



CLEANER  
PRODUCTION  
WORLDWIDE

*Volume II*



United Nations Environment Programme  
Industry and Environment



UNEP

Cleaner Production Programme



UNEP

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CLEANER PRODUCTION  
WORLDWIDE  
*Volume II*



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## **Cleaner Production Worldwide**

*Volume II*



The Editorial Board for this booklet was Ms Jacqueline Aloisi de Larderel, Director, Industry and Environment, United Nations Environment Programme (UNEP/IE), Sybren de Hoo and John Kryger, Senior Consultants UNEP/IE, and Garrette Clark, Research Assistant UNEP/IE. Mary Crass was responsible for commissioning, editing and organising the contributions.

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# INTRODUCTION

Companies around the globe are enjoying economic and environmental benefits from cleaner production. With this publication, a sequel to *Cleaner Production Worldwide* and *Cleaner Production in the Asia Pacific Region*, UNEP wishes to show the worldwide progress of cleaner production, and encourage its further development.



## Cleaner production

Industries today must remain profitable in an increasingly competitive world, while accounting for the environmental impact of their activities. This challenge requires a solution that enables firms to maximize their economic gains, while taking the necessary steps to minimize the environmental degradation caused by their production processes and products. Cleaner production meets this dual objective.

Cleaner production is a broad term that encompasses the concepts of waste minimization, waste avoidance, pollution prevention and other similar terms. It includes initiatives such as better management and housekeeping, substitutions for toxic and hazardous materials, process and product modifications and internal reuse of waste products. It is, as its definition suggests, *'the continuous use of industrial processes and products and services to prevent pollution and reduce wastes at their source'*.

Companies in all regions of the world – in both developing and developed economies, and in all industrial and service sectors – are practising cleaner production. As illustrated by the following case studies, levels of initiative vary, as companies work within their own economic and industrial contexts to more fully integrate cleaner production into their activities. All the firms included have experienced economic benefits from the initiatives they have taken, while significantly reducing the environmental impact of their production activities.

This booklet demonstrates that there are no geographic, economic, or sectorial barriers to firms interested in adopting cleaner production. Seventeen countries of both developed and developing economies, and 15 sectors, are represented here.

These case studies are illustrative of cleaner production activity around the world. They are by no means exhaustive. Cleaner production is an evolving approach to environmental management, and the sharing of ideas and experiences is vital to its development. We therefore encourage our readers to comment on this publication, and provide suggestions to us for future projects of this kind.

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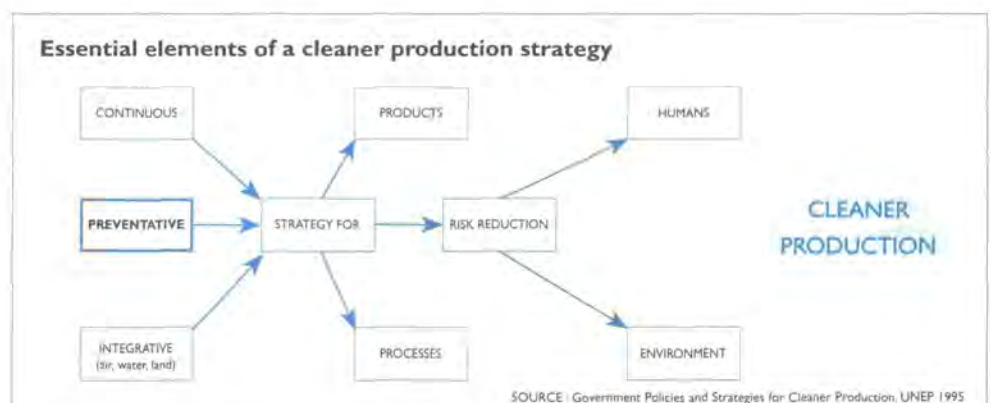
# WHAT IS CLEANER PRODUCTION?

Over the past 30 years, the industrialised nations have responded to environmental degradation in four successive steps: ignore, dilute, control and prevent. In this sequence, each step can be seen as the "solution" to the problems that could not be solved with the strategy of the former stage. Cleaner production, which promotes the preventive approach (see diagram below), is a response to the additional financial burden brought by costs of pollution control and end-of-pipe treatment. Cleaner production brings a powerful combination of economic savings and environmental improvements; this is why it has been recognised in Agenda 21 as a means of reconciling development and environmental protection.

- ❖ For production processes: cleaner production includes conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all emissions and wastes before they leave a process.
- ❖ For products: cleaner production means reducing impacts along the entire life cycle of the product, from raw material extraction to disposal.
- ❖ Cleaner production requires applying know-how, improving technology, and changing attitudes.

This marks an important departure from the traditional way of dealing with environmental impacts which, in essence, has been to collect waste by-products, and try to control them in various ways - through dilution, detoxification or solidification - or simply by trying to contain them in barrels or landfills.

Implementing cleaner production is not just a question of finding the right or new technology. It includes better management and housekeeping, substitutions for toxic and hazardous materials, process and product modifications, and internal reuse of waste products. It requires basic attitudinal changes at all levels within a firm, from top management to the shop floor.



# PREPARE: Promoting cleaner production in Austrian industries

PREPARE (**PR**eventative **E**nvironmental **P**rotection **AppR**oaches in **E**urope) is a Europe-wide initiative to develop and spread the idea that companies should cut down on waste and emissions on a preventive basis.

Offering both material resources and know-how, the project guarantees an innovative, environment- and future-orientated management that leads to good housekeeping of raw materials and energy resources and market advantages. Twelve European countries have started specific national cleaner production projects based on PREPARE.

The Austrian Federal Ministry of Science, Research and Arts and the Federal Ministry of Environment started the national PREPARE Initiative in 1991.

As of the end of 1993, more than 20 successful case studies in three different projects had been carried out within the scope of this initiative.

## Reducing chemical use in the printed circuit boards industry



**Austria Technologie & Systemtechnik**  
Leoben-Hinterberg

These projects are:

- ❖ **PREPARE Austria**
  - Twelve case studies in six industrial sectors (furniture, textiles, paper, leather, machines, printing)
- ❖ **The Printed Circuit Boards sector**
  - Four case studies
- ❖ **ECOPROFIT (City of Graz)**
  - Five case studies in three sectors (car repair shop, printers, food industry)

The process of disseminating the PREPARE idea in Austria is still going on, and a number of regional projects have started within the last 15 months. Two companies have been selected as typically representative of all the other case studies. The two following case studies – from the printed circuit board and leather watchstrap production industries – are representative of those in PREPARE.

## Reusing waste in the production of leather watchstraps



**Hirsch GmbH**  
Klagenfurt





## Reducing chemical use in the printed circuit boards industry

### Background

One of the participating companies in the Printed Circuit Boards branch concept was AT&S (*Austria Technologie & Systemtechnik*), Austria's largest producer of multilayer printed circuit boards. More than 30 pollution prevention options were identified at AT&S during the project. In the following section, two of these options are described.

### Cleaner production

#### *Use of spent acid for etching regeneration*

Copper chloride is used to etch the PCBs, and is regenerated with hydrochloric acid, hydrogen peroxide and sodium chloride.

Instead of using fresh hydrochloric acid for this regeneration process, spent hydrochloric acid – following rinsing – is used. This had not been done previously, because the concentration of the spent hydrochloric acid was not uniform enough for the tight tolerance of the etching solution.

Following numerous experiments and through use of a buffer tank, the problem was resolved, resulting in lower consumption of fresh hydrochloric acid and reduced chemical levels in the wastewater treatment.

#### *Reducing the chemical concentration*

In a number of cases, the chemical and process equipment suppliers give recommendations for the chemical concentrations in the process.

Detailed experiments showed that these recommendations have certain safety charges in reserve. In two examples, the chemical consumption was reduced significantly with only minor process modifications:

- ❖ sodium carbonate and caustic soda in the photoresist stripping process
- ❖ ferric chloride and sulphuric acid photoresist precipitate in the wastewater treatment.

### Economic benefits

Material	Reduction/year
Hydrochloric acid	45%
Sulphuric acid	50%
Ferric chloride	37%
Waste water sludge	40%
Material reuse of photoresist packing material	100%
Deionised water	25%
Electric power	30%
Natural gas	20%
Cost savings	US \$1 000 000/year
Payback period	< 6 months

### Advantages

Most of the identified options have been implemented already. This has resulted in annual savings (1994), as shown in the table.



### Country

Austria

### Industry

Printed circuit boards

### Company

AT&S is a leading producer of double-sided throughplated and multilayer printed circuit boards (up to 22 layers). Founded in 1982, AT&S employs nearly 500 workers. Annual turnover is approximately US \$58m.

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## Reusing waste in the production of leather watchstraps



### Cleaner production

#### Reuse of leather waste

Hirsch uses a variety of kinds of leather in its production of watchstraps.

During the production process, leather strips are cut from larger pieces of leather by punching machines, for the lining and inlays. These strips are used as fabrication material for the next production steps.

A large percentage of the waste leather, which had to be dumped in the past, can now be reused in a new process.

### Enabling technology

The leather scrap is unravelled in a two-stage leather defibration machine. The fibres are then mixed with several binding agents and processed into an injection moulding compound in a stirring device. In a specially designed injection moulding machine, the fibre material is applied on the leather bracelets as inlays.

After the moulding process – during which shaping of the bracelet is finished – the half-finished product is supplied to a special drying device.



Organic solvents are used for diluting laquers and glues and for cleaning the spraying guns; 95 per cent of these solvents are acetone. To lower the acetone consumption (10 000 litres/year), the solvent is used twice for cleaning processes.

With the installation of a solvent distillation facility, an additional 35 per cent of acetone can be recovered.

## Advantages

### Reuse of leather waste

With the process described, Hirsch now reuses 45 per cent of the leather scrap.

### Good housekeeping

50 per cent of the solvent is saved by using it twice for cleaning processes.



## Economic benefits

<b>Waste and emission reduction:</b>	
leather scrap	45%
acetone	85%
<b>Cost savings</b>	<b>US \$ 450 000</b>
<b>Capital investment</b>	<b>US \$ 700 000</b>
<b>Payback period</b>	<b>1.6 years</b>



## Country

Austria

## Industry

Leather

## Company

Hirsch GmbH is the world's largest producer and distributor of watchstraps, with production plants in Europe and the Far East. The company employs 650 people, and exports 90 per cent of its production (30 000 watchstraps per day) to more than 60 countries around the world.

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# Conserving water, energy and chemicals at a textile dyeing plant

## Background

The textile dyeing process used at the Hitega textile mill in Chile involves numerous changes of water, and several additions of dyes, bleaches and other chemicals. As part of the Environmental Pollution Prevention Project (EP3) sponsored by the US Agency for International Development, a cleaner production assessment was carried out at the facility by an expert in textile dyeing and a pollution prevention specialist.

The assessment identified eight opportunities which would reduce:

- water use
- energy use
- suspended solids concentrations in wastewater.
- chemical use
- emissions

## Cleaner production

### Efficient use of water

❖ *Recycling of cone-dye cooling water*  
Well water is softened to a hardness of 3–5 ppm, and is then used for most factory processes. During the cone-dyeing operation, the dye bath is cooled by passing soft water through the jacket of the dye tank. Non-contact cooling water is also used to cool the dye bath recirculating pump packing gland. Recycling these two streams of water can be accomplished by sending this non-contact cooling water back to the soft water pool, which receives the cooling water from facility jet dryers.

❖ *Recycling water from the air conditioner system*

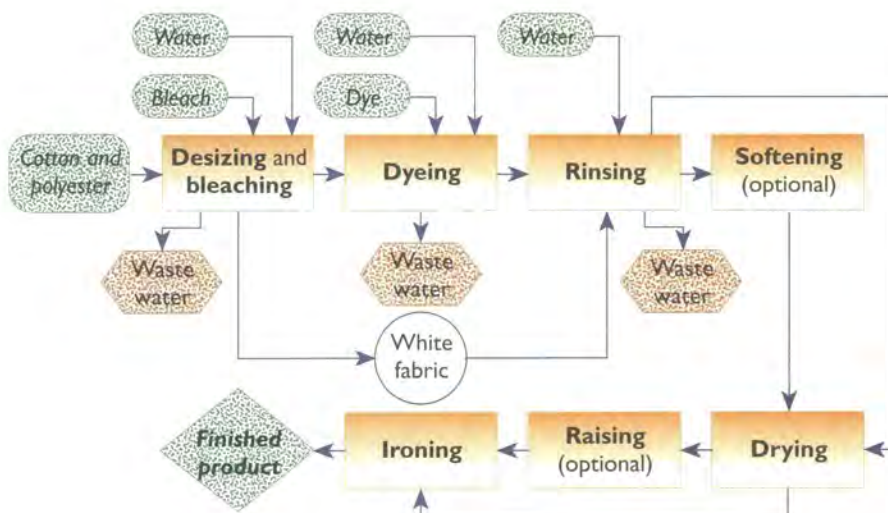
The air conditioner system used in the



spinning and weaving rooms also uses soft water evaporation for cooling. The water is currently taken from the softeners serving the dye room, but 50 per cent of this is lost through evaporation, and the rest is dumped into the sewer system. This has caused water shortages in the dye room. New softeners are being installed to produce water solely for the air conditioner system, which will recycle the non-evaporated water back to the new system.

❖ *Improving softener regeneration and service*  
During the washing, regeneration and rinsing processes in the dye room, the wash time is currently excessive, and the point at which softeners are regenerated is chosen on the basis of time since the last regeneration. This results in a loss of soft water. A digital system would enable the rinsing and service hardness end points to be determined, allowing operators to judge more accurately the exact end point for the wash period and the maximal supply capacity of each softener.

Rinse waters can also be recycled from the bleaching process, by installing a tank to store the water from one batch and using it for the one that follows.



## Country

Chile

## Industry

Textile dyeing

## Company

Hilados y Tejidos Garib S.A. (Hitega) is an integrated textile mill producing dyed yarn and fabric with an average content of 65 per cent polyester and 35 per cent rayon. It employs 270 people, and in 1993, produced 1 134 059 kg of dyed material, and an additional 1 227 974 kg of fabric that was finished but not dyed.

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### Efficient use of energy

#### ❖ Maintenance plan for steam traps

Heat transfer losses caused by leaking steam traps currently amount to around 10–15 per cent of energy costs. Leaking steam traps not only waste energy, but also result in inefficient dye bath heating, and damage to steam lines, valves, fittings, and other equipment. Workers should be trained in the operation of steam trap testing equipment, and a preventative plan for the maintenance of steam traps should be developed.

Installation of a digital monitoring system allowed the combustion efficiency of the oil-fired boiler to be monitored whenever parameters change – such as when a new lot of oil is received. This change resulted in reductions in fuel use and emissions of

particulate matter.

### Reducing suspended solids in effluent

Screens installed in dye room drains reduce suspended solids in effluent. If the plant needs to install an industrial waste water treatment system in the future, any decrease in current loading will allow a reduction in the initial investment and running costs of such treatment plant.

## Advantages

The implementation of these suggestions will result in water, energy and chemical conservation, reduced emissions and solids in effluent. Three of the opportunities were studied in enough detail to quantify savings, as shown below.

### Economic benefits

Operation	Cost (US\$)	Savings (US \$/year)	Payback period
Recycling of dye cooling water	750	400	20 months
Recycling of air conditioning system water	6 700	4 900	14 months
Softener system	3 500	1 700	24 months

## Reducing waste in a Chinese distillery

In 1993, the World Bank approved a loan to the National Environmental Protection Agency (NEPA) in China for an Environmental Technical Assistance Project. Included in the funding was US \$6.2 million for a cleaner production initiative. Upon request of the NEPA, the UNEP Cleaner Production Programme assisted in the design and development of the project, and has been active in its supervision.

The Cleaner Production Project in China aims to:

- ❖ develop and test a systematic Chinese approach to cleaner production
- ❖ prove the potential for cleaner production in 25 to 30 Chinese companies
- ❖ recommend changes to existing policies to promote cleaner production
- ❖ disseminate the idea of cleaner production in Chinese society in general, and in Chinese industry in particular.

The project is to be carried out in four integrated phases – preparation, demonstration, policy studies, and dissemination – over a period of three years. Each phase of activity will draw from and depend on the experiences gained in the previous phase.

Eighteen companies participated in the demonstration phase of the project. During this time, 492 cleaner production opportunities were identified, 340 of which were implemented in the six months following the assessment, generating benefits of RMB YUAN 5 million per year (approximately US \$750 000).

The state-owned Yantai Second Distillery, the case study of which follows, participated in the cleaner production project. Three other companies that were part of the project – the Beijing Chemical Factory No. 3, Fuyang General Distillery, and the

Shaoxing General Bicycle Plant – are featured in the UNEP-IE publication *Cleaner Production in the Asia Pacific Economic Cooperation Region*.

### Background



The most important environmental problem in the Yantai distillery was the generation of 14 tons of distillers grain (a wastewater residue from the distillation process) per ton of alcohol. In 1986, an anaerobic wastewater treatment facility went into operation, to treat the 50 000–60 000 mg/l COD in the distillers grain.

Currently, methane gas is co-fired into the coal-fired boiler. Although the distillery had made good progress in preventing and treating pollution, their efforts were based on process control.

### Cleaner production

During 1994, a plant assessment team conducted a cleaner production assessment of the distillery under the guidance of the Yantai Environmental Protection Bureau, the Ministry of Light Industry and the Chinese Research Academy of Environmental Sciences.

During the pre-assessment phase, the alcohol plant was determined as the largest source of wastewater. In addition, several good housekeeping opportunities were identified in the bottling department. The potential benefits to be derived from implementing these options encouraged the team to



proceed with assessment of the alcohol plant. A number of low-cost, equipment-optimization options were identified and implemented at no extra cost during the annual overhaul period of Summer 1994.

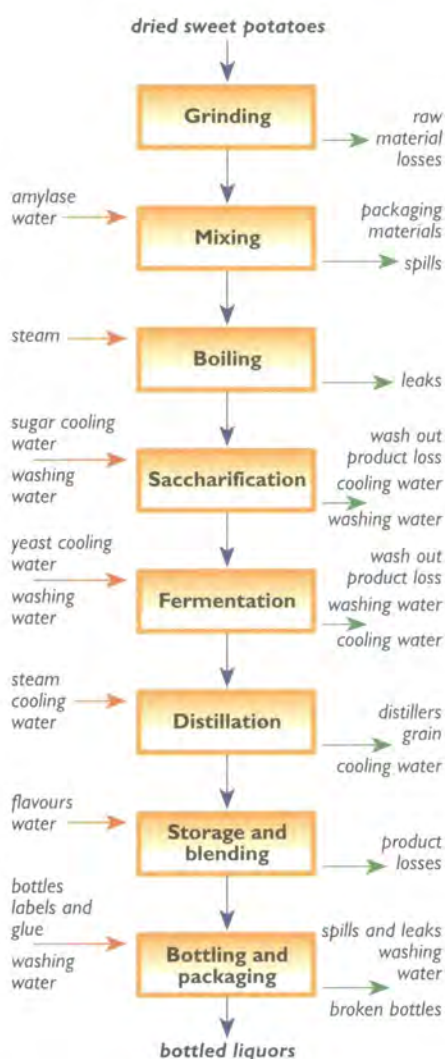
## Enabling technology

Three technology replacement options were identified, and their technical, economic and environmental aspects evaluated in detail:

- ❖ *differential distillation*: installation of six tower differential distillation systems to improve the separation of alcohol from distillers grains, increasing both the yield and the purity of the product.
- ❖ *continuous fermentation*: replacement of batch-operated with continuous fermentation jars to eliminate wash out waste and increase production efficiency
- ❖ *boiler replacement and power generation*: installation of a new, more efficient coal-fired boiler, which uses methane produced from the treatment of distillers grain for on-site electricity generation.

## Advantages

The implementation of this package of technical cleaner production options has proven especially effective in the reduction of energy and water consumption.



Moreover, product quality has been improved, so the product can now be sold at a higher price.

## Country

China

## Industry

Alcohol production

## Company

Yantai Second Distillery is a state-owned, medium-sized enterprise in the coastal city of Yantai that produces grain liquors and red sweet potato wine. The plant employs 510 people, and has a production capacity of 5 000 tons of alcohol per year.

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## Economic benefits

	Investment (yuan)	Savings (yuan)	Payback period
<b>Bottling department</b>			
<i>Good housekeeping options</i>	12 500	523 000	
<b>Alcohol plant</b>			
<i>Equipment repair and optimization</i>	None	5 040 000	
<i>Differential distillation</i>	3 454 000		1.5 years
<i>Continuous fermentation</i>	480 000		3.1 years
<i>Boiler replacement</i>	1 231 000		4.4 years

# Enzymatic bleach cleanup in cotton dyeing

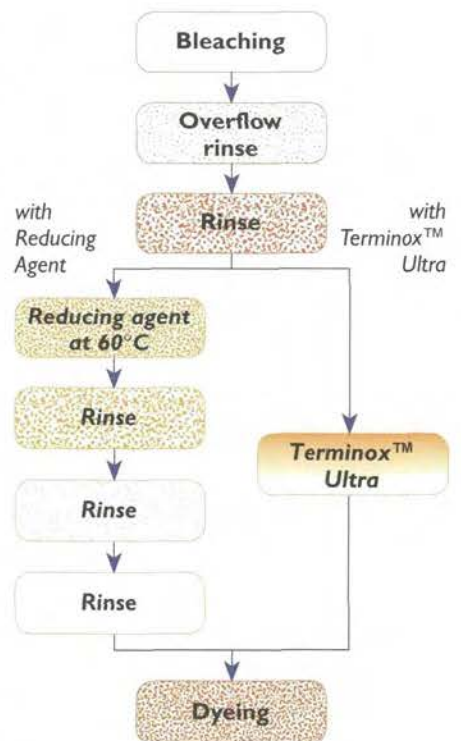


## Background

Raw cotton fabric is a light shade of brown, and is usually bleached by a treatment with hydrogen peroxide. Afterwards, the bleaching chemical has to be removed before the dye is applied; otherwise, the bleach and dye react with each other. The traditional method of removing the bleach is by rinsing the fabric with water a number of times. Alternatively, a reducing agent can be used to neutralise the bleach. In either case, large amounts of water are required for rinsing – up to 40 litres per kg of fabric. A thorough economic and environmental analysis of enzyme treatment was made in full-scale trials at Skjern Tricotage-Farveri, which dyes roughly 1 500 tonnes of fabric per year.

## Cleaner production

A new process using an enzyme preparation called *Terminox Ultra* can considerably reduce water and energy consumption in the bleach cleanup phase between bleaching and dyeing. Skjern Tricotage-Farveri switched to







Terminox Ultra from thiosulphate for bleach cleanup in 1994. The residual hydrogen peroxide is neutralised more efficiently than when using either rinsing on its own or a reducing agent followed by rinsing. No difference in the quality of the finished fabric is detectable.

## Enabling technology

This application is an example of how a biological agent (an enzyme) can be used to replace a chemical agent (such as thiosulphate). The products of the enzymatic degradation of hydrogen peroxide are two natural substances – oxygen gas and water. The enzyme itself is a protein which is 100 per cent biodegradable. *Terminox Ultra* is a catalase – a specific type of enzyme – produced by an industrial fermentation process. Under industrial conditions, it

takes 10 to 15 minutes to break down the hydrogen peroxide completely, after which time the dye can be added.

## Advantages

Saving energy and thereby preventing the associated emissions is the main environmental advantage of *Terminox Ultra* compared to conventional reducing agents such as thiosulphate. The enzyme *Terminox Ultra* works in mild temperature conditions, whereas thiosulphate requires a raised temperature in order to react efficiently with hydrogen peroxide. The bleaching liquor therefore has to be heated. Using *Terminox Ultra* for bleach cleanup has the advantages of:

- ❖ reduced water consumption
- ❖ reduced energy consumption
- ❖ reduced process time
- ❖ ease of implementation and control.

## Economic benefits

Skjern Tricotage-Farveri originally used thiosulphate for bleach cleanup, switching to *Terminox Ultra* in 1994. Existing equipment could be used, so there was no need to make any new investments. The exact savings will depend on local water charges and the cost of energy. Around 15–30 US \$/ton fabric can usually be saved.

## Comparison between processes

	Processes (per kg fabric)	
	Reducing agent	<i>Terminox Ultra</i>
Water	19 litres	10 litres
Energy	1.9 MJ	0.04 MJ
Reducing agent	8.5 g	—
<i>Terminox Ultra</i> 10L	—	3.5 g
Processing time	105 min.	50 min.

## Estimated savings

	Savings per year
Energy	2 780 GJ
CO <sub>2</sub> emissions	160 t
Water	13 500 m <sup>3</sup>
Natural gas	70 800 m <sup>3</sup>

## Country

Denmark

## Industry

Textiles

## Companies

*Terminox Ultra* is manufactured and marketed by *Novo Nordisk*, the world's leading supplier of industrial enzymes and insulin. The company also manufactures a variety of other pharmaceuticals and biotech products. It employs approximately 11 600 people, and is headquartered in Denmark.

*Skjern Tricotage-Farveri* at Skjern in Denmark is a modern dyehouse, with an annual production of around 5 000 tonnes of fabric. The company has a stated policy of reducing water and air pollution risks. The dyehouse is a major supplier to *Novotex*, a Danish company that sells ecologically sound cotton under the brand name *Green Cotton*.

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# Reduction of chemical oxygen demand in the textile industry

## Background

Among the large number of chemicals needed by the textile industry to produce woven fabrics, the *sizing agent* is predominant. It is required to protect warp yarns against abrasion during the weaving operation. Size, a kind of glue, acts as an abrasion-resistant yarn coating.

During dyeing and finishing, the fabric is treated in many ways, acquiring colour, hand and lustre. The sizing agent would disturb the chemical processes tremendously – for example, by preventing the dyestuff molecules from migrating uniformly into the fibres. It is therefore essential to remove the sizing agent before dyeing – that is, wash the size out. The washing liquor subsequently contains a low concentration of the removed sizing agent. This liquor is discharged, contributing highly to the chemical oxygen demand load in the textile effluent.

agent from the washing liquor by means of *ultrafiltration* (UF). The UF-membranes work as a sieve. When the washing liquor flows under high pressure along the surface of the membrane, extremely small pores let the water molecules pass, but the macro-molecules of the sizing agent are rejected.

Through the continuous elimination of water, the originally low size concentration increases. After about 90 per cent of the water is eliminated, the concentration reaches the level needed for the sizing operation. The size-containing concentrate generated can therefore be reused in the sizing department; in this way, the size is reclaimed.

There are only two indispensable conditions for size reclamation:

- ❖ the sizing agent has to be water-soluble and
- ❖ the processes of weaving and finishing have to be integrated.

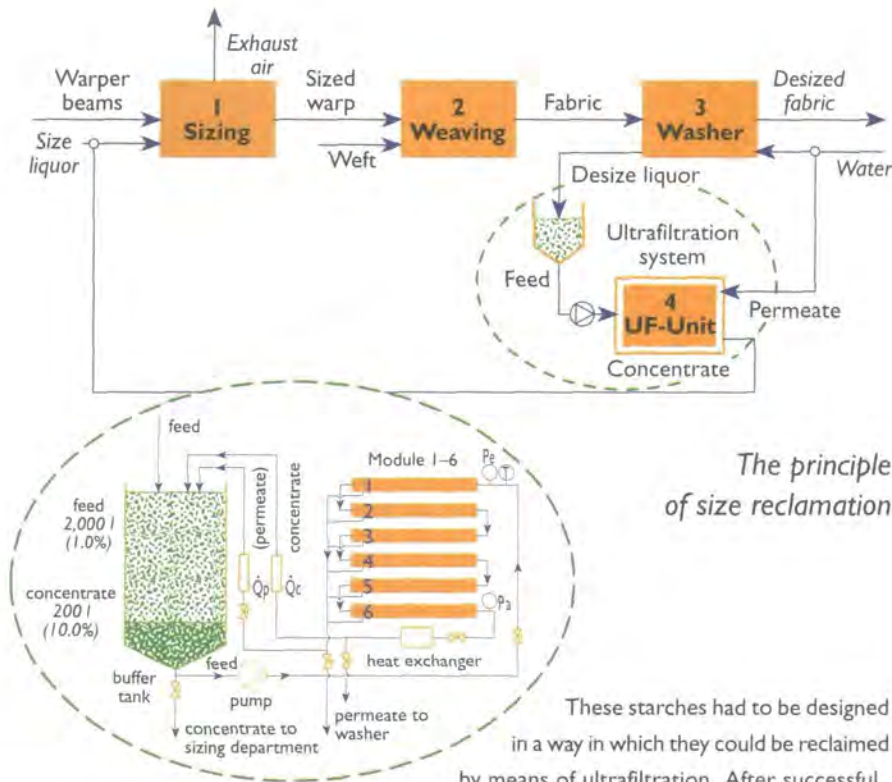
## Cleaner production

An alternative to this conventional process is the complete elimination of the sizing

## Enabling technology

The sizing agents used for reclamation are *polyvinylalcohol* (PVA), *carboxymethylcellulose*





The principle of size reclamation

(CMC), polyacrylic (PAC), and water-soluble starches (CMS). None of these are toxic, but the sizing agents represent 50 to 70 per cent of the COD. The chemicals used for size reclamation within this project were mainly water-soluble starches. However, some mixtures of water-soluble starch and PVA, or PVA and CMC, were also used.

Starch-based products are mostly used as sizing agents, due to their low prices. These cannot be reclaimed, because they are not water-soluble by nature. It was therefore the intention of the National Research Center (NRC) in Cairo to develop water-soluble starch sizes based on the resources which are available in Egypt – maize and rice.

These starches had to be designed in a way in which they could be reclaimed by means of ultrafiltration. After successful lab testing, the newly developed sizes were manufactured and tested in the field. A UF-pilot unit was installed in the largest textile mill in Egypt. Size reclamation was tested successfully with modified starch sizes developed and produced in Egypt and with various synthetic size components.

### Advantages

- ❖ Elimination of the most significant pollutant in the textile industry.
- ❖ Reuse of valuable chemicals.
- ❖ Reuse of water and savings of energy.
- ❖ Economic benefit through lower production costs, higher productivity and improved quality of the woven fabric.

### Economic benefits

- ❖ 80% of the **sizing agent** is reclaimed.
- ❖ 90% of the **hot water** used in the washing operation can be reused.
- ❖ **Running costs** in the weaving process decrease due to improved sizing.
- ❖ The **cost-intensive processes** of enzymatic or oxidative pre-treatment for making the starches water-soluble by degradation **are eliminated**.

- ❖ **No waste water fee** has to be paid.
- ❖ The reclaimed product requires a **maximum of 2 kWh/kg** – two to three times less than the energy needed for producing virgin products.

<b>Capital investment</b>	<b>1.5 MioDM</b>
<b>Payback period</b> <i>(for a medium-sized European textile mill)</i>	<b>8–18 months</b>

### Countries

Egypt and Germany

### Industry

Textiles

### Company

The Institute of Textile Research and Chemical Engineering was founded in 1921 in Reutlingen, Germany, and has been located in Denkendorf, Germany since 1979. Its research activities cover the whole range of textile processes, beginning with fibres and ending with greige fabrics. It also includes closed loop process control, development and manufacturing of membranes, effluent treatment, noise reduction, medical techniques, and operational and business management.

The National Research Center in Cairo, Egypt, is part of the Academy of Scientific Research and Technology, also in Cairo.

Misr Spinning and Weaving Company, Mehalla El Kubra, Egypt.

The development was predominantly funded by the German Ministry for Research and Technology, under Project Number 01 VQ 8705.

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# Replacing chemical with thermal treatment in equipment cleaning

## Background

Adhesive coating equipment requires thorough cleaning after each run. This is usually done by immersion in a trichlorethylene bath, with the attendant toxic hazards for personnel and risks of accidental pollution during product handling. The chlorine-based solvents must then be either regenerated or disposed of, both of which are expensive operations.

Thermal scouring represents a less hazardous and more economical solution.

## Cleaner production

Paulstra manufactures metal and rubber elastic joints for vibration-damping parts used in the construction of motor vehicles.

In 1993, as part of its Safety and Environment programme, Paulstra replaced the chemical cleaning of its equipment by a thermal treatment based on the fluidised bed principle.

Fluidisation consists of suspending fine solid particles in a gas flow. This can be achieved, for example, by passing a flow of gas up through a bed of graded silicate grains, so as to separate them but not blow them away.

As the speed of the gas through the bed increases, it produces a stirring effect among the grains. The bed takes on the appearance of a boiling liquid. A fluidised bed combines the physical and thermal properties of a liquid, including the ability to transfer heat uniformly. A gas burner of appropriate design heats the suspended grains to the exact temperature required.



The equipment to be scoured can be 'immersed' in the bed as though in a liquid, encountering no resistance other than Archimedes' buoyancy. It can be evenly heated to the correct temperature for the operation in question (420°–450°C) to remove deposits of paint, varnish or plastic.

## Enabling technology

The firm installed a natural gas-fuelled fluidised bed furnace with post-combustion of fumes and dust separation. The bed is heated to a temperature of 450°C. The equipment to be cleaned is lowered into a vessel whose base is a porous horizontal plate covered with sand. The fluidising air is blown from underneath. Scouring is effected by the heat-induced decomposition of organic components. Any remaining particles can be removed by shaking and

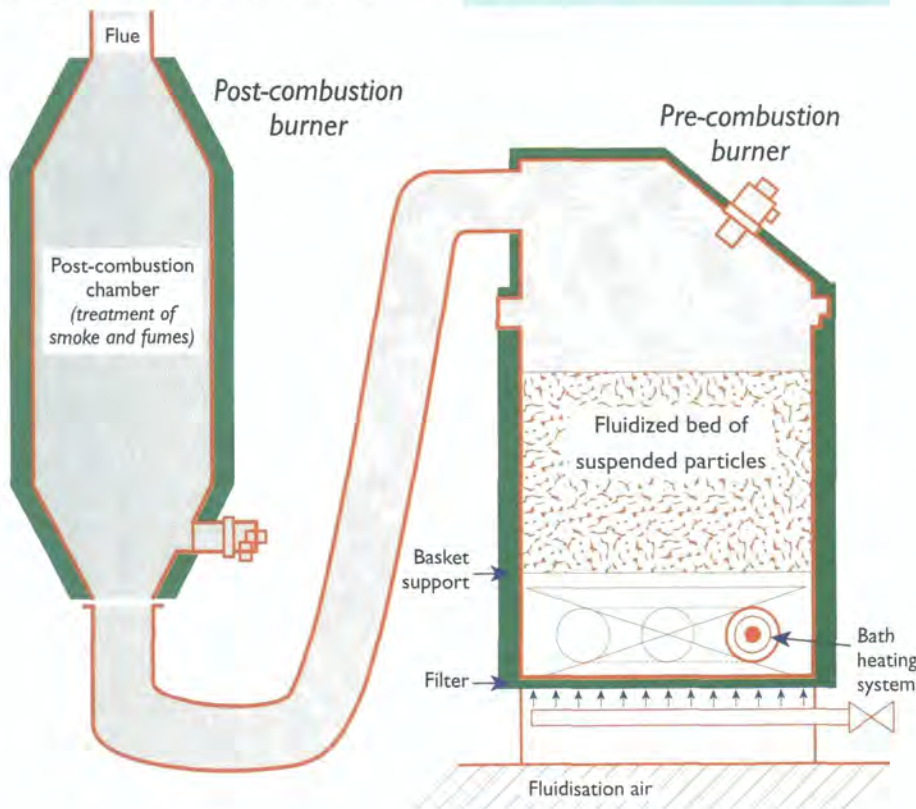


brushing. Waste gases from the post-combustion chamber comply with atmospheric emission standards, and the small amount of ash recovered from dedusting can be stored in Class I disposal sites.

The items to be cleaned are loaded in expanded metal (or similar) baskets. Heating can be turned on either manually or automatically.

Once the bath has reached the desired temperature, a gantry-mounted tackle lowers the basket into the vessel. Scouring time, controlled by a timer, depends on the substance to be removed and the item to be treated.

Temperature control is automatic, and a sound or light indicates the end of the cycle.



## Advantages

- ❖ *Over chemical methods*  
The new process eliminates the need for chlorine-based solvents, obviates the risk of accidental pollution, and improves working conditions.
- ❖ *Over the direct heating method*  
The process avoids thermal deformation of the items treated, and corrosion damage to equipment.

## Economic benefits

<b>Capital investment</b>	<b>FF481 000</b>
<i>Scouring furnace and accessories</i>	
<b>Operating cost/year</b>	<b>FF 80 000</b>
<b>Cost savings/year</b>	<b>FF 150 000</b>
<b>Payback period</b>	<b>3–5 years</b>

## Country

France

## Industry

Application of adhesive coatings

## Companies

*Industries Produits et Services (IPROS)* manufactures heating equipment. Working in partnership with Gaz de France and Evron Peinture Industrielle, it developed the first application of the fluidised bed furnace principle for scouring machine tool parts and conveyor swings. In 1995, eight furnaces applying the technique were in service in different firms. The bath capacity ranges from 0.7–3m<sup>3</sup>, and installed power (gas and electricity) from 226–563kWh.

*Paulstra* was founded in 1934. It has manufactured vibration damping parts for the motor vehicle industry since the 1950s. The Vierzon factory has produced Paulstra elastic joints since 1963. In 1974, Hutchinson-Mapa took a majority share in the company, which was taken over in 1978 by Total CFP. In 1992, Paulstra manufactured 31 million parts, using 6 tonnes of rubber and 9 tonnes of steel per day. The company employs 320 people.

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## DESIRE: Cleaner production in small-scale industries

In March 1993, the Energy and Environment Branch of the United Nations Industrial Development Organisation (UNIDO), in close cooperation with the National Productivity Council (NPC) and several other industrial organisations in India, initiated a cleaner production demonstration project targeting small-scale industries (SSIs) in India.

The project *DESIRE* (**D**emonstrations in **S**mall Industries for **R**educing **W**ast**E**) began in March 1993. Its objectives included:

- ❖ the demonstration of cleaner production opportunities and benefits to small-scale industries in India
- ❖ the development of a systematic method for cleaner production
- ❖ the identification of obstacles and incentives for cleaner production
- ❖ the formulation of cleaner production policies.

Three sectors:

- agro-based pulp and paper production
- textile dyeing and printing
- pesticides formulation

were targeted for demonstration projects, as they are sources of significant pollution and are primarily made up of SSIs.

Four to six companies in each of the sectors have participated as demonstration units in the project. Although final results are awaited on *DESIRE*, preliminary data from the participating companies show economic and environmental improvements.

The case study *Reducing waste in paper manufacture* describes the experiences of one company participating in the *DESIRE* initiative. *Reducing heat loss in a lead oxide unit* was not a part of *DESIRE*.

### Reducing waste in paper manufacture

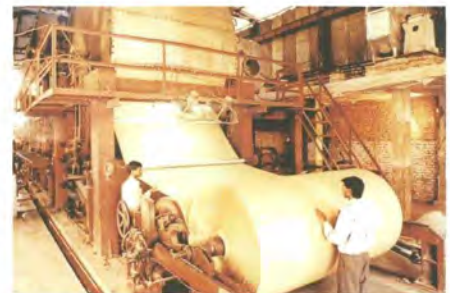
#### Background

*M/s Ashoka Pulp and Paper Mills* participated in the *DESIRE* project with the twin objectives of:

- ❖ reducing production costs, and
- ❖ bringing about cost-effective compliance with environmental regulations.

Local pressure to improve environmental performance and conserve water were other reasons behind the decision to actively pursue waste minimization. Accordingly, a waste minimization programme was launched with assistance from the National Productivity Council.

Agro-residue based pulp and paper mills generally use a chemical pulping process based on sodium hydroxide.



During digestion, steam dissolves the undesirable portion of raw material. Waste paper or purchased long fibre pulp is added to provide the required percentage of long fibre in the furnish. Hydropulping is employed for pulping the waste paper.

After cooking, the digested pulp, the spent cooking (black) liquor, and the condensed steam are discharged directly into a washer. The pulp is washed to remove the black



liquor, and is then passed through a centricleaner, where thickeners and refiners remove inerts and undigested material.

The cleaned pulp is conditioned, diluted with recycled water and fed to the paper machine. The diluted pulp forms a web on the endless wire mesh and the excess water is drained out by gravity and vacuum. Further dewatering is carried out by pressing between two rolls and felts and by steam dryers. Finally, the dried paper is cut and dispatched.

Excessive paper breakage often occurred during the final stage of the paper making process. The causes included:

- ❖ pressure fluctuations at the edge cutting nozzles due to variations in levels in the water storage tank
- ❖ variations in pulp consistency
- ❖ excessive fines in pulp due to inefficient dedusting of raw material
- ❖ a deteriorating quality of press rolls
- ❖ use of single felts, resulting in a high shear force.

The first two items were due to improper process control, and the rest due to obsolete process technology.

## Cleaner production

The problems were solved by a combination of process modification, equipment modification, and new technology.

- ❖ A separate water storage tank and pump were installed to ensure a constant water level, and thus constant water pressure at the edge cutting nozzles.
- ❖ An additional smaller water pipeline was installed at the dilution point, along with a consistency indicator for precise consistency control at the inlet of the paper machine.
- ❖ New technology, comprising mechanical dedusting of raw material, was adopted to reduce fines in the pulp.
- ❖ The existing ebonite press rolls were replaced by mild steel rolls, which have a smoother surface, and the single felt system was replaced by a double felt system.

## Advantages

Benefits gained from the implementation of cleaner production techniques included:

- ❖ reduced paper breakage, reducing fibre loss by 0.4–0.5t/day and reducing production capacity loss by 3.6–5t/day
- ❖ an increase in wire life
- ❖ reduced maintenance
- ❖ reduced stress on workers.

Reductions	per day
• Pulp reprocessing	3–4 tons
• Fibre loss in wastewater	0.5 tons
• Pollution load COD	800 kg
	TSS 600 kg
• Kerosene consumption	540 litres

## Country

India

## Industry

Paper manufacture

## Company

M/s Ashoka Pulp and Paper Mills is an agro-residue based pulp and paper mill producing unbleached semi Kraft paper. The average production of the mill is 36 tons per day.

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## Economic benefits

Item	Annual savings (US \$)
Paper making capacity	37 290
Effluent treatment plant (0.8 TPD COD reduction)	8 910
Kerosene consumption	35 640
Fibre loss	52 140
<b>Total</b>	<b>133 980</b>

	US \$
Capital investment	25 000
Operating costs/year	15 000
Net savings/year	118 000
Payback period	< 3 months

## Reducing heat loss in lead oxide unit

### Background

A lead oxide unit, employing a pot type electrical furnace, manufactures one ton of lead oxide per day.

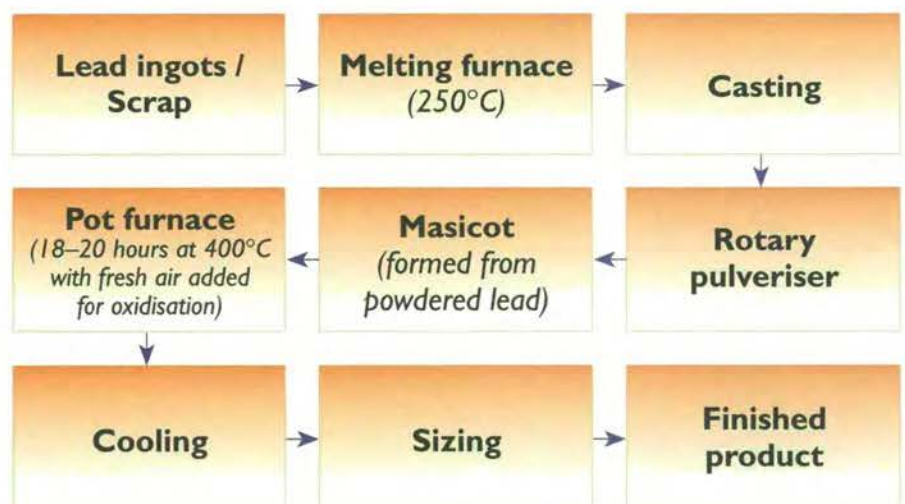
A waste minimization audit at Sager Surgicals Private Ltd found that the radiation heat losses from the side walls in the electric furnace was about 1600 KCals/m<sup>2</sup> hour, and from the top, 2400 KCals/m<sup>2</sup> hour. Due to these losses, the temperature inside the furnace was not adequate for obtaining the desired yield and quality of lead oxide.

Additionally, fuel and power consumption and batch process time were high, and the furnace life was reduced due to overheating of the shell.



### Cleaner production

The cleaner production applications mainly centred around process modifications. The furnace design was modified and better heat insulating material was used to reduce heat loss.







## Enabling technology

The existing insulation of fire bricks was replaced by better insulating materials of optimum thickness and sequence.

A ceramic fibre module was added to the top of the furnace, and ceramic fibre blankets and insulating bricks were added to both the side walls and the top.



## Advantages

- ❖ Specific fuel consumption has been reduced from 80 to 40 litres/batch.
- ❖ Specific power consumption has been reduced from 500 to 400 KWh/batch.
- ❖ The cycle time has decreased to 16 hours, from around 20–22 hours.
- ❖ The furnace temperature has increased by 70°C to 400°C.
- ❖ The percentage of lead oxide in the product has increased by around 3%, to 31–33%
- ❖ The estimated increase in the life of the furnace is 4.5 years, from six months to five years.

## Country

India

## Industry

Lead oxide manufacture

## Company

The lead oxide unit at Sagar Surgicals employs a pot type electrical furnace, and manufactures one ton of lead oxide per day.

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## Economic benefits

Savings	US \$/year	Capital investment	US \$/year
Fuel consumption	6 600	Annual operating costs	5 000
Power consumption	3 300	Net annual savings	34 600
Yield improvement	19 800	Payback period	< 3 months
Capacity improvement	9 900		
<b>Total</b>	<b>39 600</b>		

## Zero wastewater emission in the wiredrawing process



### Background

The wiredrawing process includes the following steps:

- ❖ pickling treatment by dipping in hot aqueous solution of sulphuric acid
- ❖ pre-phosphatising and phosphatising treatments by dipping in phosphoric acid solutions containing  $\text{NO}_3$  and  $\text{NO}_2$  salts and heavy metals (Fe, Zn)
- ❖ wiredrawing and annealing treatments.

Waste rinse waters contaminated with sulphate and nitrate salts account for the largest amount of pollution resulting from the wiredrawing process. The first effort made by the company to reduce the environmental impact was the installation of a chemical precipitation plant. Since the early 1980s, full water reuse has been

introduced, which enables a partial drag-out recovery; ferrous sulphate from spent pickling solutions is recovered as a chemical coagulation agent in biological treatment plants. The present process management solves the problem of wastewater pollution, but some critical aspects still remain:

- ❖ a considerable loss of chemicals – and consequently a significant amount of sludge – has to be disposed of as hazardous waste
- ❖ high energy consumption due to the heating system of the pickling baths (steam in open circuit)
- ❖ an increase in salinity of recycled rinsing water due to accumulation of sulfates and nitrates, which results in difficult control of the rinsing quality.





## Cleaner production

The previous heating system was substituted with a closed loop heat exchange. The main objective of this modification was to reduce the amount of water injected into the pickling baths as steam; as a result, the evaporation rate in the pickling solutions has been greatly improved, enabling the introduction of a counter-current rinsing system.

## Enabling technology

- ❖ Introduction of a closed cycle heating system.
- ❖ The introduction of multiple cascade rinsing after both pickling (see diagram below) and phosphatising treatments. In both processes, final rinses are carried out by recirculating water regenerated through ion exchange and reverse osmosis, respectively.

## Advantages

- ❖ A 95 per cent reduction of sludge produced by the treatment plant and 90 per cent reduction in chemical consumption due to the almost-complete recovery of the dragout.
- ❖ Savings in consumption of water (10%) and energy (3%).
- ❖ Savings in labour costs due to improved automation of the production and water treatment operations.

## Country

Italy

## Industry

Wiredrawing of stainless steel (metal finishing)

## Company

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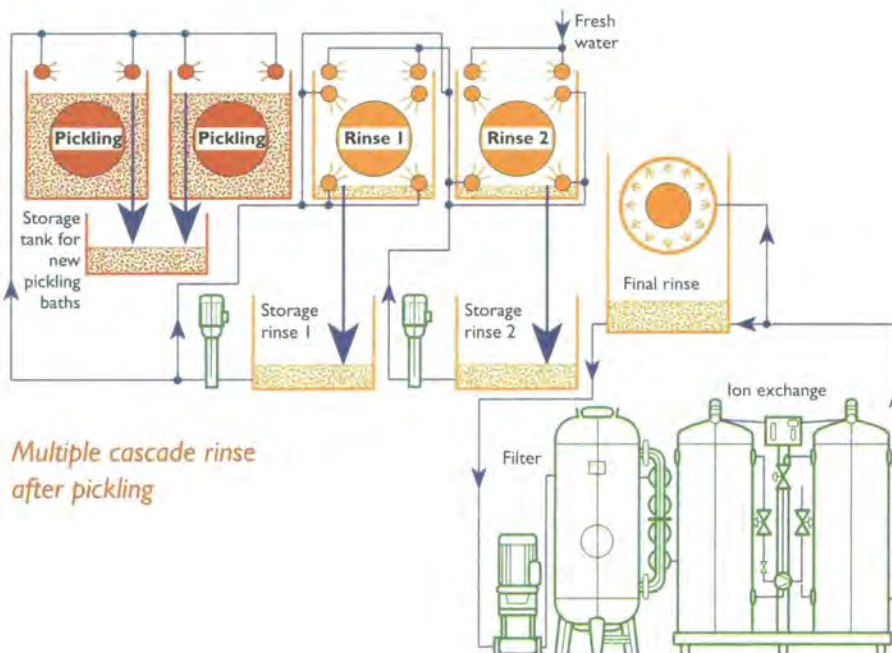
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## Economic benefits

Cost savings	Lit/year (millions)
Raw material	182
Energy and water	12
Sludge disposal	82
Treatment plant maintenance	50
Labour	20
Others	10
<b>Total</b>	<b>356</b>
<b>Capital investment</b>	<b>318</b>
<b>Payback period</b>	<b>11 months</b>



Multiple cascade rinse after pickling

# Nickel recovery from used catalysts

## Background

Raney nickel (nickel aluminium alloy) is one of the most popular reduction catalysts in the chemical industry. Disposal of the used catalyst is problematic, and it is categorised as industrial waste.

In the dry method of production, nickel is recovered from the used catalyst. However, the used catalyst remains active, and there are risks involved in its transportation and disposal. In the new process, nickel is recovered after the used catalyst has been deactivated.

Deactivation involves adding to the used catalyst a 15 per cent sodium nitrate

aqueous solution. The mixture is agitated, heated at 40°–50°C, left for more than an hour, and then rinsed with water.

Following this, the used catalyst mixture is burned three times:

- ❖ First, the mixture is burned at 800°C for 12 hours in a gas shuttle kiln, to remove the water and organic matter in the used catalyst.
- ❖ The catalyst is then roughly ground and burned again, at 1 000°C.
- ❖ Finally, the catalyst is burned at 1 200–1 300°C.





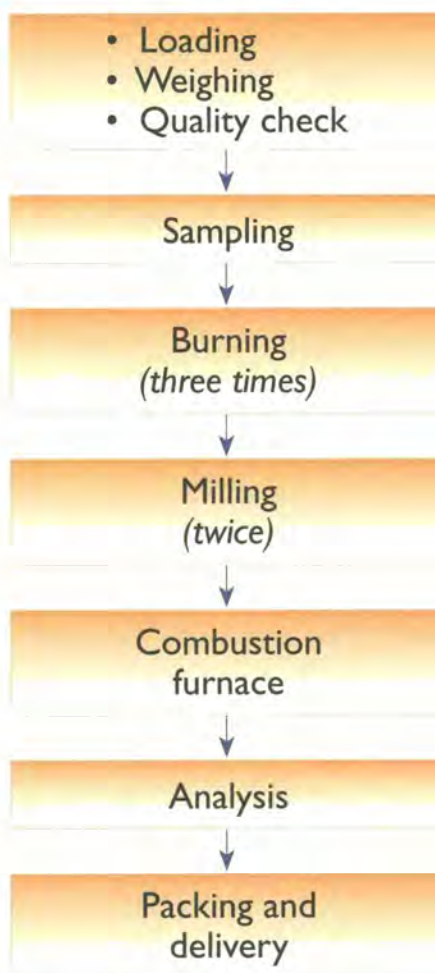
After this, the used catalyst is finely pulverised, and recovered as nickel oxide.

It is important that the temperature is monitored during each stage when the catalyst is burned. The temperature is controlled in the furnace by 10 different monitors.

- ❖ The disposal of the used catalyst is deactivated with sodium nitrate.
- ❖ Nickel from the used catalyst is recovered and recycled.

### Advantages

- ❖ The process is safe during operation, as the used catalyst is deactivated.
- ❖ It produces less waste, as it is disposed of in the dry method. Gas emissions are deodorised and made harmless by full burning with a secondary combustion facility.
- ❖ Complete oxidation occurs during a repeated direct oxidation process and pulverisation, so the nickel oxide can be used for pigments used in the ceramic industry, coloured glass bottles, and material for ferrite.
- ❖ Compared to the production of general nickel oxide, the process is both simple and low-cost.



### Economic benefits

	¥ per kg of pure nickel	
	Before	After
<b>Cost</b>	700	600
<b>Value</b>	650	1350
<b>Benefit</b>	- 50	750

Before the process was introduced, the recovered nickel was used in the production of stainless steel. Now, it is reactivated as nickel oxide. Two hundred tons of pure nickel were disposed of in 1994.

### Country

Japan

### Industry

Chemical manufacture

### Company

Nikko Fine Products Co Ltd was founded in 1966. It manufactures metals, metal oxides, inorganic chemicals, food additives, fats, and natural wax, and is also involved in the recovery and regeneration of catalysts.

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## PROMISE: A Dutch initiative for improved product design

Cleaner production can be achieved through two general lines of action:

- ❖ production processes  
*and*
- ❖ product design.

The area of *product design* using the cleaner production approach is still in its very early stages of development.

The Dutch PROMISE initiative (**P**ROductionwikkeling met **M**ilieu als **I**nnovatie **S**trategie, or 'Product Development with the Environment as the Innovation Strategy') has set forth to contribute to the understanding of cleaner products. PROMISE did not attempt to achieve complete environmentally benign products, but tried to develop a process through which products were environmentally improved in just a few steps, leading to increased availability of sustainable products in the long run.

Under the leadership and sponsorship of the Netherlands Organisation for Technology Assessment – NOTA (now the Rathenau Institute), the Ministry of Economic Affairs, the Ministry of Housing, Regional Development and the Environment, and the National Research Programme on Reusing Waste Materials (NOVEM/RIVM), PROMISE ran from 1990 to 1994, and combined the efforts of twelve organisations. In addition to those organisations mentioned above, the consultancies of TME Institute, TNO Product Centre, DUIJF Consultancy, KIEM product development support,

AdviceGroup Diemen and Van Gestel, Aries Consultancy and the Research Centre for Technology and Policy/STB/TNO and the Delft University of Technology participated in the initiative.

The objective of PROMISE was to increase understanding of cleaner product design and to provide tools and policy advice to create relevant follow-up programmes. Eight demonstration projects were developed under the Eco-design programme, which laid the basis for the PROMISE initiative.

Under Eco-design, a variety of very different products underwent redesign: a plant tray, an office chair, a hot drinks machine, a gas mask, a couch, a swing, a car dashboard, and a gas stove. Substantial improvements were made in all these products from both an environmental and an economic point of view.

Research continues on development of a revolving fund for cleaner production, and several recommendations have been implemented. Further, a large-scale, follow-up demonstration programme, also entitled *Eco-design*, has been commissioned and funded by the Ministry of Economic Affairs, the Ministry of Housing, Regional Development and the Environment, and the Netherlands Organisation for Energy and Environment (NOVEM). To be implemented by 18 Innovation Centres in the Netherlands, the programme is targeting 100 companies in 1995, and another 800 in 1996 and 1997.

The following two case studies are taken from the PROMISE/Eco-design programme.



## Reusable packaging for flowers and plants

### Background

Seven Dutch flower and plant wholesale auctions have been combined in the VBN (Vereniging van Bloemen Veilingen in Nederland). Eighty per cent of the flowers and plants are auctioned through the two biggest ones. Approximately 40 per cent of the products are sold to the internal market, and the rest exported to Germany, France, Italy and England.

Upcoming environmental legislation on packaging in the Netherlands and other countries has led to the development of new types of transport packaging. Because of their high export activity, Dutch plant nurseries were concerned about possible 'take-back' legislation in Germany on the trays used to carry potted plants. These are currently thrown away.

### Cleaner production

The Eco-design team looked closely at fully- or partly-disposable cardboard trays,



but found conclusively that they used far more energy than a reusable tray, despite the costs involved in transporting them back to source.

### Enabling technology

The team designed a strong, lightweight tray made of the most energy efficient material available – in this case, polypropylene.

### Advantages

The layout has been redesigned so that the trays are compatible with all the pot sizes manufactured by the company, thus enabling them to hold more plants.

### Country

Netherlands

### Industry

Flower and plant wholesalers

### Company

The total turnover of the seven auctions comprising VBN is US \$2 900m.

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### Economic benefits

	(approx) US \$
<b>Research and development cost</b>	<b>625 000</b>
<b>Investment cost</b>	<b>937 500</b>
<b>Operational cost</b>	<b>1 875 000</b>
<b>Current rent per tray-cycle</b>	<b>0.30</b>
<b>Total in 1996</b>	<b>10,000,000</b>
<b>Savings per tray-cycle</b>	<b>0.20</b>
<b>Payback period</b>	<b>1 year</b>

## Material use in the production of office chairs



### Background

Ahrend Zwabenburg processes steel into parts for the seats and backs of office chairs. These are made using a *reaction-in-moulding* (RIM) process. The company also coats the components, partly by the use of powder paints.

Three parts of the chair seat are assembled in an integral way: a solid seat base, the seat cover upholstery, and the padding from PUR foam. The AHREND 220 office chair was on the drawing board when the Eco-design team entered the process.

The team identified several areas of concern: primarily, the material choice for the cross foot; the possibility to recycle the seat and back; and construction of the chair, especially as concerns disassembly.

'Take-back' legislation is looming in Europe, and a cost analysis based on realistic assumptions about taxes and waste disposal costs in the year 2000 revealed that the cost of the redesigned chair would be 45 per cent of that of the current design.





## Cleaner production

As a result of this reasoning, the company was persuaded to change the production method of the seat cushions, which currently comprise layers of polyurethane foam, textile and polypropylene, welded inseparably together. The new seat cover is held on with a drawstring, which – when cut as the chair is dismantled for recycling – allows the materials to be separated into different recycling processes.

## Enabling technology

Other product changes included:

- ❖ the elimination of heavy metals in the plastics pigments  
*and*
- ❖ changing the base foot from polypropylene-coated steel to fibreglass-reinforced nylon.

The team also persuaded the manufacturers of the nylon foot to take their products back after use and dismantle them for recycling. The gas piston is able to be re-used by Ahrend.

## Advantages

Overall, the changes achieved a 50 per cent reduction in energy use and emissions of undesirable substances: for example, carbon dioxide, phenols and fluorine were reduced by between 40 and 80 per cent.

Like many of the manufacturers in the programme, Ahrend was pleasantly surprised that the process was so painless, and is now extending the work into other products in its line.

## Country

Netherlands

## Industry

Office furniture manufacture

## Company

The Ahrend company employs 2,800 workers and has an annual turnover of US \$280m. Ahrend Zwanenburg employs 350 workers, and has a turnover of US \$42m.

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## Economic benefits

No additional investment costs have been made to deal with the environmental issues of the product.

Product costs per chair have not been significantly influenced by the environmental redesign: some components have become slightly more expensive, others have become cheaper.

	US \$
<b>Research and development cost</b>	<b>156 250</b>
<b>Reduction in environmental cost per chair</b>	
<i>in 1995</i>	<b>3</b>
<i>in 2000</i>	<b>8</b>
<b>Payback period</b>	<b>approx.2 years</b>

# IEMP: Pollution management appraisals for Philippine industries

The Industrial Environmental Management Project (IEMP) of the Philippine Department of Environment and Natural Resources (DENR), funded by the United States Agency for International Development (USAID), was initiated in 1992 in response to growing concern for environmental protection.

IEMP's goal is to encourage sustained economic growth while reducing pollution and improving workers' health. To achieve its goals, IEMP has three components:

- ❖ capability building
- ❖ policy studies
- ❖ a pollution reduction initiative.

IEMP provides assistance to small- and medium-sized Philippine industrial enterprises, in conducting pollution management appraisals (PMAs). PMA is a tool that identifies financially sound opportunities for waste reduction at the source of pollution, rather than end-of-pipe treatment.

Now well into its third year of implementation (the project is to be completed in September 1996), IEMP has conducted over 50 workshops and trained over 1 000 participants from government, the private sector, and NGOs in compliance audits and monitoring, environmental impact assessment, environmental risk assessment, data collection and sampling, and pollution management appraisal.

In addition, IEMP has completed policy studies and action plans on areas including market based instruments (MBI), characterisation and standards for hazardous waste, environmental risk assessment and pollution reduction planning in the Philippine environmental impact statement system.

IEMP has conducted over 80 of the planned 150 PMAs to be completed by the end of the project in the following targeted industrial subsectors.

- Sugar milling/refining
- Vegetable/animal oils
- Food and beverages
- Industrial chemicals
- Piggeries
- Cement
- Wood products
- Pulp and paper
- Tanneries
- Fish canning
- Electroplating
- Meat processing and
- Metals/mining

It is expected that pollution prevention measures implemented by 50 per cent of the PMA firms will result in a 5 to 10 per cent reduction in production costs (savings), and a similar decrease in pollution.

The following two case studies, from the oleochemical and sugar milling and refining sectors, are examples of IEMP's initiatives to promote cleaner production.

## Glycerin recovery through process improvements

### Background

Oleochemicals are used for a variety of applications, such as the base material for cosmetics, shampoos, toothpastes, plasticisers, pharmaceuticals, and industrial and household detergents.

### Cleaner production

Pilipinas Kao volunteered for an IEMP-sponsored Pollution Management Appraisal (PMA) in October 1993. The company identified glycerin recovery as a focus of the PMA. Glycerin is a valuable product,

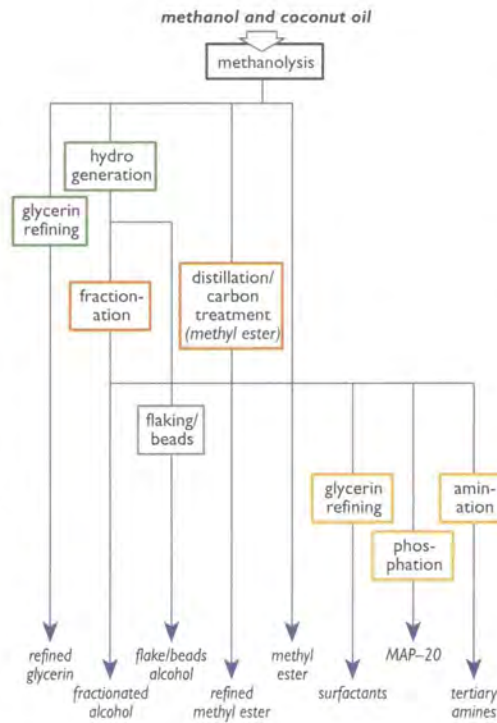




and unrecovered glycerin contributes to high chemical oxygen demand (COD) of wastewater. Pilipinas Kao's engineers evaluated the existing operating parameters of the glycerin process, revealing a substantial deviation between the actual and design operating conditions of this process. Through constant monitoring, Pilipinas Kao was able to optimize operating conditions of the glycerin process, which involves the reaction of crude coconut oil with methanol, to produce methyl ester and glycerin, using sulphuric acid as a catalyst. The process is called *esterification* – glycerol is replaced by methanol, forming coco-methylester with glycerin as by-product.

## Advantages

For Pilipinas Kao, wasted glycerin represented a loss of revenue. With the help of Japanese engineers, the company organised an evaluation team to analyse and monitor the process. By simply improving process procedures and optimizing operating parameters, PKI reduced glycerin loss by 32 per cent, thus increasing the daily glycerin yield by 5 per cent – that is, an additional 6 kilograms. Moreover, glycerin recovery at the source has eliminated the



chemical coagulant which is needed for treating wastewater.

## Economic benefits

### Savings per year

- **Increased glycerin recovery P32 000**
- **Chemical treatment costs P1 600 000**



## Country

Philippines

## Industry

Oleochemical

## Company

Pilipinas Kao, Inc. is an oleochemical plant founded in 1917 by the Kao Corporation of Japan and the Aboitiz Company of the Philippines. The company uses coconut oil to produce the following oleochemicals:

- ❖ fatty alcohol
- ❖ refined glycerin
- ❖ alkanolamides and surfactants
- ❖ monoalkyl phosphates
- ❖ methyl ester
- ❖ tertiary amines

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## Reducing waste generation in sugar milling and refining



*Ash settling pond*

### Background

Established in 1927, Central Azucarera Don Pedro (CADP) is the leading raw sugar factory in the Luzon Island of the Philippines.

Raw sugar is processed in the following way: when the sugar cane arrives at the mill, the stalks are cut into small pieces by turning knives. The cane pieces are then passed through heavy rollers which squeeze out the juice. The juice is treated with lime, causing impurities to settle to the bottom. Impurities are removed by filtration.

The clear juice is pumped to the multiple effect evaporator to concentrate the juice solids from about 12 to 65 per cent. Crystallisation follows through further evaporation under carefully controlled conditions in vacuum pans. Sugar crystals are separated by centrifugation.

### Cleaner production

#### **Water use optimization**

The Pollution Management Appraisal (PMA) at CADP, conducted by the Industrial Environmental Management Project (IEMP) in March 1993, focused on reduction in water use and wastewater generation.

CADP significantly reduced its wastewater generation by adapting the IEMP-recommended low cost/no cost waste minimization options. These included: waste segregation to dry handling of fly ash; recycling bagasse to absorb grease and oil spills; recycling clarified water from ash settling pond and condensate tank overflow for cleaning purposes; good housekeeping, such as monitoring oil spills, repair of leaking pumps, removing debris from canals.

#### **Combat against hazardous chemicals**

CADP continues to study and implement waste minimization options. Each



department now functions as an independent PMA team, investigating waste streams, checking pollution load, and recommending workable waste minimization options. CADP's chemical control and laboratory department reduced their consumption of lead sub-acetate, a toxic chemical used in the analysis of sugar content. CADP is hoping to totally eliminate lead sub-acetate by shifting to analytical instruments.

### Enabling technology

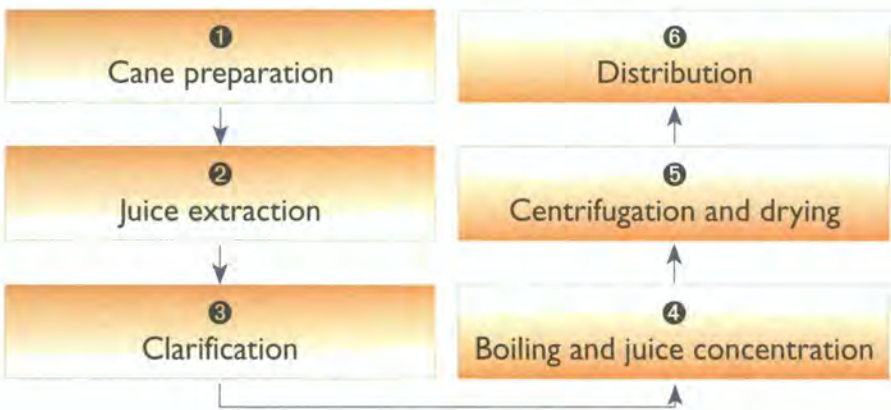
CADP's PMA team recognised the importance of tracking not only the process raw materials, but also the waste generation. Considering that water is a critical concern of the facility, CADP requisitioned an ultrasonic flowmeter. Such efforts allowed them to monitor sudden surges in the volume of the wastewater, immediately identify the cause of the rise in volume, and implement remedial measures. Through waste minimization, CADP reduced wastewater volume from 18 000 to 1 500 m<sup>3</sup> per day.

The combat against toxic chemicals was initiated by reducing the volume of samples per analysis from the Mill Department to 100ml from 250 ml, and from the Boiling House to 75g from 150g. Consequently, this reduced use of lead sub-acetate.

### Advantages

CADP is able to conserve their water source, a nearby river. Moreover, the reduction in the volume of wastewater means the extension of its holding time in the treatment ponds, making it easier for CADP to further reduce the wastewater's pollution load. CADP now easily complies with government regulations on effluent discharge. With regard to reduced consumption of lead sub-acetate, the benefits from reduced lead pollution are significant.

Economic benefits		
<b>Capital investment</b>	<b>P500 000</b>	
<i>ultrasonic flowmeter</i>		
<b>Operating costs</b>	<b>P915 000</b>	
<b>Cost savings</b>	<b>approx 990 000</b>	
<b>Payback period</b>	<b>9 months</b>	
Savings can be attributed to the avoided treatment and compliance costs, and other liability costs. CADP was not able to fully quantify the corresponding savings.		
	<i>before</i>	<i>after</i>
<b>Wastewater (m<sup>3</sup>/day)</b>	<b>18 000</b>	<b>1 500</b>
<b>Lead sub-acetate (kg/day)</b>	<b>4.5</b>	<b>2-2.5</b>



### Country

Philippines

### Industry

Sugar milling and refining

### Company

Central Azucarera Don Pedro (CADP) is the leading raw sugar factory in the island of Luzon. The plant now produces about 1 075 tons raw sugar at a rated capacity of 10 000 TCD. Enormous investments for the facility's Total Improvement Plan began in the 1987-88 crop year, with the acquisition of a Skoda mill from Czechoslovakia, capable of processing 8 000 tons of cane per day. CADP is now operating its new refinery, with a capacity of 550 tons of sugar per day.

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## NIF-NOT: Targeting cleaner production in Poland

The NIF-NOT Cleaner Production Programme is an independent, cooperative venture between the Societies of Chartered Surveyors from Norway (NIF) and Poland (NOT). Sponsored by the Norwegian and Polish governments, the programme has been in operation since 1991. After three years of active work throughout the country, over 400 companies and institutions (such as universities and local authorities) and more than 600 individuals have participated in the programme.

Between 1992 and 1993, the Polish Ministries of Environment, Industry and Trade signed a Letter of Intent, aimed at achieving sustainable industrial

development based on cleaner production as an environmental management tool.

A Declaration of Cleaner Production was subsequently issued, to be signed by companies accepting the goals of the Letter of Intent, and applying the Cleaner Production strategy at company level. Added to the NIF-NOT programme, these two documents have created a more formal and permanent structure, and stronger support for the programme.

At the time of writing, over 150 companies have signed the Declaration and are working in accordance with the Cleaner Production strategy.

## Emissions abatement in coking works

### Background

The five coking plants in the Zabrze Coking Works are of varying technological conditions.

The Knurów Coking Plant in Knurów has one M63 coke-oven battery, working in a charging system, and consisting of 50 coking chambers. The coke-oven battery has a mechanical cleaning system for the frame doors and hydro-injection to reduce pollution emissions.

### Cleaner production

A cleaner production assessment was carried out on the entire coke production

process, to establish the sources of emitted pollution. The benzol recovery plant, responsible for 71 per cent of total plant emission, was chosen as the field of study.

The coke gas open cooling system is the main source of emitted pollution from the benzol recovery plant. The cooling water contains such pollutants as benzene and its homologues, ammonia, hydrogen sulphide (H<sub>2</sub>S), phenol, and hydrogen cyanide (HCN), which are emitted to the atmosphere when the water is evaporated from the cooling tower.

Improved housekeeping led to the reduction of energy and water





consumption, as well as an improvement of the technological process. A feasibility study was carried out for three variants of the same solution, with the selected variant based on closing the coke gas cooling system by applying a spray cooler.

### Enabling technology

In the dirty water closed cycle, dirty water at 40°C flows through the pipes of a spray cooler. The pipes are sprayed with clean water, which cools the dirty water to a temperature of 25°C. This is then indirectly pumped back to a gas aftercooler to remove the pollutants. After leaving the spray cooler, the clean water is cooled in a cooling tower, and forms its own closed cycle.

In this way, two independent systems

are created:

- ❖ a closed system of dirty water and
- ❖ an open system of clean water.

### Advantages

Implementation of cleaner production applications resulted in emission reduction of the following pollutants relative to the coking plant as a whole:

Pollutant	tons/year		
	from	to	
Hydrogen cyanide	10.65	0.99	91%
Toluene	10.92	1.26	89%
Benzene	40.62	4.68	88%
Xylene	2.73	0.31	88%
Hydrogen sulphide	27.80	4.74	85%

### Country

Poland

### Industry

Coking works

### Company

The Zabrze Coking Works, in Zabrze, consists of five coking plants. The company also produces coke gas, coke-oven tar, naphthalene, benzol, ammonium sulphate, sodium phenate, and other tar derivatives.

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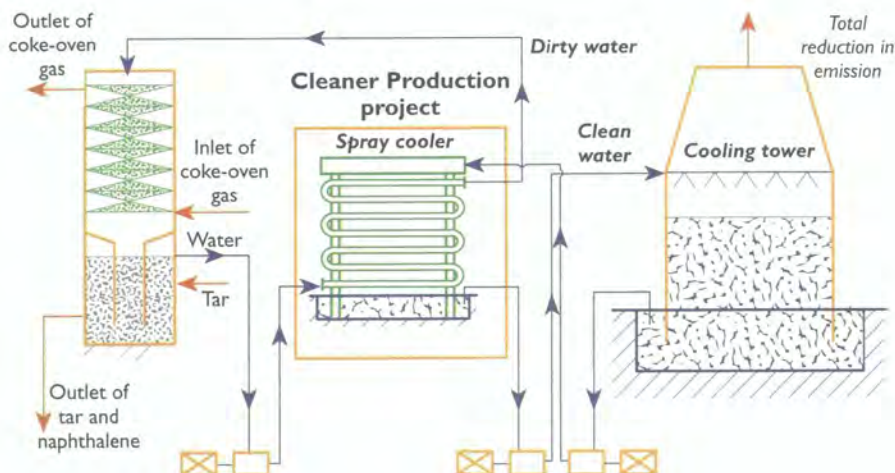
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### Economic benefits

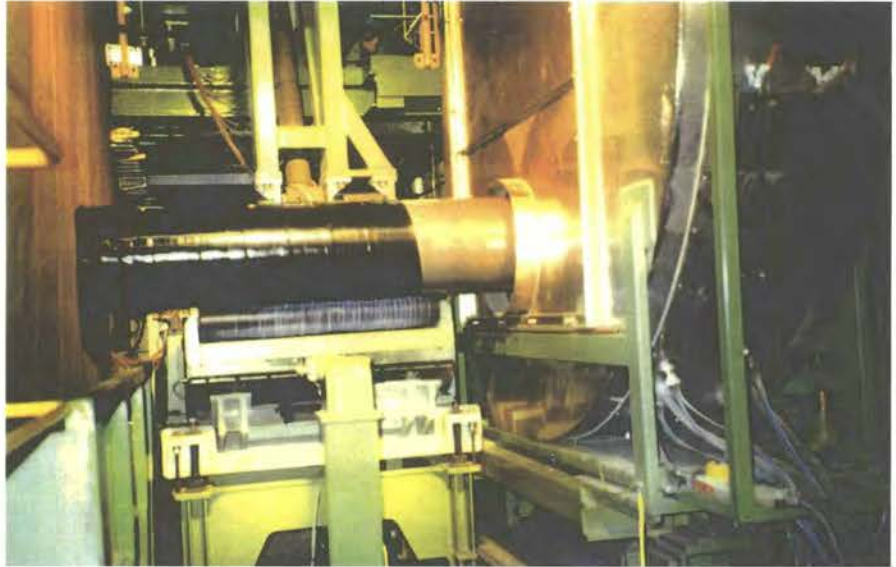
Capital investment (gas aftercooler system) US \$ 20 000

Net savings US \$ 166 000

Payback period 1 month



## Reducing emissions in steel pipe coating



### Background

According to clients' requirements, the Ferrum steelworks manufacture steel pipes must have an outside insulation which is corrosion resistant. The pipes are coated with a bitumin compound, a coating process which is very harmful to the environment, producing toxic gaseous emissions of 47.6 tons/year and generating 194 tons/year of solid waste.

### Cleaner production

The cleaner production application involves the implementation of new coating technologies.

#### ❖ Stage 1

The bitumin compound was replaced by polyethylene tape. The company achieved this without additional investment.

#### ❖ Stage 2

In the next stage, three-layer polyethylene insulation was introduced. This new process of pipe coating required the installation of a new, complete technological line, purchased from the German company Hoesch, which assures technical assistance by line installation and start-up.

### Enabling technology

The new coating technology consists of the following process.

#### ❖ shot blasting

#### ❖ successive deposition of:

- powdered epoxide resins
- copolymer as a combining agent
- ethylene plastics as the outside layer.





## Advantages

Use of the new coating technology has resulted in reductions in the emission of aromatic and aliphatic hydrocarbons and in solid wastes. This has led to a decreased impact on the municipal waste dump, and improved air standards in the surrounding area. Harmful bituminous substances have been eliminated, and the lifetime of the pipes has been prolonged by 100 per cent.

## Environmental benefits

Source and type of emission	Emissions (kg/year)	
	Before	After
<i>Air emission</i>		
Dust	140	33
CO	323	31
NO <sub>2</sub>	2492	235
Phenol	125	0
Benzenapirene	0.1	0
Aliphatic hydrocarbons	41 125	0
Aromatic hydrocarbons	6 396	0

## Country

Poland

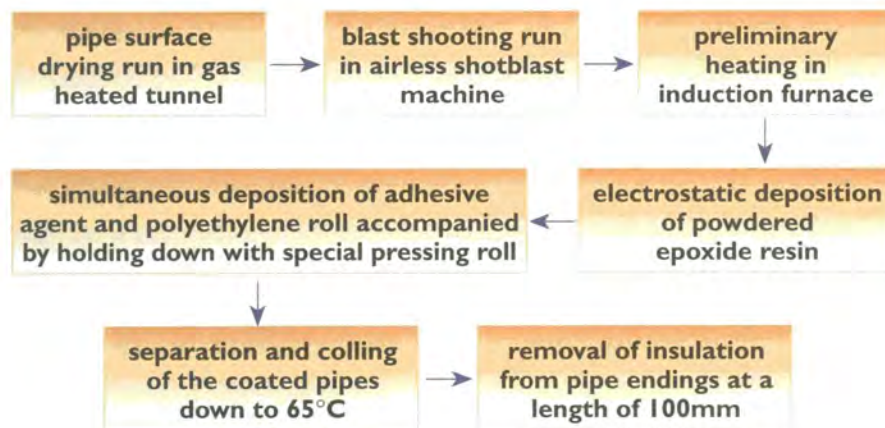
## Industry

Steel pipe processing

## Company

The Ferrum steelworks manufactures a wide range of pressure and galvanising tanks, boiler drums, turbine pipelines, constructions for the metallurgical and building machine industries, and steel pipes. The company employs approximately 1 500 people.

## The new coating process



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## Economic benefits

Reduction in environmental fees and operating costs US \$3.5m

Capital investment US \$6.2m

Payback period 1.75 years

These figures are based on a production rate of 670 000m<sup>2</sup> of insulated coating. The capital investment was half-financed by a low-interest loan from the National Environment Protection Fund.



## Biological degreasing with closed rinse water system

*Closed degreasing system*



### Background

For the Swedish electroplating company Landskrona Galvanoverk, the most important pretreatment processes are electrolytic degreasing, water-based hot degreasing, pickling and decapitation. A study showed that these processes gave rise to large amounts of waste.

Environmental efforts were directed towards degreasing and pretreatment processes, with the aim of reducing pollution of the rinsing water. The conventional alkalic degreasing bath contained NaOH, soda, phosphates, silicates, tensides, and complexing and sequestering devices. The degreasing took place at pH 11–14, with a 5 per cent NaOH solution. Waste rinsing water led to an internal wastewater treatment plant where iron, zinc and chrome ions were precipitated as metal hydroxide. The resulting hydroxide sludge was dewatered in a chamber filter press. Water pollution consisted mainly of metal ions, fats, oil and tensides. Three per cent of the zinc and 15 per cent of the chrome used for finishing ended up in the rinsing water, leaving the plant partly as a component in the hydroxide sludge, which amounted to 30 tons a year, and partly as water pollution.

### Cleaner production

Biological degreasing in combination with a closed rinse water system was developed by Camex Engineering AB of Sweden. Recently, Ikaab took over the licences. The system, based on biodegradable tensides and micro-organisms, is economical and non-polluting, with a low consumption of energy and chemicals.

In general, it consists of the following steps:

- ❖ objects are washed in an aqueous solution of tensides
- ❖ contaminants are dissolved in the washing liquid
- ❖ the washing liquid is separated from the metal objects
- ❖ nutrient salts are added to activate micro-organisms
- ❖ natural hydrocarbons are then degraded by the micro-organisms
- ❖ the tenside washing liquid can be reused.

All water-soluble tensides – preferably biodegradable – can be used. The pH value is kept between 8.5 and 9.4, with a temperature of 20°–80°C, preferably 30–40°C, and the oil content between 50–500 mg/litre.

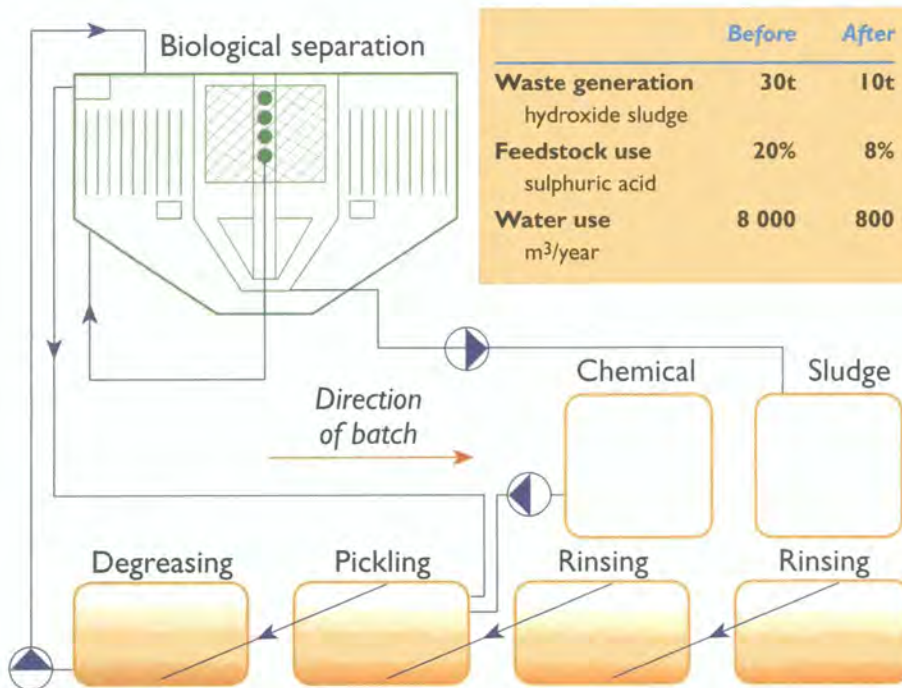


## Enabling technology

Cleansing and biodegradation can take place in one or separate baths. To activate the enzymes, BioCam 104 – a solvent free, alkaline degreasing agent with only a few additives in an environmentally benign combination – is added. The oil-eating bacteria are fed by nutrients, and become activated in the degreasing bath. The oil in which the tensides have been emulsified acts as a source for the nutrients. A separator keeps the amount of bacteria in the degreasing bath constant. The pretreatment system also includes pickling with sulphuric acid or hydrochloric acid.

This method – activated oxide scale dissolving – is patented. The goods are not rinsed, as the film of biological degreasing blocks the dissolving of iron in the pickling bath. Pickling should dissolve the oxide scale (iron oxide), while keeping iron losses to a minimum. A stable precipitation of all the metals from the rinse water is given by calcium hydroxide. The precipitate is then separated by a rotating lamella separator, and the water is returned for use during rinsing. The ion exchange equipment removes chloride ions, causing deposition of calcium sulphate (gypsum).

## Advantages



	Before	After
<b>Waste generation</b> hydroxide sludge	30t	10t
<b>Feedstock use</b> sulphuric acid	20%	8%
<b>Water use</b> m <sup>3</sup> /year	8 000	800

## Country

Sweden

## Industry

Electroplating

## Company

*Landskrona Galvanoverk* is a small electroplating company specializing in electro deposition by zinc and chrome on steel. The turnover was US \$512 000 in 1993, and seven people were employed. The company is an individual surface treatment shop with two production lines: one drum line and one conveyer line, with a joint capacity of 5 500 tons a year. Both lines are equipped with the new closed system for rinsing water, biological alkaline degreasing and activated pickling.

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## Economic benefits

**Capital investment** US \$421 700

**Savings** US \$80 300

**Payback period** 5.5 years

## Savings US \$ [1990]

**Water** 10 800

**Energy** 7 100

### Chemicals:

• Inhibitor (pickling bath) 10 100

• Degreasing substance 7 800

• Sulphuric acid 6 700 **24 600**

### Service, shutdowns:

• Sulphate handling 32 400

• Degreasing bath 5 400 **37 800**



## CEPITA: Demonstrating cleaner production benefits in Tanzania

At the beginning of March 1994, the Department of Environment (DoE) in the Ministry of Tourism, Natural Resources and Environment launched a cleaner production pilot project in collaboration with the Ministry of Industries and Trade, the University of Dar es Salaam and the Ardhi Institute. The project, named CEPITA (Cleaner Environmental Production in Industry Tanzania), is funded by Danida.

Within the framework of CEPITA, demonstration projects are being carried out in 13 companies within seven industrial sectors, whilst strategy studies are conducted by the project consultants.

The following objectives are central to CEPITA:

- ❖ raising awareness of cleaner production in collaboration with government institutions, industry, NGOs and research and development institutions
- ❖ demonstrating to Tanzanian industries the possibility of simultaneously increasing profits and reducing environmental impact at source
- ❖ formulating recommendations for an effective cleaner production policy and strategy
- ❖ training industrial personnel in cleaner production.

The seven industrial sectors selected for the purpose of the project were:

- the metal and electroplating industry
- glass manufacture
- food processing
- the textile industry
- cement manufacture
- soap manufacture
- fibre production.

A total of 169 cleaner production options – of which 105 have so far been considered feasible – have been established throughout these industries, including good housekeeping and process and product innovations. Assessment of these options continues; they will be implemented in the near future.

Extensive study will also be carried out on 94 of the options, and feasibility studies remain to be conducted on a further 50 options during the second phase of the project.

The following good housekeeping examples have led to substantial waste prevention and reduction in water, chemical and energy consumption:

- ❖ At Kimbaba Sisal Estate, installation of an automatic sensor has led to a reduction and water overflow of 30-50 per cent.
- ❖ Conservation of water and improvement in boiler efficiency at Sunflag – one of the two textile companies involved in the project – has reduced both energy and water consumption by 40-50 per cent.

The following case study on ammonia reduction in the galvanising of steel *is exemplary of CEPITA's cleaner production efforts in Tanzania.*



## Ammonia reduction in galvanising of steel



### Background

The continuous galvanising line in operation at Galco produces solid, liquid and gaseous wastes during the major processes of pretreatment, galvanisation and post-treatment. As well as the loss of materials during processing, the wastes also cause water and air pollution. The company management decided to participate in the CEPITA project. The first initiative involved an engineer from Galco attending cleaner production training workshops.

### Cleaner production

A waste minimization audit was carried out by the company in cooperation with cleaner production consultants to identify ways of preventing pollution, improving productivity, and improving the working environment.

Options identified for implementation within a year included:

- ❖ installing an ammonia fumes exhauster at the galvanising unit
- ❖ controlling the addition of ammonium chloride

- ❖ fixing the self-locking cocks (valves).

Longer term options included:

- ❖ installing a steam return line
- ❖ changing to wet process – that is, the use of zinc chloride and aluminium chloride.

The options identified involve a combination of good housekeeping and process modification. Implementation of all the cleaner production measures will hopefully be achieved in less than two years.

### Advantages

Installation of the ammonia fume exhauster provides:

- ❖ a higher quality product, due to the reduction of heavy smoke which darkens the galvanised sheets
- ❖ reduction in waste
- ❖ improvements in the working environment
- ❖ a 40 per cent reduction in ammonia emission, thereby avoiding the need to install expensive air pollution control systems.

### Economic benefits

	US \$/year
<b>Capital investment</b>	<b>1 547</b>
<b>Savings</b>	<b>700</b>
<b>Payback period</b>	<b>2 years</b>

### Country

Tanzania

### Industry

Metal processing

### Company

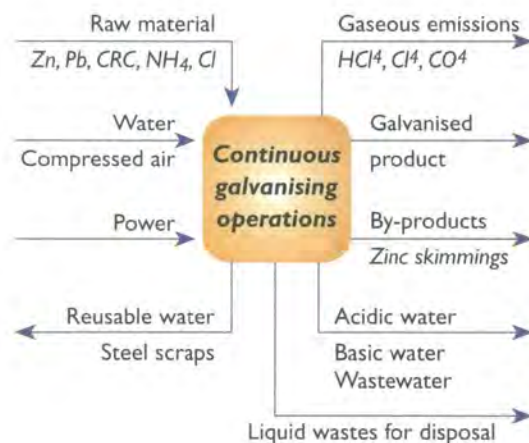
Galco is a large company specialising in the manufacture of corrugated iron sheets and galvanised products. Continuous galvanising operations involve degreasing, scrubbing, pickling, rinsing and fluxing, galvanisation, cooling, chromating and drying.

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# Process improvements in lead battery manufacture



## Background

La Societe Tunisienne de l'Accumulateur NOUR manufactures starting, lighting and ignition (SLI) batteries. The plant has six main unit operations, and uses the dry charge (*tank formation*) process for 60 per cent of the production, and the wet charge (*container formation*) process for the remaining 40 per cent.

The company was the subject of a pollution prevention diagnostic assessment carried out by the United States Agency for International Developments (USAID) Environmental Pollution Prevention Project (EP3).

## Cleaner production

Recommendations were made for all six unit operations. For example, smelting has been improved by covering the large piles of slag, dross and baghouse dust that present major environmental problems and risks to workers through exposure to lead.

During the pasting operation, the lead-rich waste is shovelled back into the hopper for reuse. The moisture content of the paste recipes (both positive and negative) is increased so that the panels enter the drying oven at between 14–15 per cent moisture.

## Enabling technology

Temperature measuring instruments, accurate in the range of 1000–1300°C, help to ensure that the kiln temperature stays close to 1150°C, so that organic materials are burned off and maximum effectiveness is achieved. An improved design of casting molds eliminates the oversized lugs and unnecessary rigid connectors (feet) between the two grids that make up a panel, reducing waste, energy, lead and paste usage, and material handling, and eliminate the dusty, high-scrap plate cutting operation.

To convert virgin lead into lead oxide, an appropriately sized mill makes the lead oxide in large, spherical particles, using air to atomise and oxidise the molten lead. The particles provide greater interstitial spaces and hold more moisture – critical to improving the curing process. Later, the interstitial space holds more sulphuric acid, giving the battery more 'cold cranking power', an important measure of battery value and quality.

Water flow to the wetting roller on the pasting machine is reduced, and de-ionised water is used, reducing water use and generation of lead sulphate-contaminated water. A simple moisture analysis oven is used for each batch of paste, and plates are sampled before entering and after leaving the drying oven. This saves energy and gives a more complete conversion of the elemental lead to lead oxide.

During curing, vertical racks accommodate the larger batch sizes that are possible to produce because of the higher moisture in the plates. A higher residual moisture content allows a longer wait until more

plates are available for curing. More heat is generated during the curing of larger batch sizes because the formation of lead oxide also generates heat. Higher temperature and saturation humidity transforms the elemental lead into a tetrabasic lead oxide, thus improving the mechanical bond, the cold cranking power, and the reserve capacity of the battery.

The container formation process has been improved by applying a low current as soon as possible after the batteries are filled with acid. Temperatures of about 50°C improve the performance of the negative plate, and help to convert residual lead sulphate and oxide into lead peroxide.

Finally, tank formation is eliminated, so the cured panels now go directly to battery assembly, eliminating the washing and drying needed after tank formation. This significantly reduces worker exposure to sulphuric acid and lead dust, saves energy, and reduces the volume of contaminated water from the plant.



### Advantages

The new process reduces:

- ❖ employee exposure to lead dust
- ❖ toxic emissions, slag and waste
- ❖ energy and water use
- ❖ the amount of lead needed
- ❖ lead acid contaminated waste water

Product quality is also improved by the increase in service life.

### Country

Tunisia

### Industry

Lead acid battery manufacture

### Company

La Societe Tunisienne de l'Accumulateur NOUR's battery manufacturing operation began in the 1950s. NOUR is a privately owned Tunisian enterprise that occupies a prominent position in the SLI battery market. The company faces increased competition, however, as a result of the Tunisian import liberalisation programme.

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### Economic benefits

The 19 pollution prevention options could produce savings of over US \$2.1 million in the first two years for an investment of \$396 116. Capital investment cost for end-of-pipe

equipment will be reduced by at least 35%, and treatment chemical costs by at least 66%. The following table shows just some of the savings achieved by the 19 options being implemented.

Operation	Cost US \$	Savings US \$	Payback period
<b>Smelting:</b> • cover slag and dust piles; clean smelting from smelting room • temperature monitoring instrument	500 1 000	10 000 1 000	3 weeks 1 year
<b>Cutting:</b> eliminate the cutting process	100 000	401 712	< 3 months
<b>Container formation:</b> apply charge to batteries immediately after filling	0	70 000	Immediate
<b>Tank formation:</b> • eliminate the process • stop washing plates	300 000 0	669 000 125 000	< 6 months immediate

## Aire and Calder: Source reduction at river catchment in the U.K.

The Aire and Calder Project was the United Kingdom's first major cleaner production project. Most of the initiative for the project took place between May 1992 and March 1993, and involved 11 companies from a wide range of industries located in the catchment of the Aire and Calder rivers in Yorkshire. Initiated by the Centre for Exploitation of Science and Technology (CEST), the project aimed to demonstrate the benefits of a systematic approach to waste minimization, by identifying ways of reducing effluent discharge at the source, rather than by applying treatment methods.

Funding for the initiative, which totalled £400 000, was provided by Her Majesty's Inspectorate of Pollution (HMIP), the National Rivers Authority (NRA), Yorkshire Water Services, the BOC Foundation for the Environment, and the participating companies.

By September 1994, two and a half years after the launch, 671 opportunities for savings had been identified, with a value of

£3.3 million a year. Ten per cent of the measures were evaluated as cost-neutral; a further 60 per cent had a payback period of less than one year.

The Aire and Calder initiative was followed by the Project Catalyst, which ran between January 1993 and May 1994. Sponsored by the UK Department of Trade and Industry and the BOC Foundation for the Environment, the project aimed to demonstrate how planned management of processes and systems can lead to financial and environmental benefits.

By April 1994, the 14 participating companies had achieved savings of £2.3 million, from 399 options identified for improving efficiency. Thirty per cent of the measures were evaluated as cost-free; a further 30 per cent had payback periods of one year or less.

The two following case studies were selected from the Aire and Calder project.

## Improving technology in soft drinks manufacture

### Background

With a consumption of 7 500 m<sup>3</sup> of water per day, CCSB is one of the largest users of mains water in the Yorkshire region of the U.K. A total of 237 cleaner production opportunities were identified at CCSB's Wakefield facility, in areas including water, liquid waste, raw material, and energy. Of particular interest is the improvement to conveyor technology.

Conveyor lubrication technology in the canning industry has remained static for



the last 15 years. Line speeds have been developed to the point at which present state-of-the-art equipment is capable of producing filled cans in excess of 2 000 cans per minute.





## Cleaner production

The aims of this project were to:

- ❖ remove the need for slat lubrication onto the line, whilst maintaining excellent can handling properties – leading to less load on the effluent treatment plant
- ❖ improve the hygiene standards on the line through the alternative belting
- ❖ reduce the energy consumption of the conveyor drives, by means of reduction in the coefficient of friction between belt and wear strips
- ❖ improve safety in the production area – the floor can be kept much drier by removing the slipping hazard
- ❖ maintain critical handling characteristics, both en masse and at varying line speeds
- ❖ allow the cans to pass in single file at high speed through the can inspection systems.

## Enabling technology

A different type of belt – in the form of an acetal belt of full conveyor width – was fitted, requiring the development of a new tracking system to maintain can handling properties at the conveyor crossover points. The drive systems were also modified with a new style of drive sprockets and fitted with stainless

steel teeth to reduce wear on the sprockets. Initially, one belt was trialled on line for one month to assess the can handling properties and wear characteristics. After assessment, a further 50 per cent of the lines were retrofitted, with the total line performance monitored to eliminate unforeseen problems. After a further two months' trial, the remaining lines were converted to the new type of conveyor belting. The project took six months from start to finish.

## Advantages

The total elimination of slat lubrication has significantly improved the environmental performance of the canning lines. The lubricant contained a biocide – isothiazoline – and its elimination has benefited the operation of the anaerobic effluent treatment plant to which the biocide is discharged in the washings from the process area. Emissions to sewer have reduced by 112 000m<sup>3</sup>/year.

## Economic benefits

### For all 237 projects:

<b>Cost savings (per year)</b>	<b>£1 491 100</b>
<b>Capital investment</b>	<b>£507 500</b>
<b>Payback period</b>	<b>4 months</b>

### For the conveyor belt project:

<b>Cost savings (per year)</b>	<b>£27 000</b>
<b>Capital investment</b>	<b>£30 000</b>
<b>Payback period</b>	<b>18 months</b>

## Country

United Kingdom

## Industry

Soft drinks manufacture

## Company

The CCSB facility in Wakefield is thought to be the largest of its kind in Europe. It has almost doubled its output in the last four years, and significantly increased its market share.

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## Reducing product loss in the chemical industry



### Background

*Rhone Poulenc Chemicals* has used a number of measures to tackle the loss of product and subsequent releases of chemical oxygen demand (COD) to effluent.

This case study outlines the results that two modifications to the operating procedures have had on material loss.

### Cleaner production

The quality control of a product requires a certain number of samples to be taken from vessels during production.

When samples are taken from the bottom of a vessel, there is unavoidable spillage, at a cost both to the company and the environment. Opportunities to reduce this problem were identified.

At the end of each product run, it is general practice to boil out a vessel, incurring loss of product and requiring the use of washing aids. Opportunities were also identified to reduce the amount of product lost in this fashion.

### Enabling technology

The company began using larger vessels, which meant fewer samples were required for the same volume of chemical.

The number and size of the samples were reduced, whilst still maintaining the standards set by quality control.

Finally, where practical, the sample was taken from the top of the vessel, to avoid the loss of product through spillage.



To reduce the amount of product lost when a vessel is boiled out, three projects were identified:

- ❖ longer product runs to reduce the number of wash outs required
- ❖ reduction in use of washing aids, by identifying circumstances where it is unnecessary to use them
- ❖ finally, as it is unnecessary to wash out the vessels between the production of certain chemicals, product runs have been planned in an appropriate sequence so the number of wash outs required has been minimized.

## Advantages

These measures have resulted in substantial reduction in product loss and in the COD of the effluent discharged from the site by 44.8 tons/year, with a potential reduction of a further 21.8 tons/year. The volume of emissions to sewer has so far been reduced by 14 934m<sup>3</sup>/year, with a potential further reduction of 11 200m<sup>3</sup>/year.

## Economic benefits

**Annual cost savings** £51 000

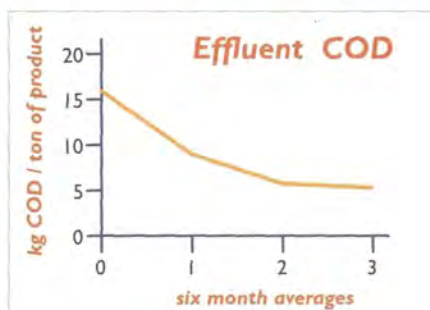
Reduction in:

- effluent volume and COD £9 741
- water usage £4 876
- product loss £36 522

**Capital investment** £10 000

**Payback period** < 3 months

The company has seen large savings as a result of the measures it has taken to reduce its water usage, product loss and effluent volume. As many of the measures taken have incurred little or no cost, any savings made through reducing disposal costs have been substantial.



## Country

United Kingdom

## Industry

Chemicals manufacture

## Company

Rhone Poulenc Chemicals Limited at Leeds occupies a six-acre site to the south-west of the city centre. There has been industrial activity on the site since 1866, with chemical manufacturing beginning in the 1930s and gradually expanding during the 1950s. Today the manufacturing operations concentrate primarily on the production of surfactants, which are used in shampoos, detergents and a variety of beauty products.

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# Recovering metals and reusing wastewater in electroplating

## Background

The Robbins Company electroplates jewelry, awards and other promotional items with valuable metals such as gold and silver. Electroplating entails the passing of electric current through the object to be plated, while it is submerged in a bath of chemical solvent that includes the plating metal. The plating of the object occurs as the current flowing through the object to be plated attracts the metal in the solvent bath. This process traditionally uses significant amounts of chemicals and water, and produces wastewater carrying toxic residuals.

In the early 1980s, new, increasingly stringent environmental regulations came into application in the United States under the Clean Water Act. At this time, Robbins was controlling its waste discharge into a nearby river with a large holding tank, in which waste substances settled out before water was discharged. This system was incapable of meeting the new regulations, and the company found itself regularly in violation of its discharge permits.

## Cleaner production

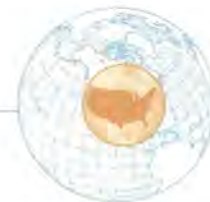
Faced with possible closing for environmental violations, the company decided to look beyond other short-term end-of-pipe control solutions to a closed-loop system, which would bring the company into compliance with regulations through process modifications that would minimize waste generation. The system would purify and recycle water, recover plating chemicals, and assure long-term environmental and economic benefits for the firm.



Two subsystems comprise the closed-loop process. In the wastewater purification subsystem, which returns clean water to the plating line, hydrogen peroxide destroys cyanide; acid and caustic from spent baths adjust pH level; particulate filters remove solids; carbon filters remove organic compounds; and ion exchange resins remove salts and metals. (Ion exchange has now been replaced with an improved reverse osmosis process. See diagram.) In the metal recovery subsystem, metals captured in the ion exchange are plated out through electrolytic recovery. The solution is sent to an atmospheric evaporator, water is boiled off and metal (without hydroxide complex) and salt sludge remains -- two gallons per year (gpy) as compared to 2 600 gpy prior to the closed-loop system. Base and precious metals are recovered from all filters, resins and cathodes from the electrolytic process.

## Annual savings from closed-loop system

Operation	Savings (US \$)
Water usage	22 000
Chemical use	13 000
Disposal of sludge as hazardous waste	28 000
Revenue from sale of reclaimed metals from sludge	14 000
Laboratory analysis	40 000
<b>Total annual savings</b>	<b>117 000</b>



## Advantages

Results of this system have included: a drop in water consumption from 500 000 to 500-700 gallons per week; chemical savings of 82 per cent; and laboratory cost savings of 87 per cent. In addition, toxic sludge generation has been replaced by metals recovery.

The company has also experienced unanticipated benefits. Because the water returned to the plating line is cleaner than the water platers previously used, quality is higher and reject rates have dropped. Moreover, from 1987-1991 following implementation of the closed-loop system, sales increased approximately 14 per cent due to quality improvements and favorable publicity from the modifications.

## Enabling technology

Robbins' efforts to minimize waste did not stop with the closed-loop system. In 1993-1994, the company replaced the ion exchange system with reverse osmosis membranes. As a result, significant hazardous chemical savings have been achieved.



## Country

United States

## Industry

Metal plating and finishing

## Company

Established in 1892, the Robbins Company, located in Attleboro, Massachusetts, manufactures jewelry, awards, and promotional items. The company employs 350 people

## Contacts

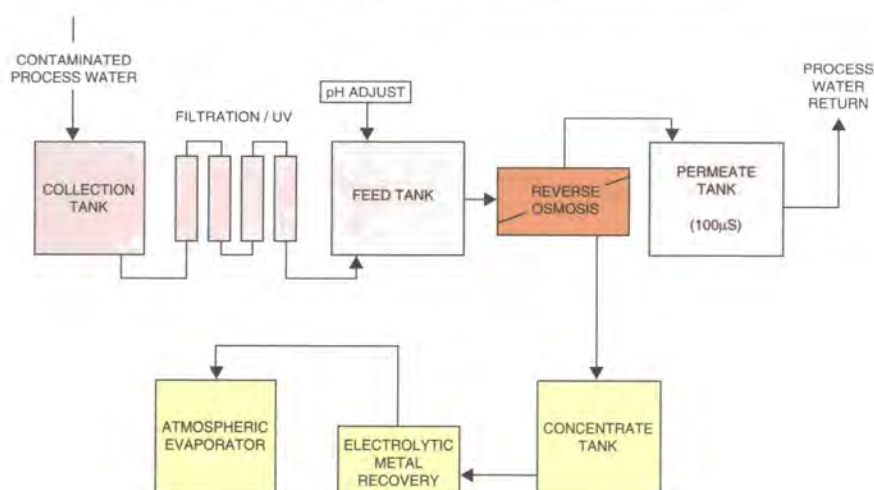
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## Economic benefits

<b>Capital investment</b>	<b>US \$ 240 000</b>
<b>Annual savings</b>	<b>US \$ 117 000</b>
<b>Payback period</b>	<b>2 years</b>

## RINSE WATER RECIRCULATION SYSTEM



# The United Nations Environment Programme

UNEP is dedicated to bridging the gap between awareness and action. Since it was created in 1972, it has worked closely with other members of the UN network and forged new relationships among scientists and decision-makers, engineers and financiers, industrialists and environmental activists on behalf of the environment. It seeks the balance between national interests and the global good, aiming to unite nations to confront common environmental problems. Unique among UN agencies, it exists as a catalyst, spurring others to act, and works through and with other organisations, including UN agencies, industrial bodies and governments.

## Industry and Environment

The Industry and Environment Office was created by UNEP in 1975 to bring together industry and governments to work in cooperation towards environmentally sound development.

## The Cleaner Production Programme

This programme was launched in response to a decision from the UNEP Governing Council to reduce global pollution and waste. The objectives of the programme are to:

- ❖ increase worldwide awareness of the cleaner production concept;
- ❖ help governments and industry to develop cleaner production programmes;
- ❖ foster the adoption of cleaner production throughout society; and
- ❖ facilitate the transfer of cleaner production technologies.

To meet these objectives, the programme focuses on training and the collection and dissemination of information on cleaner production that:

- ❖ explains the concept;
- ❖ illustrates technical applications; and
- ❖ helps people develop cleaner production programmes.

These efforts, initiated through a number of different activities, have cultivated an ever-expanding informal network of cleaner production experts, both in industry and government agencies. Further details are available from UNEP/IE in Paris.

## UNEP Industry and Environment – Cleaner Production Programme

### History:

- ❖ UNEP Governing Council: 1989 *decision on environmentally sound technologies*
- ❖ Canterbury CP Conference: October 1990 *CP concepts and network launched*
- ❖ UNCED: June 1992 *recommends to strengthen CP*
- ❖ Paris CP Conference: October 1992 *reorientation of CP as follow up to UNCED*
- ❖ UNEP Governing Council: 1993 *decision 17.17 on transfer of environmentally sound technologies*
- ❖ Warsaw CP Conference: October 1994

### Programme Highlights:

#### 1. Information and Publications:

- ❖ Cleaner Production Worldwide:
- ❖ Government Strategies and Policies for Cleaner Production
- ❖ Audit and Reduction Manual for Industrial Emissions and Wastes
- ❖ CP Newsletter
- ❖ ICPIC

#### 2. Seminars and Workshops in all parts of the world:

#### 3. Demonstration Projects (ongoing):

- ❖ Pulp and Paper and Cement industries in Egypt, Senegal, Zimbabwe, Ghana
- ❖ Cleaner Production in China

#### 4. National Cleaner Production Centres:

- ❖ UNIDO and UNEP initiation of eight centres in Brazil, China, Czech Republic, India, Mexico, Slovak Republic, Tanzania, Zimbabwe
- ❖ Creation of a network between National Cleaner Production Centres and similar centres funded by other organisations

## What to do next?

There is a variety of information and advice available from the United Nations Environment Programme at:

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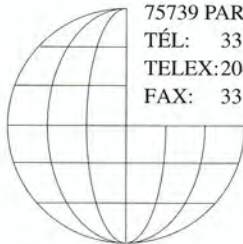
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### TELEPHONE NUMBERS

Note that all telephone numbers in this booklet have been shown in the internationally agreed format. The plus sign indicates the code for international dialling from the country you are in; these codes are generally different for each country. The next group of figures is the unique code for the country into which you are dialling. If you are telephoning from the same country, the international code is not required but you may need a national code, often a zero.