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DP/ID/SER.B/402
1 June 1983
English

Egypt.

TEXTILE DEVELOPMENT CENTRE, PHASE II

DP/EGY/77/008

EGYPT

Terminal report*

Prepared for the Government of Egypt by the
United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of G.J. Parish,
expert on water conservation

United Nations Industrial Development Organization
Vienna

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V.83-56719

ABSTRACT

DP/EGY/77/008/11-11/G/31.7.B

Water conservation in the textile industry

This mission, of one month duration, was undertaken to investigate the water usage in textile mills, to advise on water conservation and to train the staff of the Textile Development Centre in various techniques for water consumption measurement.

The consumption of water in Egypt is dominated by the usage for irrigation, and conservation by textile mills can make only a minor impact on the overall demand for water. The need for savings must therefore be related to individual mills' problems of water availability or cost. Many mills use water from the municipal supply and increasing competition for the water available may hinder expansion plans; increasing costs of water and of effluent disposal will add to processing costs.

At the present time there is no general demand for urgent action to save water, although at least one mill in Alexandria has been obliged to adopt conservation measures. It seems inevitable that the pressures for water saving will increase, with both availability and cost becoming significant factors. It is therefore recommended that the Textile Development Centre continue the work of data collection and analysis started during this mission, in order to build up a more comprehensive picture of the water consumption in Egyptian mills. The Centre will then be in a better position to advise the industry on realistic levels of water usage and on appropriate conservation measures.

The situation in respect of boiler water supplies appears to be more pressing. Few mills employ condensate recovery and most therefore use large volumes of fresh water. Concern has been expressed about high levels of solids in boiler water and excessive

loss of water and heat in the boiler blow-down. It is recommended that an expert on boiler management be appointed to examine the situation and offer appropriate advice.

The analysis of process water and boiler feed water would be assisted by the wider provision of simple instruments and test kits. The use of simple, robust instruments cannot be too strongly stressed. The Textile Development Centre could assist by obtaining such equipment and demonstrating its use in the industry.

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INTRODUCTION

This mission, to advise on water conservation in the textile industry, was based at the Textile Development Centre in Alexandria and of one month duration. Its objectives were to examine the water usage in a number of textile mills and advise on any problems encountered, to present information on water usage and water conservation during these visits and in a seminar, and to train members of the T.D.C. staff in the appropriate techniques for measuring water consumption.

In order to allow time for a thorough examination of the situation at each mill, the number of mills was limited to three, but each was visited on four occasions to collect information on overall water usage and production and to make measurements of water usage on individual machines. A visit was also paid to one of the municipal water supply plants in Alexandria. The conclusions concerning water usage and conservation are summarised in Chapter I of this report and reports on the mill visits are presented in Annex 1.

Staff of the Textile Development Centre were involved in all aspects of the mission, from the preparation of data sheets employed for collecting information on water usage and production to the measurements of water consumption. The training imparted in this way was supplemented by advice on trials of various measuring techniques adapted to the pilot-scale machines in the T.D.C. laboratories. Notes were prepared on some suitable experiments and on the measurement of suspended solids in water (Annex 2).

The seminar was attended by a total of 36 persons, of whom 26 came from industry, the remainder being T.D.C. staff. The seminar programme and the papers presented are given in Annex 3. A short note on water conservation was also prepared for the T.D.C. Bulletin (Annex 4).

During the mill visits and in discussions following the seminar reference was made to problems encountered in boiler water management. Advice was given at one mill where the problem was primarily that of high concentrations of dissolved solids in the boiler water; this report is presented in Annex 5. Boiler water problems are discussed in Chapter II; it is considered that advice from an expert in boiler management would be very useful.

Itinerary

Overall mission duration: 10 March to 9 April, 1983

10 to 13 March: travel via Vienna and Cairo to Alexandria

14 March to 4 April: on station in Alexandria

5 to 9 April : return via Cairo and Vienna

Visits were made as follows:

Arab and United Spinning & Weaving Co.	: 16,21,26,27 March
El Siouf Spinning & Weaving Co.	: 21,22,23,24 March
Orient Linen & Cotton Co.	: 16,17,20,23 March
Municipal Water Supply Works, New Manshia Plant	: 19 March
Seminar	: 3 April, 36 attending

Acknowledgments

Among the people contacted during the mission in Alexandria were the following:

Arab & United Spinning & Weaving Co:

Dr. S. Dahmoush, Chairman

Mr Anton Melica, Dyeing & Finishing Manager

Orient Linen & Cotton Co:

Mr Fathi Ahmed Ali,	Chairman
Mrs Shehira M. Besha,	Head of dyehouse
Mrs Shafika Abdallah,	Chief, Quality Control

Municipal Water Supply Works:

Eng. Nadia A. Saleh, Quality Control Chief

Textile Development Centre:

Eng. Magdi El Aref, Project Manager

Mr A.B. Khairallah, Director, Dyeing & Finishing Dept.

The visitor wishes to record his appreciation to these people and to all other contacted during the mission for assistance in all phases of the work, for unfailing courtesy in answering questions and providing the information on which this report is based. Particular thanks are due to Mr. Khairallah for detailed help throughout, from organizing visits to collaboration in water-usage measurements.

RECOMMENDATIONS

1. The Textile Development Centre to continue the work of water-consumption measurement, data collection and analysis started during this mission. The objective of this work will be for the Centre to build up a picture of the water usage in Egyptian mills and to collect comparative figures for specific water consumption in individual processes. This will enable the Centre more effectively to advise the industry on water saving measures.

Along with measurements of water usage the Centre should continue with its programme of analysis of water quality.

2. An independent expert on boiler management should be appointed to investigate the problems associated with water supply and condensate recovery. Preferably this expert should not be associated with a boiler manufacturer; a member of the staff of an organization such as N.I.F.E.S. (National Industrial Fuel Efficiency Service Ltd) in the U.K. would be ideal.

3. The greater use of simple instruments and test kits in the analysis of process water and boiler water is strongly recommended. The Textile Development Centre should be equipped with suitable portable instruments, so that their use may be demonstrated in textile mills. Advice on the most suitable instruments should be part of the brief of the boiler expert.

I. WATER USAGE

A. Overall picture

The River Nile is the only significant source of surface water in Egypt. At the present time about 56,000 million cubic metres per year are available for use downstream of the High Dam. Much the largest proportion is employed for irrigation, and the water taken for municipal and industrial use represents only 5 percent of the total (1)*. In an urban area like Alexandria the industrial consumption accounts for nearly half of the total municipal usage (2).

The textile industry's water usage in the bleaching, dyeing and printing of yarns and fabrics must represent only a small proportion of the total industrial consumption. The annual production of textiles is currently about 220,000 tonnes (3). The world-wide average of process-water usage has been estimated to be between 100 and 120 cubic metres per tonne (4); with the higher of these figures the Egyptian industry's annual water usage in processing would be about 25 million cu.m. Water usage in boiler plant may add a further 10 million cu.m.

The overall pattern of water usage in Egypt is therefore roughly as follows:

Use	Volume million cu.m. per year
Irrigation	52,000
Total municipal + industrial	2,800
Total industrial	1,200
Textile industry	35

It is clear that any water savings made by the textile industry would have a negligible effect on the country's overall water consumption. The need for savings must therefore be related to individual mills' problems of water availability or cost.

* References are presented in Annex 6.

In Alexandria the majority of mills employ water from the municipal supply in processing. In most instances this is the only available source of surface water. Shallow boreholes yield water with a high concentration of salt because of the high level of the water table in the area; deeper boreholes deliver water too hard for process use. Under these circumstances a textile mill may find it necessary to conserve water because of competition for a limited supply or because of cost. Problems in effluent disposal may be alleviated by reducing the amount of water requiring disposal.

B. Evidence from mill visits

Mill visits have enabled a direct comparison to be made between two sites with almost identical levels of production and closely similar processing sequences, but with one mill using about three times as much water as the other.

Although such a difference is by no means exceptional (5), it can hardly occur by chance. It is therefore more informative to examine the reasons for the difference between these two sites than to draw comparisons with general-purpose target figures for water usage. This is sufficient justification for a comparison of these two mills, and it must be stressed that no criticism is intended of the mill with the higher usage. The decision as to whether or not conservation measures are required or justified must be based on a mill management's assessment of the situation at its own site.

In Alexandria the municipal water supply is metered to both domestic and industrial users, but the charging rates are different. The cost of producing treated water is about 3½ piastres per cubic metre and the charge to domestic users is 1½ pt/cu.m., while the industrial charge is 5 or 10 pt/cu.m. With the growth of the city both the capacity of the water treatment plant and the size of the distribution system must be continually expanding. Under these circumstances there may be local shortages or difficulty in providing additional water for expansion at a given site, although the overall water supply keeps in line with the overall demand. The costs of water treatment and distribution must inevitably rise and the charge to industry may increase at a greater rate if the domestic charge is held down.

At the site where water conservation measures have already been extensively introduced both these factors have played a part in determining the attitude to water usage. Production at this site has increased six- or seven-fold in the last few years and it was felt that the existing water supply would be insufficient for this expansion without careful attention to economy in the use of water. The water cost has recently doubled and it is considered that further increases are not unlikely.

At the mill with the higher water usage the incoming supply is delivered from a substantial main and availability has not caused any concern. The water cost is not considered sufficiently high to justify conservation measures at the present time.

Restrictions on the disposal of effluent commonly relate to the composition of the wastewater; that is, to the amount of solid matter discharged. Under these circumstances reducing the volume of water is unlikely to make a significant contribution to solving the problem. However, when a mill is established in a congested built-up area (as is the case with many mills in Alexandria), the primary requirement is to transport the waste to some distant site for treatment. Here the advantages of having a smaller volume are evident in relation to the sizes of pipes and pumps required. This appears to be an impending problem in Alexandria and is considered by the economical mill to be a further factor affecting their attitude to water usage.

Detailed reports on the mill visits are presented in Annex 1.

C. Conclusions

The evidence from this mission is that, although at present there is no general demand for urgent action on water conservation, the need for water saving will become more pressing, possibly because supply restrictions will hinder expansion, more probably because of increasing costs. The results from the mill which has already taken action indicate that substantial savings can be made.

It would be of considerable help to the industry if the Textile Development Centre were to continue the work of measuring and analysing water consumption. This would build up a picture of the water usage in Egyptian mills and enable the Centre to advise the industry on water-saving measures. Two data sheets have been prepared for the collection of mills' water consumption and production data; examples of completed sheets are attached to the reports in Annex 1. To give T.D.C. staff experience in the methods of water-usage measurement, it is suggested that some trials be carried out in the T.D.C. laboratories; a list of suggested experiments is presented in Annex 2.

Water quality measurements should also be incorporated into the T.D.C. work programme. For this purpose the provision of some additional simple instruments is very desirable (see Chapter II).

II. BOILER WATER

A. General situation

Many mills in Alexandria do not employ any return of condensate to the boiler plant. As a result the supply of fresh water to the boilers is large in relation to process-water usage, and the quantity of water which it is necessary to blow-down from the boilers is a cause for concern to some mill managements. Concern has been expressed in respect of functioning of the boiler plant and of the amount of water and heat lost in the blow-down.

B. Condensate recovery

The influence of condensate recovery on the operation of boiler plant has been evaluated in relation to the situation at one mill in a report which is presented in Annex 5. This report lists the benefits to be expected from returning condensate for re-use, but staff at this and other mills have expressed doubts about the safety of employing condensed steam in this way. In view of experience elsewhere, where condensate recovery of about 50 percent is common, these fears appear to be groundless, but it would seem that there is a real need for authoritative advice on the subject.

Such advice would preferably come from an independent organization with practical experience in the operation of boiler plant of different types. An organization such as N.I.F.E.S. in the U.K. would be well placed to provide this service (6).

C. Instrumentation

A variety of simple instruments and test kits is available for boiler-water analysis. A suitable set of instruments, including a conductivity meter for determining the concentration of solids in water, should be available at the Textile Development Centre and could be employed in demonstrations at mills.

Advice on the most suitable instruments is perhaps best left to the expert on boiler management to specify, but the strongest recommendation is made here for the use of simple instruments. Quite apart from any question of cost, there are sound technical and practical reasons why simple instruments are to be preferred where they can perform satisfactorily. Their mode of operation will be more easily understood than that of more sophisticated devices and they can be operated by relatively unskilled personnel with the minimum of instruction. They are likely to be more robust and less liable to damage in unskilled hands; it can be an unwise policy to purchase an expensive instrument which only senior laboratory staff feel confident of using.

ANNEX 1 VISIT REPORTS

1.1 Arab & United Spinning & Weaving Co

1.2 El Siouf Spinning & Weaving Co

1.3 Orient Linen & Cotton Co

1.4 Municipal Water Supply Works

THE ARAB AND UNITED SPINNING AND WEAVING CO.

WATER USAGE IN FABRIC FINISHING.

GEOFFREY PARISH

UNIDO Adviser on Water Conservation

SUMMARY

The water usage at this mill is already carefully monitored and controlled and the overall consumption, about 60 cu.m. per tonne of fabric, is low.

If may be feasible to reduce the water consumption in washing after mercerisation. This would be beneficial to the caustic recovery plant which is about to be commissioned.

At the present time no condensate is returned to the boilers and the blowdown rate is high. Consideration should be given to returning as much condensate as possible to the boiler supply tank.

30 March 1983.

THE ARAB AND UNITED SPINNING AND WEAVING CO.

1. GENERAL

The finishing section of this mill processes plain cotton fabric with an average daily production of 180,000 metres (22 tonnes). About 160,000 metres (20 tonnes) is printed, the remainder being finished white. Some of the production is mercerised; the amount varies, but on average is about 30,000 metres (approximately 3½ tonnes) per day.

All the processing is on continuous machinery and the main water-using operations are:

Scouring and bleaching on rope range.
Mercerising.
Blanket washing on printing machines.

(There is no washing-off after printing)

The mill uses the municipal supply (tap water) for processing. It also has a borehole supply, but this is too hard for process use and is employed only to feed the water hydrants distributed round the mill.

2. OVERALL WATER USAGE

It is difficult to separate the water usage in finishing from the usage in other parts of the mill, but the total quantity of water employed in the finishing section cannot exceed 1300 cu.m per day. The overall specific water consumption is therefore about 60 cu.m per tonne of fabric processed.

This is a low figure and is a clear indication that the management has already taken action to economise in water usage and to introduce water-saving measures. Water availability, cost and problems of effluent disposal have all played a part in determining this attitude to water consumption.

Over the last few years this mill has increased its production of finished fabric from 9 million metres per year to the present level in excess of 60 million metres. It has been felt that the main water supply pipe would not have been suffient to permit this growth, or to allow for further expansion, without close attention to economy in water usage.

The cost of water to this mill has recently doubled and further increases are considered not unlikely in the near future.

At the present time the effluent from this mill receives no treatment on site. Plans are under discussion for a pipeline to take the waste from this and a number of other mills in the area to a desert region in the vicinity of Abu Qir for natural filtration. The effluent disposal problems are thus related primarily to pipe size and pumping requirements and will benefit from reduction in the volume requiring disposal.

A number of technical factors contribute to the low water consumption; for example, no washing-off after printing, the use of a new preparation range with water-saving features. However, a low water usage cannot be achieved without careful consideration of the requirements of individual process. These water consumptions have been measured and the machinery manufacturers have been consulted for their recommendations.

Regular meeting are held to discuss water usage and opportunities for savings. Plans are in hand for separately metering the flow to the more important machines.

3. WATER USAGE IN INDIVIDUAL PROCESSES

SINGE , DESIZE

These process operate for two shifts per day. Singeing is performed on an Osthoff machine which requires a flow of cooling water of about 30 cu.m per day. Desizing is estimated to use a further 40 cu.m per day.

Together, these processes have a specific water consumption of about 3 cu.m per tonne of fabric.

SCOUR AND BLEACH.

This is performed on a Brugman rope range in the following sequence; fabric from the desizing pit passes through wash, caustic impregnate, J-box, wash, hypochlorite imprregnate, J-box, wash, peroxide impregnate, J-box, wash.

The washing units in this range are equipped with heat exchangers and provided with counterflow of water in the following manner.

The desize washing unit is fed entirely with water from the caustic washer and the effluent passes through a heat exchanger to pre-heat a part (about 60 percent) of the fresh water supply to the caustic washer. The balance of the supply is provided by a separate feed of cold water.

There is a similar arrangement on the hypochlorite and peroxide washers, although here the normal procedure is to run the effluent from the peroxide wash directly to the heat exchanger and feed the hyprchlorite washer with fresh water.

The specification given by Brugman for the operation of this range quotes a water flow through each washing unit of about 12 cu.m per hour for a fabric processing rate of 1.7 tonnes per hour (i.e. a specific water usage of about 7 cu.m per tonne). However, because of the counterflow between the caustic and desize wash units the overall water consumption is three rather than four times this value; that is, 21 cu.m per tonne.

Important features of the machine are the flowmeters (of the Rotameter type) fitted to the water inputs and valves arranged to turn off the supply when the machine stops.

Since the actual rate of production on this machine is less than the figure in the manufacturer's specification (it is approximately 1.1 tonnes per hour), the specific water usage has been employed to determine the flow required. The flow meters are, of course invaluable for ensuring that the chosen flow in actually employed.

With a specific water consumption of 21 cu.m per tonne and a daily fabric throughput of 22 tonnes the average water usage on this range is about 460 cu.m. per day.

MERCERISATION

This is performed on a Farmer Norton machine which has four cascades over the chain followed by four wash boxes with counterflow. These are followed by a box containing acid and a final cold rinse; the effluent from this last unit is run separately to drain.

This machine processes about 30,000 m (3.5 tonnes) of fabric per shift and normally operates one shift per day. The rate of water usage is stated to be 8 cu.m. per hour or about 60 cu.m per shift. This represents a specific water consumption of 17. cu.m. per tonne.

PRINTING

Four roller printing machines operate three shifts per day. Each uses about 5 cu.m per hour for blanket washing and the total usage, allowing for washing down, is estimated to be 490 cu.m per day.

A rotary screen machine operates two shifts per day and has a water usage of about 80 cu.m per day.

The total water consumption in blanket washing is therefore 570 cu.m per day. The printed fabric production is about 20 tonnes per day and the specific water usage therefore about 28 cu.m per tonne.

The printing colour shop uses only about 10 cu.m per day for print -paste preparation and starch preparation in finishing is estimated to require about 20 cu.m per day.

BOILERS

The boiler water consumption is 420 cu.m per day. There is no return of condensate to the boiler supply system, although there is some use of condensate within the works. Condensed steam supplements the process water on the Brugman range, but the bulk of the condensate must be discharged as waste. The amount of boiler blow-down is a cause of some concern.

CAUSTIC RECOVERY

A caustic recovery plant has been installed and is awaiting commissioning. It is estimated that it will require 150 cu.m. per shift in cooling water, but provision has been made to use this water in the washers on the preparation range.

4. CONCLUSIONS

A summary of the water consumption figures is presented in Table 1.

As has already been stated the situation in this mill is well controlled and the conservation measures employed or planned (for example, counterflow between wash units, matching water flow to fabric throughput, re-use of cooling water) are just those which would be recommended in a water-saving programme.

However, the specific water consumption on the merceriser appears to be high. even for a washing operation to remove caustic soda. A reasonable target for this process would be a consumption in the region of 10 cu.m per tonne. It would be particularly useful to fit a water meter to this machine in view of the arrangements for recovery of caustic soda; it is obviously desireable to discharge wash water from the merceriser at the highest practicable concentration.

The consumption of fresh water by the boilers would be reduced by returning as much condensate as possible to the supply tank. Since the condensate is free from dissolved solids the volume of boiler blowdown will also be reduced.

MACHINE	NUMBER OF STAGES	WATER CU.M. PER TONNE		DAILY TOTAL	
		PER STAGE	TOTAL	PRODUCTION TONNES	WATER CU.M
SINGEING + DESIZING	1	3.2	3.2	22	70
SCOUR AND BLEACH: IMPREGNATE	3	1.0	3.0	22	66
WASH	3	7.0	21.0	22	460
MERCERISE: IMPREGNATE	1	1.0	1.0	3½	4
WASH	1	17.0	17.0	3½	60
PRINT BLANKET WASHING: TOTAL	-	28.5	-	20	570
PRINT PASTE AND STARCH PREPARATION	-	1.4	-	22	30
(TOTAL FOR THESE OPERATIONS)	-	-	57	22	1260

WATER USAGE DATA SHEET I

MILL: THE ARAB & UNITED SPINNING & WEAVING CO DATE: 31/ 3 /1983

WATER:

1. NUMBER OF SOURCES: 1

	SOURCE A	SOURCE B	SOURCE C
2. SOURCE.	City Water		
3. TREATMENT.	No		
4. PUMP CAPACITY.	No		
5. STORED VOLUME.	No		
6. RATE OF USE	70 m^3/h*		
7. COST.	0.1 Egyptian pounds/m^3		

* This figure includes boiler water
Process water = 52 m^3/hr

WASTE WATER:

8. NUMBER OF DISCHARGES:

	DISCHARGE A	DISCHARGE B	DISCHARGE C
9. SOURCE OF DISCHARGE.			
10. TREATMENT.			
11. FLOW RATE			
12. COST			

PRODUCTION:

13. MAIN FIBRES.	Cotton
14. MAIN CLASSES OF GOODS.	Printed fabrics
15. TOTAL QUANTITY PROCESSED	21 Tons/24 HRS
16. AVERAGE WEIGHT/UNIT AREA OF FABRIC.	140 gm/m

WATER USAGE DATA SHEET 2

LIST ONLY WATER-USING MACHINES

CONTINUOUS PROCESSING

MACHINE TYPE	NUMBER	AVERAGE PRODUCTION RATE	AVERAGE HOURS PER WEEK
- Singeing & desizing range	1	10000 M/hr	112
- Continuous robe bleaching range (3-stages)	1	7500 M/hr	160
- Mangling & Drying	1	7500 M/hr	160
- Mercerizing range & Dryer	1	3000 M/h	48
- Stenter	3	7500 M/hr	168

OTHER

MACHINE TYPE	NUMBER	AVERAGE CAPACITY	AVERAGE LOADS PER WEEK
- Blanket washer(Roller)	4	20 m^3/hr	168
- Blanket washer(Rotary)	1	5 m^3/hr	112
- Boiler	3	18 m^3/hr	168
- Cooling Cylinder(stenter)	2	6 m^3/hr	168
- Colour Kitchen	1	0.5 m^3/hr	168

EL SIOUF SPINNING AND WEAVING CO.

WATER USAGE IN DYEING AND PRINTING

GEOFFREY PARISH

UNIDO Adviser on Water Conservation

Summary

The water consumption at this mill is relatively high, the overall figure being about 20 cubic metres per tonne of material processed.
Fabric preparation on a Brugman range is responsible for about half of the total water consumption. This range has six washing units, in each of which the water flow rate is about 250 litres per minute. A reasonable target figure for water usage would be about half this value. If this saving were made the overall water consumption would be reduced by about 25 percent.

28 March 1983.

EL SIOUF SPINNING AND WEAVING CO.

1. GENERAL

The finishing section of this works processes cotton plain fabrics and a smaller quantity of yarn. The fabrics range in weight from 80 to 140g per meter and the major part of the production is printed.

The main water-using operations are the following:-

Continuous:	Preparation.
	Washing after dyeing or printing.
	Washing of printing blankets.
Batch	Jig preparation/dyeing or dyeing only
	Yarn dyeing.

2. WATER SUPPLY AND TOTAL CONSUMPTION

The works uses mains (tap)water which is supplied through four metered inlets, one of which feeds the boilers. Readings of these meters were taken at about 1 p.m on consecutive days (23 and 24 March). The results, corrected for the exact times of reading so as to represent the flow in 24 hours, are:-

Proccess water:	Supply 1:	1570	
	2:	1710	
	3:	1050	
	Total	4330	cu.m/day
Boiler feed water:		1570	cu.m/day

Five boilers deliver 50 tonnes/hr. of steam.

3. WATER USAGE ON INDIVIDUAL MACHINES

3.1. CONTINUOUS PROCESSES - PREPARATION

BRUGMAN ROPE RANGE

The sequence on this range is: desize, wash, caustic saturate, J-box, two washes, hypochlorite saturate, J-box, wash, peroxide saturate, J-box, two washes.

The processing speed is between 130 and 170m/min. and the machine operates during three shifts, seven days per week. The average production is 150,000 m. per day.

The tonnage of fabric processed will depend on the weight per unit length. Assuming this on average to be 110 g/m, the rate of fabric throughout is about 17 kg/min and 17 tonnes/day.

Water usage

The water flow rate was measured at the outlet of one of the wash boxes, the value being 250 litres/min. Over 24 hours the flow will be 360 cu.m.

The specific water usage per washing stage: 21 cu.m/tonne fabric

The machine has six washing stages. Allowing for a water usage of about 1 cu.m. of water per tonne of fabric in each saturator, the total daily water consumption will be about 2250 cu.m.

KIER BOIL, ROPE BLEACH

The desized fabric is run into one of a gruop of four kiers. After kier boiling the fabric passes through the following sequence: wash, bleach (impregnate + J-box), wash, sour (impregnate + J-box), two washes.

The processing speed is 25m/min and the bleaching range handles one kier load per day. It is estimated that the average load is about 2 tonnes; at an average fabric weight of 110 g/metre this would require about 12 hours to process.

Water usage. The water flow rate was measured at the inlet to one of the wash boxes, the value being 70 litres/min; over 12 hours the flow will be 50 cu.m.

The specific usage per washing stage is 25 cu.m per tonne of fabric.

The machine has four washing stages. Allowing for the water usage in the kier and in impregnation for desizing and bleaching the total daily water consumption on this range is estimated to be 210 cu.m.

3.2. WASHING ASSOCIATED WITH PRINTING AND DYEING.

WASHING AFTER DYEING OR PRINTING

It is estimated that about 100,000 metres of fabric are printed per day, but at least 80 percent is pigment printed and does not require any washing off. The total quanity of fabric (dyed or printed) which is washed is probably about 30,000 m per day (approximately 3 tonnes).

The washing is performed in sequence on a seven-box range and a two-section Artos horizantal-path washer. The Artos machine runs at about 25m/min and to process 30,000 m at this speed would require 20 hours.

WATER USAGE

At the time of the visit water was flowing into four of the boxes in the seven-box range. One of these flows was measured at 25 litres/min and the total consumption on this machine if therefore estimated to be 100 litres per min. or about 150 cu.m per day (the flow is assumed to be continuous).

On the Artos unit the pump connecting the two sections was not in use and fresh water was fed to each unit. From the discharge the total flow was estimated to be 150 litres/min or 220 cu.m per day.

The specific water usage on these machines is:

Seven-box range: 50 cu.m/tonne

Artos washer : 75 cu. m/tonne.

Washing of printing blankets

The wa‑‑r usage here could be only roughly estimated. It is considered to be in the region of 600 cu.m per day, equivalent to a specific consumption of about 50 cu.m per tonne. (the total weight of fabric printed is estimated on average to be about 12 tonne per day).

3.3. BATCH PROCESSING

Jigs

The mill has six new Smith jigs, one other hooded jig and about ten older open machines. The jigs operate two shifts per day and process two batches per shift when dyeing directs and reactives, one batch with vats and azoics.

The machines hold about 400 litres and take batches between 600 and 1000 metres in length; average weight say 80 Kg. The liquor ratio is then 5 to 1. The average total water usage in processing one batch of fabrics is estimated to be about 2.5 cu.m.

The quantity of fabric processed on the jigs is difficult to estimate. At the time of the visit only two machines were in operation, but the average production is probably about 1 tonne per day (about 12 batches). the total water usage will then be 30 cu.m per day.

Yarn dyeing

The largest unit is a Thies set comprising dyeing vessel, water extractor and dryer. This dyeing vessel has a capacity of 3.5 cu. m and liquor ratio of 10 to 1 (ie: 350 kg of yarn)

Two smaller units, one Mezzera, one Pegg, have capacities of about 1 cu.m.

The machines operate two shifts per day, processing one batch per shift. The maximum capacity is therefore about 1 tonne of yarn per day. The average water usage in processing this weight of yarn will be about 60. cu.m.

4. SUMMARY

A summary of the measurements and calculations of water consumption is shown in Table 1. The total water usage of the processes listed accounts for 82 percent of the total consumption of process water at the mill. This is a reasonable figure in view of the uncertainties in some of the estimates and the various sources of water usage not listed (for example, washing down of machines, use in colour shop, and so on).

5. CONCLUSIONS

The overall water usage at this mill is relatively high and the reason is the high level of specific water consumption in the continuous processes.

In batchwise processing on jigs and yarn dyeing machines the specific water consumption is reasonably low and these machines make only and very small contribution to the overall water usage.

On continuous processes the target figure for the specific water usage per stage is about 5 cu.m per tonne of fabric processed. There are situations where it may be difficult to obtain the required thoroughness of washing at this target figure, but any water usage above about 10 cu.m per tonne almost certainly means that the water is not being used effectively.

If it is desired to make water savings, the obvious machine to investigate first is the Brugman preparation range, which is responsible for half of the overall water consumption.

Control of the water usage in the washing sections of this range could be achieved by fixing a scale on each of the water valves to indicate the correct setting. The actual flow would be determind by the bucket-and-stopwatch method employed in this study. It is recommended that the flow be reduced in small stages. A reasonable target would be a water flow rate in each wash section of 100 to 120 litres per min.

A further saving could be achieved by running some of the wash water by counter flow between the washing stages where two stages operate in sequence (after the caustic and peroxide J-boxes). This would require pipework connecting the two stages, but would have the effect of reducing the number of washing sections to four.

PROCESS	AVERAGE NUMBER OF STAGES IN PROCESS
CONTINUOUS	
Prep. - Brugman	6
Prep. - Kiers	4
Wash off - J-box range	1
- Artos washer	1
Print blanket washing	-
BATCH	
Jigs	6
Yarn dyeing	6
TOTAL	-

TABLE 1

SPECIFIC WATER USAGE		DAILY TOTAL		
PER STAGE	FOR WHOLE PROCESS	PRODUCTION TONNES	WATER CU. M	WAT[illegible] USAG[illegible] % OF TOTAL
21	126	17	2250	52
25	100	2	210	5
50	50	3	150	3
75	75	3	220	5
-	50	12	600	14
5	30	1	30	1
10	60	1	60	2
-	205	21	4350	

WATER USAGE DATA SHEET I

MILL: EL SIOUF SPINNING & WEAVING CO DATE: 22 / 3 /1983

WATER:

1. NUMBER OF SOURCES: 1

	SOURCE A	SOURCE B	SOURCE C
2. SOURCE.	PROCESS MAINS (TAP)	BOILERS (TAP)	
3. TREATMENT.	NONE	-	
4. PUMP CAPACITY.	-	-	
5. STORED VOLUME.	NONE	-	
6. RATE OF USE	4330 cu.m/day	1570 cu.m per day	
7. COST.			

WASTE WATER:

8. NUMBER OF DISCHARGES:

	DISCHARGE A	DISCHARGE B	DISCHARGE C
9. SOURCE OF DISCHARGE.	WHOLE MILL		
10. TREATMENT.			
11. FLOW RATE			
12. COST			

PRODUCTION:

13. MAIN FIBRES. COTTON
14. MAIN CLASSES OF GOODS. PLAIN FABRIC, YARN
15. TOTAL QUANTITY PROCESSED APPROX. 21 TONNES/DAY
16. AVERAGE WEIGHT/UNIT AREA OF FABRIC. ABOUT 110g/metre length

WATER USAGE DATA SHEET 2

LIST ONLY WATER-USING MACHINES

CONTINUOUS PROCESSING

MACHINE TYPE	NUMBER	AVERAGE PRODUCTION RATE	AVERAGE HOURS PER WEEK
Rope preparation range (Brugman)	1	150 m/min	3 shifts, 7 days per week
Kiers and bleaching range	1	25 m/min	1 kier load per day
Wash-off after printing/ dyeing			
- 7-box range	1	20m/min	
- Artos washer	1	25m/min	3 shifts
Printing blanket washing		-	-

BATCH PROCESSING

MACHINE TYPE	NUMBER	AVERAGE CAPACITY	AVERAGE LOADS PER WEEK
Jigs	11	400 litres	Approx. 12 loads per day
Yarn dyeing			
- Thies	1	3500 litres	(2 batches per
- others	2	1000 litres	(day

ORIENT LINEN AND COTTON CO.

WATER USAGE IN DYEING AND PRINTING

GEOFFREY PARISH

UNIDO Adviser on Water Conservation

Summary

The overall water consumption at this mill is about 75 cu.m. per tonne of material (fabric plus yarn) processed. This is a reasonably low figure and results mainly from the use of continuous ranges with counterflow of water for washing operations.

The variety of fabrics processed is very wide, and under these circumstances it may prove difficult to achieve any further reduction in water usage. Water could be saved in continuous washing, but only by relating the water flow at any time to the weight of fabric processed at that time.

In yarn dyeing water could be saved by re-using rinse waters, but this would require the installation of a storage tank to hold the water until required.

31 March 1983.

ORIENT LINEN AND COTTON CO.

1. GENERAL

This mill processes cotton, polyester/cotton, linen and polyester/linen fabrics in a wide variety of styles and in width between 90 and 240 cm. It also dyes cotton and linen yarn.

Fabric is processed mainly in open width. Continuous equipment includes two pad-roll ranges used for scouring and bleaching a merceriser, a dyeing range, one flat-bed and one rotary-screen printing machine.

Batchwise processing equipment for fabric comprises five jigs, five winches and one beam dyer. The main yarn processing equipment is a double set of vessels for preparation, dyeing, water extraction and drying.

The mill operates for 24 hours per day, in three shifts. The average daily production of fabric is 35,000 to 40,000 metres and of yarn 2 to 2½ tonnes. Of the fabric production about 45 percent is printed, 40 percent is dyed and the remaining 15 percent is bleached only.

2. OVERALL WATER USAGE

Water is taken from the municipal supply and is not treated or stored for process use.

At the present time this mill has no restriction on the quantity of water it can use, and the present cost is not considered particularly high. The only problem is variable hardness in the water, which occasionally causes some difficulties.

The total quantity of water consumed in wet processing has proved a little difficult to determine precisely, but a reasoned estimate of the average daily consumption is 900 cu.m.

With a wide range of fabric styles and widths it is also difficult to ascertain the tonnage of fabric processed. However, the average fabric weight is probably in the region of 250g per metre, and the average daily production will therefore be 9 or 10 tonnes. Adding the yarn throughput the total weight of material processed will be about 12 tonnes per day.

The overall specific water consumption is therefore about 75 cu.m per tonne on average. This is a reasonably low figure.

3. WATER USAGE ON INDIVIDUAL MACHINES

3.1. CONTINUOUS PROCESSES

SCOURING RANGE

This pad-batch process uses a four-box washer. This runs at about 30 metres per minute and must operate almost continuously for 24 hours (to process 40,000 metres at 30 m/min would require 22 hours). The average fabric weight is taken to be 250g per metre and the production rate is therefore about 7.5 Kg per min.

Although the wash water is run counterflow on this range, there are a number of leaks from the tanks and neither the inflow not the outflow could be accurately measured. The best estimate of water flow rate is 120 litres per min. The specific water usage is therefore about 16 cu.m. per tonne of fabric.

Allowing for a water usage of about 15 cu.m. per day for impregnation the total consumption on this range is estimated to be 190 cu.m per day.

BLEACHING RANGE

This also runs at 30 m/min and will have the same average production rate of 7.5 Kg/min.

It employs a four-box washer with counterflow. The rate of flow out of the range was measured by bucket-and-stopwatch at 85 l/min. The specific water usage in washing is therefore about 11 cu.m per tonne of fabric.

Allowing for the water usage in impregnation the total water consumption on this range will be about 140 cu.m per day.

MERCERISER

The average amount of fabric mercerised proved difficult to determine and the machine was not running at the time of the visit and it was therefore not possible to make water flow measurements. However, this machine is used along with the continuous dyeing range for washing-off after printing and dyeing and the measurements on the second machine may serve for the merceriser also.

CONTINUOUS DYEING RANGE

This machine has eight wash boxes, with provision for counter-flow throughout the range. In addition to continuous dyeing this washer and the merceriser are used for washing-off after printing and after cold pad-batch dyeing and jig dyeing. In total they must process about 80 percent of all the fabric.

The outflow from this washer was not readily accessible and the water flow rate was measured by opening the bottom drain in the discharging tank until the water level had dropped a few cm. The drain was then closed and the rate of rise of water determined until it reached the normal overflow pipe. From the cross-sectional area of the tank the flow rate was calculated to be 95 litres per min. The specific water consumption is therefore about 13 cu.m per tonne of fabric.

From the quantity of fabric processed on this machine it is estimated that the total water usage is about 90 cu.m per day.

Incidentally, it may be noted that even in a long washing range such as that on this continuous dyeing mashine the volume of water in the wash tanks is relatively small in relation to the through-flow. In the present instance the total tank volume is calculated to be 10 cu.m.

PRINTING MACHINES

Printing is performed on a Buser flat-bed machine and a Stork rotary screen machine, The water usage for blanket washing on the two machines is estimated to be 100 cu.m. per day.

3.2. BATCH PROCESSING, FABRIC

JIGS

The quantity of fabric processed on the jigs must be relatively small and probably does not exceed 1 or 1½ tonnes per day. The total water usage must be in the region of 20 cu.m per day.

WINCHES

The water volume in each winch is about 2.7 cu.m The total water usage on these machines cannot exceed 30 cu.m. per day.

The beam dyeing machine was not in use at the time of the visit.

3.3. BATCH PROCESSING, YARN

The main yarn dyeing equipment is a Thies set for dyeing cotton and linen yarn on cones. The processing sequence is; scour, wash, dye, oxidise, wash, wash. The nominal liquor to-goods ratio is 10 to 1; with six fillings of the vessels the overall consumption will be 60 cu.m. per tonne of yarn. If 2.5 tonnes of yarn are processed per day the water consumption will be about 150 cu.m.

3.4. BOILERS

The boilers produce about 16 tonnes per hour of steam and use only fresh water, there being no condensate return. The concentration of solids in the boiler water is causing some concern & this is the subject of a separate report. However it may be mentioned here that following discussion of this problem, staff of the Textile Development Centre have given advice and assistance in relation to the analysis of boiler water quality.

4. CONCLUSIONS

A summary of the measurements and calculations of water consumption is shown in Table 1. The total water usage of the processes listed accounts for 80 percent of the total consumption of process water at the mill. This is a reasonable figure in view of the uncertainties in some of the estimates and the various sources of water usage not listed (for example, washing-down of machines, colour shop, so on).

The overall water usage at this mill is reasonably low. It results to a considerable extent from the use of continuous washing processes with counterflow of wash water.

The target figure for water usage in continuous washing is 5 cu.m. per tonne of fabric. It will be seen from Table 1 that the average values are greater than this, but they may not be excesive for the goods of heaviest weight (the widest fabrics or the fabrics with the highest weight per unit area).

Where a very wide range of fabric qualities is processed, it may only be feasible to achieve water savings by relating the water flow rate to the rate of fabric throughput (in tonnes per hour). This requires the installation of a flow meter and appropriate flow settings for different classes of goods. If this were done it should be quite possible to reduce the total water consumption in washing by about 50 percent.

In yarn dyeing the water consumption each time the machine is filled is determind by the machine dimensions. The only feasible water-saving procedure here is to re-use rinse waters either for further rinsing or for preparing process baths. This of course requires the installation of a storage tank or tanks to hold the water until it is required.

<u>TABLE 1</u>

PROCESS	NUMBER OF STAGES IN PROCESS	AVERAGE SPECIFIC WATER USAGE		DAILY TOTAL		
		PER STAGE CU.M/tonne	FOR PROCESS cu.m/tonne	PRODUCTION tonnes	WATER cu.m	WATER% of total
<u>CONTINUOUS</u>						
SCOURING RANGE	1	16	16	9.5	190	21
BLEACHING RANGE	1	11	11	9.5	140	16
MERCERISER	1	-	-	?	-	-
CONTINUOUS DYEING	1	13	13	7.5	90	10
PRINTING BLANKET WASHING	-	-	-	4.5	100	11
<u>BATCH</u>						
JIGS	4	5	20	1	20	2
WINCHES	-	-	-	-	30	3
YARN DYEING	6	10	60	2.5	150	17
TOTAL	-	-	75	12	900	-

WATER USAGE DATA SHEET I

MILL: ORIENT LINEN & COTTON CO. DATE: 31 / 3 /1983

WATER:

1. NUMBER OF SOURCES: 1

	SOURCE A	SOURCE B	SOURCE C
2. SOURCE.	MUNICIPAL SUPPLY (TAP)	MUNICIPAL FOR BOILERS	
3. TREATMENT.	NONE	SOFTENED	
4. PUMP CAPACITY.	NONE	$19.6 m^3/hr$	
5. STORED VOLUME.	NONE	$250 m^3$	
6. RATE OF USE	900 cu.m/day	16 tonne/hr steam	
7. COST.	(approx)		

WASTE WATER:

8. NUMBER OF DISCHARGES: 1

	DISCHARGE A	DISCHARGE B	DISCHARCE C
9. SOURCE OF DISCHARGE.	WHOLE WORKS		
10. TREATMENT.	NONE		
11. FLOW RATE	-		
12. COST	-		

PRODUCTION:

13. MAIN FIBRES. COTTON, PE/COTTON, LINEN, PE/LINEN
14. MAIN CLASSES OF GOODS. WIDE VARIETY OF FABRICS
15. TOTAL QUANTITY PROCESSED 35000-40000 m/day FABRIC
16. AVERAGE WEIGHT/UNIT AREA OF FABRIC. 2-2½ tonne/day yarn
    Probably about 250g/metre length

WATER USAGE DATA SHEET 2

LIST ONLY WATER-USING MACHINES

CONTINUOUS PROCESSING

MACHINE TYPE	NUMBER	AVERAGE PRODUCTION RATE	AVERAGE HOURS PER WEEK
SCOURING RANGE	1	30 m/min	3 shifts per day
BLEACHING RANGE	1	30 m/min	3 shifts per day
MERCERISER	1	(used for washing-off	
CONTINUOUS DYEING RANGE	1	(after printing and	
FLAT BED PRINTING MACHINE	1	(dyeing	
ROTARY SCREEN MACHINE	1		

BATCH PROCESSING

MACHINE TYPE	NUMBER	AVERAGE CAPACITY	AVERAGE LOADS PER WEEK
JIGS	5	2502	
WINCHES	5	2.7 cu.m	
BEAM DYER	1	-	
YARN DYEING (THIES)	2 sets	300 kg load 10:1 liquor ratios	2-2½ tonnes per day

VISIT REPORT

MUNICIPAL WATER SUPPLY WORKS, NEW MANSHIA PLANT

GEOFFREY PARISH

UNIDO Adviser on Water Conservation

Summary

Many dyeworks and printworks in Alexandria use the municipal water supply. This visit was made to establish the position of the textile industry in relation to the overall water requirements of the area.At the present time municipal water is readily available and relatively cheap. However, mills should be aware of the opportunities for water conservation because the growth of demand for water may lead to restrictions in supply or to higher charges.

19 March 1983

VISIT TO MUNICIPAL WATER SUPPLY WORKS

NEW MANSHIA PLANT

This is the largest of the four main waterworks in the area of Alexandria. At present it produces 400,000 cubic metres of water per day and extensions to the treatment plant are under construction.

This works takes water from a channel fed from the Nile and treats it by sedimentation, filtration and disinfection. Alum is employed as a coagulant and chlorine as the disinfectant, with the addition of ammonium sulphate to maintain the disinfectant action throughout the long distribution network.

The treated water is of high quality, with low turbidity (about 0.5 N.T.U), a pH between 7.2 + 7.8 and a low concentration of chloride ion (40 to 80 p.p.m). It is obviously very suitable for textile processing. Numerous analytical test are performed regularly for quality checking and process control.

Water is supplied for domestic and industrial use, the main industrial users being a refinery, soft-drink manufacturers, a soap works and the textile industry. Both domestic and industrial supplies are metered, but the charging rates are different. Domestic users pay 1½ piastres per cubic metre, industry 5 or 10 pts. The cost of supplying water is about 3½ pts per cubic metre.

The total capacity of all the waterworks in the area of Alexandria is about 1.25 million cu. m. per day, but the actual supply is probably closer to 1 million cu.m. The average domestic usage is about 200 litres per person per day, with some consumers taking up to 400 litres per day.

The population of Alexandria is stated to be about 3 million and therefore about 600,000 cu.m. per day will be required for domestic use, leaving 400,000 cu.m. for industry. (These proportions agree satisfactorily with the water costs and charges, assuming that the cost of supply is fully met by the combined payments from domestic and industrial users)..

RELATION TO THE TEXTILE INDUSTRY

The number of textile mills using the municipal water supply is not known, but the volume taken for textile use can not be greater than 50,000 or 60,000 cu.m per day; This is only 5 or 6 percent of the total water supply.

At the present time the textile user has plenty of water available and it is relatively cheap, but not as cheap, for example, as energy.. There should be more incentive to save water, but the cost is not yet a strong argument.

However, Alexandria is growing and the plans for expansion of the water supply system must take account of increased demand by both domestic and industrial users. The primary requirement must be to supply the domestic demand and it is possible that industrial users will be asked to economise for this reason. Local problems may occur where existing supply mains prove inadequate for an increased demand. The cost of supplying water must rise, and if the charges to domestic consumers are held down industry may be required to pay a larger share.

CONCLUSIONS

A textile mill using the municipal water suppply has no significant incentive to conserve water at the present time but would be well advised to be aware of the opportunities for conservation and to maintain a careful watch on water consumption. It will then be in a position to take positive action in response to any future changes in supply or in cost.

ACKNOWLEDGMENTS

The author wishes to thank Eng. A. El-Maghrabi for permission to visit this waterworks, Eng. Nadia A. Saleh for information helpfully given and Mr. Khairallah of Textile Development Centre for making the arrangements for the visit.

ANNEX 2

2.1 Suggested laboratory exercises in flow measurement

2.2 Measurement of suspended solids

SUGGESTED LABORATORY EXERCISES IN FLOW MEASUREMENT

1. BUCKET AND STOPWATCH.
2. DILUTION.
3. FLOW OVER WEIR IN OPEN CHANNEL.

G. J. PARISH
26 MARCH 1983.

1. BUCKET AND STOPWATCH

Measure the time for water to rise a certain height in. a rectangular sink.

Measure the dimensions of the sink : length l cm., bredth b cm. Stick a tape on the side of the sink with two marks a known distance apart, h cm (this might be 5 cm). The bottom mark should be about 5 cm from bottom of sink.

Run water into the sink through a hose so that the water rises smoothly. Close drain, Start stopwatch when water reaches lower mark, stop it at upper mark.

Suppose time is t secs. Then flow rate .

$$Q = \frac{l.b.h}{t} \text{ cc/sec.}$$

$$= 0.06 \frac{l.b.h}{t} \text{ litres/min}$$

Similar experiments can be done with buckets or barrels, using the appropriate formulae for the dimensions of the vessel.

2. DILUTION

Measure the volumes of water in tanks or in the pilot-scale machines by adding a known volume of dye solution, or of a solution of sodium chloride if you have a conductivity meter.

Make up the dye or salt solution. Retain some for comparison.

Add a measured volume to the machine; the volume may be about one hundredth of the estimated machine capacity.

Mix thoroughly in the tank or machine, remove a sample and compare the strengths of the solutions. In effect one needs to know how much the solution has been diluted:

Vol. of machine = Vol. Taken x dilution factor.

Calculation of the dilution factor is straight-forward with a colorimeter or conductivity meter. If it is to be estimated by eye on dye solution it is necessary to make a range of dilutions of the original solution and estimate the closest fit. To get reasonably accurate figures one must make dilutions differing by no more than 20 percent; for example, 1 in 100, 1 in 120, 1 in 150.

3. FLOW OVER WEIR IN OPEN CHANNEL

See separate note for the theory of flow over weirs.

Construct a channel about 10 cm high, 20 cm wide and 1 metre long. One end must be closed, the other open.

The channel should be set up so that it is horizontal with the open end over a drain and at a sufficient height from the floor that a bucket can be put underneath. A water flow from a tap should be provided at the closed end of the channel (see Fig 1).

Construct a V-notch weir as shown in Fig 2. This should be fixed in the channel about 10 cm from the open end, and the joint must be watertight.

About 10 or 20 cm upsteam of the weir fix a vertical scale marked in millimetres on the side of the channel. The position is not critical, but should be at a point where the water surface is smooth.

With no water flow the water level will be at the height of the bottom of the V-notch. Note this reference level on the scale.

For any steady flow measure the height on the scale; measure to the nearest mm if possible. Also measure the flow out of the channel by the bucket and stopwatch method. Compare the two measurements.

The relation for the weir is

Flow rate $Q = 2.67 \times 10^{-3} h^{5/2}$ litres /min

Where h is the water height above the reference level in mm.

For $h = 10$ mm $Q = 0.84$ litres/min.
$h = 50$ mm $Q = 47$ litres /min.

Note: to avoid water standing indefinitely in the channel it is useful to have a small drain plug upstream of the weir.

Note on accuracy: because of power of h involved the accuracy of determination of flow is lower than the accuracy of measurement of height. For example, if 10 mm true height is recorded as 9 mm the indicated flow would be 0.65 1/mm as 11mm 1.07/min An error of 10% in height measurement becomes about 25% in the flow figure.

WATER FLOW OVER WEIRS

Theoretically the head of water (the height above the weir) is converted to kinetic energy. In fact, some energy is lost and a correction factor must be applied. This correction factor is about 0.6.

Q is flow rate of water over the weir.
b is breadth of rectangular weir.
h is height above weir (above bottom of notch for V-notch weir)
g is acceleration due to gravity.

RECTANGULAR WEIR

$Q = 0.415b \sqrt{(2gh^3)}$

Q in cu.m /sec for b, h in m, g in m/sec^2

Hence $Q = 6700bh^{3/2}$ cu.m perhour.with b & h in m.

90^0 V-NOTCH WEIR

$Q = 0.316 \sqrt{(2gh^5)}$

Hence $Q = 5100\ h^{5/2}$ cu.m per hour with h in m.

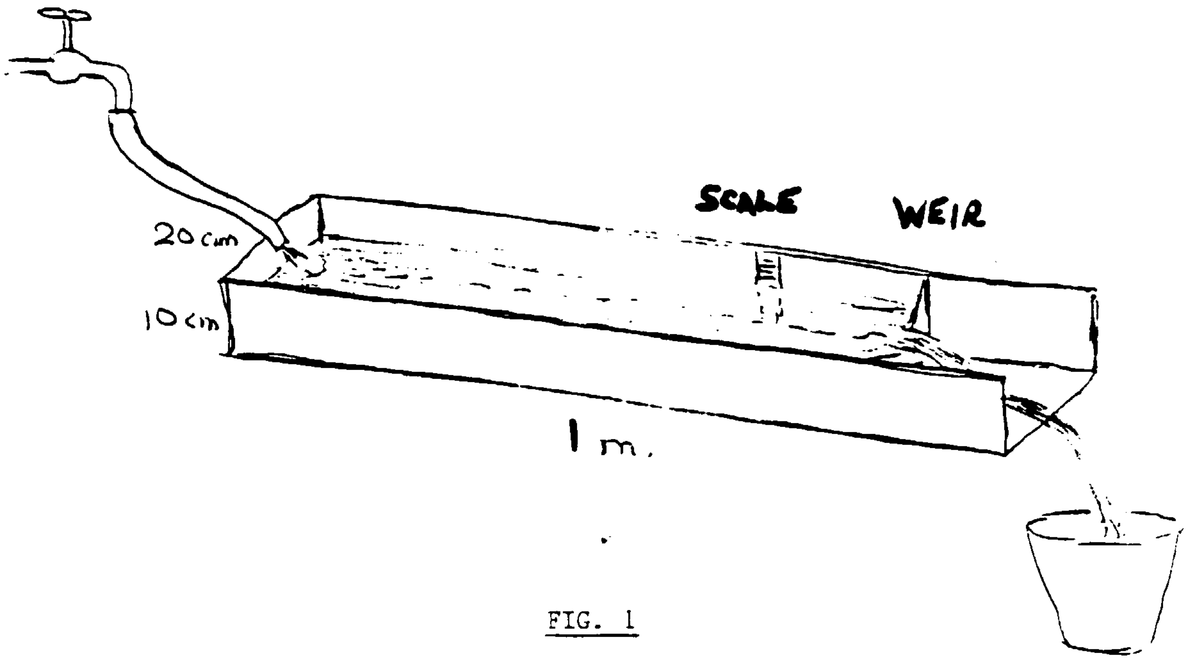


FIG. 1

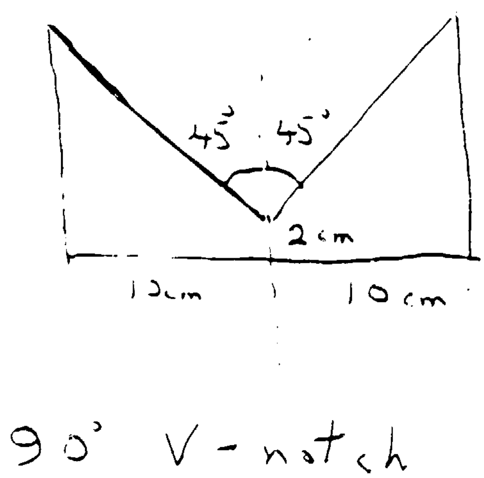


FIG. 2

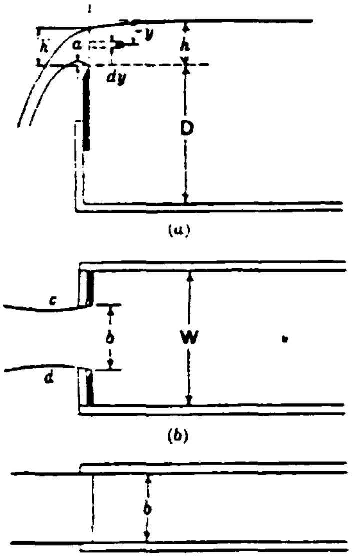


FIG. 10-85. — Details of Rectangular Weirs.

(1) *The Rectangular Weir.*—The depth of water over the crest of a weir, causing the flow, is the distance from the surface of still water, some distance upstream from the crest to the center of pressure of the cross-section of the issuing stream. The *head* of *water* over the weir is the distance h, Fig. 10–85a, from the surface of still water to the level of the crest. Let the breadth of the weir be b, Fig. 10–85b or c.

The theoretical equation for this weir may be derived as follows. Any small particle of water dy, at a distance y below the surface of still water, Fig. 10–85a, will have imparted to it a theoretical velocity $v = \sqrt{2gy}$ ft. per sec. This is the velocity possessed by a thin filament of water of thickness dy and of width b at a mean distance y below the surface. Hence the volume discharged through the infinitesimal orifice of area bdy will be

$$dQ' = bdyv = bdy\sqrt{2gy} \text{ cu. ft. per sec.} \tag{45}$$

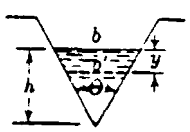
Integrating this between the limits $y = 0$ and $y = h$, we have that the theoretical quantity of discharge is

$$Q' = b\sqrt{2g}\int_0^h y^{1/2}dy = \tfrac{2}{3}b\sqrt{2gh^3} \text{ cu. ft. per sec.} \tag{46}$$

Note that b and h must be expressed in feet.

(2) *The Triangular or Thomson Weir or V-Notch.*—In Fig. 10–86a, let the apex angle be θ, and let b be the width of the crest for any head h. As in the case of the rectangular weir, the velocity of a particle of fluid a distance y below the surface level will be $\sqrt{2gy}$ ft. per sec. If b' is the width of the notch at a head $h - y$, and dy is the thickness of the filament of fluid at $h - y$, the theoretical volume discharged through orifice of area $b'dy$ is

$$dQ' = b'dy\sqrt{2gy} \text{ cu. ft. per sec.} \tag{54}$$



(a)

FIG. 10-86.

From Fig. 10–86a, we have

$$\frac{b'}{b} = \frac{h - y}{h}, \text{ or } b' = \frac{b}{h}(h - y)$$

Substituting this in equation (54), we derive

$$dQ' = \frac{b}{h}(h - y)dy\sqrt{2gy}$$

$$= \frac{b}{h}\sqrt{2g}(hy^{1/2} - y^{3/2})dy \text{ cu. ft. per sec.} \tag{55}$$

from which

$$Q' = \frac{b}{h}\sqrt{2g}\int_0^h (hy^{1/2} - y^{3/2})dy$$

$$= \frac{b}{h}\sqrt{2g}(\tfrac{2}{3}h^{5/2} - \tfrac{2}{5}h^{5/2})$$

$$= \frac{4}{15}\frac{b}{h}\sqrt{2gh^5} \text{ cu. ft. per sec.} \tag{56}$$

To eliminate the measurement of b, substitute $b = 2h \tan\frac{\theta}{2}$. Then

$$Q' = \frac{8}{15}\tan\frac{\theta}{2}\sqrt{2gh^5} \text{ cu. ft. per sec.} \tag{57}$$

The actual volume discharged is found by introducing into equation (57) a discharge coefficient C, so that finally

$$Q = \frac{8}{15}C\tan\frac{\theta}{2}\sqrt{2gh^5} \text{ cu. ft. per sec.} \tag{58}$$

The most common apex angle is $\theta = 90$ deg., for which $\tan\frac{\theta}{2} = 1.0$, so that for this special case

$$Q = \frac{8}{15}C\sqrt{2gh^5} = 4.28C\sqrt{h^5} \text{ cu. ft. per sec.} \tag{59}$$

It is claimed for this weir that it is particularly well adapted to the measurement of small rates of flow.

MEASUREMENT OF SUSPENDED SOLIDS

PROCEDURE

1) Take two filter papers from the pack, weigh them separately. Weigh to nearest 0.5 Mg.
One papre will be used for fileration, the other kept as a blank. Put the blank paper on one side but do not let it get dirty.

2) Fold the filter paper with tweezers if possible, otherwide make sure hands are clean.

3) Pour measured voluеme of shaken solution into measuring cylinder. Use at least 500 ml,

4) Filter this solution. Collect filtrate for further tests.

5) Rinse measuring cylinder with a little distilled water (25 to 50 ml) and filter.

6) Wash filter paper with 25 ml distilled water.

7) Discard filtrate from 5 and 6

8) Remove filter paper and dry carefully.

9) Put filter paper and blank paper together for at least one hour, then weigh them

10) Calculate the suspended solids as follows

	fiter paper	blank paper
Weight before	W1 mg	B1 mg.
Weight after	W2 mg	B2 mg.
Volume of solution	V ml	

$$\text{Suspended solids} = \frac{W2 - (W1 \times B2/B1)}{V} \times 1000 \text{ mg/l}$$

(p.p.m)

EXPLANATION

1) It is necessary to measure suspended solids concentration to an accuracy of $\pm$ 2 mg/l.
The procedure is designed to minimise the following problems.

2) The solution may contain only 5 or 10 mg/l of suspended matter. Use at least 500 ml to make sure that a measureable weight is collected.

3) The filter paper may change weight because of a change in moisture content. We assume that this change is in the same proportion as the blank paper.

4) Some suspended matter may settle in the measuring cylinder therefore rinse it out.

5) The filter paper holds some solution at the end of filteration. The dissolved solids in this must be washed out.

6) Only suspended solids in the solution must be measured. Therefore take care to avoid the filter paper getting dirty.

USEFUL EXERCISES

1) Follow the procedure with 500 ml of distilled water. Record the measurement and results to see how close to zero the answer is.

2) Make up a solution containing a known amount of suspended matter.

   Carefully weigh about 40 mg of some suitable material (eg. fine sand which has been previously washed and dried).
   Mix into 1 litre of distilled water.
   Follow the procedure with 500 ml of this solution.

ANNEX 3: SEMINAR

SEMINAR

WATER CONSERVATION IN THE TEXTILE INDUSTRY

Sunday 3 April 1983

GEOFFREY PARISH

UNIDO Adviser on Water Conservation

Programme

10.45 - 11.00	Welcome and Introduction.
11.00 - 11.45	Lecture No.1
	How to save water ?
11.45 - 12.00	Discussion.
12.00 - 12.45	Break.
12.45 - 1.30	Lecture No.2
	How to measure water usage ?
1.30 - 1.45	Discussion.

SEMINAR

HOW TO SAVE WATER

GEOFFREY PARISH
UNIDO Adviser on Water Conservation

3rd April 1983

1. Water usage in textile processing.
2. Reasons for saving water.
3. Ways to save water.
4. Summary of conservation measures.

1. WATER USAGE IN TEXTILE PROCESSING

A textile dyeworks or printworks uses large volumes of water. For example, a works processing 10 tonnes of yarn or fabric per day may use as much water as 5000 to 10000 people.

The most readily available figure for water consumption is the overall specific consumption, i.e. the total amount of water used by all processes in finishing divided by the total weight of material processed in the mill. However, such data show a very wide range of values. Much of this variation is due to differences in the number and complexity of the processes involved, but even where mills performing similar work are compared the range may be 5 or 6 to 1.

With such a wide range of individual values, the average figure for the industry as a whole has limited significance. At the present time this average probably lies in the range 100 to 120 litres per kg and is of use, perhaps, to provide a guide to the water consumption in a district or region in relation to its production of finished textiles.
It is of little assistance to the individual finisher, who must look more closely at his own data and at the relevance of comparable or target figures if he is to attempt a logical approach to water conservation.

Some features are common to all mills which perform a sequence of processes in preparation, dyeing or printing and finishing. These mills will normally have a steam consumption which is one quarter to one sixth of the water used directly in processing ; in other words, for each tonne of steam produced some 4 to 6 tonnes (cubic metres) of water will be used in processing.

The actual quantity of fresh water fed to the boilers will, of course, depend on the percentage condensate recovery and losses associated with the boiler operation. If there is no condensate recovery, the boiler feed water will represent 15 to 20 percent of the total; if half the condensed steam is returned to the boiler the figure will be 8 or 10 percent.

Of the steam which is not returned as condensate to the boiler, a part, at least, will be condensed in process water baths, effectively augmenting the direct water supply. This effect is off-set by losses arising from deliberate and inadvertent evaporation and by leakage, so the effluent flow from the works is typically 5 or 10 percent lower than the inflow of process water. As a final generalization it may be pointed out that the staffing levels in textile finishing works are such that the domestic water consumption is likely to be only 1 or 2 percent of the process water demand.

QUALITY AND QUANTITY REQUIREMENTS

In textile finishing operations water is used essentially for two purposes, first as a solvent for processing chemicals and secondly, and still by virtue of its solvent action, as a washing or rinsing medium. In either situation it is required to be sufficiently pure not to introduce any contaminants which would adversely affect the chemical process or the washing operation and to be present in sufficient quantity to provide a contact with the textile material adequate to give the uniformity of processing demanded.

In principle, the quality requirements may differ from process to process, so that waters of different degrees of purity could be employed, but the complications of using a multiplicity of supplies of different quality are sufficient to explain the fact that the normal practice is to have only a single supply of a quality sufficient for all purposes. In relatively few instances only are additionally-purified supplies fed to particularly crtical processes.

There is a general measure of agreement on the important contaminants and several authors have specified acceptable limits for these contaminants, as shown in Table 1. There are some discrepancies between the numerical values proposed by different authors. but it may be said that these recommendations reflect reasonably accurately the characteristics and the variability of waters currently employed for satisfactory processing. It may also be said that many water supplies, from surface or underground sources, can be purified to this degree by fitration and softening, although special treatment may be required in some instances for particular contaminancs.

The water quantity requirement (the need, that is, to have sufficient water present to achieve the required uniformity of processing) is to a considerable extent a function of machine design. Different machines have their own characteristic features which set lower limits to the amount of water they require in order to process a given quantity of material. This is most obviously the case with batch-processing machines; a long-liquor-ratio machine, such as a winch or a hank dyeing machine, cannot be expected to offer the same ultimate limit in water economy as a low-liquor-ratio jig or package dyer.

In a similar way the complexity of processing (the number of individual operations in a particular process) will be directly related to the specific water consumption for the process as a whole. When one recognises that the choice of the machine to be used for a particular process may be a question of availability or of personal preference and that the complexity of processing also admits of much personal choice, it is readily apparent how a wide divergence may quite reasonably exist between the total water consumptions at two works, although these works would be classed as performing the same general type of processing.

Within the wide range of water usage which this state of affairs permits, one general fact stands out clearly. Where water is employed in the preparation of chemical baths there is little tendency to use it extravagantly, since water usage must be matched by chemical usage to maintain the specified bath concentrations. However, this restriction does not apply to washing processes and, indeed, washing performance cannot in general be adversely affected by using "too much" water. It is in washing processes, then, that personal choice is most evident and, not unnaturally, tends to favour the use of more water rather than less. In these circumstances it is reasonable tc feel confident that substantial water savings can be made in many instances, but it remains necessary for the finisher to be satisfied that such savings will be worthwhile and safe and to find the correct way to implement them.

2. REASONS FOR SAVING WATER

Water is a renewable resource still in ample supply in many parts of the world. Although it may be accepted that savings can relatively readily be made in many, perhaps in all, establishments, it is therefore still reasonable to ask why conservation is ncessary.

There are five reasons why one might wish to save water:
(a) Shortage of supply.
(b) Effluent restrictions.
(c) Water and/or effluent costs.
(d) Energy savings.
(e) Chemical savings.

A simple reduction in the available water supply is the most obvious reason to economise. Such a situation will result from the unexpected failure of a source, due, say, to exceptional seasonal conditions, but the problem is equally severe, although its impact may be more gradual, when increasing demands on a region's water supplies reduce the quantity available for a textile works' use. It is not necessary, in fact, for there to be an actual reduction in supply; the problem will be equally significant if a fixed supply hinders expansion.

A demand for water conservation may occasionally result from restrictions on the disposal of effluent, but this situation is less likely to be encountered, since water conservation alone will be an effective solution only if the restriction is exclusively on the volume of effluent discharged. More general effluent restriction will require different corrective actions, in which water conservation may play a relatively minor part.

Although it is natural to think that a shortage of water will require the immediate introduction of conservation measures, this is not necessarily so. It may, for example, be possible at additional expense to surmount the problem by tapping a more remote water source or by treating an available water supply of unsatisfactory quality. The problem then becomes one of cost. More generally, however, the financial arguments (represented by the cost of water supply and, to a lesser extent, of effluent treatment) will be an incentive to conservation in situations where there is no physical limitation on water quantity or quality and it is costs alone that are in question. Since water and effluent costs together are unlikely to account for more than 4 or 5 percent of total processing costs, the finisher will normally not find himself forced to act hurriedly in this situation.

Energy saving can be an important reason for saving water. Reference has already been made to the close correlation between steam and water consumption in textile finishing, and it will immediately be apparent that in any situation where water is heated a water saving will produce an automatic saving in energy consumption. If the water is heated to, or close to, the boil the financial benefit from the energy saved will typically be 5 or 6 times as great as the saving in water and effluent costs.

Substantial savings can also be expected if water conservation can lead to reduced chemical costs, but the situation here is not so clear cut. A reduction in chemical consumption will obviously be achieved by reducing the volume of chemical baths, but, as preveiously pointed out, water usage in this area tends already to be limited for just this reason. A saving in wash water will not directly affect chemical usage and the main scope for saving appears to be by the recovery of chemicals in re-used water. At the present time this seems to be practicable only in a limited number of situations, although where it can be employed the chemical saving is a factor of major importance.

3. WAYS TO SAVE WATER:

There are only two ways in which it is possible to save water. One may either use less or one may use the same water more than once. These alternatives represent quite different approaches to the problem and it is preferable to discuss them separately.

3.1. CONSERVATION BY REDUCING PROCESS DEMAND

The methods by which such savings may be achieved are rather varied, but may conveniently be described under the following headings:

(i) good-housekeeping measures.
(ii) savings on existing machines and processes.
(iii) savings by machinery changes.
(iv) savings by process changes.

Within this listing there are really two distinct categories, represented respectively by those measures which require only a change in operator practice and those which require some physical alteration to be made to a machine or some other discrete change. In a general way, (i) and (ii) come into the first category, (iii) and (iv) into the second.

Savings brought about by instructing an operator to perform (or not to perform) some action are represented, for example, by a decision to fill jigs only to some specified level or by a decision to dispense with overflow rinsing. Such measures are easy to initiate and, very usefully, may if desired be introduced in small steps; however, they may be quite difficult to maintain.

Savings brought about by making some discrete change to the machine or the process are represented, for example by the introduction of counterflow on a washing range or a decision to alter a processing sequence. These measures are likely to be somewhat more difficult to initiate and may involve some capital expenditure; they can probably only be introduced as substantial step-changes, but once introduced should be self-maintaining.

Good-housekeeping measures. Although no general guidlines can really be given for the identification of measures of this type, opportunities for savings will readily be picked up by a critical eye in the course of a water-auditing exercise. Examples are taps and hoses left running when not in use, valves which will not shut properly and leaks. Individually such sources of waste may be relatively trivial, but corrective measures can collectively produce substantial savings. In addition, the attitude towards waste of this nature can have a strong influence on general attitudes to water usage; a tightening-up here will serve to emphasise the importance of conservation elsewhere.

Savings on exisiting machines and processes. On continous washing ranges counterflow of wash water is the single most important factor. The benefit in terms of washing performance from running fresh water into each tank is very small and the extra water and steam requirement is considerable. There are virtually no circumstances under which it is really necessary to introduce any substantial fractions of the fresh water imput part way along the range; apart from a possible small water consumption in nip-sprays, all the water should be fed into the last unit in the range and all the effluent discharged from the first. Even when the range contains an intermediate, standing chemical tank it may be reasonable to carry the counterflow round this unit, although in some circumstances it is preferable to treat the two washing sections separately.

Most modern machines are, of course, arranged so as to permit counterflow by gravity from one tank to the next, and this facility should be used wherever possible. Where it is not provided it will be well worth introducing some suitable arrangement, if necessary pumping the liquor between compartments.

If the water is used counterflow and its flowrate is trimmed to a modest value, there is little more than can, or need, be done while the machine is running. However, it remains important to ensure that the flow is switched off when the machine stops; there is just no advantage in maintaining the water flow with the machine stationary.

The direct reduction of the specific water consumption in batchwise processing operations (without change in the machine or in operating procedure) can be achieved only by reducing the amount of water added each time the machine is filled, or increasing the load of textile material, or both.

Water conservation measures should therefore be directed towards achieving the optimum liquor ratio as consistently as possible. On closed machines holding a fixed volume of liquor this can only be done by keeping the load as close as possible to the maximum value; on open vessels where the water volume is adjustable the problem is most conveniently dealt with by control of the water level. Over-filling and, in particular, the use of running rinses should be avoided at all costs.

Saving by machinery changes. The direct replacement of an old machine by a new one of the same general type is likely to lead to water savings, since machinery manufacturers are increasingly aware of the energy and water consumptions of their products and strive to produce designs which are more economical in both respects, and of course regularly advertise these features.

The effects of machinery replacement on water usage are perhaps likely to be more apparent in batchwise than in continuous processing. In particular, the introduction of a machine capable of operating at low liquor ratios will provide a dramatic reduction in water demand in comparison with the long-liquor-ratio machine it replaces. In this respect the latest generation of jet-dyeing machines offer significant advantages over both winches and earlier jet-dyers.

The same principle can be put into practice among the existing machines in a works, by àrranging as far as practicable to process on machines offering the lowest liquor ratios. So far as production requirements permit work should be distributed between machines of different capacity so as to maximise the machine loadings.

Savings by process changes. This category of conservation measures comprises savings achieved either by altering the processing sequence on a given machine or by processing on an entirely different type of machine. Although very substantial savings can be made in these ways, the changes involved are more intimately associated with processing requirements than any of those dicussed previously. There is therefore more scope here for individual choice and more likelihood of disagreement as to which measures really are or are not practicable.

Conservations achieved by changing to an entirely different type of processing requires the most serious consideration of production requirements, and in general production demands rather than water conservation must be the primary consideration.

Nevertheless, water savings have prompted a number of suggestions for changes of this nature and the use of very low water (and energy) consumption is a major factor in some developments. Thus for example, padding techniques have been employed to replace winch processing of knitted cotton goods. However, as an indication of the problems that may be attendant upon such a change, it is reported that one processor, although using a padding procedure, continues to wash -off in the winch, feeling that this is necessary to achieve the handle he requires. Under these circumstances, and although the procedure may be advantageous in other respects, the water saving will be very small.

3.2. CONSERVATION BY WATER RE-USE

The main attraction of conservation measures based on water re-use is that they treat water as a service to the works and make no specific demands on the processing requirements. So long as water quality is not impaired to a significant extent by recycling the processing operations can continue unhindered by worries about the adverse effects of reduced water quantity and free from the problems of implementing and maintaining direct economy measures.

The main problem attending on recycling concerns the quality of the water which it is proposed to re-use and whether it is necessary to treat it in some way before it can be employed in processing. Three categories can be distinguished.

(i) general-purpose re-use without treatment.

(ii) Specific re-use without treatment.

(iii) treatment for re-use.

General re-use without treatment. Water re-used in this way will be returned to the works' central water-storage system and must introduce no contaminant at such a concentration that, after dilution with the fresh supply water, it is present at an unacceptable level. Only small increases in most contaminants will be permissible and dyestuff concentrations must be kept to a particularly low level

For safe results, the recycled water must be substantially as clean as the normal incoming water supply. The only used water which really meets this requirement is cooling water; This stands little chance of being contaminated in use and there can be little objection to returning it to storage for process use; the heat it contains will generally be beneficial rather than otherwise.

In some, perhaps in many, instances it would also be possible to re-use clean rinse waters in the same way, but the recovery system must incorporate safety measures to ensure that more-contaminated wastewaters cannot get through in error, or must be provided with equipment to monitor the water quality before it is returned and to accept or reject as appropriate.

Specific re-use wihtout treatment. Water re-used in this way will be employed for one or two specific processes only . If will generally, although not always, be necessary to store the water for subsequent use, and these measures are particularly applicable to batchwise processing.

The most obvious procedures involve the storage of clean rinse waters for re-use either in rinsing or in the preparation of chemical baths, but the same principle can be applied to the re-use of chemical baths and dyebaths.

The general re-use of chemicals in this way is hindered by the complexity of the chemical baths involved and the number of parameters which may need to be measured in order to define the composition. The re-use of dyebaths and other chemical baths in some batch processes appears to be one of the few instances in which, at the present time, it is reasonable to look for chemical recovery associated with water re-use. It is interesting to note that those instances where chemical recovery is the primary incentive (recovery of sizing agents, or of caustic soda after mercerising) are characterised by the chemical of interest being the only, or much the largest, constituent of the liquor.

Treatment for re-use. Water contaminated to any significant extent will not be suitable for general-purpose re-use without some form of treatment. There is no doubt that it is technically feasible to purify wastewaters (either the wastes from individual machines or processes or the total mixed effluent from a works) to the required level, and a very large number of experimental and pilot-scale studies have been reported. However, it is fair to say that the successful treatments appear to require very much to be tailored to suit particular conditions, and that at the present time there is no single procedure which stands out as the obvious choice for all circumstances. Furthermore, although treatment costs are often difficult to assess, the general impression is that these costs are such that they would only be justified in exceptional circumstances.

Of the treatments which have been employed to enable wastewaters to be re-used, those which receive most frequent mention are undoubtably adsorption on activated carbon and reverse osmosis. Alone, however, these processes are unlikely generally to be satisfactory and each benefits from some pre-treatment of the waste. This may take the form of a conventional biological plant or of a sequence of flocculation and filtration or flotation. Other processes which have been employed include adsorption on other materials than carbon, electro-dialysis and catalytic oxidation. Each of these processes has its virtues and each can make a significant contribution to purification in appropriate circumstances, but in general it appears that a sequence of processes must be employed for consistently satisfactory results. The most promising sequences seem to be those incorporating flocculation and carbon-adsorption or flocculation and reverse osmosis.

4. SUMMARY OF CONSERVATION MEASURES

A reminder of the five possible reasons for wishing to save water is presented in Table 2, with an indication of their importance and of the most appropriate conservation tactics to employ.

A list of conservation measures is given in Table 3. This table includes estimates of the savings which might be achieved by each of the measures listed. It is assumed that average, 'uncontrolled' conditions are employed before the conservation measure is introduced, and the savings indicated relate specifically to the usage on the relevant machine or process. Thus, for example, if good-housekeeping practices are not already in force it is estimated that they can effect a moderate saving in the total water consumption at the works. On a more detailed level, the introduction of counterflow on a continuous washing range might reasonably be expected to make a large saving in the consumption <u>on that machine;</u> replacing an old machine of this type by a new one could produce a significant saving in all the processes involved, and so on.

TABLE 1

Water contaminants: suggested limits

Author	Colour Hazen	Turbidity FTU	Alkalinity $CaCO_3$ mg/l	Hardness $CaCO_3$ mg/l	Total Solids mg/l	Iron Fe mg/l	Manganese. Mn mg/l	Copper Cu mg/l
Little	10	5	100	70	500	0.3	0.05	0.01
Hirst and Rock	25	-	60	100	-	0.5	0.1	-
Harker and Rock	-	-	-	70	500	0.3	0.05	0.01
Nordel	10	5	-	500	-	0.1	0.1	-
Cotton Handbook	5	-	75	15	200	0.05	0.02	-
Fair and Geyer	20	5	-	-	200	0.25	0.02	-
Hetherington	5	-	75	10	200	0.05	0.02	-
Morton	-	-	-	-	-	0.3	0.05	-

TABLE 2

Incentives to water conservation

Incentive	Importance	More appropriate conservation procedure ('Use less' or 'Re-use')
Shortage of water	Major	Either
Effluent restrictions	Minor	Either
Water/effluent costs	Significant	Either
Energy savings	Major	Use less
Chemical savings	Uncertain	Re-use

TABLE 3

Summary of conservation measures

USE LESS		RE-USE	
General-purpose savings			
Good housekeeping	2*	Cooling water, possibly clean rinses	1
		(Effluent treatment for recycling	4)
On continuous machines			
Counterflow	4	(Rarely applicable; re-use is automatic if counterflow employed)	
Reduce flow rate	3		
Match flow rate to fabric	2		
Turn off flow when machine stopped	1		
Replace old machine	3		
On batch-processing machines			
Avoid underloading	2	Rinse baths	3
Avoid over-filling and running rinses	3	Dyebaths, etc	3
Match filling to load where possible	2		
Reduce number of process stages	4		
Transfer process to more economical machine	4		
Replace old machine	3		

* Approximate index of possible savings:

1 = slight, < 10%
2 = moderate, 10-20%
3 = significant, 20-40%
4 = large, > 40%

SEMINAR

HOW TO MEASURE WATER USAGE

GEOFFERY PARISH

UNIDO Adviser on Water Conservation

3rd April 1983

1. Why measure water usage?
2. The measurement of water usage.
3. Target figures for water consumption.
4. An example of water saving.

1. WHY MEASURE WATER USAGE?

If a mill manager wishes to introduce water conservation measures he must first measure his water usage in order to know how much he is using and where it is being used. He must then be able to compare these results with some target figures which relate to his processes.

A systematic approach to water conservation is represented by the following steps:-

1. Measure water consumption.
2. Compare with target figures.
3. Consider alternative conservation procedures.
   - 3a Conservation by reducing demand.
   - 3b Conservation by re-use.
4. Consider the consequences of conservation.

Water consumptions must be measured in order to put the study on to a quantitative basis and specifically to permit comparisons to be made with target values. The type of measurements required are therefore dictated by the form in which target values are presented, and target values are only really meaningful when they deal with individual unit operations; that is, with a particular process performed on a particular type of machine. The further one departs from this precisely defined situation the more unreliable does it become to compare one set of data with another.

Furthermore, target values are of necessity expressed in terms of the specific water consumption, the quantity of water used being related to the mass of textile material processed. In order to derive both target values and any comparable data it is necessary to specify a processing operation and a type of machine and to measure both the water consumption and the quantity of textile material treated.

It is necessary, therefore, to measure the water consumption on individual machines. but it would be quite unrealistic to suggest that the water usage of all the machines should be measured continuously. In fact, the methods employed should be as simple as possible and may be applied only to the more important machines.

2. THE MEASUREMENT OF WATER USAGE

2.1 Simple methods for batch-processing machines

The essential requirement for determining specific water consumptions on these machines is to ascertain the volume of water used each time the machine is filled and to count the number of fillings in the processing of a known weight of material. The counting operation calls for no comment, except to point out that it will be necessary to note what each filling is used for (dye bath, rinse, etc), unless this information is already available from processing records. The main question then is the method to be employed to determine the volume.

The simplest procedure is to calculate the volume from the dimensions of the vessel. This is simple to do when the vessel is of regular shape, and can give perfectly satisfactory results. The only equipment required is a rule or tape and the necessary measurements can be made without interfering with the production process.

If the vessel is of complex shape or is much encumbered below the water level (with fabric guide rollers, for example) dimensional measurements are less satisfactory and it is preferable to measure the water volume directly. This may be done most simply by pumping the water from the vessel into a container of known volume. Alternatively, the 'bucket and stopwatch' procedure may be used: the flow from a hose is calibrated by measuring how long it takes to fill a bucket (or, more realistically, a larger container of known volume) and the hose is then timed filling the processing vessel.

Each of these procedures requires access to the machine in order to make the measurements, but the interference with production will be quite brief. This applies also to a further alternative, which makes use of the dilution principle. The vessel is filled with clean water and a known amount of some suitable test substance is added; the solution is thoroughly stirred, a sample removed and the concentration of the test substance determined. This test may be conducted for example with a dyestuff, the concentration of which can be determined by a spectrophotometer or colorimeter, if one is available, or by sample-dilution and visual comparison. Alternatively, a readily-available inorganic salt, such as sodium chloride, may be used; this could readily be measured by conductivity.

2. 2 Simple methods for continuous machines

The essential requirement here is to determine the total quantity of water consumed during the processing of a certain mass of textile material. In contrast to batch processing machines it is primarily flow rates that must be measured, but a complicating factor is introduced by the volume of water contained in the tank or tanks of the machine. These tanks will commonly be filled with fresh water either at the start of a particular run or at the start of a shift or a day, and the question is whether or not this volume makes a significant contribution to the total water consumption.

The relative tank capacities and flow rates in a conventional washing range will be such that the through-flow will be equal to the total tank volume in a time typically between 20 minutes and 1 hour. If processing is continuous (in the sense that the tanks are not drained and refilled) for a whole shift or longer, the effect of the tank capacity will be relatively slight; in much shorter runs it could make a substantial contribution to the water usage.

In general, then, the ideal procedure for dealing with continuous-processing machines is to measure the tank capacity (any of the methods appropriate to batch processing may be employed) and the water through-flow rate, and then to record the total mass of fabric processed in an appropriate period, taking note of machine stoppages and whether or not the water flow is turned off during these intervals, in order to arrive at an accurate figure for the total water usage. This is inevitably a time-consuming procedure, and the less accurate results obtained by measuring only the water through-flow and calculating the fabric throughput from the processing speed are likely to be adequate for most purposes.

Water flow rates may be determined by the counterparts of two of the procedures applicable to volume measurement. A direct measurement is provided by the bucket-and stopwatch technique if a container of suitable size can be inserted under the inflow or the outflow (it is immaterial whether the water input or the effluent is measured). Sometimes this may be difficult to do, as for example when the input is distributed via a spray pipe at a nip, and in any event the container size is likely to be limited and timing possible for a few seconds only. The timing period can be extended and accuracy improved by using the tank on the machine as the container; having determined the tank volume, it is only necessary to measure how long it requires to fill. These methods are summarised in Table 1 along with those for volume measurement.

2.3. Instruments for flow measurement

The obvious application of these devices is in permanent installation for the continuous measurement of total flow or of the flow in sections of the works, although they may equally well be employed on individual machines or groups of machines if this is warranted.

The flow of supply water in completely-filled pipes is readily measured by flow-meters of the conventional type, in which an impeller is driven by the water flow, or by devices, of which there is now an appreciable number, which measure some other property of the flow. Effluents, which, in addition to being contaminated, commonly flow in open channels or in incompletely-filled pipes, require a different measuring procedure. The flow here is usually determined by introducing into the channel an obstruction , in the form of a weir of some specified size and shape or a more gradual flow-restrictor, such as a flume. In either situation a water head is developed upstream to drive the flow past the obstruction, and this head is measured in some way and the measurement converted into a signal proportional to flow.

The permanent installation of a flow meter to measure either the total water input or effluent discharge should be considered essential, and serious consideration should be given to the metering also of flows to sections of the works and to the most important individual machines as part of a more quantitative approach to water usage. The most important information to be derived from a permanently-installed meter is the total water consumption over a period of time. Instruments which give only a reading of the instantaneous flow rate are not suitable, and a direct reading of the total quantity should be provided. The recording of flow rate on a chart is helpful for identifying periods of high or low consumption, but a chart should not be the only output provided.

2.4 The water audit

Measurements of water usage on individual machines are made principally in order to derive specific water consumption values for selected unit operations. The same measurements, combined with data from production records, will provide average values for the total water consumption to be expected on each of the important machines in the appropriate period, which may for example be a day or a week.

These values may then be compared with one another and summed for comparison with the corresponding figure for the works as a whole and, if this data is available for individual sections of the works.

3. TARGET FIGURES FOR WATER CONSUMPTION

Two fundamentally different sources may be consulted for water consumption targets, on the one hand collected data compiled from measurements at a number of works and on the other figures derived from theoretical and experimental studies of the processes involved.

3.1. TARGETS FROM WORKS' DATA

Numerous authors have published water consumption figures in articles dealing with water usage or water conservation. It is immediately apparent from these surveys that even at the level of unit operations a remarkably wide range of specific water consumptions is obtained, wherever the study is made. A comparison is given of data collected in the UK, in India and in the USA in Table 2; although there are some interesting differences in average water consumptions, the most noticeable features are the wide ranges of variation, rarely less than 4 : 1.

This wide variability is characteristic of all, or virtually all, of the measurements quoted; it does not, however, obscure a number of salient points, of which the following are the most significant:

(a) inherent differences in water consumption on different types of machine.

(b) difference between dyestuffs, related to their processing requirements.

(c) differences in water usage between chemical baths and rinses.

(d) the effects of machine loading.

The influence of machine type is illustrated by the results summarised in Table 3. for a variety of fabric preparation and dyeing processes. In each instance the data from a large number of specific processing operations has been combined; for example, the results for dyeing related to a variety of fibres and of dyestuffs. As a consequence the range of variation is generally extremely wide, and this serves to show the reason for the difference between continuous and jig processing on the one hand and winch and beam on the other.

Continuous processing (with an average water consumption ranging from 20 to 40 litres/kg) and jig (average 20 to 80 litres/kg) use less water on average than beam (35 - 90) or winch (60 - 90), but this difference results primarily from a difference at the bottom end of the range, rather than from a difference in the whole range. Continuous and jig processing each show some low or very low water consumptions, but these low values are never obtained on the winch or the beam machine. At the top end of the ranges the differences between the machines are nowhere very pronounced.

Very large water consumptions must result mainly from the user's choice, and it is apparent that on each of these machines some users are prepared to employ large quantities of water. At the other extreme, however, the user can only be as economical as the machine will allow, and it is apparent from these figures that very low water usages cannot be employed on winch or beam machines.

The averages of the lowest values recorded in Table 3 may be taken as a rough indication of the 'best' value that might be expected in general to be attainable with each type of machine. These figures are:

Continuous	7 litres/kg
Jig	4
Winch	41
Beam	27

When comparison is made between the water usage in processing baths and in washing in the same operation, it is clearly apparent that washing is responsible for the major part of the water consumption. This is most conveniently seen by examining average usage values, and is illustrated by the data presented in Table 4

The results in this table show some interesting differences between the processing methods. In winch processing the washing operations consistently require about 70 percent of the total water usages, whereas, with jig processing the percentage is higher and in two instances over 90 percent; continuous processing also shows a higher percentage of the water employed for washing.

The reason for these differences is to be found in the inherent characteristics of the machines and the attitude towards water consumption in chemical baths and in washing operations. On the jig, for example, it is perfectly feasible to use small quantities of water, as has already been noted, and water usage in chemical baths will tend to be held down by the constraint imposed by chemical consumption. In washing, where this constraint does not apply, less endeavour is likely to be made <u>on average</u> to keep the water usage to the lowest practicable level; as a result, proportionately much more water will be employed in the washing stages. Generally similar considerations will apply in continuous processing, but on the winch it is just not feasible to use very little water, even for chemical baths. Therefore, although a generous attitude may still prevail to the use of wash water, the difference cannot be so marked.

3.2 Targets from theoretical analysis

Theoretical analyses bearing directly on water usage have in the main dealt with washing processes. In view of what has been written above concerning the relative importance of these processes and attitudes to water usage in them it is reasonable that the emphasis should be placed here.

The essential features of these analyses in the context of water consumption is that they deal with the effects of efficiency in the washing process, and specifically its influence on the quantity of wash water it is reasonable to use.

The results may be translated into general purpose target figures, as follows:

Continuous washing	:	5 l/kg, with counterflow
Batch washing, adjustable volume	:	6 l/kg per stage
Batch washing, fixed volume	:	15 l/kg per stage

3.3 Comparison of target values

Theoretical considerations can provide target values for water usage per process stage, but they cannot define the number of stages required in batch processing without reference to the complexity of the operation and the severity required of the washing treatments. It is therefore instructive to compare the above theoretical values with the lowest values observed in works processing quoted previously; this is done in Table 5

For continuous processing, where the number of stages is unimportant (if counterflow is used), the agreement is very good. The beam and winch data also are consistent with the theoretical figure for fixed volume batch processing: the

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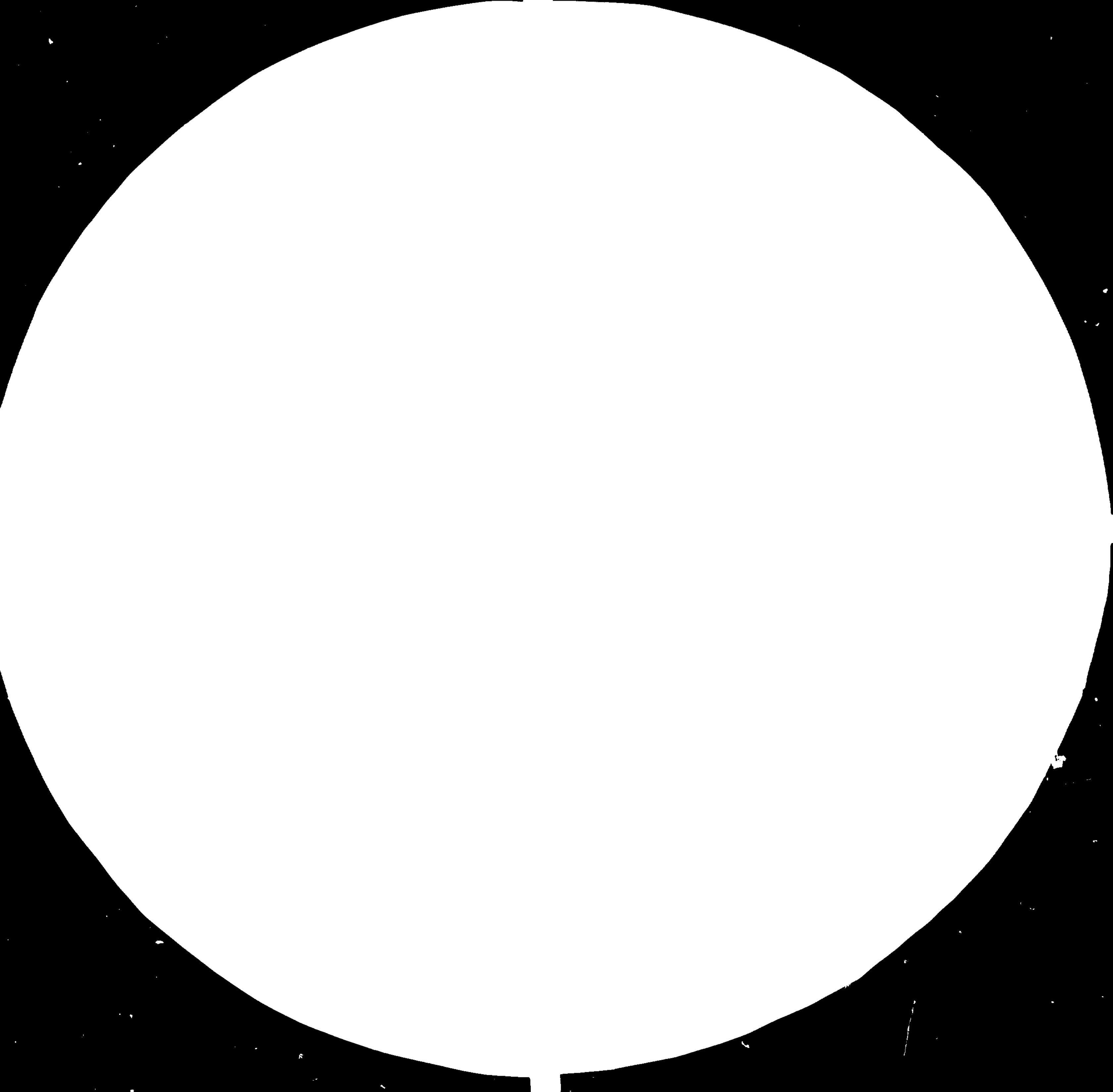

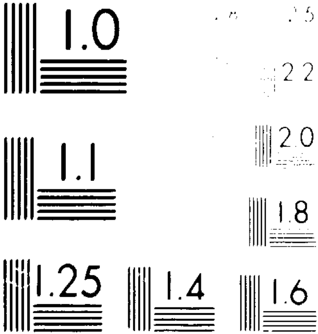
1.0
2.2
2.0
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1.8
1.25
1.4
1.6

practical results represent the water usage to be expected from one chemical bath followed by one or two rinses, which is a likely minimum processing sequence. It is only for the jig that the practical figure is lower than the value to be expected on theoretical grounds. A value as low as 4 l/kg can, in fact, only be explained if it corresponds to a single processing stage only.

It may be concluded then that the theoretical figures may be used with some confidence as target values for the water consumption in each processing stage. It remains necessary for the user to make his own decision regarding the number of stages he requires.

4. AN EXAMPLE OF WATER SAVING

A summary of the topics discussed in this paper is conveniently provided by a description of the steps leading to the introduction of simple conservation measures at a printworks. In this instance the measurements and data analysis were largely performed by staff of the Shirley Institute, but could equally well have been made by the works' staff, following the guidelines indicated here. The conservation measures were introduced by the works' staff.

(i) Background The works in question performs the operations of fabric preparation, printing and finishing, mainly on continuous machinery. The investigation was undertaken because the works' management wished to examine the possibility of using simple means to reduce water and steam consumption, not because of any external pressures on water supplies.

(ii) Data collection The works already had the following information available, expressed as average daily values:

Total water consumption
Boiler feed-water consumption
Total steam consumption
For individual machines: fabric throughput (in kg) and duration of operation (hrs)

Examination of processing schedules and observation of the machines concerned indicated that the major use of process water must occur on a rope washing range used in fabric preparation and on four open-width washing machines, and measurements of water usage were made only on these machines.

The rope washer used only cold water, but the open-width machines had compartments unheated and compartments with the water steam-heated; on each machine three or four compartments were heated in this way and it was observed that fresh water was fed into each one, although the individual water flow rates appeared to be carefully controlled by the machine operator.

Measurements of water flow into the rope washer and into each compartment of the open-width machines were made by the bucket-and-stopwatch method. In addition, tank temperatures were measured as appropriate.

(iii) Data analysis The daily water usages on the washing machines were calculated from the measured flow rates and the average operating hours. These figures were assembled with the known boiler feed-water consumption and estimates of usage elsewhere to produce a water audit for the works. The important features of this are conveniently presented by expressing the measured water usages as percentages of the total work's water consumption, as follows:

Four open-width washers:	hot	32%
	cold	7%
Rope washer		34%
Boiler feed water		12%
		85%

The balance is readily accounted for by estimates made of the usage in the *washing of printing blankets, washing-down etc,* and this audit may be regarded as satisfactory. It confirms the expectation that the washing ranges account for the major part of the total water usage and shows that no other source of significant consumption has been missed.

Specific water consumptions were calculated from water measurements and production data with the following results:

Open-width washers:	hot:	24 to 30 l/kg
	cold:	6 l/kg average
Rope washer		17 l/kg

(iv) Conservation measures The total water usage in each of the washing operations was much higher than the target figures for these processes. On the open-width machines this was because no counterflow was employed in the heated sections; in fact, the flow into individual compartments was close to the target figure at 6 to 8 litres per kg.

Suggested action: introduce counterflow, maintaining the previous flow through each compartment; leave the cold-water system unchanged (it would be physically difficult to direct this flow into the heated tanks).

The effect of these changes would be to reduce the total water consumption on these machines by about 60 percent.

On the rope washing range only a single water supply is used, but the flow was excessive.

Suggested action: reduce the flow to about half its previous value.

The steam saving resulting from the water saving on the open-width machines is calculated from the reduction in daily water usage and the tank temperatures. Expressed in terms of the overall water and steam consumptions in the works the calculated savings are:

	Saving as % of total	
	Water	Steam
Counterflow on open-width machines	22	15
Reduced flow on rope washer	17	-

(v) Consequences of conservation A total water saving of 40 percent was predicted, but it was ascertained that this would pose no problems in relation to effluent disposal.

(vi) Action After due consideration the work's management decided to proceed immediately only with the measures proposed for the open-width machines. After making the necessary modifications and introducing some supplementary changes they were able to show savings, in both water and steam, a little higher than predicted.

TABLE 1

Water consumption measurements on individual machines

	Method	Equipment required
Batch machines : volume determination		
1.	Calculate volume	Rule or tape
2.	Transfer water to calibrated vessel	Pump
3.	Time filling with calibrated flow	Hose. bucket and stopwatch
4.	Dilution	Dyestuff or sodium chloride Colour comparator or conductivity meter
Continuous machines : flow-rate determination		
1.	Direct measurement	Bucket and stopwatch
2.	Determine tank volume and time filling	Stopwatch

TABLE 2

Comparison of water usage figures

Process	Specific water usage (l/kg)					
	UK		India		USA	
	Av.	Range	Av.	Range	Av.	Range
Desizing and washing	26	1 - 47	11	-	21	17 - 25
Kier boil and washes	25	5 - 46	24	22 - 25	68	24 - 111
Hypochlorite bleach and washes	68	21 - 173	11	-	310	276 - 343
Continuous peroxide bleach	38	13 - 64	-	-	90	-
Mercerising	26	11 - 57	60	27 - 92	77	-
Jig dyeing (vat)	82	38 - 196	35	-	102	-
Continuous dyeing	38	9 - 63	-	-	32	17 - 50

TABLE 3

Effect of machine type on water consumption

Process	Processing Method	Specific Water Usage (l/kg) Average	Range
Scouring	Continuous	30	3 - 94
	Jig	18	2 - 48
	Winch	78	41 -146
Peroxide bleaching	Continuous	38	13 - 64
	Jig	41	8 - 80
	Winch	57	54 - 60
Dyeing	Continuous	38	10 - 63
	Jig	77	5 -300
	Winch	183	28-540
	Beam	92	31-166
Washing	Continuous	19	3 - 60
	Jig	52	2 -220
	Winch	81	41 -195
	Beam	35	23 - 89

TABLE 4

Distribution of water usage between processing baths and washing

Processing method	Specific water usage (l/kg average) Process	Wash	Total	Wash as % of total
Continuous:				
scouring (kier and rope wash)	4	22	26	85
scouring (kier and o.w. wash)	5	25	30	83
peroxide bleaching	1	12	13	92
dyeing	9	25	34	74
Jig:				
scouring	3	10	13	77
peroxide bleaching	2	44	46	96
dyeing	7	70	77	91
Winch:				
scouring	22	56	78	72
peroxide bleaching	26	64	90	71
dyeing	55	126	181	70
Beam:				
dyeing	14	36	50	72
Package machine:				
scouring	10	19	29	66

TABLE 5

Comparison of target values

Specific water usages in l/kg

Theoretical			Practical	
Continuous	5	with counterflow	7	
Batch adjustable vol.	6	per stage	4	Jig
Batch fixed vol.	15	per stage	27	Beam
			41	Winch

ANNEX 4: ARTICLE FOR TDC BULLETIN

WATER CONSERVATION IN DYEING & PRINTING MILLS

G.J. Parish, UNIDO

It is not necessary to employ the most up-to-date machinery or instal water flowmeters on each machine in order to use the smallest volume of water in a dyeworks or printworks. Modern machines and flowmeters will make it easier to achieve and to maintain an economical water usage, but only if they are used correctly. Older machines can provide a water consumption as small, or almost as small, as modern machines and simple methods may be employed to measure water usage with sufficient accuracy for the present purpose.

Measuring water consumption

It is necessary to measure or estimate the water consumption of individual machines in the mill in order to determine how much water each machine uses per day or per week. Then, for the more important machines (those using the most water) the water consumption must be related to the weight of fabric or yarn processed to calculate the specific water consumption in litres per kg or cubic metres per tonne.

These measurements can then be compared with target figures for the specific water consumption in the corresponding processes.

Simple methods for measuring water usage

Batch processes. It is necessary to measure the volume of water used each time the machine is filled and to count the number of fillings in the process. When related to the weight of fabrics or yarn in the machine the single figure gives the specific water consumption per stage and the total gives the specific water usage for the whole process.

The water volume can be determined most simply by measuring the dimensions of the vessel if it is of regular shape. Alternatively, water may be run into the machine from a container of known volume or pumped from the machine to a measuring container. A third alternative is to measure the time taken to fill the machine from a hose delivering water at a known rate (measure the rate by using the hose to fill a container of known volume - the 'bucket-and-stopwatch' method).

Continuous processes. Here the major part of the water usage occurs in the washing operations and it is necessary to measure the rate of flow of water through the washing range and to relate this flow-rate to the fabric production rate in kg per min. or tonnes per hour.

Water flow rates may be measured directly by the 'bucket-and-stopwatch' method if the water inflow or the effluent discharge is accessible. An alternative is to use one of the wash tanks as the container, although this normally requires the machine to be stopped. Drain the water from this tank and measure the time required to fill it to a measured level; the dimensions of the tank enable the volume introduced to be calculated.

Target figures for water usage

Target figures express specific water consumption in litres per kg or cu.m. per tonne (numerically these two ratios are of course the same) for individual processes or operations. They distinguish between continuous processes and two classes of batch process: (a) those where the volume of water employed is adjustable (for example, jigs, winches and some modern jet dyeing machines); (b) those where the water volume is fixed because the machine must be completely filled (for example, beam dyers and yarn package dyers).

Target figures are summarised in Table 1. It must be emphasised that these figures should be used as guidelines only. In no circumstances must product quality be allowed to suffer in the interests of water economy; satisfactory product quality must always be more important than achieving the absolute minimum water usage.

Nevertheless, these target figures are being achieved in many mills and they do represent values which are realistically attainable in the majority of processes. In some situations, however, they may be difficult to achieve; for example, it may be difficult to get a water usage as low as 5 litres per kg in continous washing-off after printing or after mercerising.

TABLE 1

TARGET VALUES FOR WATER USAGE IN INDIVIDUAL PROCESSES

Process	Target usage l/kg
Continuous	5, with counterflow
Batch, variable vol.	5 or 6 per stage
Batch, fixed vol.	8 to 15 per stage

Total water usage for mill

This must obviously vary from mill to mill, since it will depend on the number and complexity of the processes employed. Nevertheless, it is possible to give a very rough indication of the situation to be expected in a mill operating fabric preparation, dyeing or printing and finishing processes. This is shown in Table 2.

TABLE 2

APPROXIMATE GUIDE TO TOTAL WATER USAGE

Water usage cu.m/tonne	Comment
below 60	Very good, probably difficult to use less
60 to 80	Good
80 to 100	Better than average, but some savings probably possible
100 to 120	Average, savings almost certainly possible
above 120	Worse than average, savings certain

Water saving

A check-list of water conservation measures is presented in Table 3. On continuous washing ranges water savings must come almost entirely from using less water in the process; in batch processes savings may be made by using less water in each process stage or by re-using water where it is safe to do so.

TABLE 3

CHECK-LIST OF WATER CONSERVATION MEASURES

CONTINUOUS WASHING RANGES

1. Use counterflow
2. Aim for target water usage
3. Turn off flow when machine stops

BATCH PROCESSING MACHINES

1. Avoid underloading with fabric or yarn
2. Avoid overfilling with water (where volume is adjustable)
3. Reduce number of stages in process
4. Re-use rinse baths
5. Look for opportunities to re-use dyebaths

OTHER WATER USAGE

1. Repair leaking pipes or taps
2. Make sure taps are turned off when not in use
3. Re-use all clean water (e.g. cooling water)

ANNEX 5: REPORT ON BOILER WATER SUPPLY

TECHNICAL REPORT

ORIENT LINEN AND COTTON CO.

WATER SUPPLY TO BOILERS

Geoffrey Parish
UNIDO Adviser on Water Conservation

Summary

This mill has a high level of dissolved solids and high alkalinity in its boiler water. The following recommendations are made:

1. Arrange to return as much condensate as possible. It is understood that 30 percent recovery should be achievable.

2. Purchase a conductivity meter for the rapid measurement of solids in the boiler water.

3. Increase the frequency of boiler blow-down but reduce the volume discharged each time.

4. Add sodium sulphite to the feed water for complete removal of oxygen.

5. If necessary add caustic soda to bring the caustic alkalinity to the required level.

22 March 1983.

1. THE PRESENT SITUATION

This boiler plant produces 16 tonnes per hour of steam and uses about 16 tonnes per hour of fresh water, as there is no return of condensate to the boiler water supply. This also means that the boiler feed water is cold.

The supply to the boilers is tap water treated in a Permutit softening unit using a cationic resin; this reduces the hardness to a very low level, about 1 mg. per litre. The water is de-aerated before passing to the storage tank, but there is no addition of sodium sulphite (to ensure complete removal of oxygen).

Under conditions of low hardness the boiler manufacturer's specification for the boiler water characteristics includes the following factors:

Caustic alkalinity:	350 mg/l $CaCo_3$	minimum.
Total alkalinity:	1200 mg/l $CaCo_3$	maximum.
Dissolved solids:	3500 mg/l	maximum.
Sodium sulphite:	30-70 mg/l.	

In fact, although the boiler water has a caustic alkalinity lower than the value quoted above, the total alkalinity is greater than 2000 mg/l and the dissolved solids greater than 6000 mg/l. Both these values are about twice the manufacturer's recommended levels.

It is clear that the boiler blow-down employed is not sufficient to maintain the correct conditions. However, the staff at the mill is reluctant to increase the amount of water blown-down because of its adverse effect on the steam supply; cold water enters the boiler to replace the hot water discharged and the steam pressure drops.

2. ANALYSIS OF THE PROBLEM

The following facts cannot be avoided.

(i) The dissolved solids in the supply water have a rather high concentration. A measurement made at the Textile Development Centre on a sample of tap water taken on 17 March gave a value of 300 mg/l.

Softening will reduce the water hardness but will not change the concentration of solids significantly.

(ii) The only way in which the solids in the water supply can be removed is in the blow-down. The rate of removal at the concentration present in the boiler must be equal to the rate of supply at the concentration in the feed water.

A simplified expression for the rate of blow-down required is given in the Annex.

3. RECOMMENDATIONS

3.1. Return condensate to the boiler. This is desirable for these reasons:-

(a) It supplies water free from solids.

(b) It raises the temperature of the supply water.

(c) It reduces the demand for fresh water and hence the frequency of regeneration of the cationic resin.

It is understood that plans have been drawn up to return condensate from cylinder dryers, stenters, etc. to provide about 30 percent condensate return. This should be done as soon as possible.

3.2. Without condensate return the blow-down rate required to meet the manufacturer's concentration limit is calculated to be 1.5 tonnes per hour (see Annex). With 30 percent condensate return the blow-down rate will be reduced to about 1 tonne per hour.

To discharge this amount of water at infrequent intervals will obviously be difficult for the boiler to stand. It is preferable to increase the frequency of discharge and reduce the amount discharged each time.

3.3. To test whether the blow-down is correct a rapid method of measuring dissolved solids is required A conductivity meter should be purchased for this purpose.

3.4. With a reduction in the boiler-water solids the alkalinity will almost certainly fall to a satisfactory level. It may be necessary to add caustic soda to achieve the correct level of caustic alkalinity.

3.5. Sodium sulphite should be added to insure complete absence of oxygen.

Annex: CALCULATION OF BLOW-DOWN RATE

This analysis assumes that there is a continuous blow-down, so that the concentration of solids in the boiler water is kept always at a fixed value; the result would be only a little different with intermittent blow-down to maintain the same average* concentration.

The two relations governing the situation are:-

(i) The rate of supply of water to the boiler equals the rate of steam generation plus the rate of blow-down.

(ii) The rate of supply of solids in the fresh supply water equals the rate of discharge in the blow-down.

The following symbols are used:-

Rate of steam generation	S tonnes per hr.
Rate of fresh water supply	W tonnes per hr.
Rate of blow-down	B tonnes per hr.
Condensate return	R

For convenience R is expressed as a decimal rather than a percentage, so that the rate of supply of condensate is S.R tonnes per hr.

Concentrations of solids:-

in fresh water	C mg/l.
in boiler water	L mg/l.

* Actually identical relation if the same maximum concentration is maintained.

Note that the concentration in mg/l is numerically the same as g. per cu.m, and 1 cu.m. of water= 1 tonne.

Water balance

In= out.

$W + S.R = S + B$

Hence: $W = S(1-R) + B$ (1)

Solids balance

In= out.

$W.C = B.L$

Hence: $W = B.L/C$ (2)

From (1) and (2):

$$B = \frac{S.\ C.\ (1-R)}{(L-c)} \qquad (3)$$

$$\text{and } W = \frac{S.L.(1-R)}{(L-C)} \qquad (4)$$

In the present situation:

S = 16 tonnes /hr.

L = 3500 mg/l.

C = 300 mg/l.

	No condensate return R= 0	But condensate return R = 0.3
Blow-down B tonne/hr	1.5	1.05
Water supply W tonne/hr	17.5	12.25

Boiler with intermittent blowdown

Suppose blowdown at intervals of T hours. Assume that blowdown is instantaneous.

Let mass of water in boiler be M tonnes.
At time of blowdown $conc^n$ will be L mg/l. Let quantity blow down be Q tonnes. Then Q tonnes of fresh water, $conc^n$ C, will flow in.
Let $conc^n$ in boiler after blowdown be Lo mg/l.
Then M.Lo = M.L. - Q(L - C)

$$\text{or } M(L - Lo) = Q(L - C) \qquad (1)$$

In next period of T hrs the $conc^n$. will rise from Lo to L by virtue of inflow of solids with fresh water:

$$\text{That is } M(L - Lo) = W.C.T \qquad (2)$$

Also the water balance during this period gives

$$W = S(1 - R) \qquad (3)$$

since there is no blowdown

From (1), (2) and (3)

$$Q = \frac{W.C.T}{L - C} = \frac{SC(1 - R)T}{(L - C)}$$

Hence, blow-down rate

$$B = \frac{Q}{T} = \frac{S.C(1 - R)}{(L - C)} \qquad (4)$$

which is the same rel^n. as for continuous blowdown

ANNEX 6: <u>REFERENCES</u>

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6. Information on NIFES may be obtained from

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