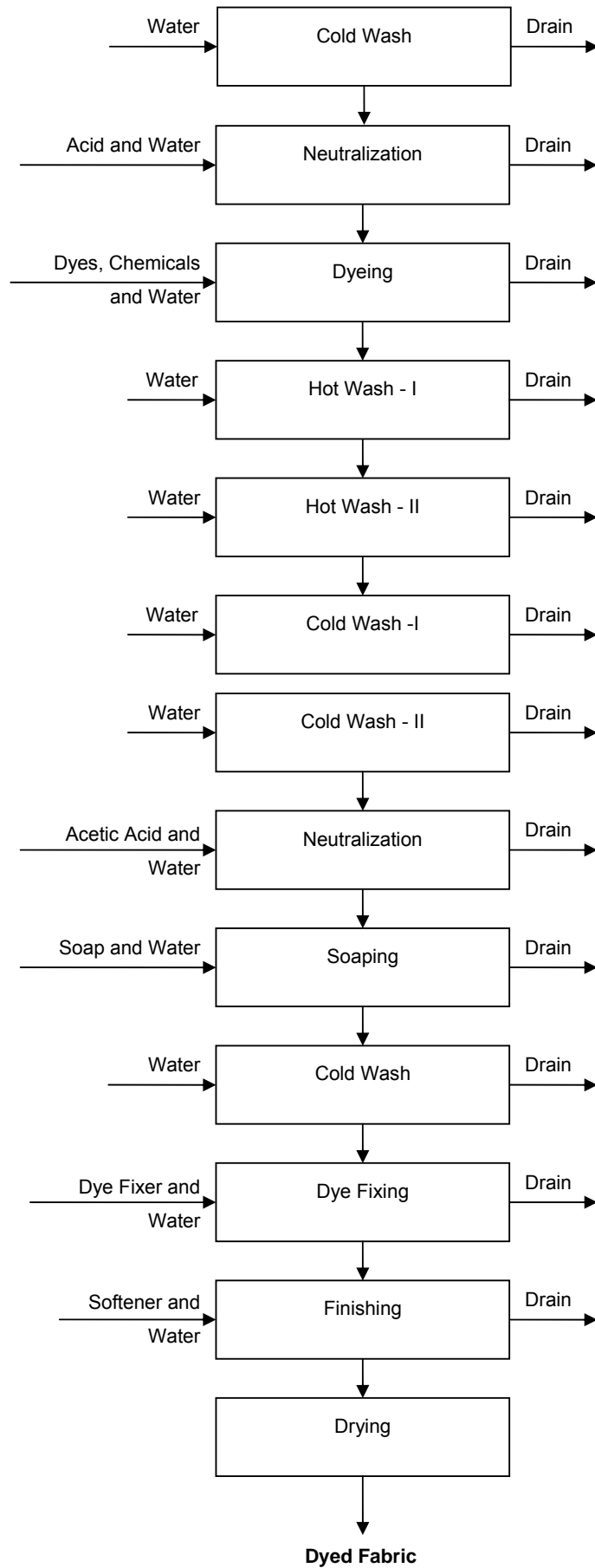
Reactive dyes are used in the dyeing of cotton fabric. The dye bath comprises common salt, soda ash and reactive dyes. The ready for dyeing fabric is subjected to the dyeing operation in jiggers at 50°C. After the dyeing operation, it is provided with hot and cold washing to remove excess dyes and salts. The washing operation is followed by soaping, cold washing, dye fixing in the case of dark shades, and finishing operations.

Reactive dyeing is also carried out by a pad dyeing method on a continuous dyeing range or padding on CP Dyer followed by washing in jiggers or continuous washing range. In the pad dyeing method, fabric is impregnated by passing it through a dye bath comprising of reactive dyes and chemical solution. The impregnated fabric on a roller is allowed to stand for a predetermined amount of time under a rotating condition before further processing. The process flow diagram of cotton fabric dyeing is shown in Figure A-10.

**Figure A-10: Process Flow Diagram for Cotton Fabric Dyeing**



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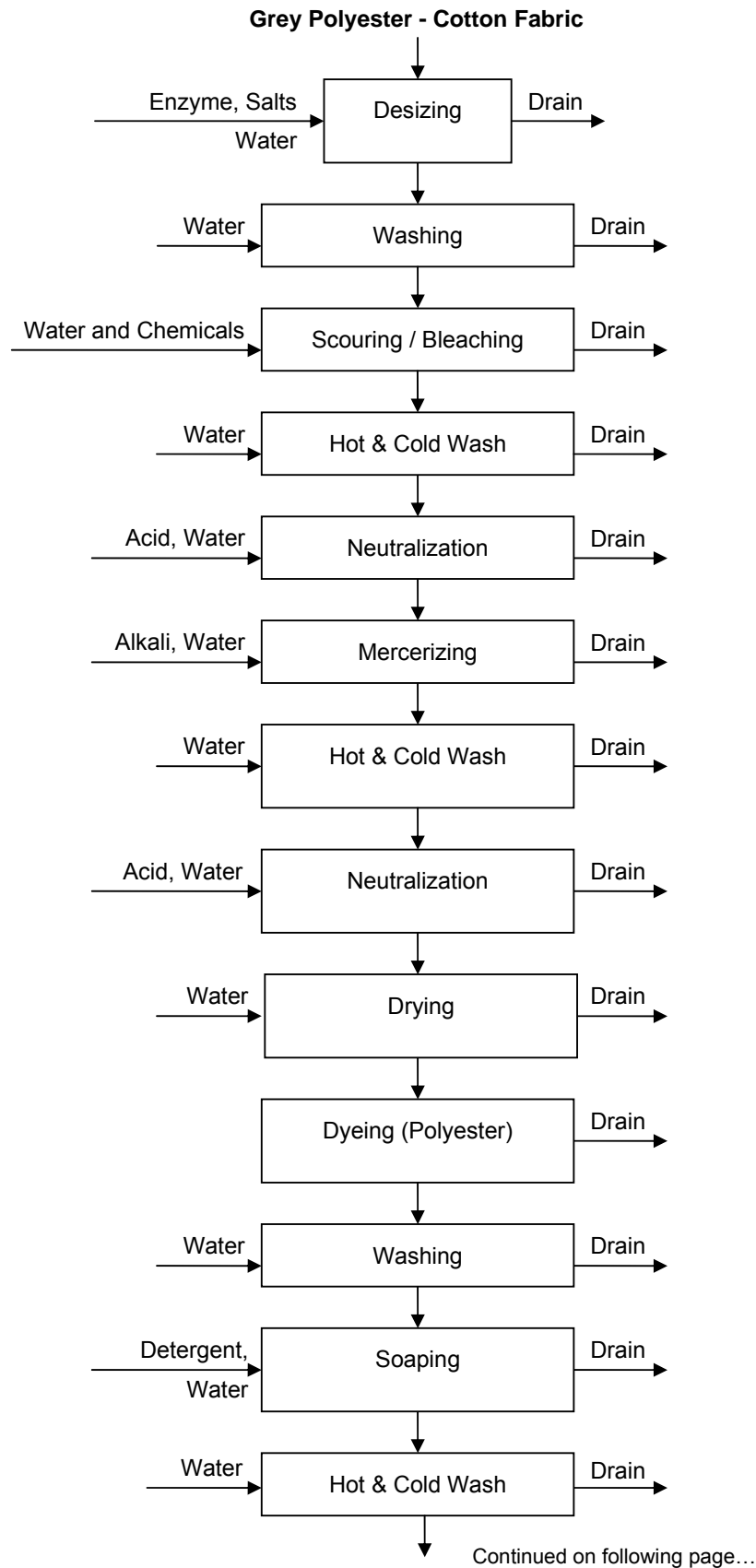
### ***Polyester Cotton Fabric Dyeing***

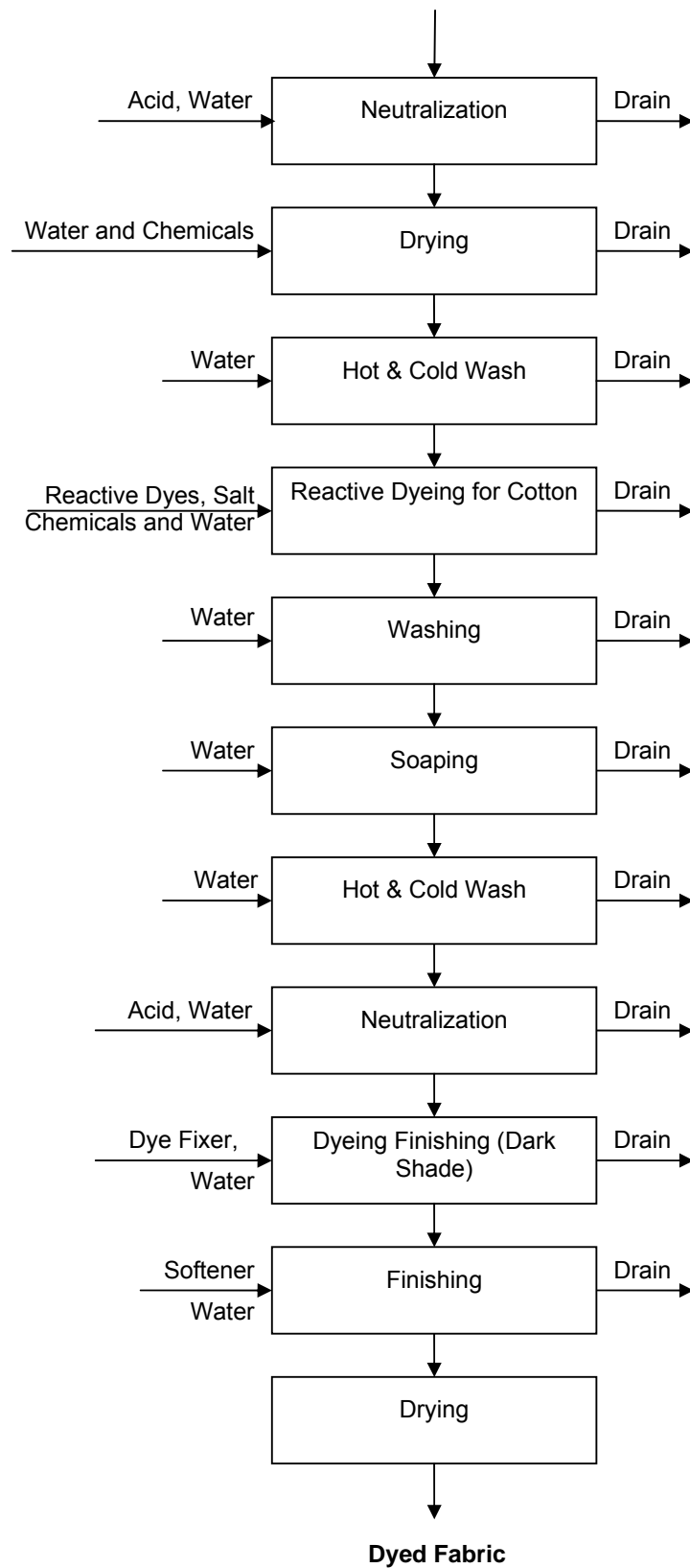
The processing of polyester-cotton blended fabrics involves more or less all the processes of cotton fabric dyeing but some of the equipment is different than that used for 100% cotton processing. One main difference in the processes is that fabric containing polyester material in any form (i.e. fiber or filament), must to be subjected to the process called heat setting carried out on a hot air stenter at a high temperature of around 210°C. The other difference is that in contrast to cotton, polyester is hydrophobic. As such, the type of dyes used and the method of dye impregnation are different. In the case of blends of polyester and cotton, dyeing therefore needs to be done in two stages, one for the cotton content and a second for the polyester content.

The yarn prepared by blending polyester and cotton fiber is used in weaving of polyester cotton fabric. The dyeing process for this type of fabric starts with dyeing of the polyester component first followed by dyeing of the cotton component. Polyester dyeing is done in a jet dyeing machine at 130-135°C. The dye bath is comprised of dispersed dyes, acetic acid, dispersing and leveling agent and water. At the end of dyeing, the machine is gradually cooled to 80°C and subjected to overflow washing until it cools down to room temperature. In the case of dark and heavy dark shades, reductive cleaning is done using sodium hydrosulphite.

The cotton component dyeing starts with ready for dyeing operations like singeing, mercerizing, scouring / bleaching and dyeing with reactive, vat and sulfur dyes. Jiggers and CP Dyers are used for performing this type of dyeing. Finishing chemical treatment and drying operations are carried out in the stenter. The process flow diagram for blend polyester-cotton fabric is shown in Figure A-11.

**Figure A-11: Process Flow Diagram for Polyester Cotton Fabric Dyeing**





### ***Polyester Viscose Fabric Dyeing***

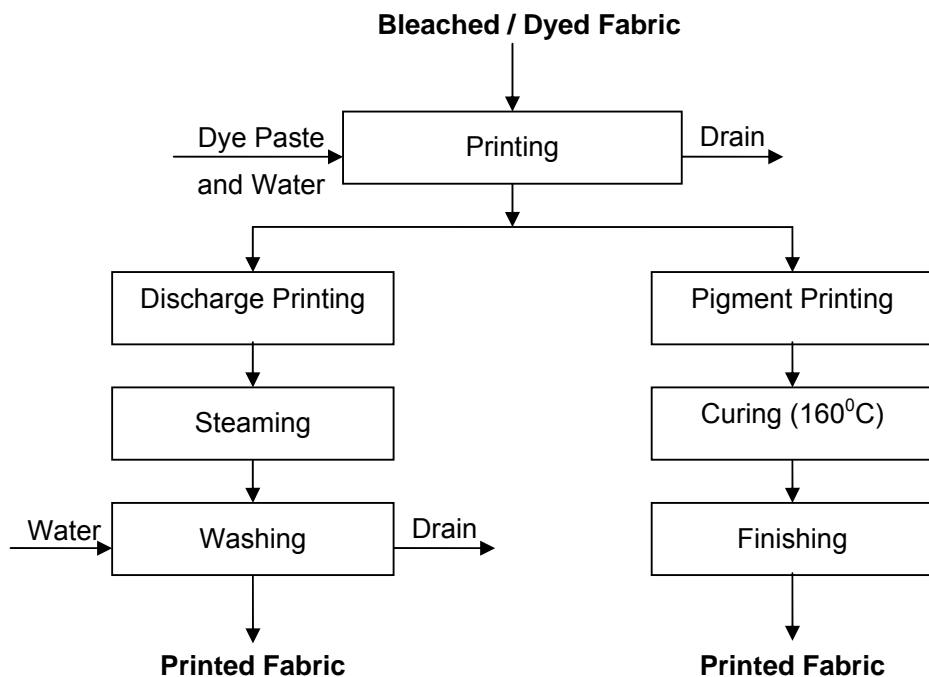
The only difference in polyester viscose fabric compared with polyester cotton fabric is that in place of cotton fiber, viscose fiber is used in yarn preparation. The dyeing process is similar to polyester cotton fabric dyeing, with the exception of singeing and mercerizing. Polyester viscose blend fabric is prepared from synthetic fibers, hence unlike cotton fabric, it contains only added impurities like spinning oil, a negligible amount of sizing chemicals and oil stains. Therefore the “Ready for Dyeing” operation of polyester viscose fabric does not include de-sizing and mercerizing operations. In dyeing, dispersed and reactive dyestuffs are used.

Grey polyester viscose fabric after wetting is subjected to a scouring / bleaching operation to remove tint, oil and yellowness from the fabric, which is followed by cold washing. The dyeing operation is performed in two parts: first dyeing of the polyester part using dispersed dyes, followed by dyeing of the viscose part with reactive dyes. Polyester dyeing is done in a jet dyeing machine at 130-135°C. The dye bath comprises dispersed dyes, acetic acid, dispersing and leveling agents and water. At the end of the dyeing, the machine is gradually cooled to 80°C and subjected to overflow washing until it cools down to room temperature. Viscose component dyeing is similar to cotton dyeing. Home furnishing textile products like rugs, bath mats, foot steps, durry, etc., and garments are also processed in a similar way in a soft flow machine. This is also known as piece dyeing.

### ***Printing of Fabric***

Dyed / pure white fabric is printed on a rotary printer. Two types of printings (discharge and pigment) are carried out by the textile industry. Water is used for blanket and rotary washing of the rotary printer. In the case of pigment printing, the printed fabric from the rotary is cured at 150°C followed by drying and finishing operations and does not require water. However, in the case of discharge printing, the material is subjected to steaming, hot and cold washing in a soaper, drying and finishing operations. The schematic process flow diagram for fabric printing is shown in Figure A-12. The finishing operation of dyed, pure white and printed fabric is done on a stenter.

**Figure A-12: Process Flow Diagram for Printing of Bleached / Dyed Fabric**





## ***Garment Dyeing***

Textiles are dyed using reactive, dispersed, indanthrene or other kinds of dyes. These dyes use various types of chemicals. The concentrations of chemical substances in the effluent from this process always vary because of compound chemical reactions taking place and the effluent is colored. In the printing process high color impurities are generated. This is the last step of wet processing. The inducted coloring process uses various dyes depending on the buyer's wishes, including:

- For cotton: Reactive dye, direct dye, vat dye (Maximum efficiency 55%-65%);
- Basic dye, Acid dye;
- Sulphur dye (more useful for black shed), azoic dye, pigments; and
- For polyester: Dispersed dye (Efficiency 95%).

## ***Pigment Dyeing***

Pigments are not technically dyes but organic coloring compounds that have no affinity to fibers due their ionic nature. Just like exhaust reactive dyeing, the attachment of a cationic polymer enhances the fixing of dyes onto the fabric, as does an application of a cationic agent prior to dyeing. This process is called cationization.

Cationization is a process wherein a cationic polymer is applied to the fiber to change its ionic nature so that an anionic material such as pigment can be strongly attracted. There are two categories of cationic reaction:

1. Cationic polymers that form a layer of cationic charges when applied to fiber surfaces. Examples of cationic polymers are polyacrylates, polyimidazoles, polyamideepichlorohydrin resins and polyamino condensates.
2. Cationic reactants which are usually small molecules that modify the fiber by forming covalent bonds with the cellulosic fiber.

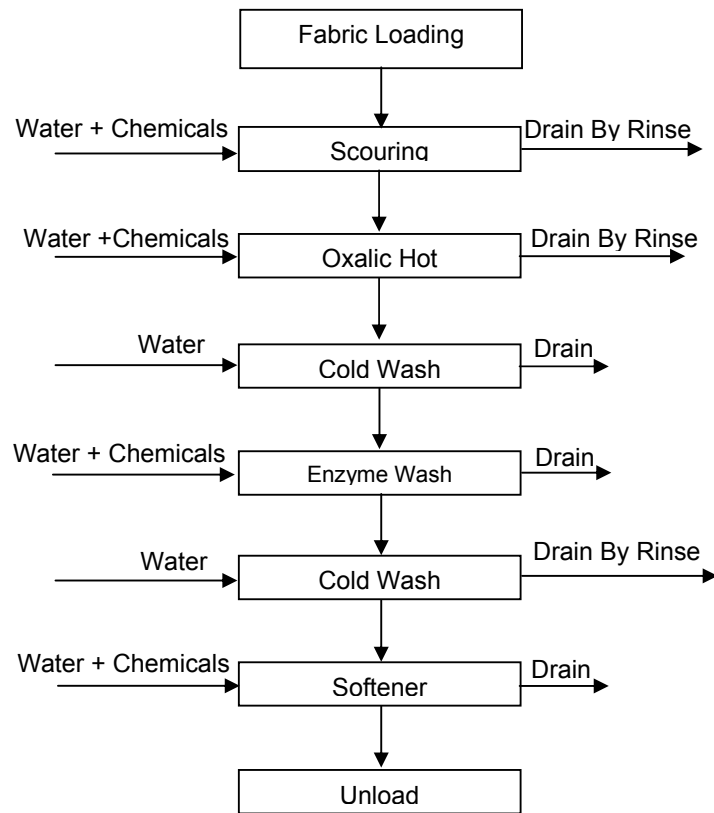
Since ionic bonding occurs only between the pigment and the cationic reactant and no pigment-fiber reaction occurs, this adsorption is not very strong, therefore an application of a binder is needed to fix the pigment and the fiber together.

The conventional pigment dyeing process follows these steps:

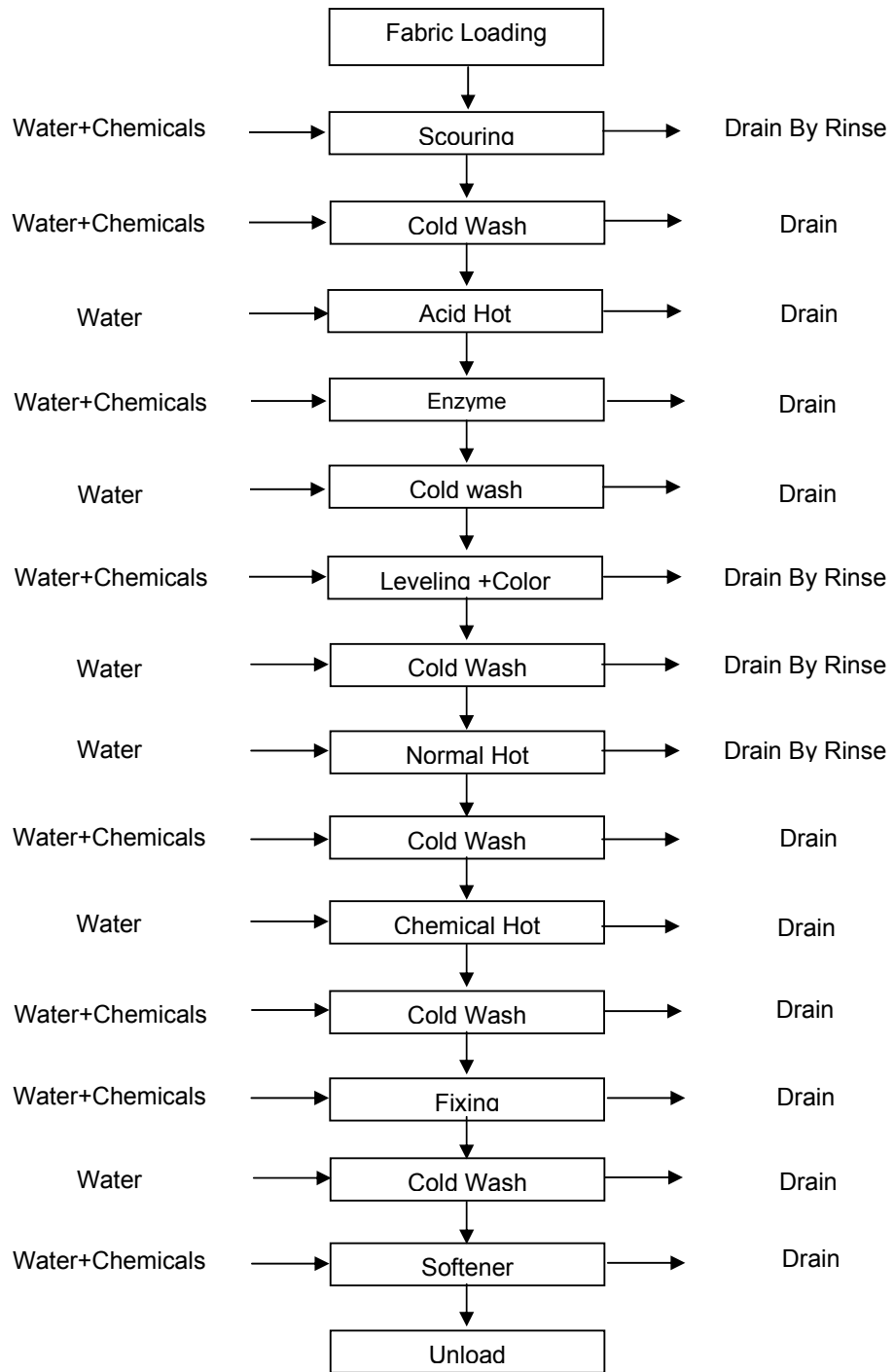
- **Preparation:** Scouring and de-sizing if required (depends on the fabric to be used); drop the bath; cold rinse.
  - For a two-step process: Set the cationization bath with Predye RMC and Crosbinder KAT at pH 8. Raise temperature to 45°C and hold for 20-30 minutes. Drop the bath and rinse. Set the bath at 30°C, then dose the pigment dyes. Raise the temperature to 70°C and hold for 20-30 minutes. Overflow rinsing and drop the bath.
  - For a one-step process: Set the bath with Predye RMC, Crosbinder KAT, hold for 20mins at 45°C, then dose the pigment dyes and raise the temperature to 70°C. Overflow rinsing and drop the bath.
- **Biofinishing** (for a washed-down effect and to reduce/eliminate pills): 1.0 g/l BioAce THF; Set the bath at pH 4.5-5 with acetic acid; Raise temperature to 50°C, add 1.0 g/l BioAce THF and run for 40-50 minutes.
- **Softening:** 1.0% Crosdurin EAR, 2.0% Crosoft MEM; Set the bath at pH 5 with acetic acid, get temperature of 40°C and run for 20 minutes.

The process flow diagram for garment dyeing is shown in Figures A-13 and A-14.

**Figure A-13: Process Flow Diagram for Garment Dyeing (White)**



**Figure A-14: Process Flow Diagram for Dyeing (Color)**



## **Garment Washing**

Garment washing includes Bio-wash (De-sizing, Bio-wash, Neutralization, Softening), Bio-bleach (De-sizing, Bio-wash, Bleaching, Neutralization, Softening), Stone bleach (De-sizing, Bio-stone, Bleaching, Neutralization, Softening), Bio-stone (De-sizing, Bio-stone, Rinsing, Softening) and Over-dyeing (De-sizing, Bio-stone, Bleaching, Neutralization, Dyeing, Fixing, Softening).

### **Process parameters**

#### **DE-SIZING**

- Alkali De-sizing: Soda Ash 1-2 g/l, Anti-back staining 0.5-1.0 g/l, 20min @ 60°C
- Enzymatic De-sizing: Alpha Amylase 0.5-1.0% of weight of garment (owg) Anti-backstaining (optional) 0.5 g/l, 20min @ 60-80°C

#### **BIO-WASH**

- Acid Enzyme Cellulase 0.5-1.0 % owg, Acetic Acid (pH 4.5 – 5.5) 0.25-0.50 g/l (depends on the strength of the acid), Anti-backstaining 0.5 g/l, 50min @ 50-55°C
- Neutral Enzyme Cellulase 0.5 – 1.0 % owg, Acetic acid (pH 5.5-6.5) 0.05-0.10 g/l, 60-75min @ 40°C.

#### **BIO-STONE**

- Stone 3-4 sacks, Enzyme: 1.0 % owg.
- Notes: process parameters, time, temp, and pH will depend on the enzyme being used

#### **BLEACHING**

- Calcium Hypochlorite 1.5-4.0 g/l (depends on the required effect), Soda Ash 2.0 g/l, 30-60min @ 60°C.

#### **NEUTRALIZATION**

- Anti-Chlor (Sodium Bisulfite) 2.5-3.0 g/l, Acetic Acid 0.3 g/l, 5min @ 50°C

#### **SOFTENING**

- Cationic Softener 1.0-2.0% owg, Silicon Softener 1.0-2.0% owg, Acetic Acid (pH 5) 0.25-0.45 g/l, 20min @ 40°C.

The schematic process flow diagram for garment washing is shown in Figure A-15.

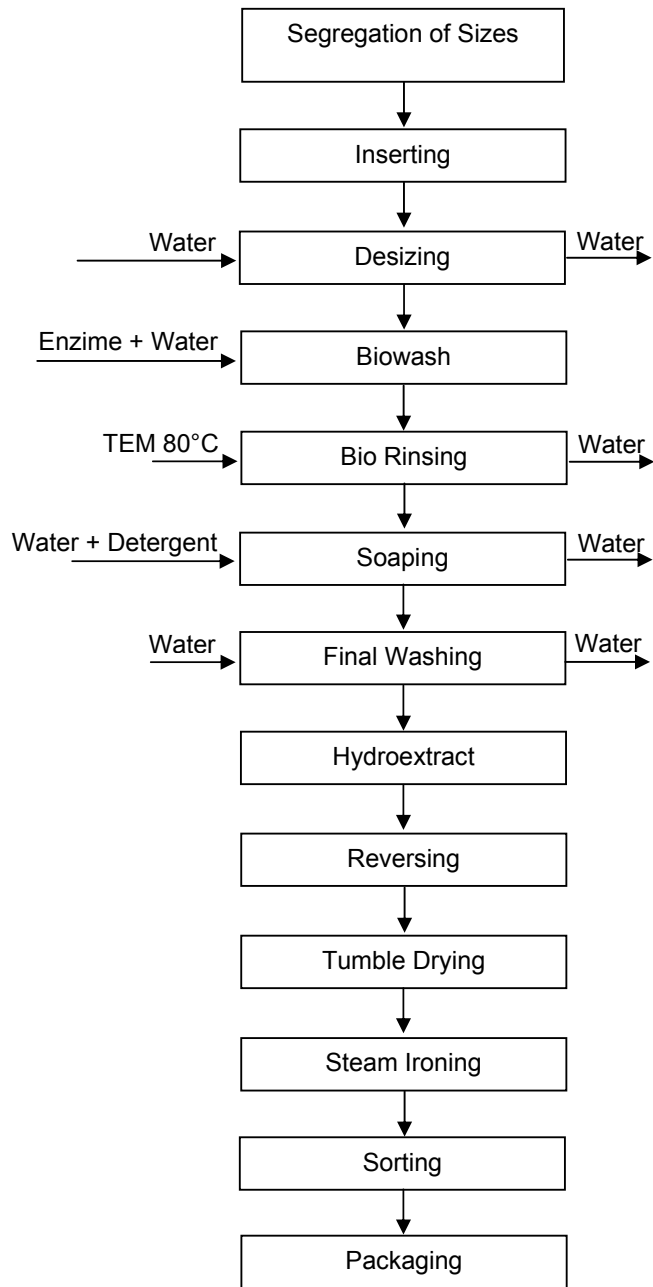
### **Ideal Liquor Ratio:**

Enzyme Wash	: 1:8 – 1:10
Softening	: 1:6 – 1:8
Bleaching	: 1:10
Dyeing	: 1:8 – 1:10
De-Sizing	: 1:8 – 1:10

#### Notes:

- enzyme or chemical dosages will vary depending on the supplier's recommendation
- time and temperature depends on product optimum application to get the best effect
- pumic stone usage approximately 3 sacks to 60kgs garments.

**Figure A-15: Process Flow Diagram for Garment Washing**



**Annex B**  
**Components of ETPs**



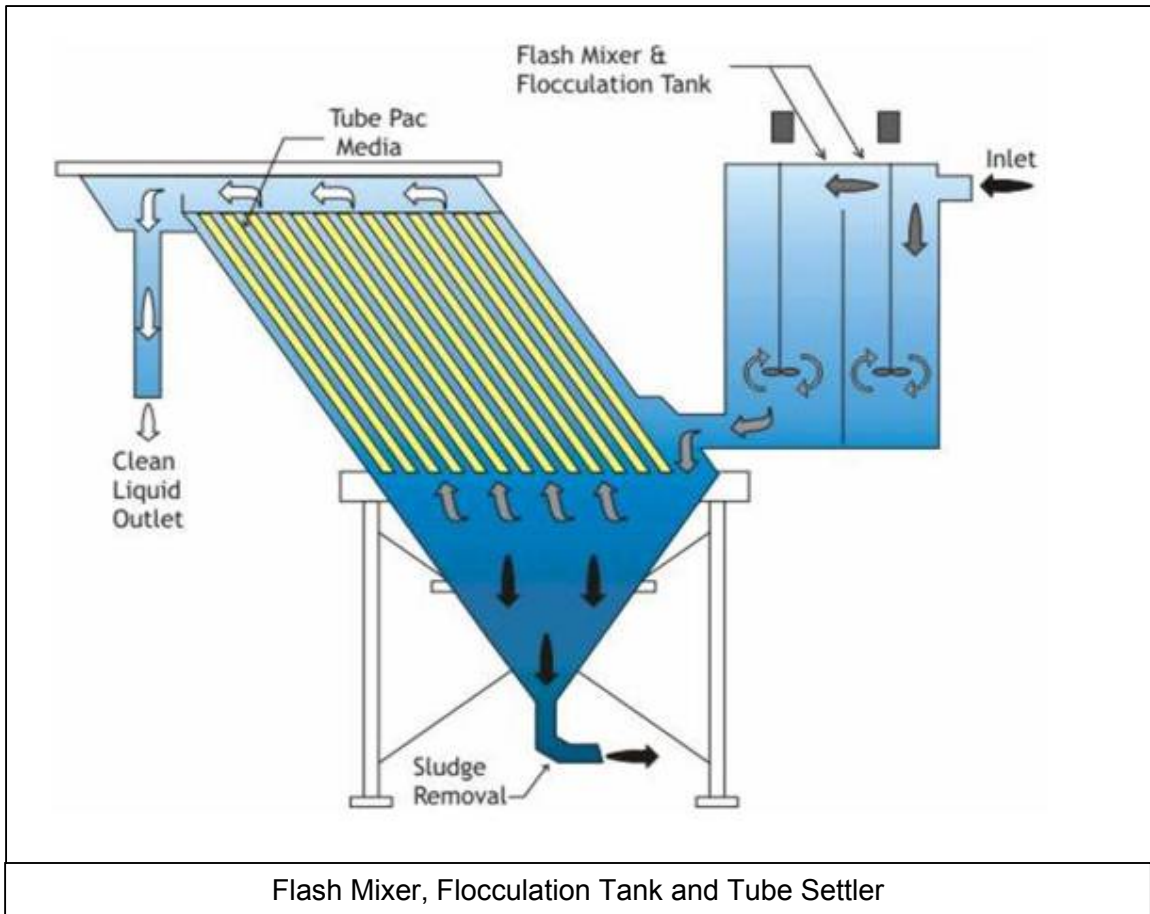


Effluent Treatment Plant



Screen





Clarifier



Secondary Clarifier



Aeration System



Air Blowers



Filtration System





Chemical Dosing



Chemical Dosing Pump



Reverse Osmosis



Filter Press



Centrifuge



Sludge Thickener



Sludge Drying Bed