PN ABS 793

Environmental Pollution
Prevention Project

A Report of the
Office of Environment and Natural Resources
Bureau for Global Programs
United States Agency for International Development

POLLUTION PREVENTION DIAGNOSTIC STUDY
PROQUINDUS, S.A.
SANTIAGO, CHILE

Final Report

Prepared for:

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HBI Reference No. 94-004

Environmental Pollution Prevention Project (EP3)
Project Number 936-5559
Contract Number PCE-5559-Q-00-3022-00

January 1994

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ACKNOWLEDGEMENTS

This publication is one of a series of technical outputs from the Environmental Pollution Prevention Project (EP3). The publication was made possible through support provided by the Office of Environment and Natural Resources, Bureau for Global Programs, U.S. Agency for International Development, under the terms of Contract No. PC-5559-Q-O-O-3022-00. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of the U.S. Agency for International Development.

The pollution prevention audit/assessment reported on herein was conducted by a team of EP3 and industry representatives. The primary purpose was to assist industry or facility management in creating a sustainable pollution prevention and waste minimization program. This report presents information from the first step in the process; a base line survey and a definition of actions which can be taken to prevent pollution, improve efficiency and pay back any required investments.

The overall EP3 program in the countries in which EP3 has activities includes a wide range of activities including audits/assessments, information dissemination, training and small scale demonstrations. These country programs are all designed to create the conditions in the country which will assure the continuation of urban and industrial pollution prevention and establish locally sustainable pollution prevention programs.

This report was prepared for RCG/Hagler Bailly, Inc. by William W. Bilkovich, Environmental Quality Consultants, 259 Timberlane Road, Tallahasee, Florida 32312-1542.

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The principal opportunities for Proquindus, S. A. to reduce the plant's impact on the environment and reduce costs are summarized in Table 1. Changes that result in reduced energy use will avoid the release of over 14 metric tons of air emissions each year in addition to unquantified reductions in the release of global warming gases and heavy metals. Water use can be reduced by 125,000 cubic meters per year. Chemical releases to the surface waters of Chile can also be reduced. Except for an expected reduction of 70.000 kilograms of sulfate ions, those reductions require more research and development before they can be quantified. Finally, it may be possible to avoid the disposal of 330 cubic meters of solid waste per year.

Of the thirty-seven opportunities recommended, the savings possible from implementing six have been quantified. These six recommendations will reduce operating costs by about $43,000,000 per year for an initial investment of $770,000. The simple payback period for these changes is one week. Another $1.2 million in investments is required to implement other changes whose savings potential cannot be quantified without further research.

All savings and costs in this report are quoted in Chilean pesos worth 414 pesos per U.S. dollar.

TABLE 1
Summary of Pollution Prevention Opportunities

SYSTEM	OPPORTUNITY	POLLUTION PREVENTION POTENTIAL	CAPITAL COST TO IMPLEMENT	ACTION REQUIRED\ SECTION
FIRST PRIORITY OPPORTUNITIES				
Steam Traps	Repair leaking traps	Reduce air emissions, reduce fuel costs by $19,500,000/year	$300,000 to replace traps	Repair traps, identify failure mode of new traps, Section 4.8.1
Steam System	Evaluate steam system components and layout, add at least two steam traps	Reduce energy use, prolong life of components, reduce bath and boiler water contamination, unquantified savings	$50,000 for insulation, $200,000 for traps	Install traps, and insulation, use information supplied by EP3, Section 4.8.3
Steam Traps	Improve knowledge of steam trap selection	Reduce energy use, avoid purchase and repair of traps, unquantified savings	None	Use information supplied by EP3, Section 4.8.2

TABLE 1
Summary of Pollution Prevention Opportunities

SYSTEM	OPPORTUNITY	POLLUTION PREVENTION POTENTIAL	CAPITAL COST TO IMPLEMENT	ACTION REQUIRED/ SECTION
Steam Traps	Purchase and use steam leak detector	Reduce fuel consumption, unquantified savings	$450,000 for instrument	Purchase detector, check traps monthly, Section 4.2.1
Dyeing Becks	Modify rinsing procedures, modify becks	Reduce water cost by $18,500,000/year	$150,000 for 16 valves, flow restrictors and siphon piping	Run rinsing kinetics experiment, modify equipment, Section 4.7.3
Dye Baths	Replace sodium sulfate with sodium chloride	Reduce sulfate emissions below effluent standards, reduce chemical costs by $3,120,000/year	None	Test dye using substitute, Section 4.9.6
Wool Laundries	Repair leaks	Reduce water and energy use by $1,520,640/year	$20,000 for screens and valve	Section 4.1.4
Zonco Washer	Repair leaks, maintain drain valves	Reduce water and energy use by $912,000/year	None	Consult with supplier, Section 4.1.3
Sulfuric Acid Decarbonizing	Filter acid continuously	Reduce release of sulfuric acid to sewer system by $115,500/year	$300,000 for in-tank filter	Purchase and install filter, Section 4.1.5
Floor Drains	Install and maintain screens to prevent lint from entering drains	Reduce suspended solids, sedimentable solids and sulfide in effluent, meet effluent standards	$5,000 for screens	Fabricate, install and maintain screens, Section 4.1.2
Beck Number 10	Relocate steam coil to prevent boil-over	Reduce loss of chemicals and energy to drains, unquantified savings	None	Relocate coil, Section 4.1.1
All Becks	Repair and maintain steam coils	Reduce fuel consumption, prevent contamination of dye baths and boiler water, unquantified savings	None	Repair all coils, check each Monday, Section 4.2.1

TABLE 1
Summary of Pollution Prevention Opportunities

SYSTEM	OPPORTUNITY	POLLUTION PREVENTION POTENTIAL	CAPITAL COST TO IMPLEMENT	ACTION REQUIRED\ SECTION
Boiler	Purchase and install combustion controls	Reduce emissions and fuel use, meet emission standards, unquantified savings	Unquantified	Procure and install combustion controls, Section 4.4.1
Jet Dyers	Monitor dye bath temperature to detect out-of-control condition	Avoid chemical loss to sewer and reduce energy use, unquantified savings	$10,000 for thermometers	Purchase and use thermometers, Section 4.5.4
Dyeing Process	Use Datacolor instrument to control process	Reduce chemical use, unquantified savings	None	Phase in use of instrument, section 4.6 and Sweeny report
EMOS Water Supply	Test plant water distribution system for leaks	Reduce water use, unquantified savings	None	Perform pressure test on Sunday, Section 4.7.6
Green Dryer	Re-balance internal air flow	Reduce emissions of H_2SO_4 mist, reduce energy use, unquantified savings	None	Re-balance air flow, reduce heat input, Section 4.4.2
Green Dryer	Install exhaust fan after re-balancing dryer	Avoid worker exposure to sulfuric acid mist, avoid future cost of medical treatment, unquantified savings	$300,000 (est)	Minimize air leakage, procure fan and ducting, install exhaust system, Section 4.4.2
Sewer Effluent	Determine nitrogen and hydrocarbon concentrations	Avoid violations, set reduction priorities, unquantified savings	$80,000 for testing	Contract testing, coordinate with reductions, Section 4.9.9
SECOND PRIORITY OPPORTUNITIES				
Wool Laundries	Install screens in catch basins	Reduce sulfide emissions, avoid water leaks, unquantified savings	$3,000 for screens	Fabricate, install and maintain screens, Section 4.1.4

TABLE 1
Summary of Pollution Prevention Opportunities

SYSTEM	OPPORTUNITY	POLLUTION PREVENTION POTENTIAL	CAPITAL COST TO IMPLEMENT	ACTION REQUIRED\ SECTION
Finishing	Replace steel drums with plastic drums	Avoid contaminating fabric with rust, unquantified savings	$5,000 for drums	Procure and use 3 plastic drums, Section 4.1.6
Becks	Repair leaks and train workers	Avoid chemical loss to sewer and reduce energy use, unquantified savings	None	Repair leaks in two becks, train workers in cost of water, Section 4.2.2
Beck Number 7	Repair hood balance mechanism	Reduce energy use, unquantified savings	$5,000	Repair hood counterbalance mechanism, Section 4.2.2
Wool Room Sump	Clean sump more frequently	Avoid generation of sulfide and sedimentable solids, meet effluent standards	None	Begin weekly maintenance, Section 4.2.4
All Processes	Monitor and document all process upsets, determine base cause of upsets	Reduce chemical and energy use, reduce emissions, unquantified savings	None	Institute prioritization of upsets and documentation program, Section 4.5.1
Jet Dyers	Use low foaming detergent in jet dyers	Reduce chemical, water and energy use, unquantified savings	None	Research other detergents, Section 4.5.5
Hot Water Rinsing	Replace hot water rinsing with more efficient multiple rinsing with cold water	Reduce energy use, reduce effluent temperature, unquantified savings	None	Perform multiple, cold rinse experiment after siphon rinsing installed, Section 4.7.3
Overflow Rinsing	Replace overflow rinsing with more efficient multiple rinsing with cold water	Reduce water use, reduce energy use, unquantified savings	None	Perform experiment comparing overflow and multiple rinsing, Section 4.7.4

TABLE 1
Summary of Pollution Prevention Opportunities

SYSTEM	OPPORTUNITY	POLLUTION PREVENTION POTENTIAL	CAPITAL COST TO IMPLEMENT	ACTION REQUIRED\ SECTION
Overflow Rinsing of Foam	Reduce time of overflow rinsing of foam, possibly install foam removal system and recycle hot water and chemicals	Reduce water and energy use, unquantified savings	None, unless foam removal system required, then unquantified	Educate workers about cost of water, Section 4.7.5
Sewer Effluent	Test effluent for pH and temperature variability, re-test for oil and grease	Avoid violations, determine reduction priorities	$250,000 for testing	Re-test for oil and grease, monitor pH and temperature, Sections 4.9.1, 4.9.2, 4.9.5
THIRD PRIORITY OPPORTUNITIES				
Becks	Calibrate volume of becks	Prevent dyeing errors from incorrect formulation, unquantified savings	None	Calibrate standard volume drum, fill becks Section 4.1.1
Becks	Tilt becks to allow complete drainage	Reduce water and chemical use through better rinsing, unquantified savings	$5,000 for shims	Re-level all becks, Section 4.1.1
Wool Laundries	Relocate pillow blocks	Increase rinsing efficiency, reduce water, energy and chemical use, unquantified savings	None	Relocate when other repairs are made, Section 4.1.4
Fabric Combing and Shaving	Recycle waste	Reduce solid waste, possible resale value, unquantified savings	None	Contact padded envelope manufacturer, Section 4.3
Sodium Sulfate Bags	Recycle waste	Reduce solid waste	None	Contact solid waste contractors, Section 4.3
Fabric Sizing Removal	Match process to sizing being removed	Reduce chemical use, reduce dyeing errors, unquantified savings	None	Contact customers, identify sizings, Section 4.5.2

TABLE 1
Summary of Pollution Prevention Opportunities

SYSTEM	OPPORTUNITY	POLLUTION PREVENTION POTENTIAL	CAPITAL COST TO IMPLEMENT	ACTION REQUIRED\ SECTION
Dye Bath Formulation	Determine reason for formula difference	Reduce chemical use, reduce dyeing errors, unquantified savings	None	Compare beck and jigger formulas, Section 4.5.3
TOTALS		$43,668,140/year plus 26 unquantified savings opportunities	$2,133,000 plus cost of combustion controls and possible foam removal system	

The purpose of this study was to perform an environmental assessment of the textile dyeing plant and to propose a program of pollution prevention. The study was done under the Agency for International Development, Environmental Pollution Prevention Project (EP3) under the direction of AMCHAM - CHILE by RCG Hagler Bailly Inc. Mr. William Bilkovich (Environmental Quality Consultants, Tallahassee, Florida) was the Industrial Pollution Prevention consultant to RCG Hagler Bailly Inc. The services of independent consultant Jorge Castillo G. were used to assist in the technical and operational aspects of the project. Mr. Ignacio Torres Silva, production manager of Proquindus, assisted with all aspects of this study.

Proquindus S.A. in Santiago, Chile is a commission dye house serving Chilean fabric manufacturers. In addition to fabric dyeing, Proquindus also washes and applies various finishes to customer fabrics. The plant operates two eight-hour shifts six days a week employing seventy shift workers and twenty technical and administrative employees. In 1992 Proquindus processed 350,000 kg of cotton and 360,000 kg of wool fabric.

EP3 program personnel visited Proquindus as part of a search for candidates who expressed interest in pollution prevention. After obtaining a committment from Proquindus to make every effort to implement pollution prevention opportunities, a pollution prevention diagnostic study was commissioned. An initial interview was conducted to discuss what such a study would cover and what data would need to be collected. Attending this meeting were: Fernando Lopez Torres, administrative manager and Ignacio Torres Silva, production manager both of Proquindus, S. A.; Mauricio Roldan of AMCHAM Chile; Eduardo Maal, RCG/Hagler, Bailly; Mario Salazar, AID; Tom Nicastro, U.S. Embassy; Jorge Castillo G., Santiago consultant; and William Bilkovich, Industrial Pollution Prevention consultant to RCG/Hagler, Bailly, Inc. The two principal concerns expressed by Proquindus personnel were reducing particulate emissions in the boiler exhaust gas and complying with proposed effluent limits in the plant's sewer discharge.

After the initial briefing, Ignacio Torres, Jorge Castillo and William Bilkovich conducted the diagnostic study by following the plant's processes from initial receipt of fabric to final shipment of finished goods. A total of 5½ days were spent studying plant processes. On one of those days, Charles Sweeny, of CDS Laboratories, pro bono consultant to EP3, assisted the team in examining uses of the plant's Datacolor instrumentation. James Gallup, Director of EP3 also visited the plant. At the end of the plant visit period, William Bilkovich prepared a preliminary report which was then translated into Spanish by Jorge David, Santiago consultant. With the report as a guide, an exit interview was conducted about two weeks after the initial briefing. The recommendations in the report and a preliminary plan of action were discussed.

Section 4.0 consists of a detailed discussion of those recommendations. Section 5.0 details the time required to implement the recommendations and presents a budget for that implementation. Section 6.0 summarizes the effect that implementation will have on the environment. Following the report is Appendix A, an outline of the processes in the plant, which details water and chemical use for each process.

4.1 Equipment Modifications

4.1.1 Modifications to Becks

The steam coil in beck number 10 was installed with the top of its coil twenty centimeters below the top of the beck. The coils in all other becks are mounted with their tops sixty centimeters below the top of the beck. When solutions in beck 10 are heated to boiling, they continuously overflow to the sump causing the loss of water, chemicals and heat energy. This steam coil should be remounted lower in the beck.

The amount of water added to a bath is currently determined by the operator based upon experience. This method does not account for individual differences in the volumes of becks. Each beck should be filled with 500 liters, 1,000 liters and 1,500 liters of water and permanent calibration marks made on the sides of the beck.

When becks are drained, some solution remains on the bottom where it is picked up by the moving rope of fabric. If this solution were removed before the next solution was added, rinsing would be more efficient. Each of the sixteen becks should be tilted around its long axis slightly so that solutions drain more completely. It should also be possible to tilt along the short axis of the beck in the direction of the drain without interfering with the alignment of the belt-drive system. Modifications to the becks that promote more efficient rinsing will be discussed in Section 4.7.3.

4.1.2 Modifications to Drains

One of the parameters of concern for sewer discharges is total suspended solids. The largest source of Total Suspended Solids (TSS) is lint (pelusa) washed off of fabric. Drains in the dye room have a rectangular grid screen. Those in the wool room have no screens. Installing screens will reduce TSS, sedimentable solids and, in the case of the wool room sump (see Section 4.9.7), sulfide in the effluent. Parallel grid screens, which can be cleaned with a small hand-rake, are easier to clean than rectangular grids which must be cleaned by hand-picking of lint. Parallel grid screens should be installed in the dye room both at the main drain exit from the room and at the places where the channels from the first three rows of becks cross under the floor. Similar screens should be installed at each wool laundry drain pipe, the full-width washing machine drain, the Zonco drain and the drain beneath the fulling machines (batans). This latter drain is important to screen because of the large amount of dry wool lint which is emitted by the fulling machines. This lint is washed into the drain during times of high water under the fulling machines. If these screens are mounted on an incline, the same drain opening can accommodate more screening area and will require less frequent cleaning.

4.1.3 Modification of the Zonco Lint Filter System

The Zonco combination fulling and washing machine has a poorly designed lint filter. Lint accumulates in the seats of the drain valves causing them to leak hot, detergent-laden water. The combined leakage from the Zonco is about 20 liters per minute. Assuming that half of the leaking water has been heated to forty degrees Centigrade, that the water is hard water, not purchased water, and using the hot water cost factors derived in Section 4.8.4, it is estimated that the yearly cost of these leaks is $912,000. The manufacturers representative should be consulted to determine whether a modification of the filter system can be made which will make it easier to keep the valve seats clear. Failing that, more frequent cleaning of these valves, perhaps after each dump, should be performed.

4.1.4 Modifications to the Wool Washing Machines

The wool laundries do not have any internal lint screens. This causes an accumulation of lint in the washer which is all dumped at once, clogging the outlet drain. This has led to the present system of draining in which the entire core of the valve is removed. When the core is replaced, the valve leaks continuously. The total leakage from the three laundries is about 50 liters per minute. The east machine leaks 15 liters per minute, the middle machine 33 liters/minute and the west machine 2 liters/minute. Assuming that one-third of the water that leaks has been heated to 40 degrees Centigrade and that all of the 14.400.000 liters of water lost each year is well water (obtained at no cost for the purposes of this calculation), the yearly energy cost of these leaks is $1,520,640. Factors for calculating the cost of hot water losses are derived in Section 4.8.4.

A lint parallel-bar screen should be installed in the catch tray of each wool laundry. This would reduce the amount of fiber that is caught in the valve. The drain valves should then be repaired or replaced. These two changes should eliminate these costly leaks and their primary cause. After the leaks are repaired, the amount of detergent used to wash wool can be reduced. The middle wool washers hold 1,200 liters and leaks 33 liters per minute. During a one hour wash cycle, 1,980 liters leak from this washer, resulting in the loss of most of the detergent. Since the wool is cleaned satisfactorily with the current leaks, it is apparent that less detergent will be required when the leaks have been repaired. Yearly detergent purchases amount to about three million pesos. No reliable information is available on the relative use of detergent in the various processes. The savings from reducing detergent use by fixing the wool laundry leaks were not determined and are in addition to the $1,520,640 energy savings calculated for these changes.

The fabric in the wool laundries passes over a roller, is sprayed with fresh water and then is squeezed between two other rollers. In two of the laundries, the slope of the fabric between the two roller sets is uphill. This causes water to run back into the sump where the rinsate

can contaminate the rest of the cloth. On the east machine, the slope is downhill toward the pressure rollers so that rinsate runs off the fabric into the catch tray as it should. If the pillow bearings of the west and middle machines ever require repair, the positions of the first roller should be changed to allow the rinsate to flow toward the pressure rollers and catch basin.

4.1.5 Modifications to the Decarbonizing Acid Bath

When wool cloth is run through the 4,000 liter dilute sulfuric acid decarbonizing bath, calcium ions in the hard water that had been used to wash and rinse the fabric are precipitated in the tank as calcium sulphate. These solids accumulate in the bottom of the tank until they begin to be deposited on the fabric. At this point, about once each month, the bath is dumped to the sewer. The pH spikes caused by this dumping will be illegal under the new sewer discharge regulations. If the bath were continuously filtered, its life would be prolonged beyond one year, saving $10,500 for each bath dump avoided. Assuming that the bath is dumped once per year (and used as pH adjustment of the dye room effluent, see Section 4.9.1), the savings in sulfuric acid purchases would be $115,500/year.

In-tank filters are available which require no external piping and have filter elements which can be removed, unrolled and rinsed and then re-used. Only the small amount of acid adhering to the filter medium would then be discharged to drain. In-tank filtering is a better solution to the pH spike problem than is automatic pH control of the effluent. In-tank filtering does not require as much labor for tank cleaning and dumping nor does it consume as many chemicals for neutralization. Assuming that the imported cost of such a filter would be $300,000, the payback for such a change would be about two years. Information on in-tank filters is included with this report.

4.1.6 Modifications to the Finishing (Apresto) Application System

Finishes are applied to fabrics in two small tanks. Unused solutions are returned to drums for storage until the next application. Three of the four storage drums are steel. They have rust on their inside walls which could contaminate solutions and fabric. It is recommended that plastic drums be used instead.

4.1.7 Modifications to the Steam System

Changes to the steam system could reduce energy costs significantly. These modifications are discussed in Section 4.8.

4.2 Maintenance Changes

4.2.1 Steam System Maintenance

Five of the six beck steam coils which were inspected were found to have holes in them. Given the present configuration of the system, these leaks not only waste energy, they contaminate baths with boiler treatment chemicals. When the steam coil is cold, bath liquids are drawn into the steam system contaminating the boiler feed water which accelerates corrosion in the steam system. This may explain the rapid degradation in the performance of steam traps that has been noted at the plant. All steam coils should be inspected under pressure and repaired as necessary. It is suggested that each beck's steam coils be checked for integrity every Monday morning as part of plant start-up procedures.

Because leaking steam traps are a major cause of energy loss (see Section 4.8.1), an ultrasonic steam leak tester should be purchased and a regular schedule of inspection instituted. Information on a tester suitable for use at Proquindus has been sent to Mauricio Roldan, EP3 Coordinator for Chile. There is a leak in the steam line in the overhead between becks six and seven.

4.2.2 Beck Maintenance

Two leaks were observed in becks during the visit. A leak slightly smaller than the size of a pencil loses about two liters per minute. If the leak is of 80 degree Centigrade softened EMOS water, it will cost $463,900 per year: $68,544 for the 576 cubic meters of water and $395,366 for the energy to heat the water (cost of hot water is derived in Section 4.8.4). Employees should be instructed to report leaks promptly and their repair should rise in priority to reflect their cost.

The door in beck 7 is improperly balanced and will not stay closed. The resulting heat loss was not quantified, but the repair is relatively easy.

4.2.3 Zonco Maintenance

If the suggested modifications to the Zonco lint-filter system is not possible, much more frequent cleaning of the valve seats should be instituted.

4.2.4 Wool Laundry Sump Maintenance

Low flow rates and lack of lint filtration result in an accumulation of lint as a mat covering the surface of a sump in the wool laundry. Wool keratin is more than 5% sulfur. This sulfur source and the anaerobic conditions in the sump create conditions for the creation of hydrogen

sulfide. The sump, located directly behind the west wool laundry, is cleaned every three months. It should be cleaned every week. If better lint interception and more frequent cleaning do not improve the conditions in this sump, then water from the dye room should be diverted through it to keep it clear. The easiest path for this flow would be through the wool room centrifuge trench.

4.3 Solid Waste

Dry wool and cotton combings and shavings are collected and discarded in a land fill. The combined waste occupies about ten large garbage bags per day. This type of waste has been used to stuff toy animals. Chile does not have a large stuffed-animal industry. The original use and continuing use of this material in the United States is to stuff padded shipping envelopes. A Chilean manufacturer of such envelopes should be contacted as possible customers for this material.

Sodium sulfate is received in 50 kilo bags which have been recycled from the sugar industry. The 125,000 kg. purchased each year results in the discarding of 2,500 bags. Similar bags are seen on Santiago's streets holding trash. Independent trash collectors should be contacted as possible customers for these bags.

4.4 Air Emissions

4.4.1 Boiler Stack Particulate Emissions

Concerns about air quality in the Santiago basin have resulted in the passage of particulate matter emissions standards. The two boilers used to heat water in the plant are subject to these standards. Currently the standard is 112 micrograms/cubic meter. By 1996 the standard will be 56 mg/m^3. Testing determined that current emissions are between 85 and 95 mg/m^3. The standard can be met by using better combustion control and/or installing pollution control equipment. The pollution prevention choice is to first invest in better combustion process controls. This equipment will reduce emissions by more efficiently burning fuel, thereby reducing fuel costs. If end-of-the-stack pollution control equipment is installed first, inefficient combustion will continue incurring additional fuel and control device maintenance costs.

The present air emissions law requires cutbacks in boiler use in times of high local pollutant levels. The amount of cutback mandated is related to the level of particulate emissions in the stack gases. Particulate levels well below the above mentioned standards would allow the boiler to operate longer. After combustion has been optimized it can be determined whether a

bag house or other pollutant-capturing equipment will be cost-effective. Information on combustion control systems is included with this report. No estimate has yet been made of the possible fuel savings or what the particulate emissions would be with better combustion.

4.4.2 Air Emissions from Wool Drying

The old green dryer, located along the south wall of the wool laundry room, is used to dry cotton and wool. When it is used to dry wool which has been through the decarbonizing process, a large volume of lint and sulfuric acid mist is discharged from the feed end of the dryer. This mist quickly fills the entire wool laundry room with very fine particles of wool and carbonized cellulose covered with sulfuric acid. The mist is irritating to the eyes and unhealthy for the workers to breathe. The amount of air being fed to the dryer forces this mist out of the dryer. Two balance valves are located at the other end of the dryer. One controls the amount of air being drawn from the dryer for recirculation back to the dryer. The other controls the amount of fresh air drawn from the room. The position of these valves has not been adjusted within the memory of the current head of maintenance.

Any fresh air drawn into the oven must be heated and will be discharged back into the room. If too little fresh air is supplied, the relative humidity in the oven will be too high to dry the fabric during its time in the oven. The current valve settings appear to allow too much fresh air makeup. It is possible that the return air valve is plugged with lint. It should be inspected. After it has been determined that the return air system is functioning, the relative humidity and temperature of the exit air should be measured and the flow rate estimated. The supply of fresh makeup air should then be reduced and the amount of steam delivered to the dryer reduced to give the same oven temperature. The exit air humidity, temperature and flow should then be remeasured. A plot of humidity against flow rate will indicate whether too much fresh makeup air is being added to the oven by showing the point where additional air flow no longer gives a substantial reduction in exhaust gas humidity. The sulfuric acid now being lost into the room should remain in the fabric where it can serve to acidify the dye bath in the next processing step. These measures therefore will not only reduce energy use but conserve sulfuric acid.

Once the flow of air from the oven is reduced, it is recommended that an exhaust fan be installed at the exit of the oven to capture the remaining sulfuric acid and lint and direct it out through the roof. This will greatly improve working conditions in the room. Reducing the flow of air out of the oven first will minimize heat energy lost to the vent system. After the installation of the vent, the oven may need to be re-balanced. The vent exit should be located so that it does not merely send contaminated air back into the room through the vented ceiling.

There is some concern that if heat and air are reduced, cotton diaper material dryer throughput will be reduced. Since diaper material does not emit sulfuric acid mist when drying, more heat flow could be sent through the oven. This would require that two basic settings for the air intake valve be determined, one for decarbonized wool and one for cotton. The savings in fuel, sulfuric acid and the capital cost of an exhaust system were not quantified.

4.5 Process Control

One of the most powerful methods of pollution prevention is improving process control. Knowledge of the manufacturing process is the key to reducing the waste of input materials and energy. This section and the following one on the use of the plant's Datacolor instrumentation offer recommendations on process control improvements. During the plant visit some potential process control problems were observed which were not investigated in detail, but which should also be mentioned here.

4.5.1 Documenting Process Upsets

When unexpected process events occur, the immediate problem is usually solved by the addition of more chemicals or other measures which, in the interest of production requirements, will keep product flowing through the factory. These measures do not, however, solve the original source of the process upset. In fact, the measures taken to patch the process frequently become standard operating procedure. This method of responding to upsets wastes chemicals, energy, and time. It will also increase pollutant loading of the plant's waste streams.

It is recommended that information be collected when upsets occur which will help to identify the process steps that preceded the upset. A list of continuing process upsets should be compiled. That list should be arranged in order or magnitude and frequency of the upset. The upsets should then be monitored in detail, one at a time, until the base cause is determined. Two examples serve to illustrate the type of conditions worth investigating.

Some becks have lids which are intended to be closed during bath heating to conserve energy. These lids are usually left open because fabric sometimes billows open from foam or steam. This can cause the fabric to catch on the transport mechanism. The cause of this problem is not known. A record should be kept of the types of dyeing operations that suffer this problem. It may be caused by improper temperature control, variations in residual detergent, other chemicals from previous steps, or a particular dyeing formulation.

Sodium sulfate is used to increase dye exhaustion. Sometimes more sulfate than is called for in the formula must be added. Knowing the process variable which causes the need for

additional sulfate will lead to a process which is out of control. Ignoring the variation in sulfate requirements results in the use of more chemicals to make up for a lack of information about the process. Sulfate concentrations in the plant's effluent are high enough to be of concern. Anything which reduces sulfate use would be helpful.

4.5.2 Sizing Compound Composition

De-sizing of cotton in alkaline media is a process whose end-point is difficult to determine. Excess caustic soda is used to assure that most sizing has been hydrolyzed. The identity of the sizing used by the plant's customers is unknown. It is recommended that these sizes be characterized. Customer's should be asked to tell Proquindus when they change sizing materials. These actions could be beneficial for two reasons. It is possible that the de-sizing bath is formulated for the worst case sizing. If more easily removed sizings are being used, less caustic soda might be required. If the size materials change without the plant's knowledge, changes might be made in subsequent processing steps to make up for problems that are actually caused by the failure to remove the new sizing.

4.5.3 Jigger and Beck Formula Differences

While examining the differences in solution concentrations between jigger and beck dyeing, it was noted that the formula for Jigger 2 called for 3 kg of caustic per 120 kg of fabric. This is one-half the concentration used in beck dyeing. This formula or the one used for beck dyeing may be incorrect.

4.5.4 Jet Cooling-water Recycle

The jet-dyeing machines are cooled with water circulating in a heat jacket. This water is drawn from the softened water supply and returns to the soft water sumps. During much of the jet cycle this return water is very hot, 80 degrees Centigrade. All cotton process water is drawn from these sumps. For dyes to work properly, the dyeing process must be begun with room temperature soft water. It is possible that a dye bath could be begun with hot water from a sump just filled with hot water from jet-dye cooling. With the present system, this out-of-control situation would not be detected. Dyeing would then begin at elevated temperatures adversely affecting dye transfer. When water use is reduced by the changes in rinsing methods recommended in Section 4.7, this problem will be more likely to occur. The same volume of hot cooling water will then be diluted with less fresh make-up water.

It is recommended that bath temperature be monitored at the beginning of each dyeing. This will determine whether there is a problem with high initial temperature. This monitoring should continue through the period during which rinsing procedures are being modified. If, after all rinses have been reduced to their minimums, there is not an initial temperature

problem then monitoring could be terminated. If high initial temperature is a problem, however, there are at least three solutions to the problem: 1) The cooling water for the jet machines could be circulated through a tank of sufficient size to dissipate the rejected heat. This system would have the disadvantage of losing the heat energy now being recovered; 2) A smaller tank could be fitted with heat exchange coils through which the jet water would pass. All incoming plant water would be passed through the tank itself. This would capture much of the heat from the jets and eliminate the possibility of temperature spikes in the inlet water to a beck; 3) A separate hot, soft water system could be created. This system could serve as the heat sink for the jet-dye heat and, by using a heat exchanger, for all hot water now dumped to the drains from becks and wool laundries. This would require devising a method of removing hot water from the becks and wool laundries without dumping it into the floor sumps. Since the effluent from wool washing is cooler and more distant from the becks than the hot waste waters from cotton processing, if this alternative is chosen, the first separate hot water system designed should be for collecting the heat from jet-dyeing and cotton processing water.

4.5.5 Foaming in Jet Dyer

Foaming is a frequent problem in the jet-dyers. The detergent used for cotton washing, wool washing and wool fulling may not be the ideal detergent to use in the different agitation and temperature conditions of the jets. Other Chilean dyers, jet machine suppliers, dye makers and the current supplier of detergent are sources of information on substitutes. The use of de-foamers, detergent, water and chemicals could be reduced and their subsequent discharge to the sewer eliminated if this problem were solved. The possible increase in detergent cost should be balanced against these savings

4.6 Color Measurement

Proquindus uses a recently-purchased Datacolor color measuring machine. The most important application of color measurement is the formulation of new shades. Software is available to do this using the most economical dyes or the least metameric. Savings can be realized in dye selection and in inventory reduction.

The use of objective measurement improves communications between the buyer and seller. It also permits the use of numeric color tolerances and shade sorting of production dye lots reducing off-grade production.

In production it can be used for inspection of incoming dye and fabric lots. This will ensure more consistent supply and fewer problems in production. For acid, direct, and disperse dyes solution techniques are available that reduce inspection time and cost.

Other major production applications are:
1. Ensuring proper dye bath composition
2. Observing the exhaustion rate of dyes
3. Identifying and measuring the amount of dye in the effluent
4. Quantification of fastness evaluations.

Perhaps the greatest gain is the increased control of the production process which will result in improved quality, more production, and savings of time and material. EP3 consultant Charles Sweeny will supply more detailed information on uses of Datacolor instrumentation in a separate report.

4.7 Water Use

4.7.1 Current Water Consumption

Proquindus, like any textile dyeing facility, uses more water than any other commodity. Water is obtained from two sources: the local water authority, EMOS; and a well on the plant site. EMOS water is softened and used exclusively for cotton processing (except for wool dyed in the jet machines and water used to make up the wool decarbonizing bath). Well water is not softened and is used exclusively for wool processing, including wool dyeing.

Based upon water use in October 1993, a typical recent month, the yearly consumption of EMOS water is 155,000 cubic meters. Water use has been rising steadily over the past three years. The total cost, including sewer charges and taxes is $119 per cubic meter. Daily water use is about 520 cubic meters worth $62,000. The cost of EMOS water for one year is approximately $18,500,000. Water obtained from the plant's well is not metered and so no accurate figure for water consumption is available. It is suggested that a water meter be installed and used to monitor well water consumption.

An estimate of the amount of well water used for wool was made. Approximately equal quantities of wool and cotton were processed in 1992: 360,000 kg of wool, including acrylic and polyester blends; and 350,000 kg of cotton, including polyester blends. EMOS water purchasing records indicate that the water used for cotton processing is 155,000 cubic meters for 350,000 kg of cotton fabric or 443 liters per kg of cotton fabric. Wool requires washing and cotton does not. Cotton requires de-sizing and wool does not. Wool is not bleached or softened and is not rinsed as much after dying because color-fastness is not as important for wool fabrics. Data from Appendix A indicate that wool processing requires 60% as much water as cotton processing does. Based on this assumption, hard water use for wool processing would be 95,000 cubic meters/year or 263 liters per kg of wool fabric. Total water use would therefore be about 250,000 cubic meters. Given this consumption, 352 liters of water are used for each kg of fabric processed. This is about two times the average water

use of commission batch dyers the size of Proquindus.

4.7.2 Process Water Use Survey Results

To determine which processes would be the best candidates for water use reduction, Jorge Castillo surveyed current water use in the principal water consuming operations. The results of this survey are detailed in Appendix A. Table 2 summarizes the water used in each major process and shows how much of that water is used for the process itself, whether it be washing, de-sizing or dyeing and how much water is used for all rinsing operations, including surface foam removal, associated with that process.

TABLE 2
Water Use by Process

Operation and Fabric	Total Use in Liters/Kg	Process Use in Liters/Kg	Rinsing Use in Liters/Kg
Desize, bleach colored cotton	300	35	265
Desize, bleach white cotton	193	57	136
Desize, soften diaper cotton	104	58	46
Desize cotton in Jet	120	12	108
Reactive dye cotton	166	19	147
Direct dye, soften cotton	98	37	61
Wool wash, wooden washers	64	11	53
Wool wash, full width	21	4	17
Wool wash and full, Zonco	21	8	13
Wool dye, acid or medium pH	147	19	128
Jet dye poly-cotton	?	?	?

One surprising result of this survey is how little water it takes to wash wool even though wool seems to contain much more grease than cotton. When the wool washing machinery is examined, however, it is found that the rinsing systems built into the design of these machines is much more efficient than that of the becks used to desize and bleach cotton and to dye both wool and cotton. This difference is addressed in the rinsing changes section below. Table 3 presents information from Appendix A arranged by the fabric processed. ("Wood" refers to the three wooden wool laundries)

TABLE 3
Water Use by Fabric

Operation and Fabric	Total Use in Liters/KG	Process Use Liters/KG	Rinsing Use Liters/KG
Desize, bleach, reactive dye colored cotton	466	54	412
Desize, bleach, soften, direct dye colored cotton	398	72	326
Desize, bleach white cotton	193	57	136
Wash (wood), dye wool	211	30	181

These two tables make it clear that rinsing is the operation which should be addressed first to reduce water use. To know which rinsing steps use the most water per month and are therefore suitable targets for water use reduction, we must combine water use figures with fabric processing amounts. Table 4 combines fabric processing data from August 1993 with rinse water use data from Appendix A to give total rinse water use for the fabric processed in that month. The "PREP" operation is the combination of all rinsing flows for all processes leading up to dyeing. One caution should be applied to this analysis. The amount of wool processed in August was unusually high because of end-of-the-season inventory adjustments by clients. Table 5 presents the same rinse water data except that the amount of wool processed has been adjusted to the same relative weight to cotton as was processed in 1992 (360,000 kg wool/350,000 kg cotton). Table 5 could be redone using a full year's actual data, but, unless the fabric mix changes drastically, the order of water use of these processes will likely remain the same.

TABLE 4
Water Use by Fabric/Process August 1993

Fabric/Process	Weight (Kg) Processed	Rinse Rate l/Kg	Water Used per Month
Wool Dyeing	44,000	128	5,632,000
Colored Cotton PREP	17,367	265	4,602,255
Wool PREP (wood)	44,000	53	2,332,000
Reactive Cotton Dye	10,700	147	1,572,900
White Cotton	8,600	136	1,169,600
Direct Cotton Dye	6,667	61	406,687

TABLE 5
Normalized Water Use by Fabric/Process August 1993

Fabric/Process	Weight (Kg) Processed	Rinse Rate l/Kg	Water Used per Month
Colored Cotton PREP	17,367	265	4,602,255 l
Wool Dyeing	26,709	128	3,418,752 l
Reactive Cotton Dye	10,700	147	1,572,900 l
Wool PREP (Wood)	26,709	53	1,415,577 l
White Cotton	8,600	136	1,169,600 l
Direct Cotton Dye	6,667	61	406,687 l

4.7.3 Suggested Changes in Rinsing Techniques and Equipment

The rinsing of cotton during desizing and bleaching as well as the rinsing that follows the dyeing of both cotton and wool is characterized by the use of two inefficient rinse methods: overflow rinsing and soak rinsing. At many steps in fabric processing the inlet water valve is turned on and the beck overflowed for anywhere from 10 minutes to one-half hour. It is probable that the actual overflow times are greater than those given in Appendix A since overflow rinsing is an unattended operation.

The rate of flow of a soft-water supply line was measured at Jigger number 1 by filling a 60 liter drum. The flow rate was found to be 243 liters per minute. At a cost of $119 per cubic meter for water, and ignoring the cost of softening, one valve left on for one hour discharges 14,580 liters of water worth $1,735. Soak rinsing is used in a number of places in fabric

processing. Becks are filled with water and then the fabric is circulated through the beck for 30 minutes or more. Both overflow and soak rinsing do not make best use of the water they consume.

Because rinsing is such a basic process at Proquindus, it was used to illustrate one of the basic principles of pollution prevention: that knowledge of process is the key to reducing the impact of that process on the environment. By looking at one rinsing process in detail, the nature of all rinsing in the plant could be clarified. To this end, two lots of fabric were dyed with the same reactive dye in adjacent becks. One lot of fabric, the one in Beck 7, was then soak-rinsed using the normal method of draining the dye solution, filling the beck with 1,500 liters of water and circulating the fabric for 30 minutes. Samples of the water dripping off the fabric were taken at the beginning of rinsing, at 15 minutes and at the end of 30 minutes. The beck was then drained, 1,000 liters of fresh water was added and the fabric agitated for an additional 10 minutes. Another sample of water was then taken by wringing the fabric.

In Beck 8, the fabric dyed with the same dye, was rinsed three times with 500 liters for ten minutes each time. At the end of each ten minute period the beck was drained and another 500 liters added. Samples were taken at the beginning of rinsing and before dumping each rinse. At the end of 30 minutes, the beck was drained of the third 500 liter rinse and, as was the case for Beck 7, 1,000 liters of fresh water added. After ten minutes the final sample was taken by wringing the fabric. The total time and total water used for each of these methods is the same.

The dye concentration in each sample was measured using a Datacolor analyzer. Because the amount of fabric in the two becks was not identical and there had been no measurement of initial dye concentration before dyeing began, the reduction in dye concentration in each beck was measured relative to the absorbance of the dye solution in that same beck at the beginning of rinsing. The beginning concentration was taken to be 100% and subsequent concentrations were expressed as percentages of that initial absorbance. The results of this experiment are presented in Table 6.

TABLE 6
DYE RINSING EFFICIENCY DATA

Beck	ABSORBANCE	RINSE NUMBER	TOTAL WATER USED	TOTAL RINSE TIME
T7 Before	100%	0	0	0
T7 15 Min	30%	1	1,500 l	15 Min
T7 30 Min	30%	1	1,500 l	30 Min
T7 Final	**20%**	**2**	**2,500 l**	**50 Min**

T8 Before	100%	0	0	0
T8 10 Min	42%	1	500 l	10 Min
T8 20 Min	25%	2	1,000 l	20 Min
T8 30 Min	**18%**	**3**	**1,500 l**	**30 Min**
T8 Final	15%	4	2,50 0 l	50 Min

The most instructive figures to compare are those for Beck 7 final rinse with a relative concentration of 20% of the original after 2,500 liters and 50 minutes, and Beck 8 with a relative concentration of 18% of the original after 1,500 liters and 30 minutes (these two runs are shown in bold print in Table 6). The use of three, small rinses removes more dye than two larger rinses and requires only 60% of the time and 60% of the water. Multiple rinses work better because relatively soluble compounds with rapid dissolution rates are being removed. Comparing the absorbance on the solution in T7 at the end of 15 minutes with that at the end of 30 minutes illustrates the point. By the end of 15 minutes all the dye that was going to be removed has gone into solution. No more dye was removed during the second 15 minute period.

Because fabric takes about one minute to make a complete revolution in the beck, it is likely that all dye that will dissolve has been removed at the end of 5 minutes or five fabric revolutions. It is suggested that this assumption be verified by running an experiment to determine the kinetics of dye removal. Samples should be taken at two minute intervals beginning at the moment the water begins to run into an empty beck. Water addition should be stopped at 500 liters. A plot of concentration, normalized for constant beck volume, against time would allow the calculation of the rinsing constant for the dye removal reaction. Rinsing for less than 5 minutes is probably not desirable. At full flow, it takes two minutes for 500 liters of water to flow into a beck. After five minutes the fabric has only circulated three times in 500 liters of water.

The logical extension of multiple rinses is continuous rinsing in which water is run across the fabric, absorbs contaminants, is removed by pressure and then diverted directly to drain without touching the fabric again or mixing with incoming water. This is approximately the system used in the wooden wool washers although the diversion of rinse water depends upon the operator properly setting the diversion valves. This does not always happen.

Counterflow rinsing is the most efficient type of rinsing that could be used at Proquindus. Rinse water from later, cleaner rinses is recycled by using it in earlier rinse stages. In the first rinse stages, the concentration of contaminants on the fabric is higher than that in the recycled rinse water resulting in a net movement of contaminants from the fabric to the rinse water. This multiple use of water substantially reduces the amount of water needed to reach a

given end-point. Counterflow rinsing either requires moving the fabric from tank to tank while rinse water is moved in the opposite direction or a system of storage tanks, piping and valves which allow later rinsings to be stored and used for earlier rinses. The first system is impractical at Proquindus because of the material handling required. The second system would be too capital intensive because of the large number of individual streams which could not be mixed for chemical or color reasons. Modern dyeing equipment has counterflow rinsing built into its design, but is only suitable for large batch sizes and long runs of the same color or process.

Given these material handling and capital constraints, rinsing efficiency can best be increased by using multiple rinsing. Because each operator has responsibility for 4 to 5 becks at once, and multiple rinsing requires action every 10 minutes, a way to automate multiple rinsing was studied. Mr. Castillo has suggested that a siphon device would be effective. A pipe of suitable diameter would be run almost to the bottom of the beck. This pipe would exit the beck at the 500 liter level and then turn down to a termination below the bottom of the beck. If the fresh water inlet were turned on at a flow rate less than the flow rate possible in the siphon pipe with a 500 liter head, the beck would fill to the 500 liter level, then empty through the siphon, then fill again. These rinses would continue until the inlet valve was closed. Rinsing would be completed when objective criteria for each process, such as pH, effluent color or presence of sodium hydrosulfite, were met.

The flow rate of the present water inlet system is sufficient to add 500 liters of water to a beck in 2 minutes. At that time the beck would begin to drain through the siphon. The diameter of the siphon pipe would have to be large enough to drain the beck faster than 500 liters per minute or the siphon would run continuously once started. This would require a siphon pipe so large that it is likely that air would be entrained into the siphon from the agitated inlet flow causing the siphon to cease operating before the beck was emptied. Allowing unattended rinse cycling at this flow rate is an invitation to waste water. In 30 minutes 7.290 liters would pass through the beck, resulting in over-rinsing.

Another problem generated from running a siphon system at 500 l/min is that two minutes is probably not enough time for equilibration between the rinse water and the fabric to occur. The rinsing kinetics experiment suggested above would determine the time necessary for that equilibration. It is suggested that a separate line for siphon rinsing be tapped off of the water inlet line. This pipe should have a separate valve and a flow restrictor which would reduce flow to a rate that delivered 500 liters of water in a time that allowed equilibration and the proper amount of fabric movement through the rinse (at one cycle per minute). Once the flow rate and siphon pipe size are determined, a simple sequence counter, taking its information from a float, could control a shutoff valve in the rinse water inlet line and terminate rinsing without operator assistance. This control system would allow cycle time to be minimized by using the maximum flow rate without the possibility of over-rinsing during

un-attended operation.

Because multiple rinsing is more efficient, those processes that rinse with hot water should be examined to see if they could be changed to cold water rinsing. The energy savings possible from such changes cannot be quantified until possible applications have been identified.

4.7.4 Overflow Rinsing Experiment

In the discussion above it is clear that soak rinsing uses more water than multiple rinsing. Even more water is used by overflow rinsing. Appendix A shows that during the desizing and bleaching of 80 kg of colored cotton, overflow rinses run for a total of 90 minutes, using a total of 21,870 liters of water. This is the equivalent of 44 five-hundred-liter rinses to rinse a batch of fabric twice. Of this water, 7,290 liters are heated to at least 60 degrees Centigrade, equivalent to 14½ hot five-hundred-liter rinses. The savings from switching from overflow to multiple siphon rinsing in these cases will be even greater than illustrated in the experiment above. It is suggested that an experiment comparing multiple rinsing to overflow rinsing be conducted to evaluate potential water use reduction. A process in which conductivity testing could be used to determine the end point would be most easily quantified.

4.7.5 Overflow Rinsing of Foam

There is one kind of rinsing which cannot be done using the siphon method. During desizing and dyeing, foam accumulates on the top of the bath. This foam would collect on the fabric if the beck were drained after the process had run its course and before rinsing began. Currently, that foam is removed by plugging the normal overflow pipe with waste plastic film and adding water to overflow the foam over the top of the tank. Two suggestions that could reduce water use during foam removal are offered. Operators are not aware of the amount of water delivered through a wide-open valve. The cost of the water delivered per hour exceeds worker hourly salaries. A training program, beginning with an discussion of the methods each operator uses to remove foam, would be helpful. It is difficult to have enthusiasm for a change in behavior if you do not know the consequences of that behavior. Our experience indicates that some operators have thought about this problem and use considerably less water to remove foam than others.

The second method of removing foam would require the purchase of some pumps, pipe and hose. When water is pumped through a venturi, a suction is created. This suction could be used to vacuum the foam off the top of the tank without even adding enough water to reach the top of the tank much less running water for 15 minutes or more. The source of water for the venturi could be drawn from the sewer sump at a point that is relatively free of lint (after the installation of more effective lint removal screens). This reuses water already headed for the sewer for an additional purpose. The pump for the venturi would be controlled by

vacuum demand. One additional advantage of such a system is that it could also be used to withdraw hot water from becks and direct it to a heat-recovery system.

The eventual results of reducing rinse water use will be a reduction in water consumption to a level at which the plant's well can supply all water needs. This will avoid the entire $18,500,000 cost of 155,000 cubic meters of EMOS water. Additional savings in hot water heating costs can be expected to result from more efficient rinsing both through the reduced use of hot water in rinses that require hot water and from switching rinses from hot to cold water. More information about processes which could be rinsed cold is needed before the additional savings can be quantified.

4.7.6 Water Leaks

It is suggested that EMOS water consumption be monitored on a Sunday when the plant is not operating and no repairs are being performed. All pumps that are normally on during plant operation should be activated. All valves that are normally open to connect the softening system to the factory floor should be open. This test will measure the volume of any system leaks. Preliminary indications are that the leaks may be substantial.

4.8 Energy Use

The energy cost reductions possible from repairing hot water leaks were discussed in another section. Energy savings that can be realized from reducing hot water rinsing cannot be quantified without further information. This section examines energy losses and structural problems in the steam system itself. Hot water and steam drying heat energy is generated by two boilers burning number six fuel oil with steam capacities of 5,000 kgv/hr and 3,000 kgv/hr. Oil consumption in the first 10 months of 1993 averaged 105 tons per month at a cost of $43,155 per ton. The yearly consumption at this rate will be 1,260 tons worth $54,375,300. Assuming that one kilogram of oil makes 10 kg of steam, the monthly steam generation at the plant is 1.05 million kg of steam. Since the combined capacity of the boilers is 8,000 kg/hr, the steam generated is approximately 131 hours of boiler maximum capacity out of a total monthly work time of 384 hours. This would mean that the boilers are operating at 34% of maximum capacity which roughly matches the use pattern observed during a monitoring experiment run earlier by Proquindus.

4.8.1 Energy Losses from Leaking Steam Traps

Observation of the amount of steam coming from the boiler water return tank led Proquindus management to suspect that steam traps in the system were leaking. The company's most recent steam trap supplier was called upon to inspect the plant's 44 steam traps with an

ultrasonic leak tester. The unit used was a Gestra Vapophon. The unit was calibrated on an open steam valve. The unit reads relative ultrasound intensity on a linear scale from 0 to 6. A reading of 1 cycling occasionally to 5 indicated a good trap. Any steady reading over 2 was judged to be caused by a leak in the trap. Table 7 details the results of this survey. Two traps could not be evaluated because the noise of a badly leaking bypass valve overwhelmed the instrument. Nineteen of the remaining 42 traps (45%) were leaking. According to literature supplied by Armstrong, a steam trap manufacturer, if the leaks from these 19 traps combined are equal to a hole only 12 mm in diameter, then the steam loss per month is 379,500 kg. This is 36% of the steam generated per month and would represent a loss of $19,500,000 per year in fuel.

A program of trap repair is suggested. Since some of the leaking traps were recently purchased Gestra units supplied by the company that did the trap survey, a recently purchased Gestra trap will be removed to try to determine what caused such rapid trap failure. Considering the leaks in the beck steam coils mentioned above and the erosion and contamination caused by the lack of traps throughout the system, especially on the main steam manifold, the problem is most likely caused by steam contaminated with air, solids, condensate, acids, bases, organic materials and salts.

TABLE 7
STEAM TRAP SURVEY RESULTS

TRAP LOCATION	LEAK TEST RESULTS	TRAP BRAND
Jigger 1	3-5, Repair	Sarco
Jigger 2	1.5, Fitting Leak?	Sarco
Jigger 3	2, Repair	Sarco
Beck 1	3, Repair	Armstrong
Beck 2	4, Repair	Armstrong
Beck 3	2, Repair	Gestra
Beck 4	6, Repair	Gestra
Beck 5	3, Repair	Armstrong
Beck 6	OK	Armstrong
Beck 7	4-5, Repair	Armstrong
Beck 8	OK	Armstrong
Beck 9	OK	Armstrong
Beck 10	5-6, Repair	Gestra

TABLE 7
STEAM TRAP SURVEY RESULTS

TRAP LOCATION	LEAK TEST RESULTS	TRAP BRAND
Beck 11	5-6, Repair	Gestra
Beck 12	OK	Unknown
Beck 13	5, Repair	Sarco
Beck 14	4, Repair	Sarco
Beck 15	OK	Armstrong
Beck 16	OK	Sarco
Jet 1	OK	Gestra
Jet 2	OK	Sarco
Jet 3	OK	Armstrong
Decarbon, Stage 1	OK	Armstrong
Decarbon Dryer Trap 1	Bypass valve leak prevents test	Gestra
Decarbon Dryer Trap 2	Bypass valve leak prevents test	Gestra
Monforts Wool Press Trap 1	4, Repair, drains to trench	Armstrong
Monforts Wool Press Roller Trap	OK, drains to trench	Unknown
Old Green Dryer Trap 1	OK	Armstrong
Old Green Dryer Trap 2	OK	Armstrong
Monforts Dryer Trap 1 (North)	OK	Unknown
Monforts Dryer Trap 2	5, Repair	Unknown
Monforts Dryer Trap 3	OK	Unknown
Monforts Dryer Trap 4 (South)	OK	Unknown
Plancha	6, Repair	Sarco
Tube Dryer	OK, very nice action	Japanese

TABLE 7
STEAM TRAP SURVEY RESULTS

TRAP LOCATION	LEAK TEST RESULTS	TRAP BRAND
Boiler Fuel Heater North Trap	4-6, Repair	Unknown
Boiler Fuel Heater South Trap	OK	Unknown
Turboaspirator Press Trap 1	4-6, Repair, drains to trench	Unknown
Turboaspirator Press Trap 2	4-6, Repair, drains to trench	Unknown
Monti Press	OK	Armstrong
Wool Room Steam Line Al-colored	4-5, Repair	Unknown
Wool Room Steam Line Brass Trap	4-5, Repair	Unknown
Dye Room Steam Line East Wall	3-4, Repair	Unknown
Dye Room Steam Line West Wall	OK	Unknown

4.8.2 Steam Trap Selection

Better information is needed about steam traps. There are a number of different trap environments at Proquindus. Some traps, such as those in the main steam distribution system, operate under relatively constant conditions. Traps on the becks are warmed and cooled many times each day. Dryer and press traps experience conditions somewhere between these two extremes. The selection criteria for traps, warm-up procedures, location (some traps are submerged under water for half the day) and physical orientation information are among some of the questions which should be answered before a rational program of steam trapping can be begun. Information on trap selection and applications been forwarded to Mauricio Roldan, EP3 Coordinator in Santiago, Chile.

4.8.3 Steam System Repairs and Modifications

As can be seen in the steam trap survey table, three of the four traps in the main steam distribution lines are leaking. These leaks cause major energy losses. There are other modifications needed to the steam distributions system. In the boiler room, steam lines from the two boilers are both connected to a manifold. This manifold should have a steam trap installed which can drain the manifold of condensate, air and carbon dioxide. It should be of a type capable of handling a large amount of boiler water carryover at once. If condensate and gases are not removed from the manifold, they will be carried into the system where they

will accelerate wear and corrosion.

At the entrance to the combing room, a drip leg was been created where a line into that room was disconnected. This pipe now collects condensate and should be trapped. The steam lines to the jet dyeing room should be insulated. The entire layout of the steam distribution system should be examined to determine whether changes made in the last 12 years have adversely affected its operation.

4.8.4 Cost of Energy for Hot Water Production

To determine the cost of energy lost through hot water leaks, the cost of heating water was determined. Assume that one kilogram of oil is required to make ten kg of steam and that ten kg of steam contains about 22,000 BTUs of energy. A kg of oil costs $43.16. Assuming perfect heat transfer from steam to water in a bath, the cost of delivering one BTU is $0,002. A more realistic assumption is a 75% heat transfer efficiency factor. This assumption results in a cost of $0.0027 per BTU delivered to water in a beck or wool laundry. Incoming EMOS water is about 15 degrees Centigrade. Well water is about 10 degrees Centigrade. The cost of heating one liter of EMOS water from 15 degrees to 80 degrees Centigrade, a difference of 117 degrees Fahrenheit, is $0.69. Heating a typical 1,500 liter cotton dyeing bath would therefore cost $1,042. There are approximately 4,800 loads of cotton dyed each year. The cost of the heat energy required for initial heating of these baths is about 5 million pesos. Wool dyeing uses colder well water which costs $0.75 per liter to heat to 80 degrees Centigrade. The 5,000 loads of wool dyed per year require $5.6 million to initially heat. The $10.6 million in heat energy to initially heat dye baths represents about 20% of the energy used in the plant.

4.9 Effluent Standards

Restrictions on the concentrations of a number of pollutants will soon be imposed for the water discharged from industrial operations in Chile. Some of these pollutants are present in the effluent from Proquindus's operations. This section discusses the pollutants of concern, their sources and the impact of reducing water use on effluent concentrations.

Table 8 lists the pollutants which initial testing indicated were detectable in the plant's effluent. The second column lists the proposed standard. Samples were taken from one of the plant's two sewer outlets on August 31-September 3. The third column gives the average of those readings. The calculated level column gives the expected concentration for pollutants whose detected concentration seemed anomalous. The final column gives the concentration for pollutants if water use were cut in half. These concentrations are based on effluent sampling unless noted with "CALC".

TABLE 8
Effluent Pollutants of Concern

POLLUTANT	STANDARD	MEASURED LEVEL	CALCULATED LEVEL	EFFECT of HALF CURRENT FLOW RATE
pH	5.5-9.0	5.94-10.1		Unknown
Temperature	35° C	22.5° C- 46.5° C		Unknown
Suspended Solids	300 mg/l	90 mg/l		180 mg/l
Sedimentable Solids	20 ml/l, 1 hr	18-23		36-46
Oils and Greases	150 mg/l	700 mg/l	85 mg/l	170 mg/l (CALC)
Hydrocarbons	20 mg/l	Not tested		
BOD5	300 mg/l	85 mg/l		170 mg/l
Total Nitrogen	80 mg/l	Not tested		
Sulfate	1,000 mg/l	555 mg/l	707 mg/l	1,114 mg/l (CALC)
Sulfide	5 mg/l	3 mg/l		6 mg/l
Detergent	2 mg/l	0.41 mg/l	14.4 mg/l	0.82 mg/l

4.9.1 pH

The measured levels given in Table 8 come from samples collected from the line that discharges to Venecia Avenue. It can receive waste from all processes except the dumping of the decarbonization sulfuric acid tank. The pH of the samples ranged from 5.94 to 10.1. The plant's other sewer line runs to Hippodromo. It receives the periodic dumping of the decarbonization acid bath. When dye room flow rates are high this line will also carry wool laundry and batan effluent, which is nearly neutral. The effluent from the dye room should have an average pH near 7 because of the approximately equal amount of wool (acid) and cotton (alkaline) dyeing. More testing of effluent pH variation should be done. Automatic pH adjustment will be necessary if the Publicly Owned Treatment Works (POTW) will not allow instantaneous excursions below pH 5.5 or above pH 9.0. The decarbonizing bath could be used as the acid source for this adjustment. Coupled with in-tank filtration, the continuous consumption of decarbonizing acid for neutralization would eliminate the need to ever dump the decarbonizing acid tank.

4.9.2 Temperature

The current effluent at times exceeds temperature limits. The combined, well-mixed effluent should meet temperature limits especially if hot water rinsing is reduced. The question to be answered by the POTW is how long a time effluent temperatures can exceed 35° C. If no instantaneous readings above 35° C are allowed, some sort of effluent cooling will be necessary. The least expensive method would involve pumping the effluent over a series of wood boards so that heat would be lost by evaporation. This cooling tower would have to be located on the roof because of lack of space on the factory floor. It would be necessary to reduce the sources of sulfide as recommended below to prevent having an odor problem in the neighborhood. A more capital-intensive system would use incoming well water to cool the effluent in a heat exchanger. This system would have the advantage of recapturing for reuse some of the heat currently lost in the effluent.

4.9.3 Total Suspended Solids

The installation of better lint traps, recommended in Section 4.1, should reduce suspended solid levels well below regulatory limits.

4.9.4 Sedimentable Solids

The effluent exceeds the limit at times and is close to the limit on average. Implementing the suggested lint screening and sump maintenance changes in the wool room should result in an effluent that meets standards even at half current water use. If the effluent must be pumped for any reason, whether for temperature control or sulfide reduction, it can be pumped through a cyclone. The centrifugal action of the cyclone will help to remove sedimentable solids, suspended solids, oil and grease.

4.9.5 Oil and Grease

The oil and grease concentrations measured in the effluent ranged from 89 to 2,151 mg/l. The average of the readings is 700 mg/l, well above the 150 mg/l standard. It is possible that samples were taken which skimmed the top of the effluent stream, carrying a non-representative amount of oil and grease into the sample. More effluent testing should be done with the objective in mind of gathering a representative oil and grease sample. A 700 mg/l oil and grease content for 250,000,000 liters implies that the incoming fabric contains 175,000 kg of oil and grease. This is 49% of the weight of the wool processed or 25% of the weight of all fabric, a figure which seems unreasonable.

If the plant processes 360,000 kg/yr of wool with 5% oil and grease and 350,000 kg/year of cotton with 1% oil and grease, the total oil and grease that must be removed is 21,500 kg or

about 85 mg/l. If none of this oil and grease is emulsified by detergent and if water use were reduced to half the current level, the effluent oil and grease level would be 170 mg/l which would exceed the 150 mg/l standard.

An experiment should be performed to determine how readily oil and grease from the wool laundry will rise to the top of the wash effluent. Removing some oil and grease at the sump in the wool laundry could allow the plant to meet standards. Alternatively, the oil and grease content of incoming wool could be measured to recalculate the theoretical figure given in the last paragraph. Which strategy is pursued depends upon the results of analysis on another representative effluent sample.

4.9.6 Sulfate

The standard has been raised from 600 mg/l to 1,000 mg/l to take into account the fact that Santiago's water has a high and variable sulfate content. In late November, 1993 both EMOS and well water were tested. EMOS water contained 218 mg/l of sulfate. Well water contained 304 mg/l. The current effluent contains 555 mg/l including the sulfate originally in the EMOS water. Assuming that the plant incoming water averages 300 mg/l over the course of the year, the test of the effluent sulfate level indicates that 255 mg/l is being added by plant processes. Because only one sulfate analysis was done on the effluent, and considering the amount of sulfate used in plant processes, the effluent concentration was calculated based upon sulfate purchases. The plant uses 103,490 kg of sulfate (as SO_4^{--} from sodium sulfate and sulfuric acid) per year. At the current water consumption rate, this use adds 407 mg/l to the effluent. If modifications to rinsing processes result in reducing plant water use to one-half current levels, the plant would add 814 mg/l to the existing 300 mg/l for a total effluent concentration of 1,114 mg/l which would exceed effluent limits.

If in-tank filtration of the decarbonizing acid tank extended bath life from one month to six months, the amount of sulfate released from the dumping of this tank would fall from 33,140 kg/year to 5,500 kg/year for a net reduction of 27,600 kg or 110 mg/l at the present level of water use. At one-half the current water use, that reduction is equivalent to 220 mg/l less sulfate in the effluent which would bring total effluent concentration down to 894 mg/l, under the present standard. As was discussed above, in-tank filtration has about a two year payback. If the decarbonizing acid is used for pH adjustment, not all of this sulfate reduction will be realized.

Much greater sulfate reductions are possible if sodium chloride is substituted for sodium sulfate in cotton dyeing. In the first nine months of 1993 Proquindus used 94,000 kg of sodium sulfate or about 125,000 kg per year. Two kinds of sodium sulfate are purchased. Sodium sulfate suitable for wool processing accounts for one-sixth of sodium sulfate use and costs 74 pesos per kilo. A second type is used for cotton dyeing and accounts for five-sixths

of use or 104,000 kg per year. The most recent price of sulfate suitable for use with cotton was 61 pesos per kilo. Dye manufacturers specify that sodium chloride can be substituted kilogram for kilogram for sodium sulfate. The most recent price of sodium chloride is 31 pesos per kilo, a savings of 30 pesos per kilo over the sulfate salt. Substituting sodium chloride for sulfate for all cotton dyeing would therefore save 3,120,000 pesos per year in chemical purchase costs. Sulfate (as SO_4^{--}) added would fall by 70,300 kg/year or 132 mg/l at current water use levels and 264 mg/l if water use were cut in half. If both sodium chloride substitution and rinse water reduction were implemented, total effluent concentration would be 564 mg/l, well within effluent standards. Reductions in sulfate discharges from filtering decarbonizing acid would be in addition to this.

4.9.7 Sulfide

Based on effluent sampling, sulfide levels would exceed standards at half the current water flow. The principal source of sulfide is probably the wool room sump which collects wool fibers in a stagnant sump where anaerobic digestion and the sulfur content of the keratin in wool combine to create a source. The sump is now cleaned every three months. It should be cleaned weekly. Better wool lint interception, proposed in Section 4.2.4, will help alleviate this problem.

4.9.8 Detergent

The average reading of 0.41 is well below the 2 mg/l standard. Based upon detergent purchases, however, the average content of the effluent would be 14.4 mg/l. Some of this difference is due to the nature of the methylene blue test on which the standard is based. Detergent which is combined with soils is not detected. More testing should be conducted to make sure that the sampling was representative. Fixing leaks in the wool laundries will eliminate the main source of uncombined detergent releases.

4.9.9 Nitrogen and Hydrocarbons

Proquindus's effluent has not yet been tested for nitrogen and hydrocarbons. These tests should be done as soon as possible. Nitrogen may be a problem because of the use of ammonium sulfate. The high calculated reading for detergents may be reflected in the effluent's hydrocarbon concentration.

Table 9 presents a schedule of implementation, subject to the availability of personnel and capital, for thirty-eight of the recommendations made in this report. Many can be implemented with no capital investment. For those projects that do require expenditures, the approximate amount of the required investment appears in the shaded window which shows the time required for implementation. Many projects can be implemented in less than two weeks. Most of those projects are not dependent upon other projects for their initiation. Instead of specifying the order in which these short projects should be done, the table places the start date for all of them in week one. The prioritization of projects used in Table 1 in the executive summary, however, is also repeated here and can be used as a guide for deciding the sequence of implementation.

TABLE 9
Schedule of Implementation and Capital Budget

PROJECT	WEEK															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
FIRST PRIORITY OPPORTUNITIES																
Steam Trap Repair (4.8.1)	$300,000															
Steam System (4.8.3)																
Review Basic Design	None															
Install Traps					$200,000											
Insulate Lines							$50,000									
Purchase Steam Leak Detector (4.2.1)	$450,000															
Steam Trap Testing (4.2.1)																
Modify Beck Rinsing (4.7.3)																
Kinetics Experiment	None															
Size Siphon & Flow Rate			None													
Install 1st Siphon					$10,000											
Tune System							None									
Install Other Siphons											$140,000					
Sulfate Reduction (4.9.6)	None															
Repair Wool Laundry Leaks (4.1.4)	$20,000															

TABLE 9
Schedule of Implementation and Capital Budget

PROJECT	WEEK															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Zonco Washer (4.1.3)	None				Unknown											
Sulfuric Acid Decarbon (4.1.5)	$300,000															
Install Parallel Screens (4.1.2)	$5,000															
Maintain Parallel Screens (4.1.2)	None															
Relocate Steam Coil, Beck #10 (4.1.1)	None															
Beck Steam Coil Repair (4.2.1)	None															
Weekly Steam Coil Testing (4.2.1)																
Boiler Combustion Control (4.4.1)																
Engineering Design	Unknown															
Bid Request																
Procurement						Unknown										
Installation								Unknown								
Training/Monitoring										None						
Jet Dye Cooling H_2O Recycle (4.5.4)																
Monitor Temperature	$10,000															
Remedy If Excessive									As Needed Basis							
Datacolor Machine Use (4.6)																

TABLE 9
Schedule of Implementation and Capital Budget

PROJECT	WEEK															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Purchased Dye Checking	None															
Dye Bath Composition	None															
Exhaustion Rate	None															
Dye in Effluent	None															
Quantify Fastness	None															
EMOS Water Leak Check (4.7.6)																
Green Dryer Air Re-balance (4.4.2)	None															
Install Dryer Exhaust System (4.4.2)			$300,000 (est)													
Analyze Sewer Effluent (4.9.9)																
pH	$80,000															
Temperature	$80,000															
Oil & Grease	$80,000															
Total Nitrogen & Hydrocarbons	$80,000															
SECOND PRIORITY OPPORTUNITIES																
Install Catch Basin Screens (4.1.4)	$3,000															
Replace Re-cycling Drums (4.1.6)	$5,000															
Beck Leak Monitoring (4.2.2)	None															

TABLE 9
Schedule of Implementation and Capital Budget

PROJECT	WEEK															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Repair Beck #7 Hood (4.2.2)	$5,000															
Maintain Wool Room Sump (4.2.4)																
Monitor Process Upsets (4.5.1)	As Needed															
Replace Jet Detergent (4.5.5)	None															
Hot Water Rinse Experiment (4.7.3)										None						
Replace Overflow Rinsing (4.7.4)																
Select Pilot Process	None															
Run Rinsing Experiment				None												
Install Multiple Rinse								As Needed								
Modify Foam Rinsing (4.7.5)	None															
THIRD PRIORITY OPPORTUNITIES																
Calibrate Beck Volume (4.1.1)	None															
Tilt Becks for Drainage (4.1.1)	$5,000															
Wool Laundry Pillow Blocks (4.1.4)									None (During Other Repairs)							
Recycle Fabric Shavings (4.3)	None															
Recycle Salt Bags (4.3)	None															

TABLE 9
Schedule of Implementation and Capital Budget

PROJECT	WEEK															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Sizing Composition Study (4.5.2)	None															
Dye Formula Anomaly (4.5.3)	None															

Implementing the recommendations in this report will lower operating costs for Proquindus, S. A. by over $40,000,000 per year. Just as importantly, these projects will reduce the impact that the operation of the plant has on the environment. This section summarizes those environmental benefits.

6.1 Air Emissions

Many of the proposed changes will reduce steam consumption, lower fuel use and thereby reduce air emissions. Only the savings that can be gained through repairing leaking steam traps have been roughly quantified. Repairing all traps should reduce fuel consumption by 36% or 454 metric tons of number 6 residual oil per year. Other proposed changes which will reduce energy use but whose savings are not included in this figure are: 1) installing better combustion controls; 2) installing steam traps in the main distribution manifold and at drip legs; 3) insulating the jet-dye steam pipes; 4) repairing leaks in beck steam coils; 5) reducing hot water use by modifying rinsing procedures, relocating the steam coil in beck #10, and plugging leaks in becks, wool laundries and the Zonco machine and; 6) re-balancing the green dryer air flow. Re-balancing the green dryer will also reduce emissions of sulfuric acid mist into the wool room, the air emission with the most immediate health effect on Proquindus workers. Only the effect of the repair of defective steam traps will be considered in quantifying air emission reductions. Significant reductions can be expected from other changes, especially installing better combustion controls and reducing hot water leaks and usage.

Using USEPA document AP-42, the effect of reducing consumption in a commercial steam boiler by 454 metric tons of number 6 oil can be calculated. Table 10 presents the expected reductions. They total over 14 metric tons of air pollutants avoided each year. Not included in these figures are reductions in carbon dioxide emissions which reduce the plant's contribution to global warming. Heavy metal emissions will also be reduced, but cannot be quantified without fuel analysis.

TABLE 10
Reductions in Air Emissions

POLLUTANT	AP-42 EMISSION FACTOR in Kilograms per Metric TON of #6 OIL BURNED	YEARLY REDUCTION FROM BURNING 454 FEWER TONS OF #6 OIL
Particulate Matter (All)	2.57 kg/MT	1,197 kg
Sulfur Oxides	20.62 kg/MT	9,361 kg
Nitrogen Oxides	7.15 kg/MT	3,246 kg

TABLE 10
Reductions in Air Emissions

POLLUTANT	AP-42 EMISSION FACTOR in Kilograms per Metric TON of #6 OIL BURNED	YEARLY REDUCTION FROM BURNING 454 FEWER TONS OF #6 OIL
VOCs	0.036 kg/MT	16.3 kg
Carbon Monoxide	0.65 kg/MT	295 kg
Lead	0.00055 kg/MT	0.25 kg

6.2 Water and Chemical Use

When all rinsing changes have been implemented, Proquindus should consume half the water it now does. The yearly reduction in water use will be about 125,000 cubic meters. Chemical use will decline due to a number of changes. Sulfate in the effluent will be reduced by more than 70,000 kg/year by changing to sodium chloride and filtering the decarbonizing acid bath. Whether this change from sulfate to chloride has a salutary effect on the environment is debatable. The high concentrations of sulfate in Santiago-area water dictated the sulfate limits. Other areas of the world might put strict limits on chloride levels.

Releases to the sewer of other chemicals such as dye, dye stabilizers, de-foamers, detergents, sodium hydrosulfite, bleach, optical brighteners, acetic acid, equalizers and boiler treatment chemicals will be reduced by the recommended changes. Among the changes which will affect chemical releases are: 1) better process controls, both from use of the Datacolor instrument and pursuing the causes of process upsets; 2) screening drains and cleaning sumps regularly to prevent sulfide generation; 3) preventing beck boil-over; 4) repairing coil steam leaks which contaminate boiler feed water and process baths; 5) using a lower-foaming jet-dye detergent; 6) calibrating and shimming becks; 6) repairing and modifying becks and wool laundries and; 7) determining sizing formulae. Until these changes have been made it is not possible to calculate how much releases will be reduced.

6.3 Solid Waste

Solid waste discarded by Proquindus consists mainly of sulfate chemical bags and shavings and combings from fabric finishing. Assuming that the eight sulfate bags generated per day fill one large (0.1 cubic meter) garbage bag and that the combings fill ten bags per day, the yearly un-compressed volume of these solid wastes is 330 cubic meters. If both wastes can be recycled, this volume of waste will be reused at least once before being discarded.

APPENDIX A

Outline of Dyeing Process Water and Chemical Use at Proquindus, S.A.

Report of field work done on December, 1993 by Jorge Castillo G.

PROQUINDUS, S.A. DYEING MILL

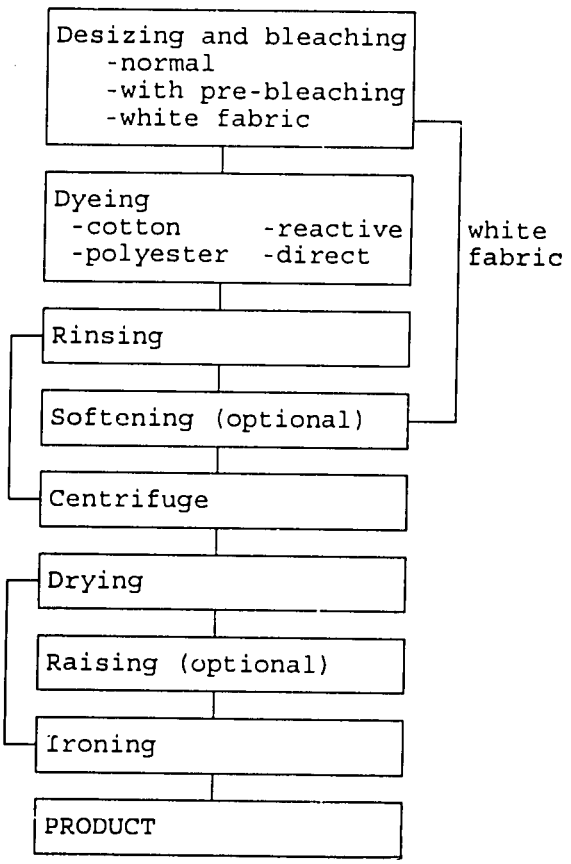
Flow rates:

Overflow rate for Becks	243 liters/minute
Overflow rate for Jets	360 liter/minute

Volumes:

To fill a Beck	1,500 liters
To fill a Jet	1,800 liters

GENERAL FLOW DIAGRAM FOR COTTON PROCESSING



DETAILED PROCESSES FOR COTTON

Desizing and bleaching in becks

General procedure
Put the fabric in the tank
Fill tank with 1,500 liters cold water
Add chemicals
Heat to boiling point and keep boiling for about 45 minutes
Overflow for 15 minutes to discharge foam and floating materials
Dump
When H_2O_2 is used for desizing:
- Fill tank with cold water
- Add hydrosulfite
- Heat to 60°C for 20 minutes
- Overflow 15 minutes to discharge foam

Overflow for 15 minutes, dump, fill, overflow 15 min again
Dump
Fill and heat to 70°C, overflow 20 to 30 minutes, up to pH neutral (7-8).
Dump

Formulas for each process

Assume 80 kg fabric and 1,500 liters beck capacity.

Normal desizing (used for light and less brilliant colors)
5.0 kg 38° Beaume NaOH
5.0 kg detergent to 4.5%

Desizing with pre-bleaching (used for brilliant colors)
5.0 kg 38° Beaume NaOH
5.0 kg 4.5% detergent
5.0 kg 50% H_2O_2
0.75 kg TINOCLARIT (stabilizer for H_2O_2)
Reducing bath, 20 minutes at 60°C with 0.75 kg hydrosulfite

Desizing and bleaching for white fabric
5.0 kg 38° Beaume NaOH
5.0 kg 4.5% detergent
After 45 minutes at boiling point, overflow for 15 minutes to discard foam, dump, fill with cold water, then add

18 liters of sodium hypochlorite at 10% active chlorine
1.5 kg 4.5% detergent
1.0 kg NaOH
After 60 minutes at ambient temperature, overflow for 15 minutes, dump, fill tank, then add
0.75 kg of TINOCLARIT
1.5 kg of NaOH
3.0 kg of H_2O_2
Heat to 60°C, then add
0.25% optical brightener (0.2 kg for 80 kg fabric)
Continue heating to boiling point for 1 hour, overflow for 15 minutes, dump, fill tank, then add
2.0% of softener (1.6 kg for 80 kg)
Heat to 40°C and hold for 20 minutes, dump, and centrifuge.

Desizing of diaper cotton
3.0 kg of 4.5% detergent
0.75 kg of stabilizer
5.0 kg of NaOH
5.0 kg of H_2O_2
0.25% of optical brightener (0.2 kg for 80 kg fabric)
5 % of sodium sulfate (4.0 kg for 80 kg fabric)
Heat to boiling point for 45 minutes, overflow for 15 minutes
Dump, fill tank, then add 2% softener (1.6 kg for 80 kg fabric)
Dump and centrifuge

Desizing in Jet machines

Usually desizing is done in Jet machines when dyeing is also done in a Jet. This is the case for all fabric containing synthetic fiber.
Flow at Jet machines is 1,800 liters/5 minutes = 6 liters/second
Same concentrations are used as in non-jet dyeing, but water to fabric ratio reduces to about 12:1.
Detergent and caustic soda are used at 3.5 gr/L concentration.

General procedure
Put fabric in tank
Fill tank with 1,800 liters cold water
Add chemicals
Heat to 98°C and circulate for about 1 hour
Overflow for 15 minutes with cold water to discharge foam and floating material
Dump

Fill, and circulate for 20 minutes
Dump
Fill and heat to 70°C, circulate for 30 minutes, overflow 20 minutes, up to pH neutral (7-8)
Dump

Dyeing

General procedure for reactive dyeing
Fill tank
Add dyes at 25°C (ambient temperature)
Mix (circulate) for 10 minutes
Raise temperature gradually to 80°C in 45 minutes, adding sulfate as follows:
- 10% after 15 minutes
- 30% after next 15 minutes
- 60% after next 15 minutes

Mix for 20 minutes at 80°C
Add 50% of alkali
Mix for 10 to 15 minutes
Add remaining 50% of alkali
Mix for 60 to 90 minutes
Overflow for 15 minutes
Dump
Refill with cold water
Circulate for 10 minutes
Dump
Refill
Heat to 60°C
Circulate for 30 minutes
Overflow for 15 minutes
Dump
Fill and heat to 70°C
Circulate for 20 minutes, take a sample and test fastness of dye, and repeat washing if necessary.

Sodium Sulfate and Alkali Additions

Color Intensity %	Anhydrous Sodium Sulfate (grams/liter)	Sodium Carbonate (grams/liter)	Calcium Carbonate and 100 % Caustic Soda (g/l)	Time in Minutes
>0.10	10	10	5 + 0.2	30
0.11-0.30	20	10	5 + 0.2	30
0.31-0.50	30	10	5 + 0.2	45
0.51-1.00	45	15	5 + 0.2	45
1.01-2.00	60	15	5 + 0.5	45
2.01-4.00	70	20	5 + 0.5	60
>4.00	90	20	5 + 0.5	60

0.2 g/l of caustic soda is equivalent to 0.6 gr/L at 38° Beaume
0.5 g/l of caustic soda is equivalent to 1.5 gr/L at 38° Beaume

Notes:
1) More than 80% of cotton dyeing processes do not use caustic soda.
2) An average color intensity is around 2-3%.

Dyeing of Poly-Cotton (polyester and cotton mix)
Desizing and dyeing is performed in Jet machines.
Reactants are estimated for Jet tube of 2,000 liters capacity and 150 kg of fabric.
Normally, cotton is dyed first, then polyester.
After cotton is dyed, alkaline water is dumped and tank refilled, then add the following reactants:

Approximately 1 liter acetic acid to pH 5
1 gr/L ammonia sulfate (equivalent to 2.0 kg)
0.1 gr/L dispersant (equivalent to 0.2 kg)
1 gr/L protector for cotton dye (2.0 kg in 2,000 liters)
Dyes added depending upon each particular case

Temperature is then raised to 130°C for 10 to 45 minutes, depending upon the color. Reduce temperature by heat exchange to 80°C and take sample to check color. If color is OK, as it usually is, overflow to get clean water (approximately 30 minutes). After this, cotton is rinsed and washed in the same way as it is in the becks. If color is not satisfactory, dyeing procedure is repeated.

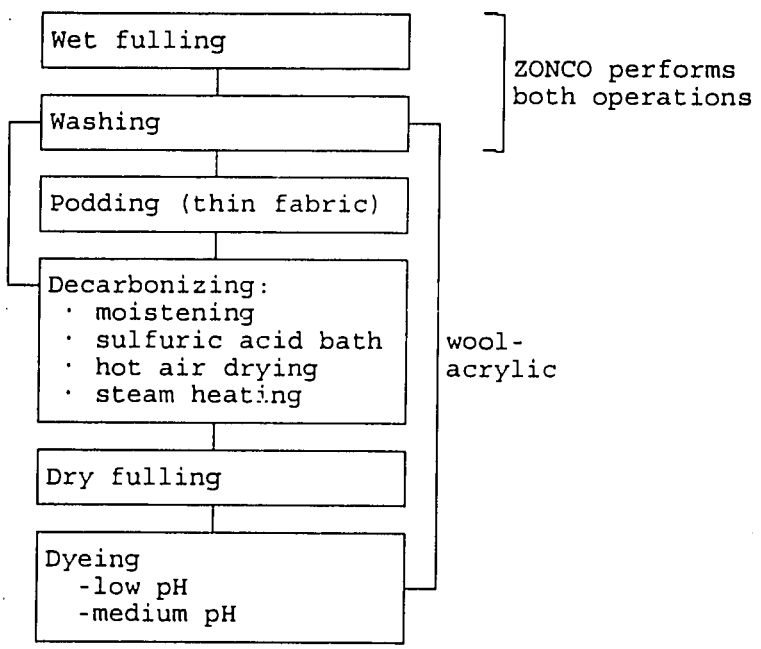
General procedure for direct dyeing

Fill tank
Add reactants:
- leveling agent at 1% of fabric weight
- 5 to 30 gr/L sodium sulfate
- 0.5 gr/L of soda ash

Raise temperature to boiling point, hold for 45 to 60 minutes
Overflow for 20 minutes
Dump
Refill and add:
- 0.5 to 1 liter acetic acid to pH 5
- 2% of fabric weight of fixing agent (TINOFIX or another resin)

Heat to 60°C
Circulate for 20 to 30 minutes
Dump
Next step is softening.

GENERAL FLOW DIAGRAM FOR WOOL PROCESSING



DETAILED PROCESSES FOR WOOL

Wool washing

Wooden washers
Fill tank with 100 kg fabric
Add 1,100 liters of water at 50 to 60°C (inlet water flow averages 70 l/min)
Add 3 liters of 9% detergent
Circulate for 20-30 minutes, adding makeup water for leaks (leaks average 16.5 l/min)
Dump
Fill with warm water (30°C)
Dump when level reaches maximum (equivalent to 1,200 liters)
Repeat 3 to 4 times until water looks clean (without foam)
De-water in centrifuge
(Overall process takes about 1 hour and 45 minutes)

Full width-machine
The full-width machine is a plain washing machine used mostly for the washing of draperies. The machine recirculates water using a pump. It washes 120 kg fabric for 40 minutes, using 500 liters water and 3 liters 4.5% detergent. It then rinses 4 times in 1 hour and 20 minutes, refilling before each rinse. The complete process takes 2 hours using 2,500 liters of water and 3 liters of detergent to wash 120 kg of fabric.

ZONCO washing and fulling machine

General procedure
Fill machine with an average of 300 kg wool (50 minutes)
Add water for moistening fabric (40 min.)
Fulling (3 to 4 hours)
Rinsing (15 minutes)
Washing (1 hour)
Rinsing (25 minutes)
After fulling, fabric is rinsed with continuous flush of water for about 15 minutes to remove lint and loose dirt.

Washing procedure
Fill tank to 1,200 liter level
Add 8 liters 4.5% detergent
Continue filling to 1,750 liter level
Heat to 45°C and mix for about 15 minutes

Flush water up to 1,200 liter level
Refill to 1,750 l and repeat 3 or 4 times until water looks clean.
Dump
Rinse for about 25 minutes with drain valves at the bottom of the tray open
Moistening water is drawn from a tank with marks at different levels and is estimated at 250 liters.
Fill flow rate is estimated as 550 liters in 11 min (0.83 liters/second).

Using this flow rate, water use for each process is:

Moistening	250
First rinsing	750
Washing	4,000
Rinsing	1,250
	6,250 liters

Zonco machine processes 300 kg of wool in 7 hours using 8 liters detergent and 6,250 liters of water.

Podding Operation

The podding operation consists of heating fabric in boiling water and then cooling it in ambient temperature water. This process is used only for thin wool fabric and helps improve its appearance and brightness. Hot water is added after each operation to replace water that goes out with fabric. Some water is drawn out of the cold water tank after each operation to prevent overheating. Approximately one-half tank capacity is used during each operation. The cold water tank has a volume of about 180 liters. The hot water tank has a capacity of 430 liters.

Wool Dyeing

Assume 30 kg in 1,500 liter beck

Low pH procedure
Fill tank, then add following reactants:

- 2.0 kg detergent
- 8.0 kg sodium sulfate
- 1% equalizing agent
- Sulfuric acid to pH 2 to 3 (only if fabric was not decarbonized)
- Dye according to formula

Raise temperature to boiling point and mix for 45 to 90 minutes
Circulate for 60 minutes to cool water gradually
Overflow for 20 to 30 minutes to cool water and raise pH to 6.5-7
Dump
Fill with cold water and circulate for 15 minutes
Dump, refill and circulate again
Dump

Medium pH procedure
If fabric was decarbonized, neutralize with 1.5 gr/L ammonia (2.25 kg)
Rinse, then add chemicals as in the low pH procedure with the exception of sulfuric acid.

Polyester-wool dyeing (seldom dyed)
Dyeing is performed in Jet machine, polyester fiber dyed first
If fabric was decarbonized, neutralize with 1.5 gr/L ammonia (equivalent to 3.0 kg in 2,000 liter Jet), then add the following reactants:

1 liter of acetic acid (should reduce pH to 5 approx.)
1 to 3 gr/L of carrier
Dye according to formula

Heat to 106°C and mix for 60 minutes
Cool to 80°C and take sample
Repeat dyeing, if necessary
Overflow for 15 to 20 minutes, dump, refill, control pH as required and continue with dye process as described in the low pH procedure.

Acrylic-wool dyeing (seldom dyed)
Acrylic-wool is not decarbonized. Clean, more expensive wool is used.
Wool is dyed first, then acrylic, light colors in becks, dark colors in Jet machines.
Mix 30 to 45 minutes until water reaches 40°C
Dump
Fill
Add reactants for acrylic dyeing:

0.5 liters acetic acid to reduce pH to about 4.5
Dye according to formula

Mix for 1.5 hours at 104°C (or boiling in case of dyeing in a beck)
Cool to 80°C and sample
Repeat dyeing process if necessary
Overflow to get neutral pH (approximately 30 minutes)
Dump
Fill with cold water
Circulate for 20 minutes
Dump

APPENDIX B

Statement of Work

AMCHAM-CHILE
ENVIRONMENT COMMITTEE

EP3 CHILE PROGRAM.

TEXTILE DYEING MILL INDUSTRIES.
TECHNICAL ASSISTANCE REQUISITION.

BACKGROUND.

The Environmental Steering Committee of AMCHAM has approved two Textile mills to participate in EP3 projects, technically assisted by the Prime Contractor.

The plan is to perform Environmental Industrial Pollution Prevention Diagnostic studies in the two Plants selected.

In order to do the job, the Prime Contractor will provide its assistance through US.experts,Probono consultants and local chilean consultants, contracted and paid by the Contractor.

All the Consultants should posses proven technical capabilities in PP for the Textile dyeing industrial processes, as well as expertise in dealing with gaseous emission, liquid discharge and solid waste situations in these industries.

US.CONSULTANT WORK TASK.

To technically assist the Plant Team in the identification of changes/ modifications to the processes, in order to reduce or abate the generation of contaminants, resulting in increased productivity and improved profitability to the operations.

SPECIFIC TASKS.

To assist and/ or work with the plant Team, the EP3 Coordinator and the local consultant,to achieve the listed objectives.

.-Diagnostic Study of the Plant processes.
.-P2 opportunities identification and analyses.
.-Determination of the effluent base line .
.-Technical recommendations and Reports.
.-Implementation of P2 recommendations and options.
.-Monitoring of changes and follow up of results.
.-Evaluation of results.
.-Exchange and transfer of technical information.
.-Identification of possible capital investment solutions.
.-Recommendations for ongoing environmental improvement.
.-Participation in Seminars and workshops on P2.
.-Education and training to Plant personnel.

QUALIFICATIONS OF THE US.CONSULTANT.

.-Proven expertise and know-how in P2 measures and procedures.
.-Experience in developing and supervising textile dyeing mills P2 projects. (Assessment, implementation, monitoring, evaluation and reporting).
.-Capability to specify and recommend technical solutions.
.-Ability to train plant personnel.

REQUIREMENTS FOR THE US.CONSULTANT.

.-Provide a biodata sheet for each proposed consultant.
.-Computer data/ info. processing (Wordperfect, Lotus).
.-Bilingual spanish-english desired.

CONDITIONS FOR THE US.CONSULTANT.

.-Should be selected and contracted by the Prime Contractor.
.-Will belong to the Plant team.
.-Will supply his own computer, printer and software.
.-Will coordinate activities with EP3 Coordinator.
.-Will report to the Prime Contractor.

DATES FOR IMPLEMENTATION.

1st.VISIT: NOVEMBER 15 through DECEMBER 03.
(or earlier if Technical Assistance Agreements signed out by Plant Board/ Managers in advance).

BEST AVAILABLE DOCUMENT

AMCHAM-CHILE
ENVIRONMENT COMMITTEE

EP3 WORK PLAN FOR TEXTILE DYEING MILLS.

BACKGROUND.
The AMCHAM Steering Committee has approved one Textile dyeing mill as candidate to initiate individual Plant projects in this industrial sector.

These Projects should start right after signature of a Private Agreement with each candidate plant.

INDUSTRIES SELECTED.

QUIMICA Y TEXTILES PROQUINDUS SACI.(Mid size plant).

POLLUTION SITUATION.
This plant works in batch processes, producing mostly wool and cotton fabrics; they also treat polyester and synthetic mixes in small volumes as per customer orders.

Main concern here is the water pollution from extensive usage of a variety of chemicals to treat, dye and finish the fabrics; waste water flows dierctly into the sewage system.

The gaseous emissions come from their boilers and some treatment processes, whereas the solid waste is restricted to trimmings, pile and minor amounts of residues left behind in the vessels and tanks, after washing or cleaning.

WORK PLANS.
The Prime Contractor should conduct a Diagnostic Study in each of these Plants in order to identify Pollution Prevention opportunities, aimed at reduction/ abatement of pollution through low cost changes and modifications to their processes.

In order to perform the Study, the Contractor must develop a specific Execution Work Plan for every Industry Sector (and/ or plant) already approved by AMCHAM Steering Committee.
The Execution Work Plans should be submitted to the Steering Committee for approval, right after the first plant visit as per the Work sequence to follow.

BEST AVAILABLE DOCUMENT

TASKS AND ACTIVITIES-WORK SEQUENCE.

The Contractor Execution Plans for each Plant will include tasks and activities following the sequence below.

.-Orientation meeting with EP3 Coordinator upon arrival of Prime Contractor team to Chile (1st.visit of Experts).
.-Meeting with Plant Board and/or Managers.
.-Diagnosis Study of plant and processes.(Plant tour assessment).
.-Develop Execution Work Plan (Copy to Steering Committee and Plant Board).
.-Effluent base line: recommendations and determination.
.-Plant data/ information collection:cost, processes,functions.
.-Pollution prevention opportunities analyses /identification.
.-Draft report on recommendations with strategies and actions, incorporating the Execution Work Plan.
.-Review of draft Report with Plant Managers.
.-Team formation and task definitions.
.-List of criteria to analyze/ select P2 options. .-
.-Exit meeting with Steering Committee.
.-Final report on Recommendations to Plant Board with confirmatory analyses and suplemental information for best preferred option to implement in plant.
.-Implementation of best option in plant (2nd.visit of Experts)
.-Monitoring/ follow-up.
.-Information transfer and control.
.-Periodical reports on progress.
.-Evaluation of results (3rd.visit of Experts).
.-Final report of results.
.-PLAN II assessment after evaluation (Capital intensive solutions).
.-Report recommendations for PLAN II capital intensive solutions.

During the visits of P.C.team, time should be spent in seminars, workshops and training sessions to members of the Plants involved.

Similarly, the participation of experts in open seminars dealing with general P2 topics, waste minimization techniques and procedures, clean technologies and related subjects directed towards Academia, Industry Associations and University students may be considered if time permits.

PRIME CONTRACTOR RESPONSIBILITIES.
The Contractor will have to select and contract US.experts and Probono consultants, as well as hiring local chilean consultants in order to provide in-plant assistance to the projects.

BEST AVAILABLE DOCUMENT

TIMEFRAME.
First visit of US.Team experts should be programmed and take place immediately after Contractor receives written fax notice from EP3 Coordinator, of the signature of Technical Assistance Agreement by the Plant Board/ Managers.

It is expected that the entire process of Diagnostic Study to the stage of Exit meeting with the Steering Committee, will not extend beyond 5-6 working days for every one of the Projects, during the first visit of the team of experts.

On return to the US. the experts will review their preliminary analyses and recommend the most attractive P2 options to address waste reduction opportunities; a Final Report sent to the EP3 coordinator for review of the Plant Board, will allow the Plant to choose the option which would best fit its capabilities and undertake its action plans.

The implementation of the best option selected by the Plant will take place immediately after Plant Board approval, during the second visit of the Team of experts. This step may not take more than 2-3 working days.

Time for monitoring/ follow-up will vary for every particular project and plan.

A third final visit of experts has been programmed for the Evaluation of results, Final Project Report and PLAN II Capital intensive recommendations. It is expected to complete this stage in 5 working days.

It is important to stress that, to the extent possible, experts in such disciplines as Water treatment and Boiler/ burner operations should be used in several plant visits during their trip to Chile.

BEST AVAILABLE DOCUMENT

November 10, 1993

EP3, CHILE Textile dyeing Industries Technical Assistance

DESCRIPTION:

EP3 Chile has identified interested industrial plants in the textile dyeing sector. A letter of intent has been received, from three industrial plants in this sector. The plan is to perform Pollution Prevention (PP) environmental audits (for Chile they'll de called Diagnostic Analyses because of a negative connotation of the word "audit" there) in those three industrial plants.

EP3-HBI will let sub-contracts with USA and/or local consultants with proven technical capabilities in PP for the textile dyeing industrial process. For each industrial sector (ie. three industrial plants), one individual from a US Sub-contractor or Chilean Sub-contractor will be assigned as Team leader, and he/she will be responsible for the diagnostic analyses/audits and follow-up of each industry. It is expected that diagnostic analyses/audits will not extend beyond 2-3 calendar days. The objective will be to identify as many as possible **low-no** cost changes to process/controls/materials which will result in pollution reduction and improved efficiency. The diagnostic analyses/audits will also identify possible capital intensive PP modifications and/or equipment, instrumentation modification and/or installation. The Team leader will have operational responsibility, including supervision/coordination of the other Team members (local consultants, US pro-bono experts and/or other US consultants). It is expected that the Teams will be made up of three individuals, a Team leader, an Industrial Pollution Prevention, IPP, expert and a Chilean consultant counterpart. The Team Leader will coordinate closely and report to EP3/Chile through it's coordinator, Mauricio Roldán. The PPI will also assure that the Chilean consulting/engineering team members will be active participants in all technical activities with the objective of maximizing PP transfer of expertise. EP3-HBI through the EP3 coordinator, will have overall responsibility for supervision of all sub-contractors.

The Team will use the UNIDO, UNEP, **AUDIT AND REDUCTION MANUAL for INDUSTRIAL EMISSIONS AND WASTES**, supplemented by the EPA **WASTE MINIMIZATION ASSESSMENT WORKSHEETS** for the diagnostic analyses/audits.

POSITION TITLE: Industrial pollution prevention (IPP) expert

QUALIFICATIONS: Proven experience in performing similar PP activities, experience/expertise in identification of PP measures, in development of the necessary instructions/specifications required for the implementation of the recommended modifications, in training of operators, monitoring/evaluation of results in textile dyeing industrial plants. **Candidate** must provide a brief (2 page max.) outline of proposed plan for the Pollution Prevention Diagnostic Analysis for a textile dyeing plant.

DATES: November ~~15~~ 22 through December ~~3~~ 8, 1993

REQUIREMENTS:

Provide a BIODATA sheet for each proposed candidate.

Once the IPP expert is selected, he/she will actively participate, jointly with EP3-HBI, in the selection process for the other Team members as well as in the coordination of Environmental Field sampling to be done by Chilean contractors.

Electronic word processing, spreadsheet proficiency and Windows familiarity, as well as Spanish Language capabilities and International consulting experience.

Names and contact tel. #s of individuals who can provide references related to consultants' PP experience/expertise in textile dyeing industrial plants in USA or elsewhere.

There will be a "pre-trip" briefing in EP3-HBI project office in Arlington, VA, (1-2 days). Upon arrival to Chile, EP3 Team will review their workplan/schedule with the appropriate USAID mission personnel.

IPP expert will assist Team leader to prepare a brief (one page MAXIMUM) weekly status report for the appropriate USAID mission person/office.

EP3 IPP expert will assist the Team leader in the EP3 Team's preparation of a Trip Report. This Trip Report will be presented by the Team to the appropriate USAID mission person/office BEFORE leaving the host country. If necessary, this Trip Report can be presented in "draft" form, for finalization, formatting, etc. upon return to the EP3-HBI project office.

Whenever possible, the EP3 Team will use the Windows based, PRIDE-EP3 USAID Audit Assessment System. WordPerfect 5.1 and LOTUS 123 will be used for all reports. The consultants will supply their own computers and software. A diskette with all electronic, WP5.1 and LOTUS, files will be submitted to the EP3-HBI Project office with the hard copies of the reports.

There will be a one day, "post-trip" briefing, by the IPP expert, at the EP3-HBI project office in Arlington, VA, (within 1 week after departure from the host country). At this time, the final Trip Report must be completed and delivered to the EP3-HBI project office, together with the computer files.

APPENDIX C

Industry Agreement

CONTRATO DE MUTUA COOPERACION
ENTRE
El Programa EP3 Y (EMPRESA)

Se celebra el presente Contrato con fecha 20 de Nov de 1993, por y entre El Programa de Prevención de Contaminación (en lo sucesivo denominado "El Programa **EP3**") financiado por la Agencia de los Estados Unidos para el Desarrollo Internacional, (en lo sucesivo denominado como "USAID") en Chile, y que cuenta con el respaldo de la Cámara Chilena Norteamericana de Comercio A.G. (en lo sucesivo denominado como "AMCHAM"), y que recibirá asistencia técnica de RCG/Hagler, Bailly, Inc. como Contratista Principal (en lo sucesivo denominado como "**EP3**-HBI"), con sus oficinas situadas en la Cámara Chilena Norteamericana de Comercio A.G., Avenida Américo Vespucio Sur 80, piso 9, Casilla 82, Santiago 34, Chile, por una parte; y por la otra parte Productos Químicos e Industriales SA. PROQUINDUS,(en lo sucesivo denominado "EMPRESA"); domiciliada en Venecia 1637, Independencia,Santiago, Chile;

Y

POR CUANTO "**EP3**-HBI" ha sido contratado por la Agencia de los Estados Unidos para el Desarrollo Internacional para que le proporcione al Programa **EP3** servicios de administración y apoyo técnico;

Y

POR CUANTO la EMPRESA manifestó su deseo de participar en El Programa **EP3**, de ejecutar un Estudio de Diagnóstico de Prevención de Contaminación y de implementar sus recomendaciones;

LAS PARTES VIENEN, EN VIRTUD DE LO EXPUESTO, A CONVENIR LO SIGUIENTE:

1. <u>RESPONSABILIDADES DEL PROGRAMA EP3</u>

1.1 El Programa **EP3** y EP3-HBI ejecutarán directamente y/o contratarán (sin costo para la EMPRESA) un análisis diagnostico de prevención de contaminación que será hecho por técnicos/expertos Chilenos asistidos por técnicos/expertos extranjeros, cuando sea necesario. Entre la primeras actividades del estudio diagnostico será establecer una base de referencia de las composiciones actuales de los efluentes de la EMPRESA.

1.2 El Programa **EP3** y EP3-HBI le enviarán a la EMPRESA, para su respectiva aprobación y consentimiento, un Alcance de trabajo recomendado para la EMPRESA.

1.3 El Programa **EP3** designa aquí al señor Mauricio Roldán como Coordinador del Proyecto, quien asume una responsabilidad

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contractual y operativa directa en virtud del presente Contrato.

El señor Roldán será también responsable de verificar el cumplimiento de las condiciones del presente Contrato.

2. RESPONSABILIDADES DE LA EMPRESA

2.1 La EMPRESA cooperará con los técnicos del Programa **EP3**, suministrará las informaciones técnicas, administrativas y contables, relacionadas a los procesos de fabricación necesarias para analizar los sistemas de producción. El objetivo de esto es identificar posibles cambios en ellos, en las materias primas (si es posible), en los productos químicos, en los controles de producción, y en otros variables para reducir la emisión de contaminantes, y que incidirá en el mejoramiento de la productividad y la rentabilidad operacional.

2.2 La EMPRESA también proveerá a los técnicos del Programa **EP3** las informaciones, mediciones o datos relacionados a las actuales composiciones de los efluentes de nuestra EMPRESA y sobre proyectos de mejoramiento ambiental en ejecución o en planificación. En caso que no tengamos datos cuantitativos sobre la composición actual de efluentes, permitiremos que El Programa **EP3** directamente o usando sub-contratistas de USA o Chilenos tome mediciones cuantitativas sobre la composición de los efluentes como parte del estudio diagnostico de prevención de contaminación.

2.3 La EMPRESA requiere que todos los datos confidenciales de procesos de propiedad de la EMPRESA, o datos relacionados a composición de efluentes que suministre, o cualquier información operacional o comercial que obtengan los técnicos del Programa **EP3** en la EMPRESA, serán tratados con **máxima confidencialidad**, y que no serán divulgados a ninguna entidad Publica o Privada sin previa aprobación por escrito por parte de la EMPRESA.

2.4 La EMPRESA tendrá la última decisión y aprobación de cualquiera recomendación que haga el programa **EP3**, y por ende, la EMPRESA releva al Programa **EP3** de toda responsabilidad legal relacionada a la implementación de las recomendaciones del Programa **EP3** o de sus resultados.

2.5 La EMPRESA está de acuerdo con que el Programa **EP3** inicialmente, tratará de identificar modificaciones que no impliquen mayores inversiones o costos.

2.6 La EMPRESA implementará las modificaciones identificadas y recomendadas por El Programa **EP3**, siempre y cuando estas, según evaluación de la EMPRESA, no sean perjudiciales a los productos, a los sistemas de producción, ni a las prácticas

comerciales y de ventas.

2.7 La EMPRESA permitirá que El Programa **EP3** le dé publicidad a los resultados de las innovaciones recomendadas por el Programa **EP3**, y permitirá que otras industrias con procesos similares se beneficien de las experiencias de nuestra EMPRESA, siempre y cuando esto no involucre procesos de propiedad de la EMPRESA, y que se puedan transferir a otras industrias del sector. Los resultados no serán divulgados a ninguna entidad Publica o Privada sin previa aprobación por escrito por parte de la EMPRESA. Esta divulgación de resultados se podrá hacer durante los dos (2) primeros años siguientes a la puesta en marcha e iniciación operativa de las modificaciones o aplicaciones, de forma que otras empresas puedan observar las tecnologías en operación. Estas visitas serán aprobadas por el Gerente de Proyecto de la EMPRESA, y se programarán de forma tal de minimizar perturbaciones en las operaciones de la EMPRESA.

2.8 La EMPRESA obtendrá también las licencias, permisos y otros documentos oficiales que puedan requerirse. La EMPRESA se encargará del pago de cargos locales. La EMPRESA será responsable del almacenamiento y de la seguridad de todos los instrumentos y/o equipos de los técnicos del Programa **EP3** desde su llegada a ésta.

2.9 La EMPRESA se compromete a pagar los costos de implementación de la recomendaciones del Programa **EP3** que sean aceptadas por la EMPRESA.

2.10 La EMPRESA accede a proporcionar personal operativo y de mantenimiento que esté capacitado para recibir entrenamiento para la Operación y Mantenimiento de los equipos, instrumentos o recomendaciones operacionales según lo soliciten El Programa **EP3** y EP3-HBI o el consultor/contratista local que contrate El Programa **EP3** para el Programa **EP3**. La EMPRESA tambien se compromete a promocionar una ética de Prevención de Contaminación que adoptará e implementará la siguiente politica ambiental formalizada, que incluirá a todo su personal:

> "Para la EMPRESA, la protección del medio ambiente tendrá máxima prioridad. Nuestro compromiso será eliminar o reducir la utilización de sustancias tóxicas y reducir al mínimo el uso de la energía y la generación de todo tipo de desechos, siempre que sea posible. Preferimos prevenir la contaminación en la fuente que controlarla y/o tratarla al final del proceso industrial. En los casos que no se puede evitar que haya desechos, trataremos de reciclar, de tratar o eliminar desechos por medios que reduzcan al mínimo los efectos nocivos para la atmósfera, las aguas y la tierra."

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2.11 La EMPRESA proporcionará personal con capacidades técnicas suficientes para ejecutar las funciones de verificación o implementación que identifique El Programa **EP3**. Se le proporcionará toda la información disponible a Programa **EP3** que sea necesaria para formular sus recomendaciones.

2.12 Luego de la ejecución del presente Contrato, el personal técnico de la EMPRESA y del Programa **EP3** realizarán conjuntamente el seguimiento de los resultados. Se registrarán toda medida y parámetros necesarios, como ser las emisiones y los efluentes, para verificar la reducción de los efluentes y de las emisiones.

2.13 La EMPRESA designa a Fernando López T. como su Gerente de Proyecto, quien asumirá las responsabilidades de revisión técnica de la EMPRESA en relación a la implementación del Programa **EP3**. El Gerente de Proyecto actuará también como enlace entre la EMPRESA y El Programa **EP3**/EP3-HBI y/o con los consultores/contratistas extranjeros o Chileno, que contrate El Programa **EP3** para este Proyecto.

2.14 La EMPRESA le proporcionará espacio de trabajo a los representantes del Programa **EP3** cuando éstos se hallen en la EMPRESA durante las fases de medición, implementación de las recomendaciones, y puesta en marcha de operaciones, y también durante el seguimiento de las implementaciones de las recomendaciones y las evaluaciones y/o mediciones de los resultados.

2.15 La EMPRESA conviene en participar, con otras firmas y con El Programa **EP3**, en la promoción de la "aplicación de tecnologías de prevención de contaminación", asistiendo a seminarios y talleres.

2.16 La EMPRESA declara que ni El Programa **EP3** ni USAID ni EP3-HBI ni sus respectivos contratistas y sub-contratistas, serán responsables por ningún daño directo o indirecto, especial o consecuencial; incluyendo, sin que esta enumeración sea limitante, pérdida de energía, costo de reponer energía, imposibilidad de uso o pérdida de ganancias que pudiesen resultar de la implementación de recomendaciones emanadas de los Estudios Diagnósticos de Prevención de Contaminación o de cualesquier otros servicios prestados por El Programa **EP3**, por USAID o por EP3-HBI o por sus respectivos contratistas y sub-contratistas en virtud de este Contrato.

2.17 La EMPRESA declara que ni El Programa **EP3** ni USAID ni EP3-HBI ni sus respectivos contratistas y sub-contratistas, serán responsable por daños personales, pérdidas o daños a la propiedad que pudiesen resultar de la Aplicaciones Técnicas descritas en este documento. La EMPRESA se compromete a indemnizar, a defender y a mantener libre de perjuicio al Programa **EP3**, a USAID y a EP3-HBI y a sus respectivos contratistas y sub-contratista por y ante

cualesquier demandas, juicios o procedimientos provocadas por o relacionadas con cualquier acto o emisión en relación con la ejecución de los servicios objeto del presente Contrato.

2.18 Queda convenido que la EMPRESA procurará sus propios seguros como única medida paliativa ante daños personales, pérdidas o daños a la propiedad o ante cualquier otra pérdida o daño resultantes de o relacionados con la prestación de los servicios ejecutados por El Programa **EP3**, por USAID y por EP3-HBI y por sus respectivos contratistas y sub-contratistas en el cumplimiento del presente Contrato. La EMPRESA acepta liberar, por el presente instrumento, al Programa **EP3**, a USAID y a EP3-HBI y a sus respectivos contratistas y sub-contratistas, de responsabilidad por cualesquier pérdidas o daños que pudiese sufrir la EMPRESA por razones de cualquier clase que sean, en este respecto.

2.19 Se espera que la EMPRESA proporcione indemnización o cobertura a su propio sub-contratista, si lo hubiese, sobre cualquier equipo o instalación de instrumentos en el transcurso de sus prácticas normales de contratación, y que tales medidas puedan incluir cualesquier fuerzas mayores, retrasos, daños liquidados o garantías de cumplimiento que la EMPRESA pueda desear, pero se entiende también que tales medidas no involucrarán en forma alguna los resultados de cualesquier actos u omisiones del Programa **EP3** ni de EP3-HBI ni de ninguno de sus contratistas y sub-contratistas.

3. OBLIGACIONES FINANCIERAS DE AMBAS PARTES

3.1 El Programa **EP3**/EP3-HBI o el consultor/contratistas extranjeros o Chilenos contratados por El Programa **EP3** para este Proyecto, no tienen obligación financiera alguna para con la EMPRESA. En igual forma, la EMPRESA no tiene obligación financiera alguna para con el Programa **EP3**/EP3-HBI o el consultor/contratistas extranjeros o Chilenos contratados por El Programa **EP3** para este Proyecto.

4. DURACION DE ESTE CONTRATO

4.1 Este contrato tendrá una duracion suficiente para efectuar los estudios diagnósticos descritos anteriormente, y para implementar las recomendaciones del Programa **EP3**, pero en ningún caso será mayor de un (1) año a partir de la fecha de la firma de este contrato. El período de duracion solamente podrá ser modificado por medio de un acuerdo formal por escrito, entre las dos partes.

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5. DISPOSICIONES GENERALES

5.1 Honorarios Eventuales

A) La EMPRESA garantiza que no ha empleado ni le ha pagado a ninguna persona ni agente de ventas para que solicite u obtenga este Contrato en base a un contrato de entendimiento por comisión, porcentaje, corretaje u honorarios anticipados; a excepción de empleados de buena fe o de agencias comerciales o de venta establecidas que la EMPRESA mantenga para efectos de procurar negocios.

B) En caso de infringimiento o violación del presente Contrato, el Programa **EP3** tendrá el derecho de detener todas las actividades sin contraer responsabilidad por ello.

5.2 Efecto Legal de la Aprobación y Decisión de USAID

Las Partes suscritas manifiestan entender que el presente Contrato reserva ciertos derechos para USAID, tales como (pero no limitándose a): el derecho de aprobar las condiciones del presente Contrato, y también la EMPRESA y cualesquier otras industrias, los informes, las especificaciones, los sub-contratos, los documentos de licitación, los planos u otros documentos relacionados con el presente Contrato, como también el Proyecto del que este Contrato forma parte. Las partes suscritas declaran también entender y aceptar que USAID, al reservarse cualesquiera o todos los derechos de aprobación mencionados, actúa únicamente como una entidad financiera para asegurar el uso adecuado de los fondos del gobierno de los Estados Unidos, y que cualquier decisión que USAID tome de ejercer o de abstenerse de ejercer tales derechos de aprobación, será en cuanto parte financiante en el curso del financiamiento de este Proyecto, no significando que USAID entre a ser una parte del presente Contrato.

Las Partes suscritas declaran entender y aceptar que USAID puede, de vez en cuando, ejercer los derechos de aprobación mencionados, o bien discutir materias relacionadas con tales derechos y con el Proyecto, ya sea con las partes en conjunto o separadamente, sin que por ello incurra en responsabilidad alguna ante las partes, ni en conjunto ni en forma separada. Cualquier aprobación (u omisión de aprobar) por parte de USAID no privará al Programa **EP3** ni a EP3-HBI ni a USAID de ejercer sus derechos, ni liberará a la EMPRESA de ninguna responsabilidad que ésta pudiese tener, de no haber mediado al ejercicio, ante El Programa **EP3**, ante EP3-HBI o ante USAID.

5.3 Inspección

La EMPRESA consiente en permitir acceso a los representantes autorizados del Programa **EP3** y de USAID, en cualquier momento razonable, para que inspeccionen las instalaciones, las actividades y el trabajo relacionado con este Contrato, y también para que adopten medidas de trabajo y realicen pruebas durante la vigencia del presente Contrato.

5.4 Notificaciones

Cualquier notificación que entregue al Programa **EP3**/EP3-HBI tendrá validez y efectividad solamente si se emite por escrito y se entrega al coordinador del Programa **EP3** o a la EMPRESA en las direcciones consignadas en este Contrato. Las notificaciones entrarán en vigencia al momento de su entrega o a la fecha consignada como efectiva, lo que ocurra primero.

5.5 Ley que Regirá

El presente Contrato se interpretará de acuerdo con las leyes de la República de Chile, y en caso de litigio, este se tramitará en la ciudad de Santiago.

6. COPIAS DE ESTE CONTRATO

6.1 Este documento se hará en cuatro originales, uno para el Programa **EP3**, uno para la EMPRESA, uno para AMCHAM y uno para EP3-HBI.

Se declara que las partes, por medio de sus representantes debidamente autorizados, están de acuerdo con las cláusulas de este contrato.

Por la EMPRESA	Por el Programa EP3
Nombre: Fernando López Tarrés	Nombre: Eduardo S. Maal
Cargo: Gerente General	Cargo: DEPUTY DIRECTOR
Firma:	Firma:
Fecha: 03 Diciembre 1993	Fecha: 03 Diciembre 1993