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Annex 5

INDUSTRIAL POLLUTION REDUCTION PROGRAMME
DG/SRL/91/019

OPPORTUNITIES FOR WASTE MINIMISATION
IN THE TEXTILE PROCESSING INDUSTRY IN SRI LANKA

WASTE AUDIT

JB TEXTILES COMPANY LTD

CEYLON INSTITUTE OF SCIENTIFIC AND INDUSTRIAL RESEARCH
363, Bauddhaloka Mawatha, Colombo 7, SRI LANKA

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Summary

JB Textiles Co. Ltd, is a medium scale textile processing industry situated in a Colombo urban area observed to be a mixed residential Community. Major environmental pollution issue of this industry is disposal of textile processing effluent. This industry consumes 133 l of water and 1.4 l of furnace oil for each kg of fabric produced.

Fabric cleaning processes of scouring, padding and weight reduction generate 16% of the total COD load and balance 84% is mainly due to material waste in the dyeing process. Most expensive waste stream is the weight reduction stream and waste streams from dyeing, scouring/padding and padding also exceed the average value of the waste cost. Sixty two waste minimization options were identified and the benefit of the ten highest priority for implementation options is given in the Table. Of these, three have been implemented and four more are being implemented. Actual cost and savings is indicated wherever values are available.

Option	Investment Rs		Operating cost Rs/y		Net saving Rs/y		Pay back period (M)		Environmental benefits
	Exp.	Act.	Exp.	Act.	Exp.	Act.	Exp.	Act.	
1. Avoid reduction clearing for light & medium shades	Nil	Nil	Nil	Nil	94,962	-	N/A	N/A	1.2% reduction in organic load & effluent volume
2. Chemical substitution	Nil	Nil	Nil	Nil	180,960	146,208	N/A	-	7% reduction in organic load
3. Lagging steam lines	12,775	-	2,682	-	9,614	-	16	-	0.3% reduction in fuel consumption
4. Lagging boiler	29,640	-	6,224	-	22,510	-	16	-	0.7% reduction in fuel consumption
5. Lagging condensate line	30,300	-	6,363	-	39,188	-	9	-	1.1% reduction in fuel consumption
6. Condensate recovery	Nil	-	Nil	-	22,548	-	N/A	-	0.2% reduction in fuel consumption
7. Installation of press button switches	200	-	Nil	-	4,800	-	N/A	-	-
8. Lagging jet area	14,196	18,000	2,981	3,780	9,022	-	18	-	0.3% reduction in fuel consumption
9. Cooling water collection	59,838	-	13,530	-	142,002	-	5	-	3.8% reduction in fuel consumption
10. Print paste recovery	Nil	-	Nil	-	344,690	-	N/A	-	37% reduction in organic load

List of Abbreviations

COD	Chemical Oxygen Demand
°C	°Centigrade
h	hour
J	joule
°K	°Kelvin
km	kilometre
kg	kilogram
kWh	kilo Watt hour
l	litre
min	minute
m	meter
mg	milligram
N	Newton
Ref	Reference
s	second
y	year
M	month
w/w	weight/weight
T	Tonnes
d	day
g	gram
PET	Polyester
hp	horse power

PART 1 - ENVIRONMENTAL STATUS

J. B. TEXTILES CO LTD

1.0 Introduction

JB Textiles Ltd is a textile weaving and processing industry carrying out dyeing and printing of viscose and polyester viscose and polyester fabrics.

1.1 Organisational chart	:	Attached (Annex A)
1.2 Ownership	:	Messers. Jafferjee brothers
1.3 Contact persons	:	Mrs. N. Baldsing, Managing Director, Mr. T. Vasanthakumar Coordinating Officer.

2.0 Site details

2.1 Location : No. 133 Meethotamulla Road, Wellampitiya (Annex B)

2.2 Physical Descriptions

(i)	Area	:	76882 m^2
(ii)	Topography	:	Flat filled low lying land
(iii)	Factory layout	:	Attached (Annex C)
(iv)	Sealed surface	:	40-50 % of the site
(v)	Depth to groundwater	:	3 m
(vi)	Surface water bodies	:	Pond and marshes
(vii)	Surface drainage channels	:	

2.3 Current use

(i)	Processes	:	Textile weaving, dyeing, printing, and drying
(ii)	Products	:	100 % polyester sarees and dress materials, 100 % viscose and 65/35 polyester viscose materials, 100 % nylon fishing
(iii)	Raw materials	:	100 % polyester, viscose and nylon yarns
(iv)	Major chemicals	:	Caustic soda, dispersive and reactive dyes, soda ash, acetic acid, H_2O_2, kerosene, gums, $NaHSO_3$, oxalic acid and surface active agents (Annex D)
(v)	Energy source	:	Furnace oil, LPG and electricity

2.4 Site drainage (type & discharge points)

(i)	Process effluent	: Through open drains to marshes and lake
(ii)	Domestic waste water	: Connected to process effluent drains and then to marshes and lake
(iii)	Storm water	: Connected to process effluent drains and then to marshes and lake
(iv)	Toilet effluent	: Through pipe drain to septic tanks

3.0 Environmental Emissions

3.1 Atmospheric emissions	: Flue gas from steam boilers (2 stacks of 35'), solvents from printing and curing machines, exhaust from dryer and stentor, and open air burning.
3.2 Aqueous discharge points	: Effluents from bleaching, dyeing, printing, and washing
3.3 Solid waste	: Packaging and wrapping materials and empty chemical dye containers.

4.0 Site history and Neighbouring sites

4.1 History of the site

(i)	Start date	: 1964
(ii)	Former use	: Marshy land

4.2 Current and former use of neighbouring sites

(i)	Northern	: Residential
(ii)	Southern	: Lake, railway bund, residential
(iii)	Western	: railway bund, marshes
(iv)	Eastern	: CMC landfill

4.3 Significant spills : None

5.0 Environmental Receptors

5.1 Abstraction points

(i)	Dug wells	: One dug well being used
(ii)	Tube wells	: None
(iii)	Surface water	: None

5.2 Sensitive neighbours within 2 km

(i)	Residence	: North and south within 200 m
(ii)	Hospitals	: none
(iii)	Schools	: none
(iv)	Others	: none

5.3 Protected Natural Habitats : None

5.4 Water Bodies

(i)	Surface	: A Mini Tank and a pond
(ii)	Sub-surface	: Residents in the neighbourhood use dug wells for domestic purposes and gardening

6.0 Solid Waste Issues

(i)	Type and disposal method	: Metal and plastic drums-sold; packaging, wrapping s and rejected yarn-open air burning

7.0 Environment Licence issues

7.1 Current status	: EPL not issued due to high pollution level in effluent discharge
7.2 Current compliance issues	: Non-conformance of effluent discharge to standards; Given one year to install treatment plant

PART 2 - WASTE AUDIT

1.0 General Information

WORKSHEET 1	
Name of the Company : JB TEXTILES CO.LTD.	
Waste Minimisation Team	
Name / **Designation**	
1. Mr. H.N. Gunadasa — Manager,Environmental Technology/CISIR	
2. Mrs. K.D. Attanayake — Senior Technical Officer/CISIR	
3. Mrs.S. Wickramaratne — Research Officer/CISIR	
4. Mr.W.R.K. Fonseka — Research Officer/CISIR	
5. Miss.S. De.Costa — Research Officer/CISIR	
6. Mr. K. Pavanandan — Research Officer/CISIR	
7. Mr.R. Illankumaran — Research Officer/CISIR	
8. Mr. G.R. Vaidya — Processing Manager/JB	
9. Mr. T. Vasanthakumar — Coordinating Officer/JB	
A. **Major Raw Materials Consumption**	
1) Fabric	
a) 100 % Polyester (PET)	§100,363 kg/y
b) 100 % Viscose	§7,111 kg/y
c) 65:35 Polyester Viscose	§2,308 kg/y
2) Chemical	
a) Dyeing	§19,635 kg/y
b) Printing	§11,465 kg/y
c) Finishing	§1,928 kg/y
B. **Energy Consumption**	
a) Electrical energy	§520,821 kWh/y
b) Fuel for boilers	
Steam Boiler	§377,730 l/y
Thermic Boiler	§204,390 l/y
C. **Water Consumption**	
a) Municipal water	§48,864 m^3/y
b) Well water	§6,192 m^3/y

D.	**Production**	
	Installed Capacity	
	Jet Dyeing - Thies machine	225 kg/Batch
	Jet Dyeing - Fongs machine	225 kg/Batch
	Jigger No 1 to No 5 - Pretreatment/Dyeing	1000 m/Batch
	Jigger No 6 - Pretreatment/Dyeing	2500 m/Batch
	Printing machine - Flat bed printing	12000 m/Day
	Stentor - Heat setting/Finishing	50000 m/Day
	Fishing - Dyeing/Bleaching	125 kg/Batch
	Actual Production (February 95)	
	Dyeing	
	- Light shade 100% PET	3709.11 kg/month
	- Dark shade 100% PET	3150.23 kg/month
	- Dark shade 65:35 PolyViscose	192.37 kg/month
	- Super White 100 % PET	1504.30 kg/month
	- 100% Viscose fabric	592.60 kg/month
	Printing	
	- 100% PET Saree fabric.	4261.15 kg/month
	- Viscose dress fabric.	1992.06 kg/month
	Fishing Nets	
	- Dyed net	11125 kg/month
	- White net	7875 kg/month
E.	**Type of Effluent Treatment**	No treatment
F.	**Any Other Relevant Information :** The plant has about 1200 workers.Average production time per day 13 hours. JB has placed an order for an Effluent Treatment Plant of 120,000 l/day capacity.	

§ Annual values were estimated from February 1995 figures

2.0 Availability of Information

Available information was very limited. The team had to collect most of the information first hand. The information required for the material and water balance was collected and the balances are presented in sections 5.0 and 6.0. In the absence of measurement facilities and emission records, it was found to be difficult to make an energy balance.

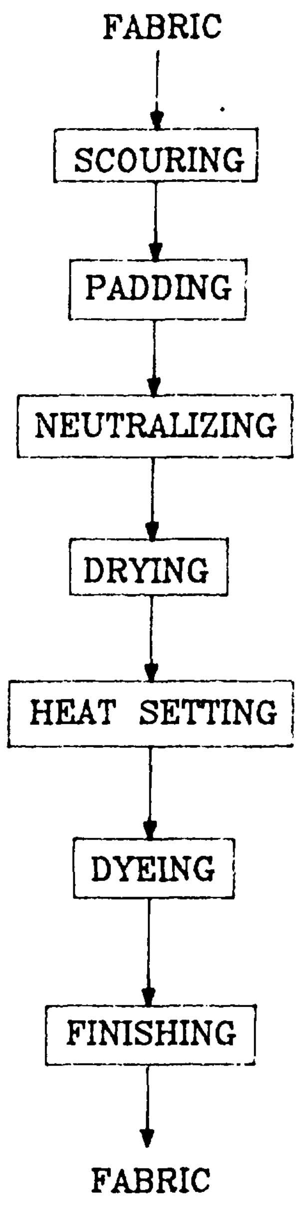
WORKSHEET 2		
Information	**Availability**	**Remarks**
Process flow diagram	Available	Satisfactory
Material Balance	Not available	Only monthly material consumption available
Energy balance	Not available	Monthly electricity and fuel consumption available
Water balance	Not available	Total and machinewise monthly consumption available
Plant layout	Available	Satisfactory
Waste analysis	Available	Only for waste water
Emission records	Not Available	No provision for recording
Production log sheets	Available	
Maintenance log sheets	Not available	

3.0 Process Flow Diagram

There are number of process utilized for manufacturing of dyed and printed fabrics. Worksheets 3.1 to 3.3 depict the most commonly used wet process. Further worksheets 3.4 to 3.13 depict more description of individual steps involved .

WORKSHEET 3.1

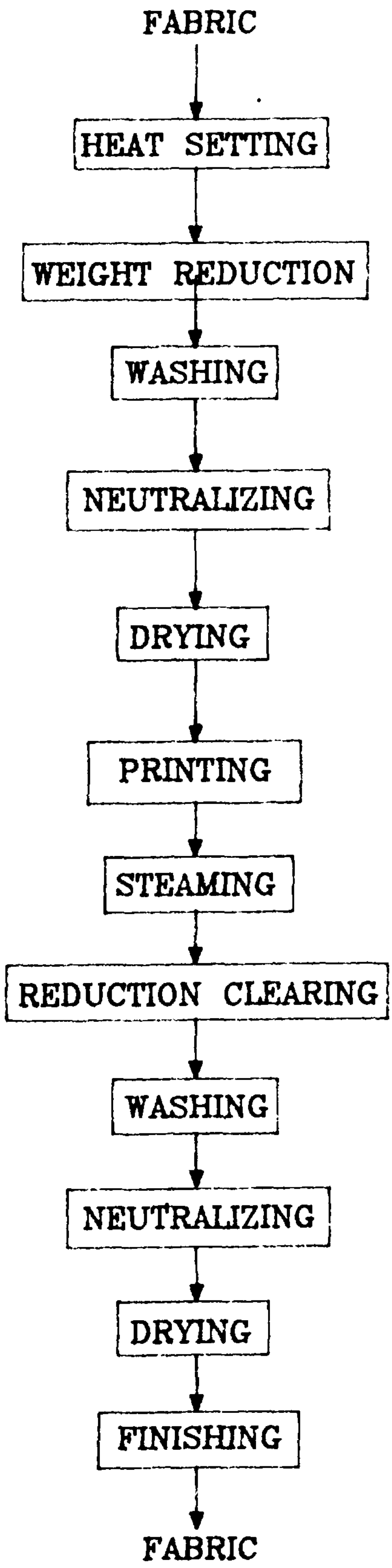
PROCESS FLOW DIAGRAM
FOR 100% POLYESTER DRESS FABRIC



WORKSHEET 3.2

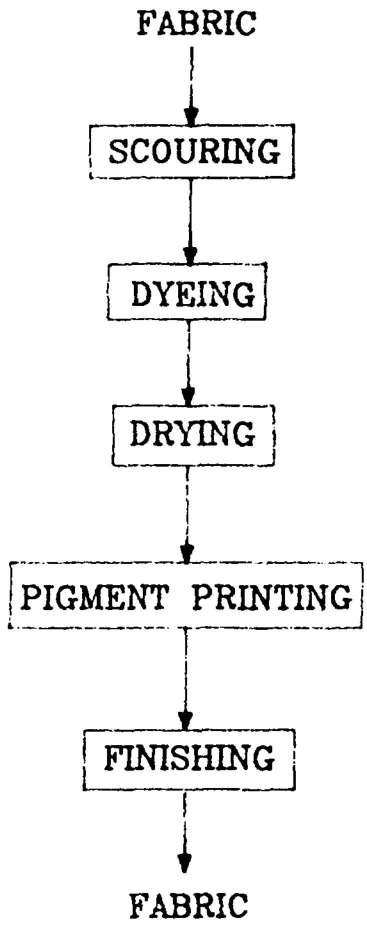
PROCESS FLOW DIAGRAM

FOR 100% POLYESTER SAREE FABRIC



WORKSHEET 3.3

PROCESS FLOW DIAGRAM
FOR 100% VISCOSE DRESS FABRIC

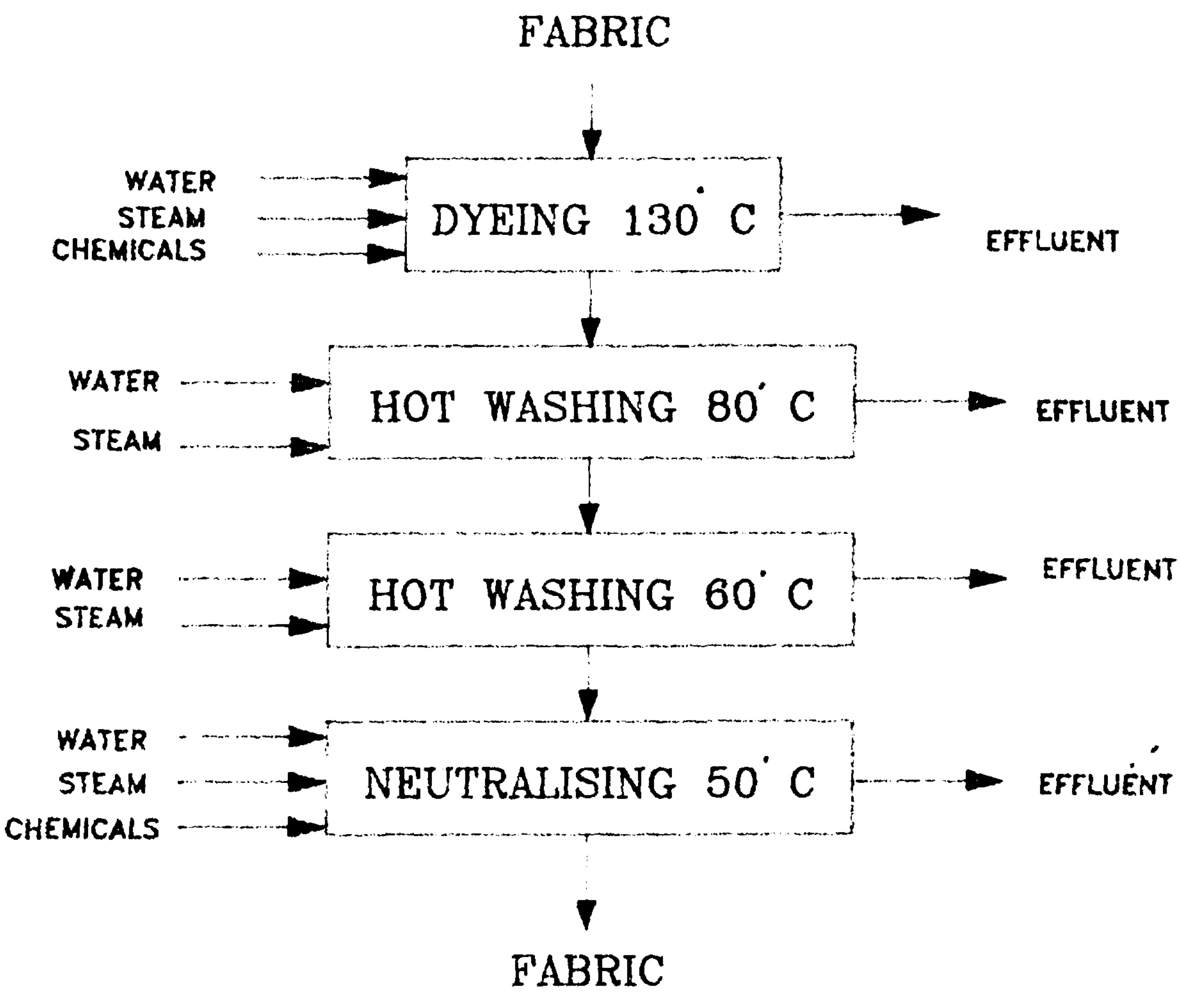


WORKSHEET 3.4

PROCESS FLOW SHEET

100% PET - RB101/1, B869, B247.

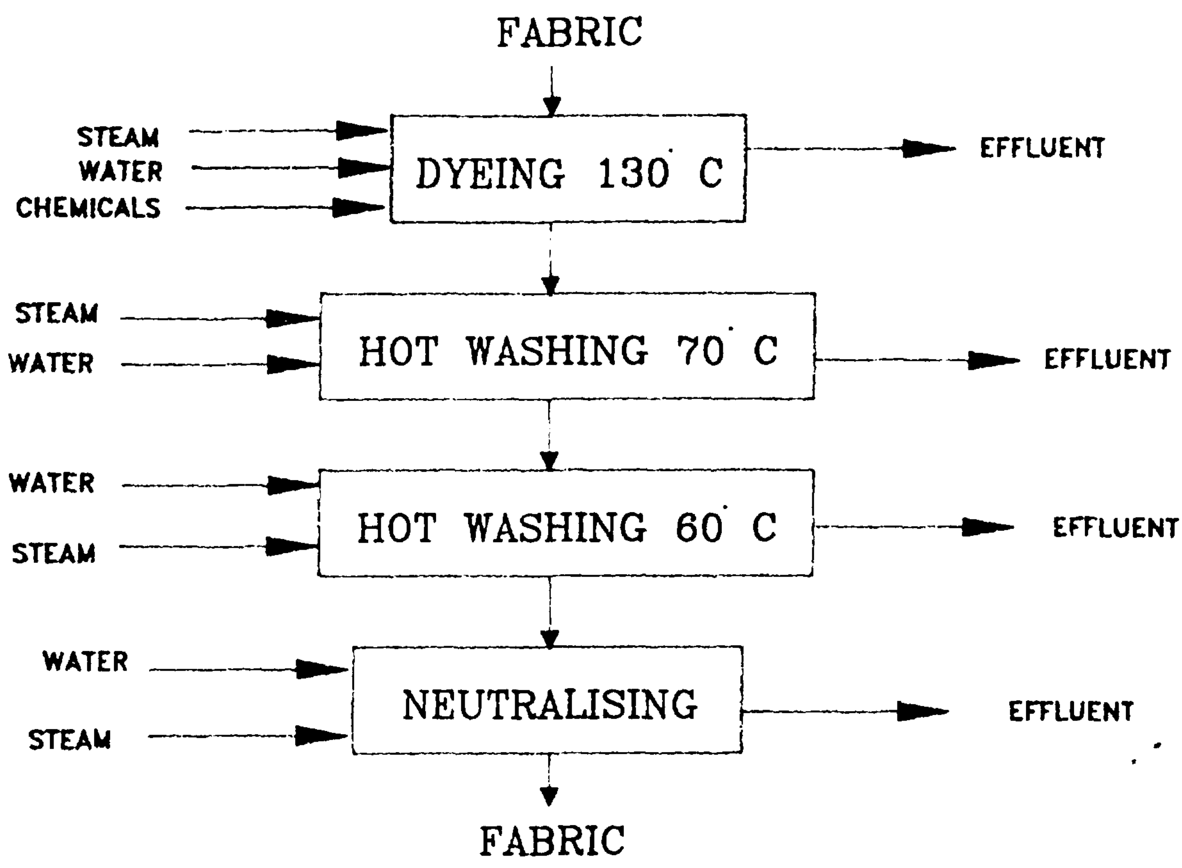
(JET DYEING)



WORKSHEET 3.5

PROCESS FLOW SHEET – DARK SHADE

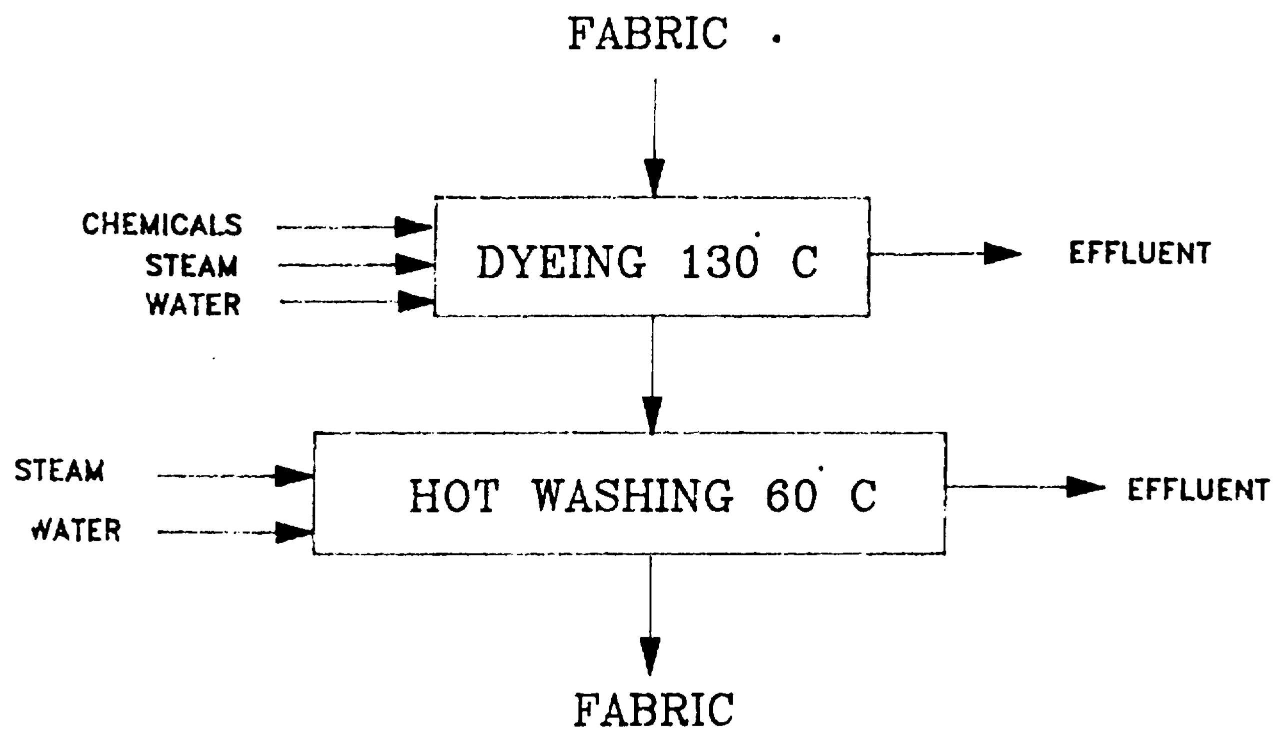
100% PET – S103, B454.
(JET DYEING)



PROCESS FLOW SHEET - LIGHT SHADE

100% PET - RS97/2, S104, RS69/2, S103.

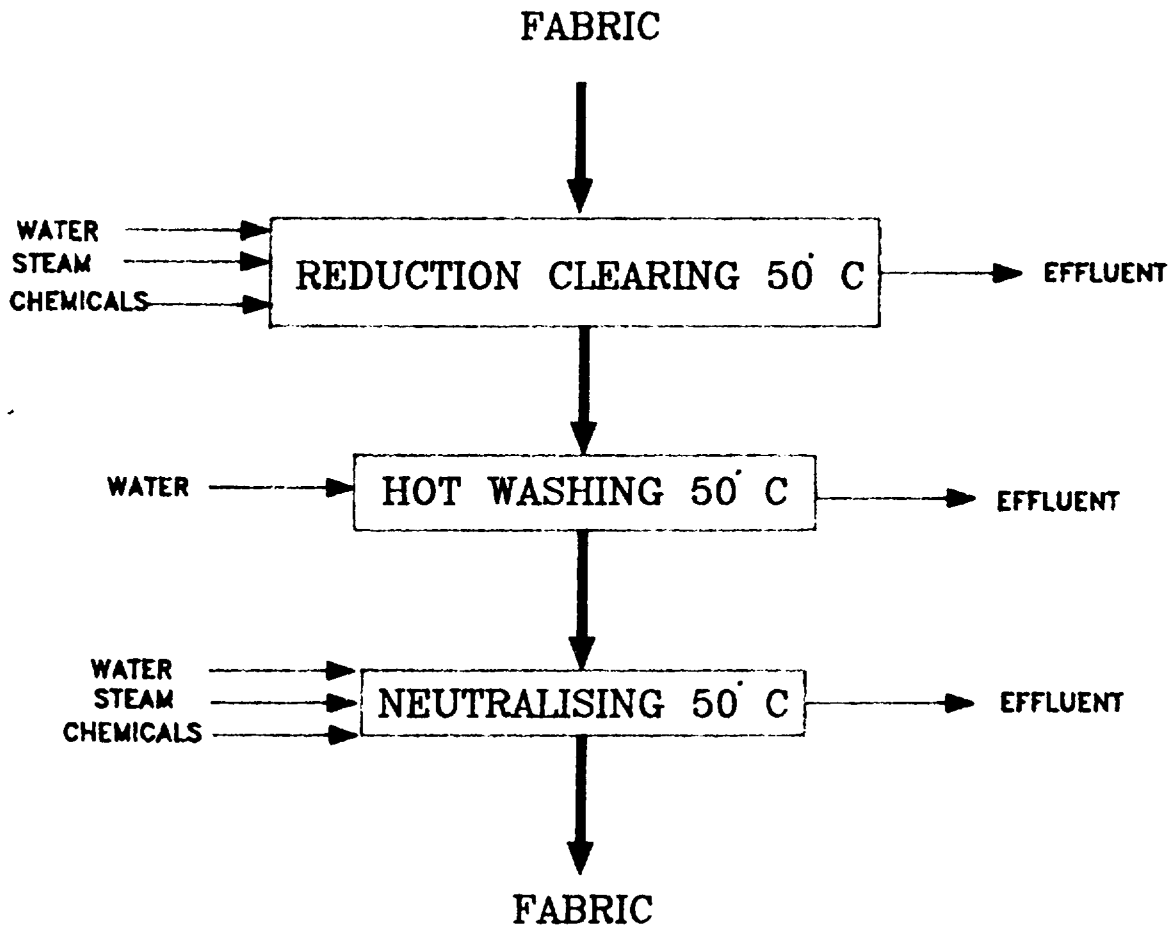
(JET DYEING)



WORKSHEER 3.7

PROCESS FLOW SHEET

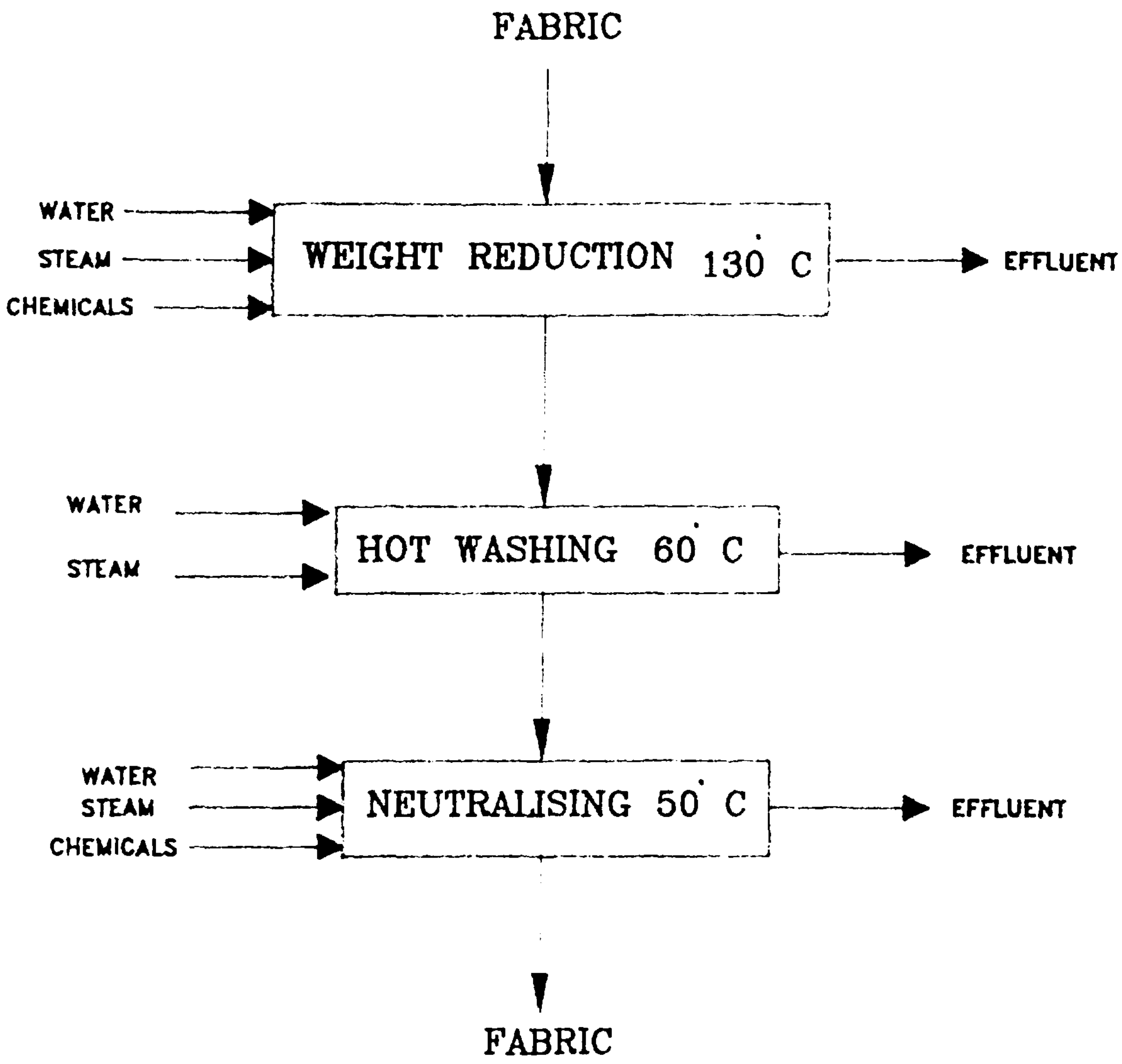
100% PET PRINTED SAREE
(JET REDUCTION CLEARING)



WORKSHEET 3.8

PROCESS FLOW SHEET

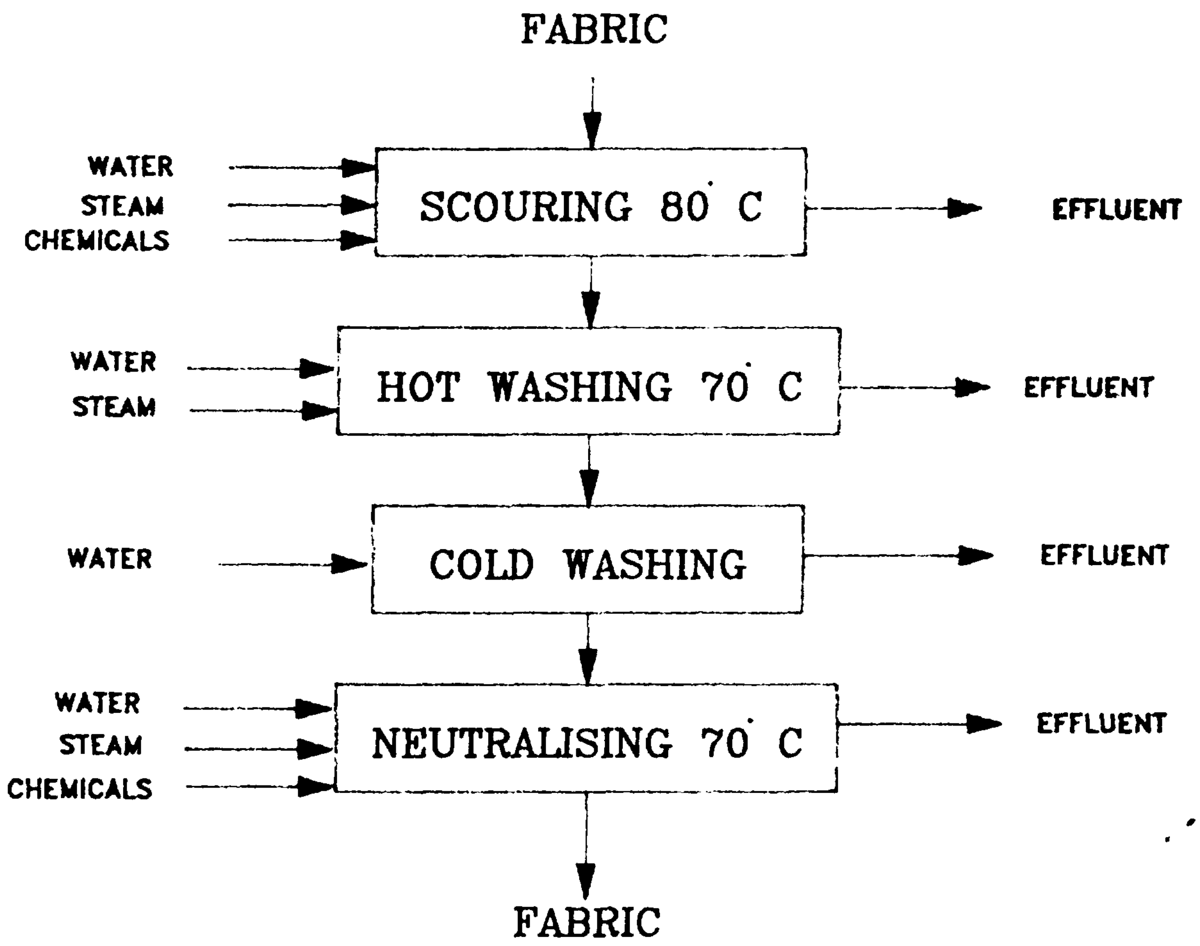
100% PET SAREE RS69 RS97/2 RB101/1 RS98 RS104
(JET WEIGHT REDUCTION)

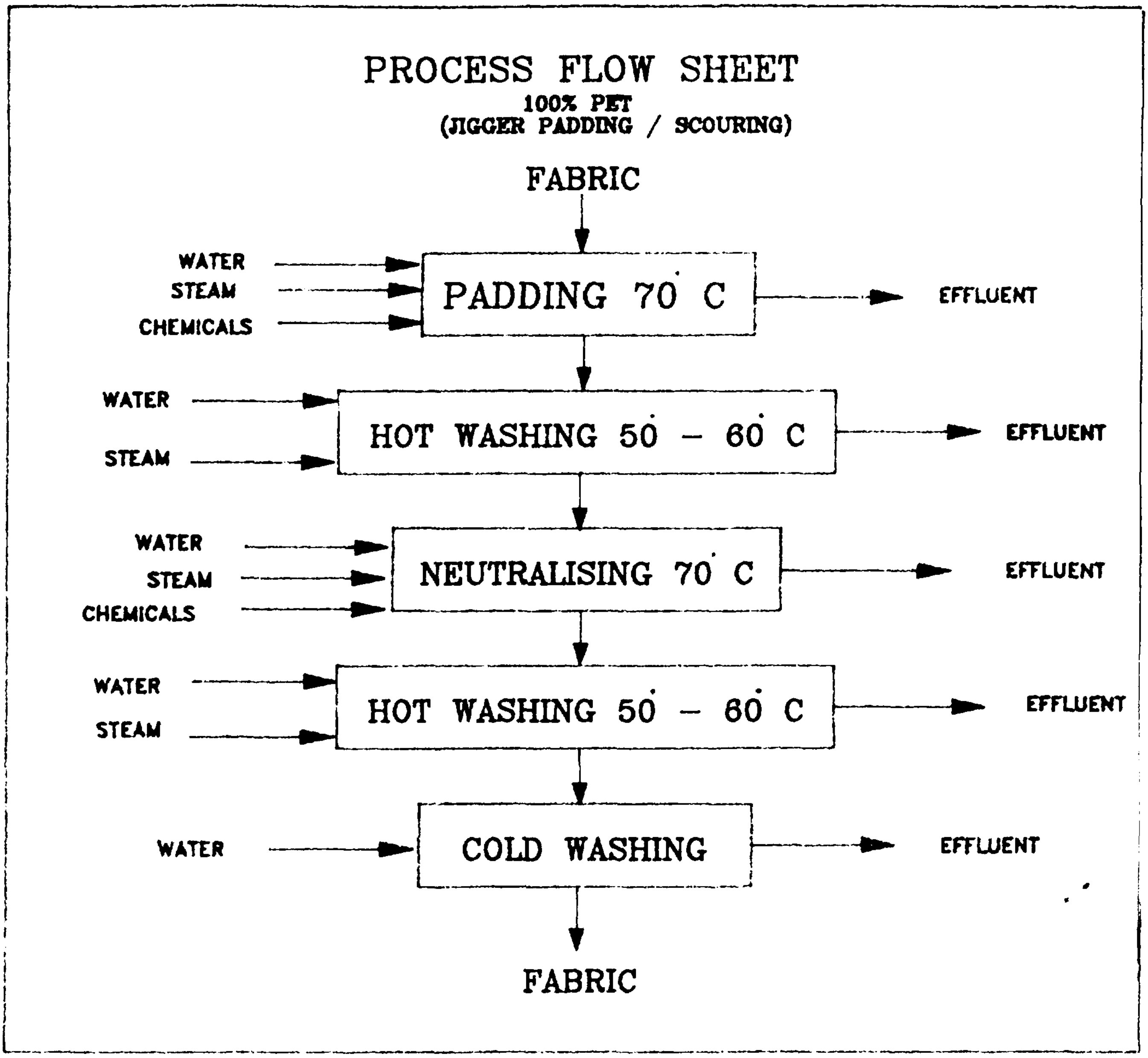


WORKSHEET 3.9

PROCESS FLOW SHEET

100% PET – DYED YARN SHIRT (JIGGER SCOURING)

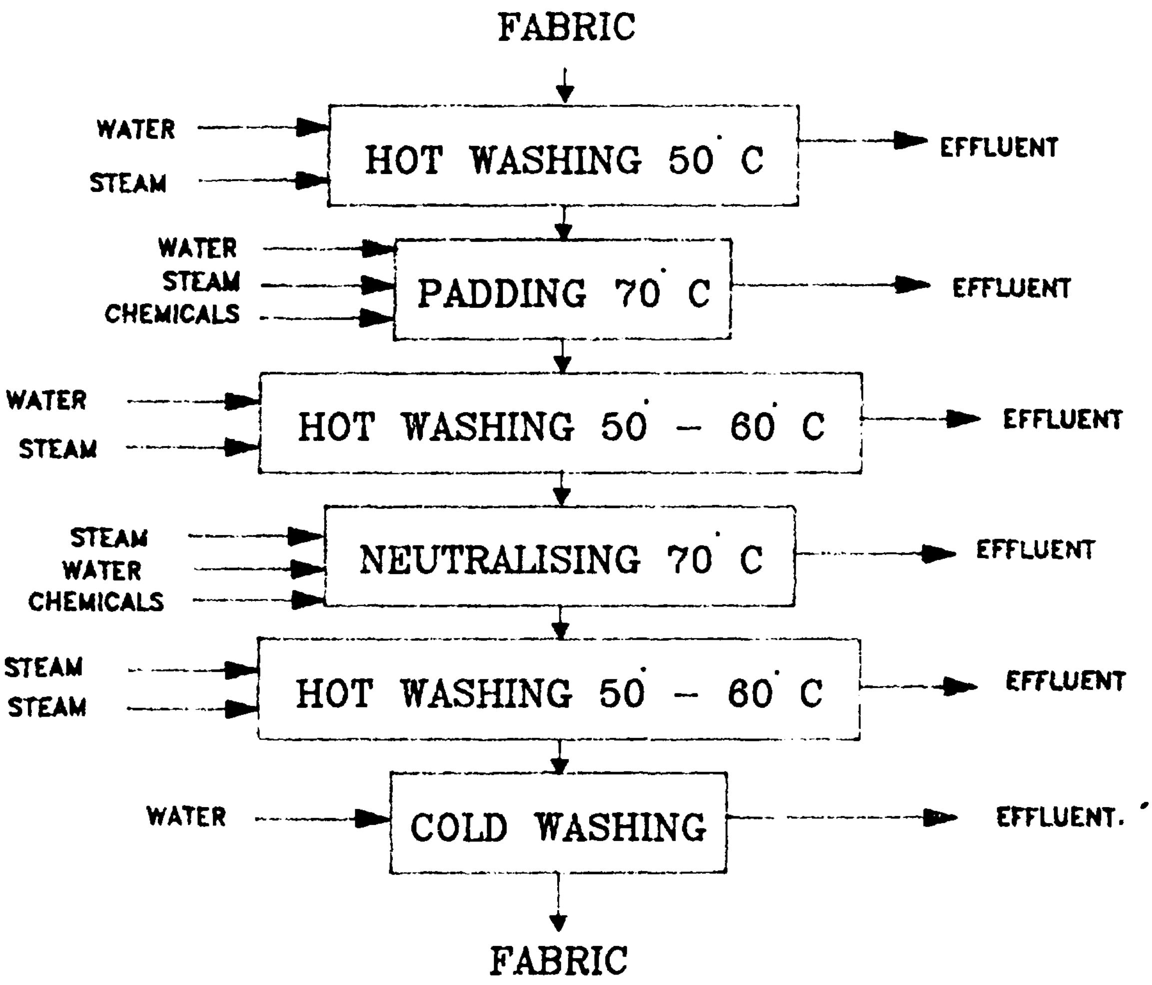


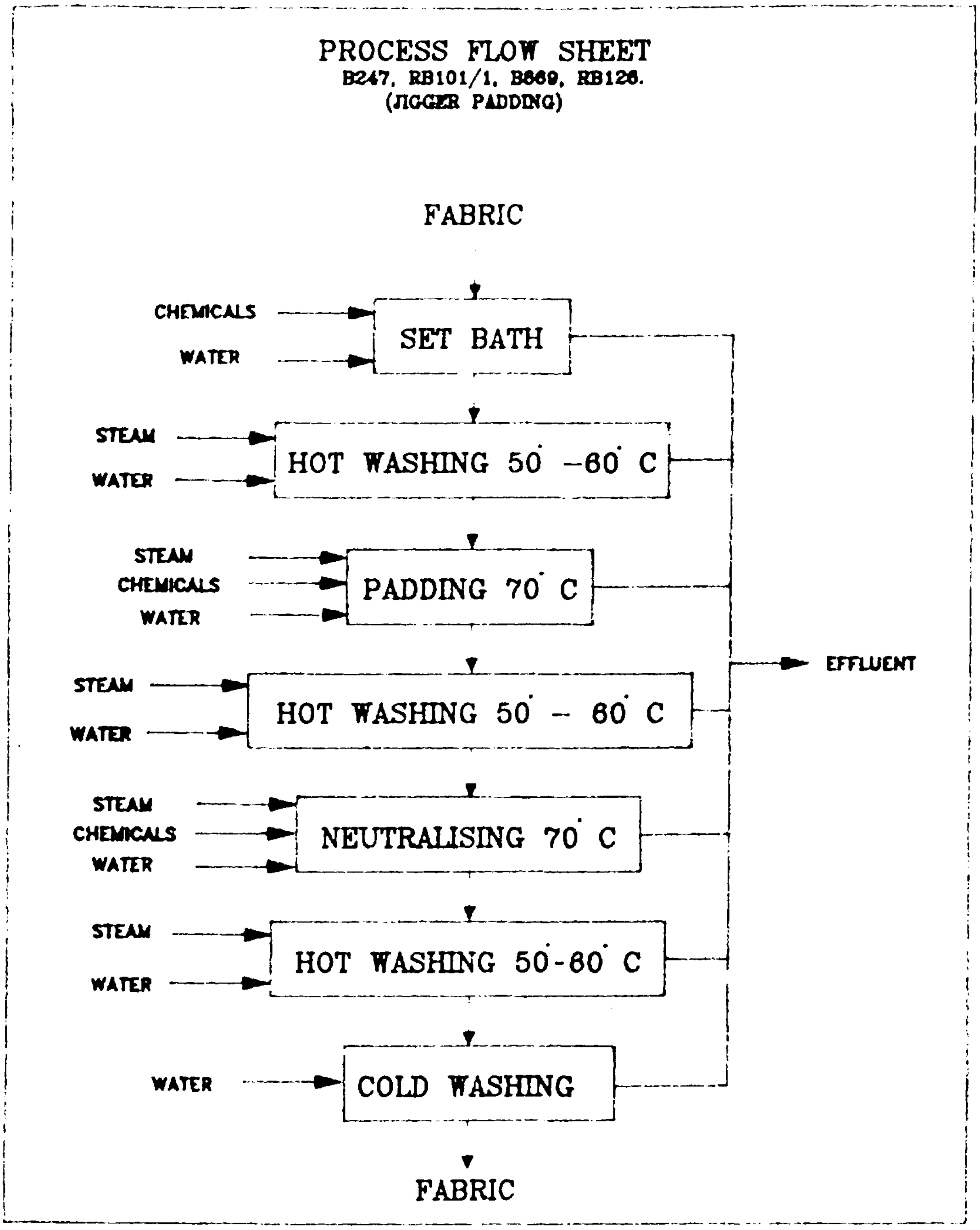

PROCESS FLOW SHEET
100% PET
(JIGGER PADDING / SCOURING)
FABRIC
WATER
STEAM
CHEMICALS
PADDING 70° C
EFFLUENT
WATER
STEAM
HOT WASHING 50° - 60° C
EFFLUENT
WATER
STEAM
CHEMICALS
NEUTRALISING 70° C
EFFLUENT
WATER
STEAM
HOT WASHING 50° - 60° C
EFFLUENT
WATER
COLD WASHING
EFFLUENT
FABRIC

WORKSHEET 3.11

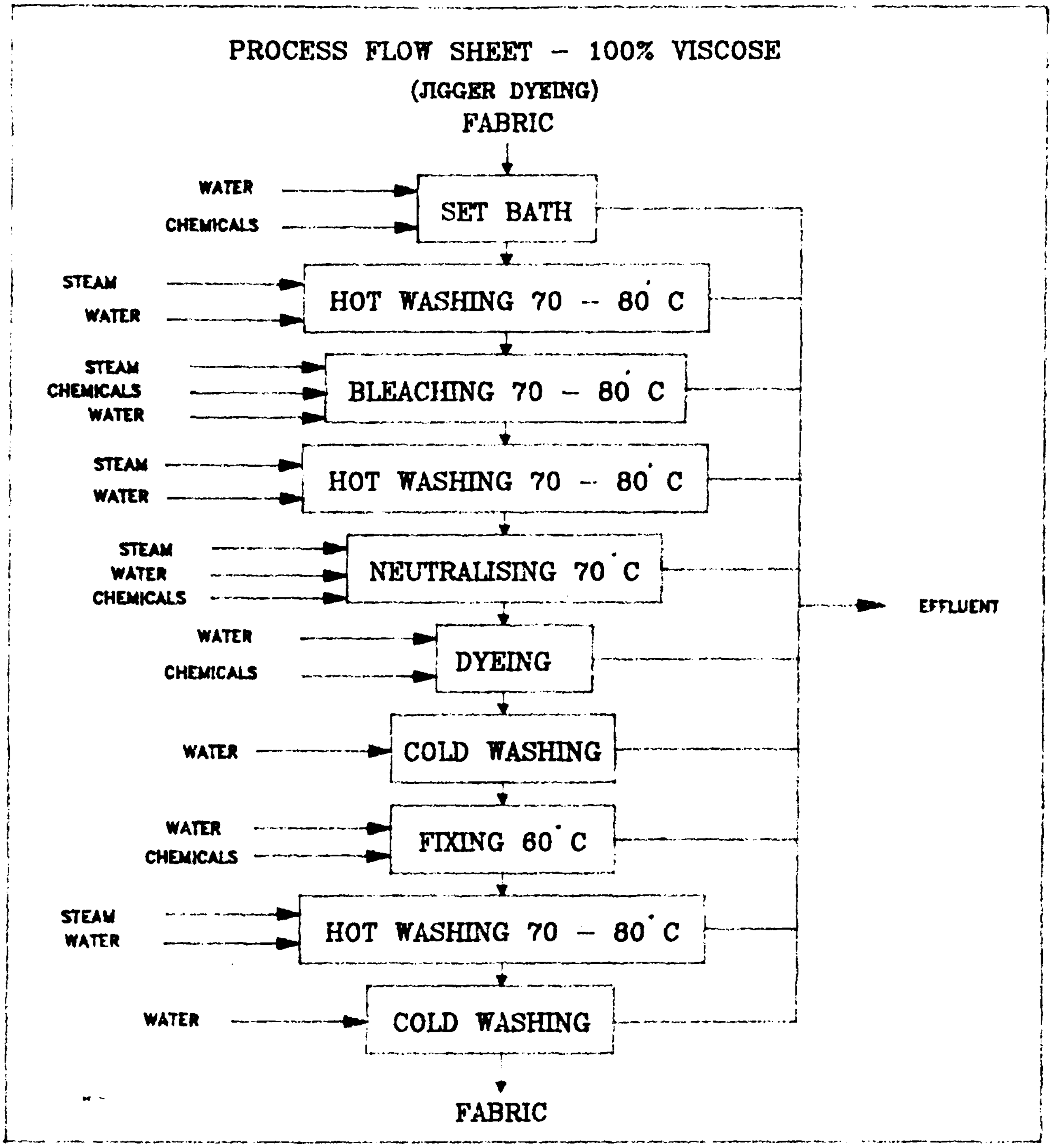
PROCESS FLOW SHEET – S103, S104, RS69.

(JIGGER PADDING)




PROCESS FLOW SHEET
B247, RB101/1, B869, RB126.
(JIGGER PADDING)
FABRIC
CHEMICALS
WATER
SET BATH
STEAM
WATER
HOT WASHING 50° -60° C
STEAM
CHEMICALS
WATER
PADDING 70° C
EFFLUENT
STEAM
WATER
HOT WASHING 50° - 60° C
STEAM
CHEMICALS
WATER
NEUTRALISING 70° C
STEAM
WATER
HOT WASHING 50-60° C
WATER
COLD WASHING
FABRIC

WORKSHEET 3.13



4.0 House keeping status

The waste audit team had a detailed look at the plant and identified several housekeeping lapses that can't be quantified financially. However these will affect the production output by decreasing the productivity of the workers.

WORKSHEET 4.0 General remarks related to housekeeping	
Sections	**Lapses in Housekeeping**
Main Stores	* Chemicals,Solvents,Dyes are not stored separately from other miscellaneous materials like spare parts,nails, electrical items etc. * Spillage in issuing of kerosene. * Fire hazardous materials are not stored safely. * Wrapping materials, empty packing boxes, cans consume considerable space.
Dye House	* Chemical Preparation sub-stores - Chemical spillage during weighing, preparation and handling. - Dust generation when handling chemicals powders. - Empty cans and wrapping materials.

5.0 Material Balance

Material balance presented in Worksheet 5 was carried out using actual material consumption figures of the month of February 1995 (Annexure E), and calculated values of water and steam consumptions. (Assumptions and other calculation details are given below the worksheet)

WORKSHEET 5

Unit operation	Input material		Output material(Quantity in kg)		
			Product(kg)	Waste stream(kg)	
	Name	Quantity (kg)		Liquid	Solid/ Gaseous
Scouring	Fabric	658.07	638.32	¶ 19.75	Nil
			(403.14)		
	Water	5600.00		5196.86	
	Steam	442.83		442.83	
	Acetic acid	1.69		1.69	
	Soda ash	2.80		2.80	
	Detergent	1.40		1.40	
Scouring & Padding	Fabric	1919.46	1861.87	¶ 57.59	Nil
	Moisture		(1175.9)		
	Water	22000.00		20824.10	
	Steam	1634.50		1634.50	
	Oxalic acid	44.00		44.00	
	Soda ash	4.94		4.94	
	Detergent I	2.46		2.46	
	Antifoam I	8.80		8.80	
	Levelling agent	4.40		4.40	
Padding	Fabric	3836.23	3836.23		Nil
		(2416.80)	(2416.80)		
	Water	57400.00		57400.00	
	Steam	5300.00		5300.00	
	Hydro sulphate	1.43		1.43	
	Oxalic acid	49.00		49.00	
	Soda ash	9.34		9.34	
	Detergent I	4.67		4.67	
	Antifoam I	16.80		16.80	
	Caustic soda	5.75		5.75	
	Detergent II	0.71		0.71	
	Levelling agent	3.31		3.31	
	HCl	8.40		8.40	

Dyeing	Fabric	9,209.90 (5,802.00)	9,209.90 (5,802.00)		Nil
	Water	194,000.00		194,000	
	Steam	26,920.00	§ 14,035.00	12,885.76	
	Acetic acid	162.25		162.25	
	Disperser I	37.50		37.50	
	Disperser II	37.50		37.50	
	Antifoam II	12.00		12.00	
	Wetting agent I	31.25		31.25	
	Wetting agent II	22.00		22.00	
	Levelling agent	60.00		60.00	
	Reactive dye	2.50	1.5	1.00	
	Disperse dye	129.45	122.97	6.48	
	Direct dye	2.80	2.46	0.34	
Reduction clearing	Fabric	3,336.83 (2,102.20)	3,336.83 (2,102.20)		Nil
	Water	78,000.00		78,000.00	
	Steam	3,416.00	§ 921.00	2,495.00	
	Caustic	41.60		41.60	
	Antifoam II	5.20		5.20	
	Acetic acid	20.80		20.80	
	Wetting agent 3	10.40		10.40	
Weight reduction	Fabric	4,115.28	3,497.98	¶ 617.30	Nil
	Moisture	(2,592.00)	(2,203.00)		
	Water	102,000.00		102,388.00	
	Steam	11,142.10	§ 3,259.00	7,882.00	
	Acetic acid	238.00		238.00	
	Detergent I	241.40		241.00	
	Antifoam I	238.00		238.00	
	Whitening agent	85.00		85.00	
	Caustic soda	24.49		24.49	
	$NaHCO_3$	11.90		11.90	
Printing	Fabric	6,253.21	6,253.21		Nil
	Water	1913,280.00		1913,280.00	
	TiO_2 ink	750.00	525.00	225.00	
	Buffer	80.00	56.00	24.00	
	Thickening agent	825.00	577.50	247.50	
	Levelling agent	42.50	29.75	12.75	
	Citric acid	160.00	112.00	48.00	
	Dyes	42.50	29.50	13.00	
Finishing	Fabric	19,409.50	19,409.50		**
	Finishing agent I	45.00			
	Finishing agent II	25.00			
	Whitening agent	27.50			
	Catalyst	14.00			
	Fabric softener	214.00			
	Finishing agent III	432.50			
	Poly vinyl acetate	80.75			

Dyeing/ Washing	White net	11,125.00	11,125.00		Nil
	Dyed net	7,875.00	7,875.00		
	Water	516,000.00		516,000.00	
	Acetic acid	85.20		85.20	
	Citric acid	34.20		34.20	
	Glauber salt	285.00		285.00	
	Na hydrosulpite	45.00		45.00	
	Tri Na phospate	45.00		45.00	
	Optical whitener	132.00		132.00	
	Dye	85.50		85.50	

Total volume of process effluent calculated as 2918 m^3/month, of which 516 m^3/ month is generated from fishing net production.

§ The steam condensate from Thies jet is presently recycled. The steam condensate generated from the other machines is discharged into the drain.

* Fabric weight with moisture content of 7% weight/ weight

¶ Weight loss during scouring and weight reduction processes.

** All chemicals absorbed into the fabric and volatile matter will be evaporated during finishing in the stenter

ASSUMPTIONS

1. Fabric weight loss is 3 % and 15 % after scouring and weight reduction processes respectively. [Ref 1]

2. Moisture content of wet fabric in weight basis

   Grey fabric - 7%

   After wet processing - 43%

   After drying - 6%

   The above figures are based on analytical results, obtained by the audit team.

3. The fixation of Reactive, Disperse and Direct dyes are 60%, 95%, and 88% respectively [Ref 2] and all other chemicals are not absorbed into the fabric.

CALCULATIONS

1) Weight reduction of fabric

Raw weight of polyester fabric = m_1

Weight after scouring = $0.97\ m_1$

2) Moisture absorbed into wet fabric

Moisture absorbed into wet fabric	=	(Weight of wet fabric - Weight of raw fabric)
Weight of raw fabric	=	m_2
Dry weight of fabric	=	$0.93m_2$
Weight of wet fabric	=	$0.93m_2 / (1 - 0.43)$
Moisture absorbed into wet fabric	=	$(0.93m_2 / 0.57) - m_2$
	=	$0.63m_2$

3) Water consumption

Water consumption for processing steps are calculated using water capacity of machine. Water capacity of jigger no 1 to no 5, jigger no 6, and jets are 200 l, 400 l and 1000 l respectively. Water consumption for printing was obtained from industry.

4) Steam consumption

Steam consumption is calculated using heat requirement for each process to achieve required temperature and properties of boiler steam.

Steam consumed = $(cp_f \times m_f + cp_l \times m_l)(T_o - T_r) / h_f)$

Where, cp_f & cp_l are specific heats of fabric & liquid

$cp_f = 1.4$ kJ/kg°K; $cp_l = 4.2$ kJ/kg°K [Ref 3]

m_f & m_l; mass of fabric & liquid

T_o & T_r; operating & room temperature $T_r=30^0C$

h_f is heat released from steam condensation $h_f = 2000$ kJ/kg

Heat absorbed into the machine and other losses are neglected.

5) Chemical consumption

Chemical consumed = (consumption according to the recipe) x (Machine water capacity)
eg.; for scouring process in jigger no 6
Soda ash concentration is 2.0 g/l
Water capacity 400 l
Caustic consumed for a batch = (2.0 x 400)/ 1000 kg
It is assumed that quantity of chemicals retained on the fabric is negligible

Recipes are given in Annexure F.

6) Loss of dyes

Quantity of dye going out with effluent = (quantity of dye use/month) (100 - % fixation)

Reactive dyes	60 % fixation
Disperse dyes	95 % fixation
Direct dyes	88 % fixation [Ref2].

6.0 Total Water Balance

A breakdown for water consumption for each unit operation was calculated on a theoretical basis, and is presented in Worksheet 6. This enabled the determination of the high water consuming activities and the undefined consumption.

WORKSHEET 6.0					
Operation		**Estimated water consumption. (m^3)**	**Product (kg/month)**	**Water /fabric (kg/kg)**	**% usage**
Scouring	✡	6	658	9	0.12
Scouring & Padding	✡	22	1,919	11	0.47
Padding	✡	58	3,836	15	1.25
Reduction Clearing	✡	78	3,336	23	1.70
Weight Reduction	✡	102	4,115	25	2.22
Dyeing	✡	194	9,209	21	4.22
Printing	♫	1,914	6,253	306	41.70
Cooling water	♫	11			0.23
Design department	♫	5			0.10
Stenter finishing & cleaning	♫	45			0.97
Boilers	♫	352			0.21
Workers bathing	✡	100			2.17
Domestic usage & Sanitation (hostel)	♫	550			11.98
Fishing net section	♫	516	19,000	27	11.24
Total quantified water consumption		3,953			86.11
Actual water consumption	♫	4,588			100
Undefined water consumption		635			13.88

♫ Obtained from industry
✡ Estimated by team

* Process water for fabric processing is obtained from municipal water supply and was estimated from municipal water meter readings. Water for fishing net section is obtained from deep well. The factory does not have any provision to measure water consumption as well as effluent volume.

* The 636 m^3 undefined water consumption may be attributed to floor washing, leakage or additional rinses.

* Boiler, domestic usage, cooling, printing and stenter water consumption were obtained from industry

* Water consumption for processing was estimated using water capacity of machine.
Water consumption = (no of discharges / month) x (machine water capacity/batch)

* Domestic water consumption is estimated from usage per head
(workers 40, working days for the month 25, usage per head 100 l)
(40 x 25 x 100) = 100,000 l

* For fishing net production well water is being used.
Monthly fishing water consumption is 516 m^3 and the rate estimated to be Rs 1.50/ m^3

7.A COD Analysis of effluent

COD analysis was carried out for several discharges of machines operated on one day to obtain an understanding of the discharges that contribute the highest to the pollution load. Results are presented in Worksheet 7A. COD values are co-related with volume of water discharge/batch. The COD analysis was carried out by Central Environmental Authority (CEA) laboratory staff in October 1995

WORKSHEET 7.A

STREAM	COD mg/l	WATER l/batch	COD kg/batch	COD%
JET WEIGHT REDUCTION				
Weight reduction	1780	1000	1.78	24.82
Hot wash	2715	1000	2.71	37.79
Neutralizing	1460	1000	1.46	20.36
Printing				
Blanket washing	370	3300	1.22	17.01
TOTAL		6300	7.17	100

7.B WASTE AND EMISSIONS COST

Material consumption figures from the material and water balance (worksheet 5 & 6) and COD analysis data presented in worksheet 7A,were utilised, to estimate the amount of waste generated from each unit operation. Total cost of waste stream of each process operation was calculated using the cost of its constituent and the treatment cost based on COD removal.

WORKSHEET 7.B				
UNIT OPERATIONS	**COST COMPONENT**	**QUANTITY (kg/MONTH)**	**UNIT COST (Rs/kg)**	**TOTAL COST (Rs/MONTH)**
SCOURING	Chemicals	5	45.4	227
	Steam	443	0.75	332
	Water	5,600	0.021	453
	COD removal	5.7	30	171
	Total Cost Assigned to Waste Stream **Cost assigned per m³ effluent**			**1,183** **195**
SCOURING & PADDING	Chemicals	64	90.35	5,783
	Steam	1,634	0.75	1,225
	Water	22,000	0.021	462
	COD removal	73	30	2,190
	Total Cost Assigned to Waste Stream **Cost assigned per m³ of effluent**			**9,660** **408**
PADDING	Chemicals	99	86.6	8,578
	Steam	5,300	0.75	3,975
	Water	57,400	0.021	1,205
	COD removal	112.8	30	3,384
	Total Cost Assigned to Waste Stream **Cost assigned per m³ of effluent**			**17,142** **273**
WEIGHT REDUCTION §	Chemicals	802	221.5	177,658
	Steam	11,142	0.75	8,356
	Water	102,000	0.021	2,142
	COD removal	202	30	6,060
	Total Cost Assigned to Waste Stream **Cost assigned per m³ of effluent**			**194,246** **1,760**

REDUCTION CLEARING	Chemicals	78	68.8	5,371
	Steam	3,416	0.75	2,562
	Water	78,000	0.021	1,638
	COD removal	43	30	990
	Total Cost Assigned to Waste Stream **Cost assigned per m³ of effluent**			**10,561** **131**
PRINTING §	Chemicals	557	285.1	103,155
	Water	1913,280	0.021	40,178
	Dye	13	500	6,500
	COD removal	708	30	21,240
	Total Cost Assigned to Waste Stream **Cost assigned per m³ of effluent**			**171,073** **89**
FISHING NET PROCESSING	Chemical	711	87	61,857
	Water	516,000	0.021	10,836
	COD removal	903	30	27,090
	Total Cost Assigned to Waste Stream **Cost assigned per m³ of effluent**			**99,783** **193**
DYEING	Water	194,000	0.021	4,074
	Steam	26,920	0.75	20,190
	Dye	8	500	4,000
	Chemical	362	117	42,354
	COD removal	460	30	13,800
	Total Cost Assigned to Waste Stream **Cost assigned per m³ of effluent**			**84,418** **382**
COMPOSITE EFFLUENT	**Total Cost Assigned to Waste Stream** **Total waste stream** **Cost assigned per m³ of effluent**			**Rs 588,066** **2945 m³** **Rs 200**

Unit cost of disposal based on the COD of the effluent which includes both chemical and biological treatment cost (Details are given in Annexure G)
Details of steam cost calculation is given in Annexure H
Utility costs and utility costs/ kg fabric are given in Annexure I

§ COD load is estimated from the actual COD data measured by CEA

Total COD load = 2,507.50 kg/month
The average COD of process effluent = 851 mg/l
Assuming COD of the domestic effluent is 300 mg/l
Average COD of the total factory effluent = 751 mg/l

8.0 Waste minimisation options

Waste minimisation options were identified by the waste audit team based mainly on observations made during visits to the industry. Losses identified from the material and water balances helped in identifying some of the options. The options identified together with other details are presented in Worksheet 8.

Actions were identified for each option, which would help in assessing the costs and benefits of implementing the option. It is anticipated that these actions would help the industrialist subsequently in determining the suitability of implementation. The time required to implement the option and the cost also were noted, as it is these features, that would help in motivating the industry in its implementation/nonimplementation. The priority that would be given for implementing each option was determined in discussion with the management of the industry.

WORKSHEET 8.0								
Process Unit	**Unit operations**	**Waste Minimisation (WM) Option**	**Actions to assess WM Options**	**Category**	**Effect**	**Priority**	**Timing**	**Cost**
JIGGER	All operations	J 1: Installation of temperature control system	- Measure maximum variations in temperature Estimate cost of installation of control system & energy savings	PC	WM ES	3	LT	M
	All operations	J 2: Substitute formic acid for acetic acid	- Estimate cost reduction by substitution - Carry out trials - Evaluate COD loads	MC	WM PR	8	ST	L
	Padding	J 3: Reduce oxalic acid amount in padding	- Do trials with reduced quantity of oxalic acid - Determine COD levels before and after	RC	WM PR CR	5	MT	L
	Padding	J 4: Use oxalic acid if only rust stains are found on grey fabrics	- Train supervisor in identifying rust stains on grey fabrics	RC	WM PR CR	5	ST	L

CR - Chemical Reduction
HK - Housekeeping
MC - Material Change
QI - Quality Improvement
SI - Safety Improvement
DCB - Di Chloro Benzene
IC - Inventory Control
MT - Medium Term
RC - Resource Conservation
TC - Technology Change
EM - Equipment Modification
L - Low Cost
PC - Process Control
RR - Resource Recovery
WM - Waste Minimisation
ES - Energy Savings
LT - Long Term
PCP - Penta Chloro Phenol
ST - Short term
1 - 10 - Increasing priority
H - High cost
M - Medium Cost
PR - Pollution Reduction

WORKSHEET 8.0								
Process unit	**Unit operation**	**Waste Minimisation (WM) option**	**Actions to assess WM option**	**Category**	**Effect**	**Priority**	**Timing**	**Cost**
WEAVING	Weaving	W 1 : Minimise yarn waste on the weaving looms	- Determine yarn waste - Develop methods for minimisation	RC	WM	3	ST	L
	Weaving	W 2 : Minimise loom oil getting to the fabric	- Estimate oil content in fabric - Discuss with factory management - Estimate savings in scouring & bleaching chemicals	RC	WM PR	4	ST	L
	Weaving	W 3 : Avoid buying tinted yarn	- Discuss with factory management regarding possibilities	RC	WM PR	3	MT	L
	Weaving	W 4 : Regular quality control of yarn for oil content	- Check the oil content in yarn - Estimate reduction in chemicals	RC	WM PR			L
JET DYER	All operations	J 1 : Condensate recovery of Fongs jet	- Measure condensate flow rate - Determine the running time of the machine - Estimate the pipeline cost upto the common condensate pipe line - Estimate total energy & water saving	RR	ES WM	7	MT	M

Process unit	Unit Operation	Waste Minimisation (W M) option	Actions to assess W M options	Category	Effect	Priority	Timing	Cost
JET DYER	All operations	JD 2 : Jet dyer lagging	- Estimate the cost of lagging of jet dyer surface - Measure present surface temperature - Estimate the energy savings assuming the surface temperature is 35-40°C after lagging	RC	ES	6	MT	M
	All operations	JD 3 : Collect cooling water	- Estimate flow rate & water savings	RC	ES WM	7	MT	M
	All operations	JD 4 : Recycling of wash water	- Identify rinse water for recycling - Carry out trials - Estimate water/ chemical/ energy savings	RC	WM ES	4	MT	M
	All operations	JD 5 : Installation of press button switches for view glass bulbs	- Calculate the energy loss by keeping bulb on during processing - Estimate cost of installation & energy savings	RC	ES	7	ST	L

Process unit	Unit Operation	W M option	Actions to assess W M options	Category	Effect	Priority	Timing	Cost
JET DYER	Scouring	JD 6 : Discontinue use of DCB, Perchloroethylene, carcinogenic & toxic chemicals	- Check for the presence of these chemicals in scouring aid/terry dye - Look for chemical substitution	MC	SI	5	MT	M
	Scouring	JD 7 : Check quality of HCl	- Check presence of HF (can cause corrosion) - Check presence of Fe^{2+} (can cause dullness in shades)	PC	QI	4	MT	L
	Dyeing	JD 8 : Use straight chain fatty alcohol ethoxylate based detergent instead of nonipol, nonionic detergent	- Check cloud point of nonipol - Determine the cost reduction with new substitute	MC	PR SI	4	MT	L
	Scouring	JD 9 : Adding Thiourea dioxide in scouring & reduction clearing operation	- Do trials to find out Thiourea dioxide quantity required - Estimate cost reduction - Evaluate low COD loads	MC	PR WM	4	MT	L

Process unit	Unit Operation	W M option	Actions to assess W M options	Category	Effect	Priority	Timing	Cost
JET DYER	All operations	JD 10 : Reduce the number of washings	- Carry out trials	RC	WM	4	MT	L
	Dyeing	JD 11 : Select dyes which exhaust with minimum salt	- Select suitable dyes - Compare cost	RC	WM	4	MT	L
	Dyeing	JD 12 : Avoid reduction clearing for light & medium shades	- Do trials without reduction clearing for light & medium shades	TC	WM ES	6	ST	L
STORES	House keeping	ST 1 : Reorganization of main stores	- Store chemicals, solvents, spare parts separately in the main stores	HK	SI WM	3	LT	L
	House keeping	ST 2 : Monthly physical verification of actual stocks	- Do a stock balance of chemicals issued in volume basis (mugs) with the computer stocks	IC	WM	5	ST	L
	House keeping	ST 3 : Keeping kerosene drums closed	- Educate stores supervisor & others	RC	SI WM	5	ST	L

Process unit	Unit Operation	W M option	Actions to assess W M options	Category	Effect	Priority	Timing	Cost
STORES	House keeping	ST 4 : Exchange of non-moving chemicals with other textile industries	- Identify non-moving chemicals - Identify ways of exchanging of non moving chemicals with other textile industries	IC	WM	4	LT	L
	All operations	ST 5 : Selling of empty plastic cans, wrapping material, bobbins without burning	- Identify a regular buyer - Estimate amount	RR	WM	4	LT	L
BOILER	All operations	B 1 : Lagging of unlagged steam lines & valves	- Measure the length of unlagged steam lines & valves - Calculate lagging cost - Estimate heat losses & savings	RC	WM ES	7	MT	M
	All operations	B 2 : Lagging of condensate lines	- As above	RC	WM ES	7	MT	M
	Boiler operations	B 3 : Improve boiler efficiency	- Carry out flue gas analysis - Tune the burner for maximum combustion efficiency	RC	ES PR	6	MT	M
	Boiler operations	B 4 : Filter cleaning	- Clean filter every 3 months - Estimate energy efficiency	RC	ES	4	ST	L
	Boiler operations	B 5 : Improve boiler water quality	- Check water quality for TDS, pH, Total hardness, DO - Estimate chemical savings	RC	ES	4	MT	L
	Boiler operations	B 6 : Lagging of boiler surface	- Estimate surface area - Calculate cost of lagging - Estimate heat losses & savings	RC	ES WM	5	MT	M

Process unit	Unit Operation	W M option	Actions to assess W M options	Category	Effect	Priority	Timing	Cost
BOILER	Boiler operation	B 7 : Install heat recovery unit for the boiler flue gas	- Measure and estimate heat loss with the gas - Estimate cost ofinstallation of the system to heat boiler feed water	RC	ES	3	LT	H
	All operations	B 8 : Inspect & repair main steam valves, steam traps & steam leaks	- Estimate losses Repair or replace if necessary	RC	ES WM	4	MT	M
STEAMER	Colour fixing	S 1 : Feed synthetic fabric in the form of "bound book" instead of conventional wrap with black grey in pressure steaming	- Carry out trials - Estimate increase in loading & energy savings	RC	ES WM	4	LT	M
PRINTING DRYER	Drying	PD 1 : Maintain residual moisture at 3-4% in viscose fabric	- Do trials to standardize the temperature & fabric speed to maintain the residual moisture - Estimate savings	PC	ES	4	LT	M
STENTER	Drying	STR 1 : Reduce idling time of stenter	- Plan use of stenter - Try to avoid heat-cool-heat system	RC	WM ES	5	LT	L

Process unit	Unit Operation	W M option	Actions to assess W M options	Category	Effect	Priority	Timing	Cost
STENTER	Drying	STR 2 : Eliminate grey fabric heat setting	- Do heat setting after scouring & weight reduction only - Check quality & estimate energy savings	RC	WM	6	ST	L
	Drying	STR 3 : Install vacuum extraction device after padding mangle on the stenter	- Estimate cost of installation & energy savings	EM	WM ES	3	LT	H
DYE HOUSE	Effluent treatment	DH 1 : Segregation of coloured effluent from alkaline effluent	- Estimate cost of segregation - Evaluate the cost of treatment	RC	WM	3	MT	H
		DH 2 : Neutralization of the alkaline effluent with the flue gas	- Carryout trials - Estimate the cost	RC	WM PR	3	LT	H
PRINTING	Printing	P 1 : Substitute citric w for citric acid	- Estimate cost reduction & reduction in COD loads	MC	WM	4	MT	L
	Printing	P 2 : Substitute kerosene with synthetic acrylic based thickner	- Do trials with 1:1 kerosene & acrylic based thickener & evaluate quality - If no problems regarding brilliancy of shades or viscosity do trials with 100% acrylic based thickener Estimate savings with pollution load component	MC	WM	6	MT	M
	Printing	P 3 : Recycling of blanket wash water	- Quantify blanket wash water amount - Select water treatment method for recycling - Estimate savings	RC	WM	6	MT	M

Process Unit	Unit Operation	W M option	Actions to assess W M options	Category	Effect	Priority	Timing	Cost
PRINTER	Printing	P 4 : Introduce a screen washing bath to minimise water use in screen washing	- Measure water usage in screen washing - Estimate cost of constructing a bath	RC	WM PR	7	MT	L
	Printing	P 5 : Proper cleaning of screens before washing	- Measure print paste remaining on screen - Estimate COD reduction & water savings	RC	WM PR	7	MT	L
	Printing	P 6 : Use high pressure water guns for washing	- Estimate water consumption for washing operations	RC	WM PR	6	MT	L
	Printing	P 7 : Proper removal of print paste from buckets before washing	- Quantify print paste waste getting into the effluent - Explore possibility of using print paste for dark shades	RC	WM PR	5	LT	L
	Printing	P 8 : Improve chemical handling	- Have separate spoons or cans to handle chemicals - Avoid washing spoons or cans	HK	WM PR	5	MT	L
	Printing	P 9 : Fix a doctor blade to the blanket	- Estimate cost of installation - Quantify print paste recovery - Estimate water savings	EM	WM PR	5	MT	M

Process unit	Unit Operation	Waste Minimisation (WM) option	Actions to assess WM options	Category	Effect	Priority	Timing	Cost
PRINTER	Printing	P 10 : Reuse of print paste collected from screens, squeezees etc.	- Quantify print paste returns - Estimate cost benefit	RC	WM PR	5	ST	L
	Printing	P 11 : Avoid PCP in gums	- Check the presence of PCP - Look for a substitute without PCP	MC	WM PR	4	MT	L
GENERAL	All operations	G 1 : Use an overhead tank for process water distribution	- Estimate water requirement & tank capacity - Estimate energy & water savings	RC	WM	4	LT	H
	All operations	G 2 : Repair or replace broken valves & joints in water lines in toilets	- Identify broken valves & joints - Estimate cost of replacing	RC	WM	5	MT	M
	All operations	G 3 : Replace water taps in toilets with self closing valves	- Estimate water usage with present system - Estimate cost benefit	RC	WM	4	MT	M
	All operations	G 4 : Separation of solid waste from effluent of weight reduction process	- Precipitate dissolve PE by adding acid - Separate solid waste before sending to the effluent treatment	PC	WM PR CR	5	MT	L
	All operations	G 5 : Calibrate water meters	- Take meter readings - Quantify water coming to the storage tank to check accuracy	RC	WM	4	MT	M

9.0 COST BENEFIT ANALYSIS

Cost Benefit analysis was carried out for the 10 waste minimisation options given the highest priority by the management (from Worksheet 8). The investment, savings and pay back period for each option is presented in a worksheet, while relevant details for each calculation are presented below the respective worksheet.

WORKSHEET 9.1	
Avoid reduction clearing process for light and medium shade (option JD13 in worksheet 8)	
Investment Rs Nil	**SavingRs/y** Chemical 83,650 Treatment cost 11,312 **TOTAL** **94,962**
Annual operating cost Rs/y Nil	**Net saving** **94,962** =(Saving - Operating Cost) **Payback period** =(Investment/Net Saving) x 12 **Not applicable**

Fabric material undergoes reduction clearing process (light & medium shade) during the February 95 was 2405 kg. Details about the saving of water, chemicals, steam and treatment cost by avoiding reduction clearing given below

Process	Saving (kg)	Unitcost (Rs/kg)	Saving (Rs/month)
Water	57,000	0.021	1,197.00
Steam	2,495	0.75	1,871.00
Acetic acid	15.2	42	638.40
Antifoam II	3.8	255	969.00
Wetting agent III	7.6	190	1,444.00
Caustic soda	30.4	28	851.00
Total	57	-	6,970.40

Treatment cost saving can be estimated from worksheet 7.B
COD load saving = 11,312 Rs/y (31.4 kgCOD/M)
This option will reduce water consumption by 1.2% and COD load by 1.2%

WORKSHEET 9.2			
Chemical substitution: acetic acid to formic acid (option J2 in worksheet 8)			
Investment	**Rs** **Nil**	**Saving** Chemicals Treatment cost **TOTAL**	**Rs/y** 17,064 68,140
Annual operating cost	**Rs/y** Nil	**Net saving** (saving - operating cost) **Payback period** (Investment/Net Saving) x 12	**180,960** **Not applicable**

	Rate (Rs / kg)	COD (kg/kg)
Acetic acid	42	1.04
Formic acid	72	0.52

(Chemical costs were obtained from the industry and suppliers)

Monthly consumption of acetic acid	= 243 kg
Sustitution of formic acid required	= 122 kg
Chemical saviving	= (243 x 42) - (122 x 72) Rs/month
	= Rs 1422 /month
COD reduction	= (243 x 1.04) - (122 x 0.52) kg COD
	= 189.28 kg COD (i.e.7% of total COD load)
Unit treatment cost	= 30 Rs /kg COD
Treatment cost saving	= 5,678 Rs/month

WORKSHEET 9.3			
Lagging unlagged steam lines and valves (option B1 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Lagging (glass wool)	12,775	Fuel oil	12,297
		Net saving	**9,614**
Annual operating cost			
Interest (21%)	2,682	**Payback period** (Investment/Net Saving) x 12	**= 16 Months**

Total area exposed to ambient environment (35 x 2")	= 5.49 m^2
Average surface temperature	= 103°C
Lagged surface area temperature	= 40°C
Convective heat transfer coefficient	= 10 $W/m^{2o}K$ [ref 4]
Heat loss	= (103 - 40) x 10 x 5.49 x 3600/1000
	= 12,451 kJ/h
Boiler efficiency	= 70 %
Calorific value of oil	= 40,500 kJ/l
Operating hours per year	= 4000
Energy loss (l of oil/h)	= 12,451 /(0.7 x 40,500)
	= 0.439 l oil/h
	= 0.439 x 4000 l/y
	= 1756 l/y
	= Rs 12,297 /y
Lagging cost (obtained from supplier)	= Rs 12,775

Diameter of pipe	Lenth(m)	Lagging cost (Rs)
2"	35	12,775 (@365)

This option will reduce 0.3 % of the total boiler fuel consumption and air emission as well as boiler water consumption

WORKSHEET 9.4			
Lagging of the boiler surface (option B6 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Lagging (glass wool)	29,640		
		Fuel oil	28,735
	Rs/y	**Net saving**	**22,510**
Annual operating cost		(saving - operating cost)	
Interest	6,224	**Payback period**	
		=(Investment/Net Saving) x 12	
			=16 Months

Unlagged area exposed to ambient environment = 19 m^2
Average surface temperature = 120°C
Lagged surface area temperature = 40°C
Convective heat transfer coefficient = 5.317 $W/m^{2\circ}K$ [ref 4]
Heat loss = (120 - 40) x 19 x 5.317 x 3600/1000 kJ/h
= 29,094 kJ/h
Boiler efficiency = 70 %
Calorific value of oil = 40,500 kJ/l
Operating hours per year = 4,000
Energy loss (l of oil/y) = 29,094 x 4,000 /(0.7 x 40,500)
= 4,105 l
Saving = Rs 28,735
Lagging cost (obtained from supplier) = Rs 1560 / m^2
= 29,640

This option will reduce 0.7% of the total boiler fuel consumption and will also reduce boiler emissions.

WORKSHEET 9.5			
Lagging the unlagged condensate lines (option B2 in worksheet 8)			
Investment	**Rs**	**Saving Rs/y**	
Lagging (glass wool)	30,300		
		Fuel oil	45,551
		Net saving	**39,188**
Annual operating cost			
Interest (21%)	6,363	**Payback period**	
		(Investment/Net Saving) x 12	
			9 Months

Unlagged condensate pipe in factory (4",75 m) & (1",27 m)

Total area exposed to ambient environment	= 25.6m^2
Average surface temperature	= 90°C
Lagged surface area temperature	= 40°C
Convective heat transfer coefficient	= 10 W/m$^{2\circ}$K [ref 4]
Heat loss	= (90 - 40) x 10 x 25.6 x 3600/1000 kJ/h
	= 46,080 kJ/h
Boiler efficiency	= 70 %
Calorific value of oil	= 40500 kJ/l
Operating hours per year	= 4000
Energy loss (l of oil/y)	= 46080 x 4000 /(0.7 x 40500)
	= 6501.5 l
Saving	= Rs 45,511
Lagging cost (obtained from supplier)	= Rs 30,300

Diameter of pipe	Length(m)	Lagging cost (Rs)
4"	75	26,250 (@350)
1"	27	4.050 (@150)

This option will reduce 1.1% of boiler fuel consumption and further reduce emission load as well as water consumption

WORKSHEET 9.6			
Condensate recovery from jets (option J1 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
	Nil	Fuel oil Treatment chemicals Water **TOTAL**	7,728 12,228 2,592 **22,548**
Annual operating cost	**Rs/y**	**Net saving** =(Saving-Operating Cost)	
	Nil	**Payback period** =(Investment/Net Saving)x 12	**Not applicable**

In this factory steam condensate from Thies jet is being collected.Steam condensate from Fong jet to be collected

Condensate amount that can be collected from Fong jet	= 10,300 kg
Temperature of condensate	= 90°C
Feed water temperature	= 30°C
Energy that can be saved by recycling	= 10,300 x 4.2 x (90 - 30) kJ/month
	= 92 l oil/month
(ie. 0.2% of total boiler fuel)	= 644 Rs/month
Estimated boiler water treatment cost	= Rs 99 /m^3
Treatment cost saving	= (10.3 x 99) Rs
	= 1019 Rs/month
Water saving	= 10.3 m^3
(ie. 0.2% of total water consumption)	
Unit cost of water	= 21 Rs
Water saving	= 216 Rs/month

Reduce boiler emission and effluent voluume

WORKSHEET 9.7			
Install press button switches for view glass lights (option JD5 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Press button switches (2 Nos)	200	Electricity	4,800
		Net saving =(Saving-operating cost)	**4,800**
Annual operating cost	**Rs/y** Nil		
		Payback period =(Investment/Net Saving) x 12 Month	**Negligible**

No of bulbs	= 2
Operating hours	= 4000 h/year
Power of a bulb	= 120 W
Total power loss	= 2 x.12 x 4000 kWh/year
	= 960 kWh/year
Unit cost	= 5 Rs/kWh
Saving	= 4800 Rs/year
Number of switches needed	= 2
Cost of a switch	= 100 Rs

WORKSHEET 9.8			
Lagging of the jet surface area (option JD2 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Lagging Cost	14,196		
		Fuel	12,003
		Net saving	**9,022**
	Rs/y	(Saving-Operating Cost)	
Annual operating cost			
Interest (21%)	2,981	**Payback period** =(Investment/Net Saving) x 12	**18 months**

Unlagged area	= 9.10 m^2
Average surface temperature	= 110°C
Average lagged surface temperature	= 40°C
Convective heat transfer coefficient	= 5.3 $W/m^{20}K$ (ref4)
Time duration	= 4000 h/y
Energy loss (kJ/y)	= 9.10 x.0053 x (110 - 40) x 4000 x 3600
	= 4.8 x 10^7 kJ/year
Boiler efficiency	= 70 %
Calorific value of oil	= 40500 kJ/l
Energy loss (l of oil/y)	= 4.8 x 10^9/(0.7 x 40500)
	= 1,715 l oil (i e . 0.3% of total boiler fuel consumption)
	= Rs 12,003
Lagging cost	= Rs 14,196 (1560 x 9.10)

Reduce boiler emmission load

WORKSHEET 9.9			
Cooling water collection from jets (option JD3 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Collection tank	45,188	Fuel oil	155,532
Pump	10,000		
Piping with lagging	4,650	**TOTAL**	155,532
Total	**59,838**		
		Net saving	**142,002**
Annual operating cost	**Rs/y**	=(Saving-Operating Cost)	
Interest	12,565		
Pump running cost	965	**Payback period**	
Total	**13,530**	=(Investment/Net Saving) x 12	
			5 months

Cooling water to be collected from thies & fong jets to be used for hot wash. Cooling water is pumped through a pipe (diameter 2", lenth 10 m) with pressure 3.5 bars.For each batch it takes 15 to 16 minutes

Cooling water flow rate	= 9090 kg/h
Total number of batch	= 110
Time taken	= 110 x 15 /60
	= 27.5 h
Cooling water that can be collected from jets	= 249,975 = (9090 x 27.5) kg
Temperature of coling water return	= 80°C
Feed water temperature	= 30°C
Energy that can be saved by recycling to hot wash	= 249,975 x 4.2 x (80 - 30) kJ/month
	= 1851.6 l oil/month
(ie. 3.8% of the total boiler fuel)	= 12,961 Rs/month

Cooling water collection tank (2m x 2m x 2m)

Excavation cost(180/m^3)	= 1,440
Concrete cost(Rs 17,500/m^3)	= 42,000
Platform(Rs 437/m^2)	= 1,748
Total collection tank cost	= 45,188
Pump (1 hp, domestic)	= 10,000
Piping with lagging (2", 10 m)	= 4,650

WORKSHEET 9.10			
Print paste recovery from screen (option P5 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
	Nil	Print paste	344,690
		Net saving	**344,690**
Annual operating cost	**Rs/y**		
	Nil	**Pay back**	
			Not applicable

Average printing production	= 10,000 m/day
Number of screens used for a day	= 60
Print paste left over on a screen	= 2 kg
Water flow rate at screen washing	= 22 l/min
Time taken for washing one screen	= 4 min
Total washing water used per day	= 5280 l
Total paste wasted through screen washing	= 120 kg
Let 80 % of paste be recovered	
Paste saving per day	= 96 kg (80% for reuse)
(let fresh paste Rs 15 / kg)	= Rs 720
Water saving per day	= 4224 l (5280 x 0.8)
	= Rs 88.62/10,000 m production
Treatment cost saving	= 100 kg COD/10,000 m production
	= 930 kg COD /M (37% of the total)
	= 100 kg x 30 Rs/kg
	= 3000 Rs/10,000 production
Total saving	= 3088.62 Rs/10,000 m production

10.0 IMPLEMENTATION OF WASTE MINIMISATION OPTIONS

The status of implementation of the ten waste minimisation options identified to be of high priority for this mill is summarised in Worksheet 10. Chemical substitution and lagging of the two jet machines have been implemented at present, while avoiding of reduction clearing was implemented previously. Implementation of four other options is in progress viz. lagging of steam lines, boiler and condensate lines and condensate recovery. Reasons for non-implementation of the other three are given. Comparison of the actual savings of the options implemented with the theoretical expected savings (from Worksheet 9.1 - 9.10) with respect to unit production is also given in Worksheet 10.

Details of the actual annual savings obtained by the industry for the chemical substitution are given below. The treatment component of the saving is given separately, since this is not an actual saving at present. This saving will be obtained only when the industry installs and operates an effluent treatment system.

It was not possible to calculate the savings obtained from lagging the jets because the fuel consumption saving is small (estimated to be 0.3% of total fuel consumption) and fuel consumption does not proportionally change with production (kgs). The investment for this option was Rs. 18,000.

COST BENEFIT CALCULATION FOR IMPLEMENTED OPTION

(1a) Substitution of Formic acid for Acetic acid

Before implementation

Acetic acid consumption (Feb. 95)	= 243 kg for the production of 128,685 m
Cost	= 243 (kg) x Rs 42
	= Rs 79.30/1000m
Treatment cost	= COD x Treatment cost/kg of COD
	= 234 kg x 1.04 (kg COD/kg) x 30(Rs/kg COD)
	= Rs 58.91/1000m

After implementation

Formic acid consumption = 66kg for the production of 124,311 m

Cost	= 66kg x 68 (Rs/kg)
	= Rs 36.10/1000m
Treatment cost	= 66 x 0.34 (kg COD/kg) x 30 (Rs/kg COD)
	= Rs 5.41/1000m

Actual Chemical Saving = Rs 65,318/y
Actual Treatment Cost Saving = Rs 80,890/y

(Average monthly production figure 126,000m was used in the calculation)

Worksheet 10										
Waste minimization option	Parameters	Before Implementation		After implementation						
		Actual Consumption/ Generation*		Expected Consumption/ Generation*		Expected Saving	Actual Consumption/ Generation*		Actual Saving	Remarks
		per kg or m of fabric (10^{-3})	Rs per kg or m of fabric (10^{-3})	per kg or m of fabric (10^{-3})	Rs per kg or m of fabric (10^{-3})	Rs per kg or m of fabric (10^{-3})	per kg or m of fabric (10^{-3})	Rs per kg or m of fabric (10^{-3})	Rs per kg or m of fabric (10^{-3})	
1) Avoid reduction clearing for light & medium shade	Chemical (kg) COD (kg) Water (kg) Fuel (l)	23.37 12.88 7004.5 50.55	1600.35 386.4 147.09 333.63	6.29 3.47 6293.08 13.63	430.93 104.1 132.15 89.96	1169.42 282.3 14.94 243.67	-	-	-	Implemented previously.
2) Acetic acid with Formic acid	Chemical (kg) COD (kg)	1.88 1.96	79.30 58.90	0.56 0.49	40.28 14.78	39.02 44.12	0.53 0.28	36.10 8.28	43.20 50.62	Implemented in the Dye House and in the Fishing Net section
3) Lagging steam lines	Fuel (l)	589.45	3890.37	587.53	3877.69	12.68	**	**	**	Implementation in progress
4) Lagging of boiler	Fuel (l)	589.45	3890.37	584.96	3860.74	29.63	-	-	-	Implementation in progress
5) Lagging of condensate line	Fuel (l)	589.45	3890.37	582.34	3843.44	46.93	-	-	-	Implementation in progress
6) Condensate recovery	Water (kg) Chemical (kg) Fuel(l)	6591.5 - 589.45	138.42 652.56 3890.37	6398.64 - 588.24	134.37 633.47 3882.4	4.05 19.09 7.97	-	-	-	Implementation in progress
7) Install press button for jets	Electricity (kWh)	1.498	5.992			5.992	-	-	-	Not implemented as savings are perceived to be small and implementation impracticable
8) Lagging jet area	Fuel (l)	589.45	3890.37	587.59	3878.13	12.24	**	**	**	Implemented

8) Lagging jet area	Fuel (l)	589.45	3890.37	587.59	3878.13	12.24	**	**	**	Implemented
9) Cooling water collection	Fuel (l)	589.45	3890.37	565.17	3391.04	499.33	-	-	-	Not implemented as not convinced about practicability
10) Print paste recovery	Paste (kg) Water (kg) COD (kg)	- 528 12	- 11.09 360	9.6 105.6 2	72 2.22 60	72 8.87 300.0	-	-	-	Doctor blade cannot be installed, easily on this machine but presently reusing as much as possible, manually.

* Consumption of chemical, fuel, water etc. / Generation of COD

** Saving of fuel consumption due to lagging could not be calculated.
However the temperature reduction on the lagged surface was measured to be as follows:

	Before	**Expected**	**After**
Jet	110°C	40°C	40°C
Steam lines	103°C	40°C	44°C

Note For before implementation and expected unit consumption and generation calculations production figures utilised were 3337 kg for option 1, 128685 m for option 2, 53402 kg for. options 3,4,5,6,7,8 and 9 and 10,000 m for option 10. For after implementation unit consumption and generation calculations production figures utilised were 124311m for option 2.

10.0 CONCLUSIONS

The process flow diagrams prepared depict the activities involved in the processing of the major products and the inputs and sources of output, together with process conditions. Those were seen to be invaluable in the preparation of subsequent worksheets (eg. material and water balances).

Carrying out the material balance, enabled the quantification of the inputs and outputs for the unit operations. These values have been useful in identifying waste minimisation options. eg. quantification of steam emitted suggested that recovery of steam would be a valuable waste minimisation option. The quantity was utilised in the Cost Benefit analysis.

Carrying out the water balance enabled the identification of the highest water consuming activities and the undefined water consumption.

Calculation of the Wastes and Emissions costs enabled the consideration of the wastes generated in terms of the financial loss. On implementation of the options, the reduction in the financial value of the wastes can be determined.

On the basis of observations made, and values obtained in the material balances and other quantifications, 62 waste minimisation options were identified. Of these 62, 36 were Resource Conservation, 3 Technology Change, 3 Resource Recovery,10 Material Change and 2 Equipment Modification. Considering the cost of implementation, 34 were considered to be Low Cost, 22 Medium Cost and 6 High Cost.

Of the 10 options for which Cost Benefit analysis was carried out, it was seen that 5 options did not require any investment. Of these only two have been implemented at present. Practical problems and lack of conviction about the benefits have prevented the implementation of the other three. Of the other five, it is noteworthy that the option with the longest payback period (18 months) has been already implemented and implementation of all the other four options is in progress. It is hoped that once these are implemented, the industry will continue to implement other options.

12.0 REFERENCES

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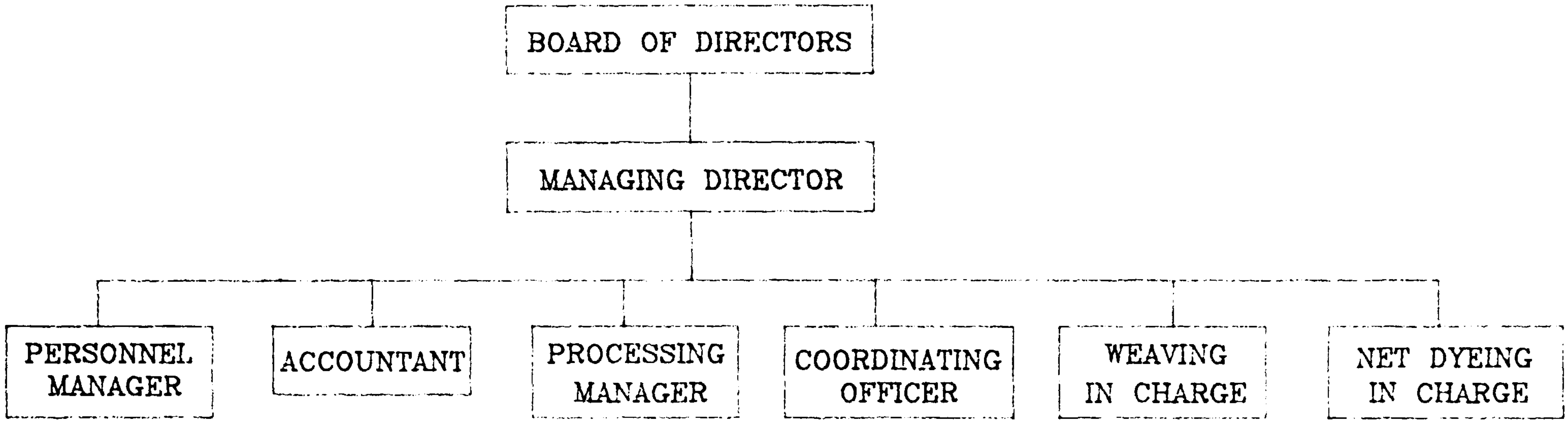
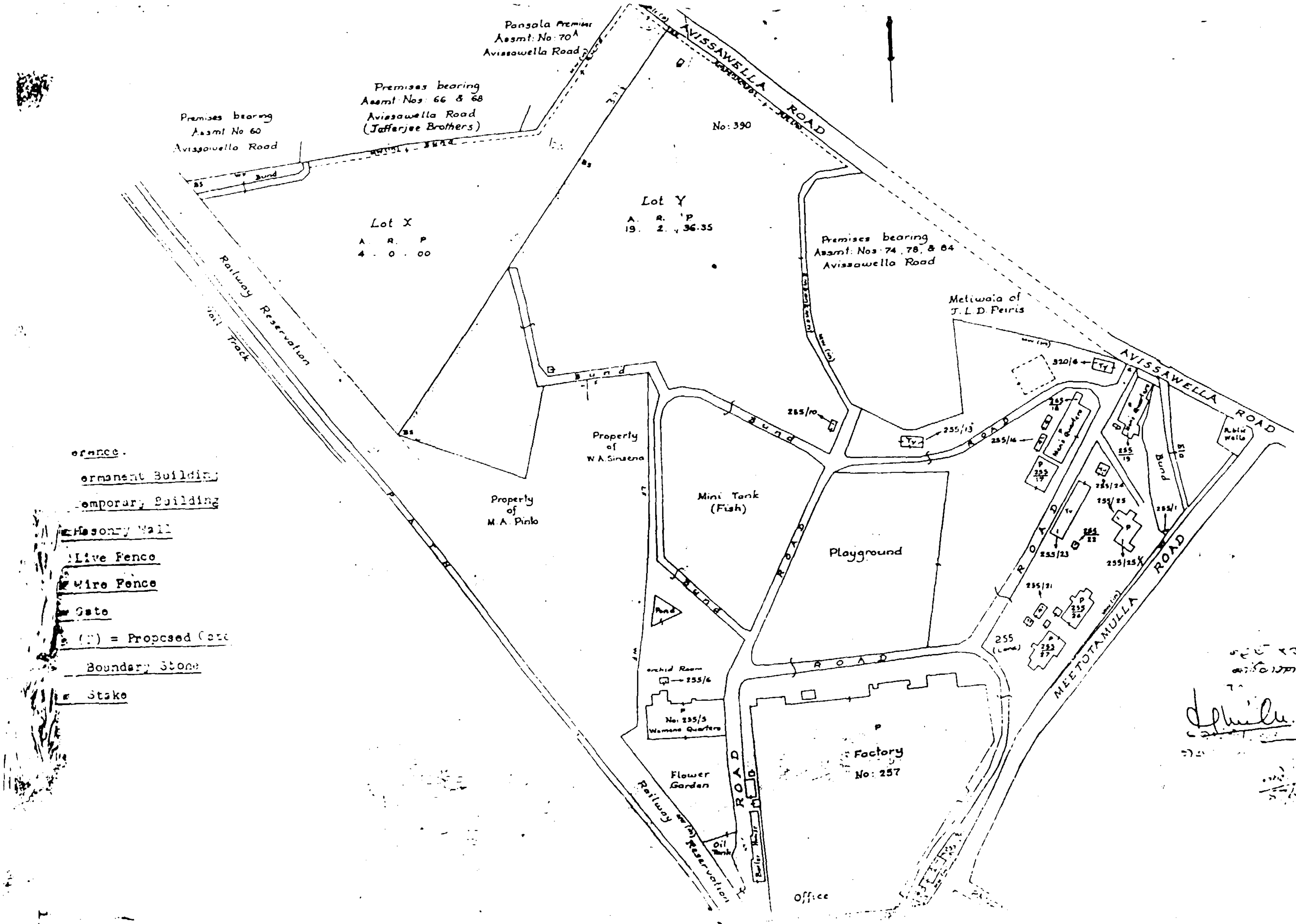
ANNEXURE A

ORGANIZATION CHART
J B TEXTILES LTD



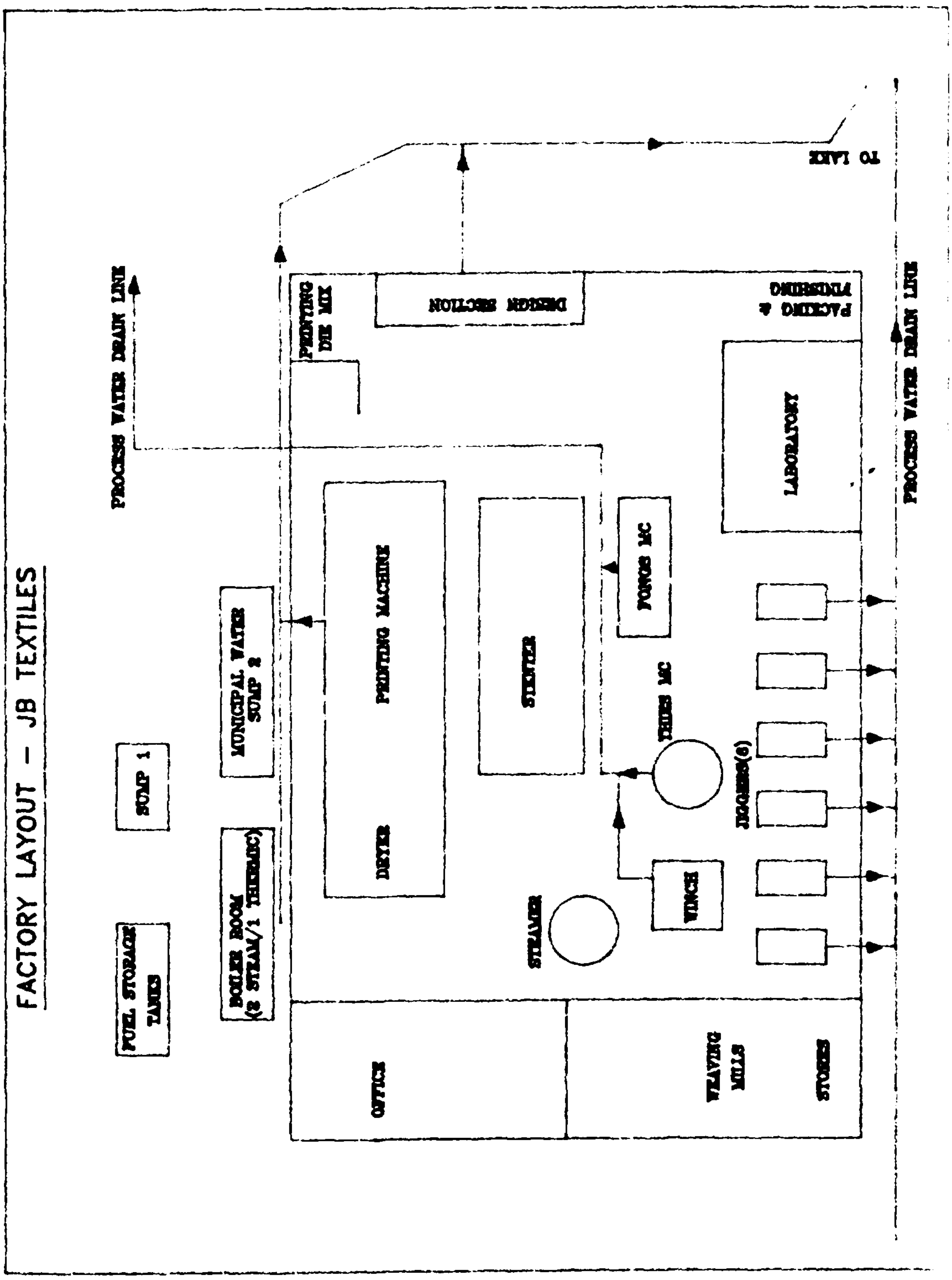
ANNEXURE B



Pansala Premises
Assmt: No: 70A
Avissawella Road
Premises bearing
Assmt Nos 66 & 68
Avissawella Road
(Jafferjee Brothers)
Premises bearing
Assmt No 60
Avissawella Road
AVISSAWELLA ROAD
No: 390
Lot X
A. R. P
4 . 0 . 00
Lot Y
A. R. P
19. 2. 36.35
Premises bearing
Assmt: Nos 74, 78, & 84
Avissawella Road
Metiwala of
J. L. D. Peiris
Railway Reservation
Rail Track
Bund
Property
of
W. A. Sinsena
Property
of
M. A. Pinto
Mini Tank
(Fish)
Playground
ROAD
255/10
255/13
255/16
255/19
255/17
255/24
255/25
255/22
255/23
255/21
255/26
255/27
255/1
320/6
Public Wells
AVISSAWELLA ROAD
MEETOTAMULLA ROAD
Pond
Orchid Room
255/6
No: 255/5
Womens Quarters
Flower
Garden
Factory
No: 257
Oil Tank
Boiler House
Office
Railway Reservation
PATH
erence.
ermanent Building
emporary Building
Masonry Wall
Live Fence
Wire Fence
Gate
(P) = Proposed Gate
Boundary Stone
Stake

ANNEXURE C

FACTORY LAYOUT – JB TEXTILES



Annexure D

List of major chemicals

1) Dye House

Chemicals	Cost (Rs/kg)	Consumption (kg/Month)
Rustol ASM	255.00	10.90
Appolene SSA	82.00	40.37
Soda ash	15.00	84.37
Acetic acid	42.00	167.08
Tedecafix CWA	145.00	2.50
Product WA/LF	193.00	1.92
Appolene RBS	152.00	0.60
Terry dye	174.00	103.00
Common salt	3.50	58.50
Product Lap	-	-
Sodum Sulpate	-	-
Na HydroSulpite	80.00	204.30
Caustic soda	28.00	520.44
Glaubers salt	18.00	65.00
HCl acid	37.00	11.06
H_2O_2	37.50	58.90
Oxalic acid	65.00	153.00
Intramine SPL	226.00	71.02
Intramine WR	210.00	36.20
Ciltraphor SFG	1115.00	30.20
Product 3CSR	147.00	1.60
MS.powdered	207.00	1.80

2) Printing

Chemical	Cost (Rs/kg)	Consumption (kg/Month)
Sekafix K 750	376.00	74.10
Citric acid	72.00	25.87
NH_3SO_4	9.00	12.93
Indelka gum	85.00	286.72
Terry dye	174.00	-
Nonipol	162.00	5.56
Kerosene	12.00	502.00
Oritex Binder	155.00	44.96
Emafix TK	500.00	3.32
Acetic acid	42.00	-

3) Finishing

Chemicals	Cost Rs/kg	Consumption kg/Month
Alcomine	43.00	38.45
Cryset 381	78.00	51.30
$MgCl_2$	60.00	10.05
Octex EM	377.00	27.04
Poly Vinyl Acetate	65.50	3.65
Silico soft	-	-
Ultraphor SFG	1115.00	30.20

Annexure E

I Production data for February 1995 in Jiggers (kg)

Process	Jigger No 1 to No 5	Jigger No 6
Scouring	256.1 (3)	401.97 (2)
Scouring & Padding	1739.36 (20)	180.1 (1)
Padding I Padding II	64.30 (1) 1439.14 (17)	452.69 (3) 1880.1 (9)
Dyeing (100 % viscose)	592.69 (6)	-

(xx) no of the batches
Padding I & II are Processes based on worksheet 3.11 and 3.12 respectively

II Production data for February 1995 in Jet (kg)

Process	Fong			Thies	
Weight reduction	Light 3071.68 (24)	Dark -	Super -	Light 917.8 (8)	Dark 125.8 (2)
Reduction clearing	2405.26 (19)			931.57 (7)	
Dyeing	2650.33 (21)		1503.8 (14)	1059.43 (10)	3403.64 (26)

Light - Light shade   Dark - Dark shade   Super - Super whitening

III Production data in stenter and printing machine for February 95

Process	Quantity (m)	Quantity (kg)
Printing	93,397	6,253.20
Drying	190,484	12,319.00
Heat setting	161,887	
Finishing	128,685	19,409.5

IV Fishing net production data for Feb 1995 (kg)

Process	Quantity (kg)
Dyed nets	11,125
White nets	7,875

Annexure F

RECIPES FOR MAJOR PROCESSES

Jigger scouring	
Soda ash	2 g/l
Appolene (Detergent I)	1 g/l
Acetic acid	0.2857 g/m
Jigger padding / scouring	
Oxalic acid	10 g/l
Terry dye (Levelling agent I)	1 g/l
Intramine	2 g/l
Soda ash	0.2857 g/m
Appolone (Detergent I)	0.1428 g/m
Padding 1	
Oxalic acid	10 g/l
Soda ash	0.257 g/m
Appolone (Detergent I)	0.1428 g/m
Intramene (Antifoam I)	0.4 g/l
Terry dye (levelling agent)	1 g/l
Padding 2	
Oxalic acid	5 g/l
Soda ash	0.2857 g/m
Appolone (Detergent I)	0.1428 g/m
Intramene (Antifoam I)	2 g/l
Terry dye (levelling agent)	1 % w/w
Caustic soda	2% w/w
Nonipol (Detergent II)	0.25% w/w
Hydro sulphate	0.5% w/w
HCl	1 g/l
Jigger dyeing (100% viscose)	
Acetic acid	3.0 g/l
Appolone (Detergent I)	0.25 g/l
Soda ash	3 g/l
Stabilizer	1 g/l
H_2O_2	4 g/l
Reactive dye¶	
MS powder¶ (Reducing agent)	
Salt¶	
Fixing agent¶	
Soda ash¶	

Jet dyeing (light shade)

Acetic acid	1 g/l
Terry dye (Levelling agent)	5.2 g/l
Dyes¶	

Jet dyeing (Dark shade)

Acetic acid	1 g/l
Terry dye (Levelling agent)	5.2 g/l
Dyes¶	

Jet dyeing (Super whitening)

Na silicate	1 g/l
Acetic acid	1 g/l
Terry dye (Levelling agent)	1 g/l
Dyes¶	
Na_2SO_4	5 g/l
Ultrephor (Whitening agent)	3.68 g/l
H_2O_2	4 g/l
Caustic soda	10.5 g/l

Weight reduction (100% PET)

$NaHSO_3$	3.5 g/l
Caustic soda	73.5 g/l
Ultrephor (Whitening agent)	2.5 g/l
Appololne (Detegent I)	7.1 g/l
Intramine (Antifoam I)	7 g/l
Acetic acid	7 g/l

Reduction clearing

Caustic soda	1.6 g/l
Rustol (Antifoam II)	0.2 g/l
Acetic acid	0.8 g/l
Product WAA (Wetting agent III)	0.4 g/l

Printing¶

Seka fix (TiO_2)	30.00
Citric acid	6.40
Amonium Sulphate (Buffer)	3.20
Induka gum (Thickening agent)	33.00
Terry dye (Levelling agent I)	1.70
Dye	1.70

Dyeing¶

Rustol ASM (Anti foaming agent II)	0.48
Product LAP (Dispersing agent)	1.50
Appolone (Detergent I)	3.85
Soda ash	3.75
Acetic acid	6.49
Sodium sulphate	24.50
Hydro sulphite	13.30
Common salt	7.00
Rucowet RNU (Wetting agent I)	1.25
Product LAP 70/LF (Dispersing agent II)	1.50
Product WA/LF (Wetting agent II)	0.88
Terry dye (Levelling agent)	2.40

Finishing¶

Poly Vinyl Acetate	3.23
Octex EM (Finishing agent I)	1.80
Ultraphor SFG (Whitening agent)	1.10
Alccomine (Finishing agent II)	0.10
Sil cosoft 1000 (Fabric softner)	8.56
Magnesium chloride (Catalyst)	0.56
Cry set 3.81 (Finishing agent III)	17.30

¶ Daily average consumption given

Annexure G

ESTIMATION OF EFFLUENT TREATMENT COST ON THE BASIS OF COD REMOVAL

Assumptions

a) Capacity of plant - 200 m^3/day
b) Typical COD of textile effluent after equalization - 800 mg/l
c) Chemical consumption
Coagulant, Alum (400 mg/l) - 80 kg/day
Flocculant, Polymer (2 mg/l on dry solid basis) - 400 g/day
Neutralizer, Lime (120 mg/l) - 24 kg/day

Cost (Rs)

Chemicals	
Alum (Rs 16/kg)	=1280
Polymer (Rs 1000/kg)	=400
Lime (Rs 5/kg)	=120
Total Chemical cost	**=1800/day**

Electricity	
Feed pump (1 kW)	=24 kWh
Chemical preparation(0.25 x 3	=18 kWh
Dosing pump (0.1 x 3)	=7.2 kWh
Flash mixer (0.5 kW)	=12 kWh
Clarifier scraper(0.75kW)	=18 kWh
Sewage pump (0.5 kW)	=12 kWh
RBC (1.5 kW)	=36 kWh
Secondary clarifier	
Scraper(0.75 kW)	=18 kWh
Total power	=145.7 kWh

Electricity cost (Rs 5/kWh) =726 Rs

Labor cost for operation of treatment plant (24 labor hours per day)
Total cost of labor including EPF, ETF,
and annual overtime =Rs 25/h

Labor cost	**=Rs 600/day**
Sludge handling cost	**=Rs 150/day**
Total operational cost	**=Rs 3276/day**

COD removal required	=200(800-250)10^{-3} kg/day
per day	=110 kg/day
Cost for removal	=3276/110
of 1 kg COD	=Rs 29.78/ kg
	=Rs 30/ kg

Annexure H

ESTIMATION OF THE STEAM COST

Fuel oil cost	= 31477(l) x 7.0 (Rs/l)
	= 222,342
Electric power cost	= 354(kW) x 4.0(Rs/kWh)
	= 1,416
Water cost	= 352(m^3) x (21)(Rs/m^3)
	= 7,392
Boiler water treatment	= 15,000
Labour cost	= 8000
Total cost	= 250,734 Rs
Total steam produced	= 352,000 kg
Average unit steam cost	**= 0.75 Rs/kg**

Annexure I

UTILITY COSTS

Utility	Unit Cost (Rs.)	Cost Rs./kg of Fabric
Water	21 / m^3	2.2
Steam	0.75 / kg	6.6
Electricity	4.00 /kWh	4.5
Fuel oil (boiler & thermic)	6.66 /l	8
Treatment cost §	30 / kg COD	1.9

§ To be installed