

# Environment Report 1996

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# Preface

## On an international course

Here is Henkel's fifth annual Environment Report. This year the information was complemented by Group-wide environmental data, so that both the text part and the data section have an international character.

The published Group-wide environmental data is of relevance for all Henkel Group companies and locations, and must be viewed in the context of increasing environmental sensitivity. We regard the nature and scope of this data as a mere beginning. The figures were initially collected from 31 different key locations of the Henkel Group. Although they are representative of the whole Group, the reporting systems will be further refined, and in future more locations will be included. We also intend to report on the waste situation and [emissions](#) into water. The relevant data collection systems are being developed and will be designed so that local circumstances can be taken properly into account. This applies to, for example, the currently differing wastewater purification situation for direct and indirect dischargers. In the 1995 Environment Report we specified a number of quantified objectives for the Henkel Group's largest production location, the Düsseldorf parent plant, for the first time. This proved to be an additional stimulus and source of motivation for our employees, and has encouraged us to formulate objectives for other Group locations, thus enhancing the international character of the 1996 Environment Report.

The efforts being made across the whole Group to reduce [emissions](#) are part of a comprehensive program for implementing the chemical industry's global "Responsible Care" initiative throughout the Henkel Group.

We aim to introduce this comprehensive management system throughout the Henkel Group by the end of 1997. The system will include documented standards and specifications concerning key management sectors such as product stewardship, [occupational safety](#) and internal systems for measuring progress and the achievement of objectives. We intend to exploit far-reaching synergies within the Group; procedures and practices which have proved effective at one location will be adopted at other Group locations.

The Management Board has deliberately chosen this demanding timetable in the expectation that it will be a key instrument in accelerating the adoption of binding

standards of environmental protection and safety in everyday practice throughout the Henkel Group.

*Dr. Wilfried Umbach*

Executive Vice President

Research/Technology

## Henkel in brief

Henkel is a world specialist in applied chemistry. The Henkel Group comprises 214 companies in 59 countries.

Group sales in 1995 amounted to DM 14.2 billion, of which 29 percent was generated in Germany.

The parent company is Henkel KGaA in Düsseldorf. The Group employs 41,664 people, of whom 26,710 work for companies outside Germany. 9,474 of the 14,954 employees in Germany are employed in the Düsseldorf parent plant, which is the Group's largest production site.

The Henkel Group is the world's largest supplier of oleochemical base materials ([chemical products](#) derived from renewable raw materials such as coconut oil and palm kernel oil) and products for the surface treatment of metals. Henkel also supplies the most varied range of adhesive products in the world. In Europe, the Group is a leading manufacturer of toiletries, detergents and cleaning agents. Together with Ecolab Inc. of St. Paul, Minnesota (USA), Henkel operates the joint venture Henkel-Ecolab in Europe. This joint venture is the market leader in institutional [hygiene](#) and industrial cleaning products.

Applied research and development are among the Group's core fields of competence. Extensive know-how, creativity and imagination are the starting points for successful innovation, high product quality, optimal price-performance ratio and the best possible environmental compatibility in all the Group's research projects.

One of Henkel's central objectives is to be a global leader in the fields of environmental and consumer protection.

Sales by product groups 1995	in DM millions
<a href="#">Chemical Products</a>	4.025
<a href="#">Metal Chemicals</a>	949
<a href="#">Industrial Adhesives/Technical Consumer Products</a>	2.165
<a href="#">Cosmetics/Toiletries</a>	1.377
<a href="#">Detergents/Household Cleansers</a>	4.096
<a href="#">Industrial and Institutional Hygiene</a>	1.371
Other	215
<b>Total</b>	<b>14.198</b>

All Henkel companies, irrespective of their geographical location, take account of environmental protection requirements in relation to all their activities.

The production processes in the individual facilities must be safe for employees and the local community. The Group works to increase public awareness of its ecological leadership role and to take advantage of it on the market.

There are adequate instruments within the Group for actively dealing with environmental topics. Henkel has two central departments in its Corporate Sector Research/Technology which have focused on these tasks for many years.

The Environmental Protection and Safety unit handles all production and site-related topics, including [emissions](#) and [immissions](#), energy, waste gases, wastewater and noise, while the Biology/Product Safety unit deals with all aspects of product safety relating to mankind and the environment. Environmental protection and safety are by no means restricted to experts. All employees are competent and responsible for environmental protection, [occupational safety](#) and health protection at their workplaces.

# The products

The Henkel Group manufactures almost 10,000 products. Worldwide responsibility for these products rests with six business sectors.

## Chemical Products

([Specialist in Applied Chemistry](#), [Metal Chemicals](#), [Bright prospects for renewable raw materials](#), [Safety exercises](#))

### Oleochemicals/Care Chemicals

[Fatty acids](#); [glycerine](#) and fatty acid [derivatives](#); [fatty alcohols](#) and their [derivatives](#); products for the cosmetics, toiletries and pharmaceutical industries, for detergents and household cleansers; aroma chemicals/perfume compositions; food and feedstuff [additives](#); natural-source vitamin E and beta carotene.

### Organic Specialty Chemicals

Base materials and [additives](#) for plastics, paints and coatings; auxiliary products for textile, leather and paper production; specialty products for mining, oil drilling, and for lubricants, for plant care formulations and the construction industry.

### Inorganic Products

[Water glass](#).

### Metal Chemicals

([Specialist in Applied Chemistry](#))

[Chemical products](#) and application systems for the surface treatment of metals and metal substitutes; lubricants; cleaning products; corrosion [inhibitors](#); products for conversion processing and water treatment; engineering services; anti-freeze agents and corrosion [inhibitors](#) for motor vehicle cooling systems; CFC substitutes for cleaning applications; polyurethane adhesives and sealants; epoxide structure adhesives; PVC and SMA plastisols; [dispersion](#) adhesives; acrylates.

## Industrial Adhesives/Technical Consumer Products

[\(Specialist in Applied Chemistry\)](#)

### Technical Consumer Products:

Wallpaper pastes; ceiling, wall covering and tile adhesives; home decoration products; sealants; polyurethane foam fillers; contact adhesives; wood glues; PVC pipe adhesives; flooring adhesives; building chemicals; coatings; automotive after products; superglues; glue sticks, glue rollers and correction products.

### Industrial Adhesives

[Dispersion](#) adhesives; starch-, dextrin- and casein-based adhesives; hotmelts; polyurethane adhesives and sealants; contact adhesives; [anaerobic](#)- and [aerobic](#)-curing acrylates; cyanoacrylates; polyamides; epoxide structure adhesives; flock adhesives; rubber-to-metal bonding agents; cable sealing compounds.

### Cosmetics/Toiletries

[\(Specialist in Applied Chemistry\)](#)

Toilet soaps; bath and shower products; deodorants; skin creams; skin care products; dental care and oral [hygiene](#) products; hair shampoos and conditioners; hair colorants; hair styling and permanent wave products; perfumes and fragrances; hair salon products.

### Detergents/Household Cleansers

[\(Specialist in Applied Chemistry\)](#)

Universal detergents; specialty detergents; fabric softeners; dishwashing products; household cleansers; scouring agents; floor and carpet care products; bath and toilet cleansers; glass cleaners and lens wipes; furniture and kitchen care products; shoe care and laundry conditioning products; plant care products.

### Industrial and Institutional Hygiene

[\(Specialist in Applied Chemistry, Cosmetics/Toiletries\)](#)



Products, appliances, equipment, systems and services for cleaning, washing, maintenance, sanitizing and disinfecting applications at major institutional and industrial customers, the food and beverage industry and the agricultural sector.

## Henkel-Group

### Principles and Objectives of Environmental Protection and Safety

[\(Hand in hand toward our joint destination, Instilling life into principles and objectives, Preparation for EU Eco Audit\)](#)

#### How we interpret our responsibility

As a leading company and [Specialist in Applied Chemistry](#), Henkel accepts its responsibility to society. As one of the first companies to endorse the [Business Charter for Sustainable Development](#) of the International Chamber of Commerce, we are committed to its principles and to the international program [Responsible Care®](#). We are committed to developing and supplying products and systems that offer special benefits to our customers in all parts of the world. Along with this performance and quality leadership, we are committed to ecological leadership (Eco Leadership). This includes continuously improving plant safety, environmental and health protection, as well as [occupational safety](#).

We set ambitious goals for ourselves. With the aid of efficient [management systems](#), we monitor the progress, making our results available both internally and externally. We encourage our business partners and suppliers to aim for the same standards of environmental protection and safety.

Our corporate culture promotes our employees' true dedication to their jobs. Through multifaceted programs, we develop and promote our employees' understanding of environmental protection and safety. We recognize that these demanding standards can only be met by motivated and creative employees.

## Goals we have set for ourselves

Sustainable Development must give equal priority to economic, ecological and social goals. Only economically successful companies will be able to contribute to effective environmental protection and social progress.

### Products

Henkel supplies only products and systems that are recognized by acknowledged scientific criteria as [environmentally compatible](#). To make sure that our products and systems are used safely, we inform and advise our customers on an ongoing basis.

### Production

Throughout the world, all our production processes are designed in such a way that, if properly operated, our employees and our neighbors are not exposed to any health hazard. In order to maintain and enhance the safety of our existing manufacturing plants, we carry out regular and systematic checks according to uniform Group-wide criteria. Through continuous improvements, we reduce the potential for accidents and any adverse impact our plants may have on the environment.

In the development of new production processes and in the construction of new plants, important components of conception and planning are environmental protection and safety, low consumption of resources, as well as minimizing [emissions](#) and waste.

### Occupational safety

([On an international course](#), [Specialist in Applied Chemistry](#), [How we interpret our responsibility](#), [Employee motivation](#), [Hand in hand toward our joint destination](#), [Instilling life into principles and objectives](#))

Protecting employees at work from health hazards is a top priority for Henkel. Our occupational safety concept is based on an integrated approach that includes the organization of the work, safety management, safety technology, production processes, the substances used, and occupational health precautions.

## How we intend to achieve our goals

## **Management systems**

[\(How we interpret our responsibility, Eco Management\)](#)

We utilize management systems to maintain our environmental standards and monitor the degree to which our environmental and safety goals have been achieved. Regular audits are part of these systems. Henkel's own internal rules are binding for all concerned.

## **Employee motivation**

With our ongoing environmental protection and safety training, we sensitize our employees and ask them to contribute to environmental protection and safety at each workplace and in each working environment.

All our employees are committed to the goals of plant and [occupational safety](#) and environmental and health protection. To achieve this, employees with leadership responsibility are given the necessary decision-making authority, adequately qualified personnel and the necessary resources.

Employee performance in matters of environmental protection and safety is taken into account both in performance reviews and career planning.

## **Technology transfer**

We systematically carry out the Group-wide transfer of technologies and management methods in the fields of environmental and health protection and safety. In that way, we also contribute to global social progress.

## **Dialogue**

We encourage our employees to work at all levels on issues relating to environmental protection and safety.

In dealing with the public, we seize the initiative. We inform the public regularly, candidly and fully - even when we have made mistakes. Questions and concerns on the part of the public are treated seriously and are responded to.

# Eco Management

[\(Hand in hand toward our joint destination\)](#)

The improved environmental compatibility of our products and production facilities cannot be left to chance. This is why comprehensive [management systems](#) for environmental protection and safety play a key role in the Henkel Group. They are the instrument with which we ensure that all procedures and processes conform to our principles and objectives.

**Environmental protection and safety in practice**

## Hand in hand toward our joint destination

Henkel's "Principles of Environmental and Consumer Protection" were first formulated in 1982. They were followed in 1983 by the "Henkel Group's [Occupational Safety](#) Principles and Measures." In 1995 these two sets of principles, which apply across the whole Group, were integrated into a single program, which was published in its own right.

This was a necessary response to the social changes which have occurred in recent years, and to the widening and deepening of the system of [Eco Management](#) within the Henkel Group. The new "[Principles and Objectives of Environmental Protection and Safety](#)" take account of the much wider understanding of environmental protection and safety in our modern society. They conform to the global Responsible Care initiative of the chemical industry.

High priority is accorded to themes such as [occupational safety](#) and health protection, external and internal dialog, and a holistic philosophy of product responsibility. One of the basic ideas of the globally binding Responsible Care program is the continuous improvement of environmental protection and safety.

## Commitment to social responsibility

Henkel's commitment to social responsibility is also a major obligation. In 1991 Henkel was one of the first German corporations to endorse the principles of the International Chamber of Commerce's [Business Charter for Sustainable Development](#), thus also endorsing a business strategy which takes account of the needs of future generations.

Redeeming this pledge to future generations will be a long-term task. Currently relevant Henkel Group projects include the Konrad Henkel School "Kanchanabuti" in the province of Nakorn Panom in Thailand. The school was built by Henkel's Thai employees, who have been supporting it since. In this way, 150 Thai children receive an education which would otherwise be denied them. There are scarcely any other schools in this troubled region on the western border of Thailand.

### **Instilling life into principles and objectives**

It is one thing to formulate principles and objectives. Translating them into practice and imbuing them with meaning is an entirely different matter. This is the duty of all Henkel employees, and this is why the "[Principles and Objectives of Environmental Protection and Safety](#)" were distributed, explained and discussed "from top to bottom" within the Group in the course of a comprehensive communication process. One of the objectives: managers were asked to point out concrete opportunities for translating these principles into practice and to follow them up. Detailed documentation and information were provided to support the Group's managers in this task. The intention was to demonstrate that environmental protection and safety are not matters for just a few specialists but that each and every employee should be responsible for environmental protection, [occupational safety](#) and health protection at his or her own workplace.

### **Preparation for EU Eco Audit**

A key element of the "[Principles and Objectives of Environmental Protection and Safety](#)" is consistent focus on improvement. This management strategy is also a component of the specifications of the [EU Eco Management and Audit Scheme](#) (EMAS). Henkel is undertaking intensive preparations for certification in the context of the EU Eco Audit. The Düsseldorf parent plant - the Group's largest, highly complex production site - is closely involved in these activities.

After an Environment Manual had been drawn up, a start was made on the first environmental audits. The audits were carried out in the individual plant sections, and were coordinated and directed by a team from the Environmental Protection and Safety unit and the Henkel subsidiary COGNIS Industrial Consulting in Düsseldorf. The results were described as very useful by the plant managers; they not only

highlighted areas where high environmental standards prevail but also showed where further improvements can be achieved.

### **Global environmental information network**

Another instrument which Henkel intends to employ to achieve its objectives is a worldwide computer network. The Group's individual facilities and organizational units will be linked more closely than ever in future. The SHE (**S**afety, **H**ealth, **E**nvironment) global network, which came on line in 1995, will play a role in this. The system is kept up to date by 15 regional representatives, who ensure smooth and uninterrupted communication on SHE themes within the Henkel Group.

One of the great advantages of the SHE global network is that it can function as an early warning system; environmental problems have to be solved not only in Europe, the USA and Japan; newly industrialized countries such as China, the Philippines or India must also be given prompt information and involved in preventive measures.

The SHE global network serves to draw attention to necessary changes, so that prompt action can be taken to ensure compliance with legal regulations in international trade, for the protection of mankind and the environment.

Besides its regular reports, the SHE global network provides a hotline for especially urgent information. The sophisticated network architecture enables every Henkel Group location to be directly linked, and to receive all necessary information from all parts of the world.

### **The sunflower as a raw materials supplier**

Detergents from sunflowers? This is no utopian vision of the future but hard reality. Henkel, the world's largest and oldest processor of oils and fats derived from renewable raw materials, is taking a very close interest in sunflower and rapeseed oil from Germany. The background: species of sunflowers with a very high oleic acid content have been developed, which could open up completely new prospects for the chemical industry.

Sunflower oil must contain at least 83 percent oleic acid before it can be used as a raw material for the production of detergents and cosmetic products and in lubricants.

Researchers are currently developing varieties which contain more than 90 percent oleic acid. The German chemical industry's total annual demand for this raw material is estimated at 100,000 tons.

### **2,000 hectares of arable land for a pilot project**

In the context of a German model project, sunflowers with a high oleic acid content were cultivated in Saxony-Anhalt, North Rhine-Westphalia and Bavaria in 1995. A total of 2,000 hectares of arable land was given over to this pilot project, which was coordinated by the German Ministry of Food, Agriculture and Forestry. Besides Henkel, the participants in the project for developing and exploiting this new raw material included agricultural cooperatives and plant breeders, the University of Giessen and the C. Thywissen oil mill in Neuss.

High [erucic acid](#) rapeseed oil could also have a big future in the chemical industry. A wide range of [additives](#) for plastics, lubricants and detergents are obtained from [erucic acid](#). The cultivation of high [erucic acid](#) rapeseed steadily decreased in Germany between 1975, when the use of rapeseed in food was banned, and 1988, when cultivation contracts concluded between the industrial and agricultural sectors gave it a new impetus. The extent to which Henkel will be able to rely on rapeseed and sunflowers depends on three factors: guaranteed availability of sufficient quantities, from reliable sources of supply, with consistent quality.

### **Bright prospects for renewable raw materials**

The fourth symposium on the subject of "Renewable Raw Materials - Perspectives for Chemistry" was jointly organized by Henkel, the German Ministry of Food, Agriculture and Forestry, the Association of the German Chemical Industry, and the specialist agency "Nachwachsende Rohstoffe" (Renewable Raw Materials) on September 27 and 28, 1995 in Düsseldorf.

As a global leader in the processing of renewable raw materials, Henkel had invited 500 international experts from the worlds of politics, science, industry and agriculture to this symposium. They discussed the prospects for renewable raw materials in industry. In one of the addresses, Dr. Wilfried Umbach, Executive Vice President

Research/Technology of Henkel KGaA, emphasized that "Optimizing products - and especially [chemical products](#) - solely on the basis of price and performance is outdated. Ecological compatibility is now the new quality dimension." Umbach concluded that "[Chemical products](#) made from renewable raw materials may not be able to solve all our problems immediately. Nevertheless they were, are and will continue to be a key component of economic, ecological and socially acceptable solutions."

## Life cycle analysis on oleochemical and petrochemical raw materials

### Environmentally compatible

([Products](#), [On the right track](#), [Products](#), [A new production process for detergents](#), [Laminated film refills](#), [New coup with refill cartridges](#), [Persistence pays](#), [Silicone emulsion for impregnating facades](#), [Product characteristics are not easily transferable](#), [Comprehensive ecological safety assessment](#))

For many years Henkel has placed great store on eco balances and studies which take account of the whole life cycle of a product, looked at in terms of environmental considerations.

Comparisons of different production paths are not carried out just for their own sake but serve to highlight scope for ecological improvements. This is an essential part of ensuring a sound environmental input into management decision-taking processes.

[Surfactants](#) in particular have been scrutinized very closely in this context.

In 1995, together with 12 leading European surfactant manufacturers, Henkel presented a study which looked at 22 key detergent [surfactants](#) obtained from renewable raw materials and petroleum. The results showed that both types of raw material have their advantages and disadvantages.

As part of the study, comparative life cycle analyses were also drawn up for [fatty alcohol sulfates \(FAS\)](#). In the case of [fatty alcohol sulfates](#) obtained from renewable raw materials, for example palm oil, all stages are taken into account from agricultural production of the initial raw materials through to chemical processing - availability of raw materials, energy input, raw materials consumed, wastes generated, wastewater pollution and atmospheric [emissions](#). The life cycle analysis for petrochemical [FAS](#) products took the oil production as its starting point.



## Clear facts facilitate evaluation

In terms of energy consumption, [fatty alcohol sulfates](#) obtained from oleochemical raw materials proved to be unusually economical. Significantly smaller amounts of fossil fuels were needed for their manufacture. Oleochemical [fatty alcohol sulfates](#) are also superior with regard to atmospheric [emissions](#), which are appreciably lower.

## Wastewater purification in small sewage treatment plants

Petrochemical [fatty alcohol sulfates](#) only have the edge over their oleochemical rivals when it comes to wastewater pollution. This is attributable to the fact that oil fruits are generally processed in decentralized mills in their countries of origin. The wastewater from the mills is currently purified in relatively small sewage treatment plants, which are often not as efficient as could be wished.

## Weak links highlighted

Such insights are a considerable help. They highlight the weak links in the raw material processing chain, and this is the first step on the road to eliminating them. There is still a lot that can be done to improve the processing of renewable raw materials. In contrast to industrial-scale petrochemical processes, there is considerable scope for optimization.

## From the cradle to the grave

### [\(Products\)](#)

Eco balances describe the totality of the environmental effects of a product during its manufacture, use and disposal, i.e. "from the cradle to the grave."

Henkel collects and processes all key data: from the extraction of the raw material and the processes by which the individual raw materials are produced, through the manufacture of the products and their packaging, to their distribution, use and ultimate disposal.

Petrochemical raw materials play a role in the life of oleochemical [surfactants](#): as fuel raw materials for processing and transport, and in small amounts as chemical building blocks.

The new ecological balance of 22 detergent [surfactants](#) was published in 1995 by the "Ecosol Surfactant LCA" work group of the European Council of Chemical Industry Federations (CEFIC) in the journal "Tenside", issues 2 and 4.

## **Henkel tests biodiesel**

### **Small flower, plenty of power**

Is biodiesel fuel obtained from [rapeseed methyl ester](#) an alternative to diesel fuel refined from petroleum? Henkel experts hope to be able to answer this question within the next two years.

In a test study, 20 cars in the Düsseldorf parent plant were driven from January to April 1996 with diesel fuel based on petrochemicals. Now the drivers are using only biodiesel, which is obtained as an intermediate product when Henkel manufactures [surfactants](#) from rapeseed oil. The staff of an independent institute have been carrying out extensive exhaust gas analyses at regular intervals during the two phases of the study. Henkel will use the comparative data to evaluate the environmental compatibility of biodiesel fuel.

## **New emergency drill program**

### **Safety exercises**

A dust explosion occurs in a dry mixing plant. One employee is badly injured and another missing. A few employees are in shock and others are running around in panic. There are flames everywhere. In a situation like this everyone must know the answers to the following questions: What must be done first? What can wait? How is information distributed? Employees who can answer these questions have the best chance of preventing a bad situation from becoming even worse.

In theory every one of the Group's employees knows how to react. Henkel has documented all necessary information and measures in detailed hazard prevention plans. Theoretical knowledge is always useful - but it is better if theory has been reinforced by practice and applied knowledge.

This is why the [Chemical Products](#) Business Sector has drafted a program of emergency drills. In 1995 this consisted of seven drills: three at the German Henkel subsidiaries Kepec Chemische Fabrik (Siegburg), Neynaber Chemie (Loxstedt near

Bremerhaven) and Grünau (Illertissen in Bavaria), and four in Henkel's Düsseldorf parent plant.

### **Coping with emergency situations**

These emergency drills are designed as a planning game, which can be individually tailored to the different locations and production facilities. However, the objective always remains the same: the participating companies test the emergency management system and cooperate with the emergency services and fire department for the purpose of implementing improvements. Those responsible must demonstrate, under realistic conditions, that they can cope with an emergency situation quickly and safely: rescue the injured, limit risks to human life and the environment, and provide the authorities, the immediate neighborhood and the media with relevant and prompt information.

The exercises involved some 250 foremen, supervisors and works managers as well as the Plant Fire Department and soon revealed where things run smoothly and where they could be better. The teams in the plants are generally so well coordinated that they can overcome any emergencies. However, coordination within the emergency management team and the assignment of areas of responsibility could be improved.

Considerable interest is being shown in the new emergency exercise program, which was designed in late 1994 and is intended to have a long-term character. A further 6 emergency drills are planned in Düsseldorf alone in 1996.

The program is international. This is illustrated by the fact that the Group's subsidiary in the USA, Henkel Corporation, is expected to carry out exercises aimed at testing and improving its emergency management system in the second quarter of 1996.

### **Wastewater data on tap**

The Henkel Group and the "Kanal- und Wasserbauamt" (Sewage and Waterworks Department) of the city of Düsseldorf signed a very special agreement on December 6, 1995: in a "Wastewater Contract" the two partners defined how they would work together more closely and above all more effectively in future. This form of

partnership between a city and a chemical company is without precedent in Germany.

The Henkel parent plant in Düsseldorf discharges 13,000 cubic meters of wastewater into the Düsseldorf-Süd municipal sewage treatment plant each day. In the past the Municipal Sewage and Waterworks Department and Henkel used to monitor this wastewater in parallel: Henkel at the point where the water enters the municipal sewerage and the city officials immediately downstream of this point. Samples are regularly taken at short intervals in continuously operating sampling stations, and the parameters for assessing the wastewater are determined and documented by modern automatic analyzers. These parameters include temperature, volume, [pH](#), conductivity, content of organic carbon compounds, and toxicity.

The new form of cooperation means that with effect from January 1996 duplication of work is avoided and costs are reduced. Henkel determines the measured values with the help of automatic analyzers and registers them directly in a computer system.

The analysis values are shown simultaneously on a monitor at the Municipal Sewage and Waterworks Department and a monitor at the Düsseldorf-Süd sewage treatment plant, both of which are connected with Henkel by dedicated lines.

### **Simultaneous evaluation of measured values**

The computer system allows the measured data to be called up at any hour of the day or night. This means that the values measured from Henkel's wastewater can be reliably evaluated without delay by both parties. This is extremely helpful for the operators of the municipal sewage treatment plant. In return, the Municipal Sewage and Waterworks Department determines additional biological data on the water quality, which it makes available to Henkel.

### **Eco Logistics Concept wins award**

### **On the right track**

[\(Other detergents in the form of Megaperls\)](#)

Awards are nothing new for Henkel: the Group's [environmentally compatible](#) products have often won prizes from national and international juries.

But in 1995 the Company was honored not for a product but for the introduction of a new distribution idea: the Eco Logistics Concept.

In 1994 Henkel switched from road to rail for the long-distance transportation of the detergents and cleaning agents it produces in Düsseldorf and Genthin to other German destinations. This gained it the Dynamit-Nobel Prize for Logistics and the Environment from the "Deutsche Gesellschaft für Logistik" (German Society for Logistics).

This prize is awarded biennially to companies which, inter alia, develop and implement new and more environmentally benign solutions to logistical problems. Lower Saxony's Economics Minister Dr. Peter Fischer presented the prize at the "Qualität durch Qualifizierung der Logistik" (quality through qualification of logistics) congress in Hannover.

Henkel's cooperation with Deutsche Bahn AG has progressed so well that the two parties initiated a new joint test in April 1996. The regional depot in Viernheim in the Mannheim-Ludwigshafen-Heidelberg conurbation was selected to participate. Larger freight cars were introduced on the Düsseldorf-Viernheim and Genthin-Viernheim routes. Instead of 38 pallet positions for some 22 tons of detergents and cleaning agents, these freight cars have 61 positions and can therefore accommodate about 50 tons each.

There was a good reason for choosing the regional depot in Viernheim for this test. It is one of the depots with the highest throughput, an essential precondition for the efficient use of the new jumbo freight cars.

The environmental benefits of the new Eco Logistics Concept are considerable. It has reduced the number of truck journeys by up to 20,000 - equivalent to almost 7 million truck kilometers!

This means that [emissions](#) of pollutants have been dramatically reduced: the Institute for Transport Sciences of the University of Münster has calculated that the reduction is of the order of 7,600 tons of pollutants per year. A really worthwhile result.

## **Environmental protection and safety on the timetable**

### **Dialogue with the future**

When an operational accident occurred at the Düsseldorf parent plant on October 20, 1994, Henkel immediately informed not only the relevant authorities and its neighbors but also the local and national media. However, one important target group was overlooked: schoolchildren and their teachers. This was only noticed when a neighboring school complained to the plant management that it had not been adequately informed. The reaction was immediate. All surrounding schools are now in the parent plant's notification file. Even more: in the fall of 1995 Henkel invited the teaching staffs of the five primary, secondary and special schools in the Düsseldorf suburb of Holthausen to a discussion evening.

The main focus was on the subjects "Environmental protection and safety in production" and "Environmental compatibility of products."

The participants took part in detailed discussions with Henkel's experts and were able to see for themselves how the Company translates theory into practice.

### **Teachers help to shape the dialogue**

In January 1996, Henkel and the principals of all secondary schools in Düsseldorf exchanged views on their ideas and expectations concerning a regular dialogue.

How these should be translated into practice will be discussed in further talks.

One thing is already clear, for both Henkel and the school heads: the schoolchildren should participate actively in this dialogue.

### **Brazil - environmental protection initiatives**

### **Tree nursery on factory site**

Henkel's Brazilian subsidiary Henkel S.A. Indústrias Químicas in Jacarei produces basic chemicals for the detergent, cosmetic, textile and leather industries as well as adhesives and auxiliaries for the plastic, paint and dye industries. In addition, it will soon be producing seeds and seedlings.

To be more precise, they will be produced by the 860 trees which were recently planted on a large area of greenery on the factory lot.

With these seeds and seedlings the company wants to restore the rich variety of vegetation in a region in which mankind has destroyed the original flora.

Moreover, this should help to provide long-term protection for the strongly eroded areas.

The Henkel subsidiary regards this as a contribution to maintaining [native](#) plant and animal life, in line with the [Business Charter for Sustainable Development](#).

Henkel is cooperating with the power utility Companhia Energética de São Paulo (CESP) on this project.

The Brazilian power utility supports numerous projects aimed at saving the environment: by generating energy from water power, by protecting the indigenous fauna and flora and by restoring ecological systems.

In future, CESP will receive seeds and seedlings from Henkel for afforestation, which will be given free of charge to environmental initiatives.

All trees planted by Henkel on the factory lot in Jacarei are [native](#) species: fruit trees and hardwoods, as well as trees which mainly benefit bees.

## Products

In line with our commitment to [Responsible Care®](#) we monitor the whole life cycle of our products - [from the cradle to the grave](#). We consistently apply the concept of product stewardship, especially when we develop new and innovative products. These products must provide our customers with a special benefit, especially in respect of their environmental compatibility.

Megaperls® even more [environmentally compatible](#)

### All-round power

Small, heavy and round - Megaperls stand for a new generation of compact detergents. Even their pearl-like appearance distinguishes them from conventional powdered detergents and other compact powders. And they soon show what they are capable of when they have to: just small amounts of Megaperls yield top results -

not only for laundry but also for the environment. Because less detergent means less wastewater pollution.

### **A new production process for detergents**

In the early 1990s, Henkel decided to improve the efficiency of its detergents by introducing a completely new manufacturing process and simultaneously reducing the detergent dosage. Henkel was the first manufacturer to succeed in using an [extrusion](#) process to compress detergent raw materials into pearls at high pressure. In February 1996, Henkel rewarded the development team for this achievement by awarding it the "Fritz Henkel Award for Innovation."

The packaging of Megaperls also illustrates that "[less is more](#)" (see Environment Report 1995). Less packaging means savings in energy and raw materials, not only for the production of the packaging material but also for the subsequent transportation of the handy cartons and refills.

The small pearls were first marketed in 1992, in Austria, Switzerland and the Benelux countries. They were subsequently introduced in Spain in 1993, Italy and Germany in 1994, and France in 1995. Megaperls have steadily increased their market share and were soon made even more efficient and [environmentally compatible](#). This was done by improving the formulation. In Germany, for example, the detergent experts increased the proportion of [surfactants](#) derived from renewable raw materials and introduced additional special stain removers such as the enzyme [amylase](#). This means that high temperatures are no longer needed to achieve good washing results, because [enzymes](#) and other stain removers can now eliminate grease at 30 or 40 degrees Celsius. This helps to save water and electricity.

### **Other detergents in the form of Megaperls**

The success of Persil Megaperls confirmed that the product developers were [on the right track](#). The process was developed still further and in the spring of 1996 Henkel started to use it to produce two other well-known Henkel detergent brands for the German market as well as a number of Henkel brands for other European countries, e.g. the Netherlands, Switzerland, Austria. One thing is clear: these powerful pearls have promising prospects.

### **New [inhibitors](#) for the mining industry**



## Innovative scale products

Henkel places a high value on teamwork - and not just within its own ranks. Cooperation between suppliers, customers and Henkel experts is gaining in importance, especially where protection of the environment is concerned. The latest example concerns the mining industry, which uses water treatment products supplied by Henkel COGNIS GmbH. Together with a supplier of raw materials and a customer, Henkel developed a specialty: a scale inhibitor with much better environmental properties than conventional products. Mining operations extract more than just mineral resources such as coal and ores. Where there is mining there is also pit water, which is pumped to the surface and discharged without further treatment into surface waters.

## Dedicated search for alternative products

The water comes from various levels and therefore contains a variety of dissolved substances. It is mixed and collected underground, which sometimes results in the formation of poorly soluble precipitates, e.g. [barium sulfate](#). In the long term these precipitates slowly but surely block the rising pipes and pumps. Installing new pipes and pumps underground would be a costly and time-consuming process.

Scale [inhibitors](#) based on organic phosphorus compounds are added to the pit water to inhibit the precipitation of poorly soluble substances such as [barium sulfate](#). These [inhibitors](#) are, however, pumped to the surface with the water and are therefore discharged with it into surface waters. The poor biodegradability and the phosphorus content of the [inhibitors](#) make them a burden on the environment. On the other hand the volumes of water involved are very large and the concentration of [inhibitors](#) is very small, and any form of purification treatment would therefore not be economically feasible for the mine operators.

The new scale inhibitor from Henkel COGNIS solves this problem. Based on a polypeptide, it inhibits precipitation, is readily biodegradable, contains no phosphorus or dangerous substances, and is assigned to water pollutant class zero in terms of German classification, i.e. the least dangerous category.

The product is the result of a dedicated search for a new alternative product unlike anything already on the market. This is why Henkel's specialists got together with one of their most established suppliers of raw materials and developed a new active

agent. They increased its efficiency and gradually improved its degradability until they had a made-to-measure alternative substance which was based on [polypeptides](#). Ecological studies confirmed the good result, and the responsible supervisory agency soon licensed the new product for use.

### **Practical tests in the mine**

Practical tests of the new product in a mine posed no problems. The third member of the triple alliance, Ruhrkohle Bergbau AG, a strong advocate of the use of a rapidly biodegradable active agent, is currently testing the new inhibitor in a pilot project. The unanimous opinion of the experts: the product is just as effective and safe as conventional phosphorus-based [inhibitors](#), but much kinder to the environment.

### **Oleochemical [combing lubricants](#) for wool**

#### **A smooth spin**

Wool sheared from a sheep is unfortunately not very clean. This is why it is so difficult to turn it into combed yarn for men's and women's outerwear. Wool can contain burrs, food residues, straw, animal droppings and any amount of sand, dust and suint salts - foreign substances which have to be removed before the wool can be processed.

The first step is to wash the wool, reducing its volume by about 50 percent. Unfortunately this also brings about a considerable change in the frictional properties of the wool fibers. This is hardly surprising, because washing also removes substances from the fibers themselves to a large degree, especially waxes and fats.

#### **Wool flocks sprayed with combing lubricants**

The absence of waxes and fats would have a negative impact during processing. Wool which is not smooth and supple cannot cope with the stresses of mechanical spinning on very fast machinery. The staple length, i.e. the average length of the individual fibers, would become shorter. And because short fibers cannot be used for the spinning process they would be rejected.

In order to prevent this the wool flocks are sprayed with [combing lubricants](#). This overspraying has a significant effect on the frictional properties and staple length of

the wool, and therefore on the amount of combing waste. Products derived from petroleum were once used for this essential processing stage. They performed their task very efficiently but had one serious disadvantage: they were poorly biodegradable, so when the finished yarn was washed they polluted the wastewater.

### **Technical and ecological advantages**

Henkel prefers to use [combing lubricants](#) derived from [oleochemicals](#). They are made from renewable raw materials and are rapidly biodegradable. Moreover they are technically superior to petroleum-based products.

Oleochemical [combing lubricants](#) are now in demand in Germany and other countries, and Henkel is the market leader. The products are manufactured not only in Düsseldorf but also by Henkel subsidiaries in Meaux (France), Jacarei (Brazil) and Broadmeadows (Australia).

Henkel works closely together with the Australian wool research institute.

The objective is always to process wool in such a way that high quality woolen fabric can be produced with the smallest possible amount of waste and environmental pollution. The oleochemically based products have brought this objective a lot closer.

### **Trend to functional packaging continues**

#### **Less is more**

##### [\(A new production process for detergents\)](#)

When an artist like Christo packages a building, a bridge or an island he doesn't worry about how much material he uses. Henkel's packaging developers have to take a different view of their work: the less covering, the better. Because less is more from an environmental point of view. Take detergent refills for example. They help to save large amounts of packaging material.

#### **Laminated film refills**

Since 1993 Henkel has supplied detergent refill pouches made from paper which weighs about 160 grams per square meter. After all, paper is generally assumed to be more [environmentally compatible](#) than plastic film. However, this assumption is not always correct. The eco balance reveals that, in this particular case, the

manufacture of plastic refill pouches is much more [environmentally compatible](#), because it results in fewer [emissions](#) into the atmosphere and surface waters. However, this is not the only reason why Henkel switched to [polyethylene](#) and [polypropylene](#) laminated films last year. These films use less material (they only weigh 130 grams per square meter), and they tear less easily, making them more reliable than their paper predecessors.

Henkel's specialists have also developed a form of packaging which will reduce transport packagings by about half. Refill pouches were previously packed in a tray, with a further inverted tray on top of them to facilitate their transportation. Now the top flaps of the refill pouch are folded over and glued down, giving the package a flat top. The inverted tray is no longer needed, because a second layer can simply be placed on top of the first.

### **"Prakti" packs for dishwasher cleaner tabs**

The experts have also succeeded in making considerable savings in the packaging of dishwasher cleaner tabs. A defined number of tabs were previously poured into a cardboard folding box. The tabs fell at random and therefore took up more space than strictly necessary.

Since January 1996 this excess space has been abolished. With the help of new filling machinery the cleaner tabs are arranged in layers in the box. The ecological advantage of the so-called "Prakti" pack: the amount of cardboard needed has been almost halved (42 percent reduction). The cardboard contains at least 80 percent wastepaper, can be laid flat in any paper container, and can be easily reutilized.

### **More boxes per pallet**

Less volume means more boxes per transportation pallet. Depending on the size of the box, over 40 percent more product can be accommodated. This means less trips, which in turn means savings in energy consumption and fewer [emissions](#).

The improvement is remarkable: energy consumption, atmospheric pollution and water consumption are down by more than 30 percent from the levels for the previous packaging.

Ecological advantages of the "Prakti" pack for dishwasher cleaner tabs	40 tabs	80 tabs
Energy consumption down to	55.7 %	51.6 %
Atmospheric emission down to	59.5 %	55.4 %
Water consumption down to	67.9 %	63.7 %

The standard for comparison is the conventional packaging for 40 or 80 tabs. The reductions in energy and water consumption and atmospheric [emissions](#) relate to the manufacture of the packaging material.

### **New folding box for powdered detergents**

The packaging developers scored a big success with a new folding box for powdered detergents. The two flaps at the sides make a gentle snapping noise as the lid is closed, hence its name: the snap pack.

The real change is the box itself. Conventional packs for powdered detergent consisted of a "box in a box", with an inside frame and a paper covering. Their advantage was that they were stable enough to withstand the stresses of transportation. Their disadvantage was that two components meant more material. Moreover some of the detergent tended to become trapped between the two parts of the box. Not much, but too much for the packaging developers.

### **20 percent less packaging material**

Since early 1996 not even the smallest amount of detergent escapes into the gap. This was achieved at the cost of the inside box, resulting in a reduction of 20 percent in the packaging material used. Nevertheless the snap pack is stable and safely transportable, thanks to its reinforced sides. Because it consists almost exclusively of used paper, and can also be refilled, Henkel's packaging experts regard the snap pack as a practical and ecological step forward.

### **Glue sticks**

#### **New coup with refill cartridges**

When it comes to environmental compatibility, Henkel has led the way for many years. And a small glue stick has been in the forefront from the very beginnings. A torn page in a kindergarten storybook, a schoolchild's work of art made from colored paper, a painted paper heart on a first love letter - when it comes to gluing

paper and board the practical little solvent-free stick has come up tops for more than 25 years.

Most of the children who have become adults in the intervening years still use the [environmentally compatible](#) little stick, only these days they might glue a magazine recipe into a cookbook, a cinema ticket into a book of souvenirs, or simply the flap of an envelope.

The stick has kept up with the times and has slimmed down considerably: in the latest revamp the long protective cap was replaced by a small green model: a 20 gram refill system with a refill case and a refill cartridge. Instead of 16.5 grams of packaging for 20 grams of adhesive (traditional stick), the refill needs only 4.1 grams. This represents a saving of 70 percent plastic compared with the traditional stick. The simple and clean refill procedure is especially impressive.

### **Success and failure of products**

#### **Persistence pays**

When Henkel's product developers conclude a project they know for sure that the new and more [environmentally compatible](#) product will win over even critical consumers. But sometimes the expectations of researchers and developers, applications technologists and marketing experts are only haltingly fulfilled, if at all, because customers simply do not take to the product.

The success or failure of a new, more [environmentally compatible](#) product may be attributable to a number of causes. Sometimes such a product has to be used in a different way to its predecessor because its characteristics have been changed; and sometimes a product needs a number of fresh starts before it becomes a success. If a product is good, user habits can be changed in the long term. For example: water-based Thomsit products such as carpet adhesive are gaining in popularity. Their sales, expressed as a proportion of the sales of solvent-based products, have risen from 30 percent in 1980 to more than 80 percent today.

#### **Silicone emulsion for impregnating facades**

A water-based facade impregnation compound suffered a different fate. Despite its user-friendly properties it failed to establish itself in the market. The reason: it was more expensive than solvent-containing impregnation compounds.

Henkel's experts refused to be discouraged. They turned the product "upside down" and developed a stable, reactive silicone [emulsion](#) with convincing advantages: it is available as a concentrate and is, depending on the circumstances, diluted with water and applied with a brush or a garden spray. There is no need to put protective covers over windows and doors, because the impregnating compound can simply be washed off with water. The brushes, spray, etc. can also be cleaned with water after use. This saves time and money.

Moreover the more [environmentally compatible](#) product, which has been available since early 1995, is no longer more expensive than its conventional, solvent-containing rivals. The consumers still need to gain experience with water-based contact adhesives. The product has been marketed since mid-1995.

### **Product characteristics are not easily transferable**

In this case it is clear that product characteristics are not always easily transferrable. The water-based contact adhesive has different properties and has to be used more carefully than its solvent-containing predecessor.

Henkel's specialists are also using their powers of persuasion on behalf of an adhesive for wall coverings which has been on the market for many years. It has undergone a considerable change - not in quality but in appearance.

Instead of being supplied in ready-to-use form in buckets, since 1994 it has been available as a concentrate in 200, 1,000 and 2,500 gram packs. The concentrate can be mixed with water to produce five times its volume of ready-to-use adhesive (see Environment Report 1995).

On first sight the new (old) product incorporates a number of advantages: less packaging is needed, so less energy is needed for production and transport, and less waste is generated. Even the price of the [dispersion](#) adhesive in the pack is 10 percent lower than that of its predecessor in a bucket, but consumer behavior is proving slow to change. And this is why marketing specialists and field staff are working hard to overcome set habits.

Lubricants and hydraulic oils produced from [native esters](#) are also proving slow to establish themselves in the German and the central and northern European markets. In Germany the technical, ecological and toxicological demands made on the products are defined in the "Blue Angel" environment symbol for fats and hydraulic

oils. Henkel's experts anticipate a significant surge of interest in the market if the Federal German Government is able to push through a catalogue of measures, for example a ban on so-called total loss lubricants which are not rapidly biodegradable, in environmentally sensitive areas such as water protection zones.

This will open the door for Henkel's [esters](#) and other oleochemical [derivatives](#). Many lubricant manufacturers will now follow the trend and include these products in their sales program. The experience gathered by Henkel (see Environment Report 1995) will enable it to put forward persuasive arguments.

Nevertheless, some new developments have not yet been a success. One such is the inexpensive paper refill pouch for Henkel rapid anchoring and fixing cement mortars. This has been available since 1993 to help customers cut down on the mountains of plastic buckets, but not even the lower price has persuaded them to switch. Henkel knows that it cannot simply give up; one day customers may be won over by the benefits of more [environmentally compatible](#) packaging.

**Look, touch, try**

### **Milestones on the computer**

While the Henkel film "Washing phenomena" appeared on the monitor the computer described the Group's environmental activities during the last 40 years: this example of environmental protection as an educational game could be viewed and tested last year in ten German cities at the traveling exhibition "Environmental protection made in Germany." In cooperation with the German Ministries of the Environment and Economics and the Federal German Environmental Agency, Henkel and twelve other large German companies presented their innovations and strategies for environmental protection with products and other demonstration material to look at, touch and try out. The Group's Brazilian subsidiary Henkel S.A. Indústrias Químicas also presented a Portuguese version of the computerized "Milestones in the history of environmental protection at Henkel" (see Environment Report 1995) at the German-Brazilian commercial trade fair FEBRAL '95 in São Paulo. A PC version is now also available in English, and a CD-ROM with all three language versions is currently being prepared.



# Production

A conserving approach to resources, the minimization of [emissions](#) and wastes, and the safe and trouble-free operation of our plant and machinery: these are the key demands we make on our production processes - throughout the whole world. Environmental audits and risk analyses help us to systematically spot and eliminate any weak points.

**New APG plant in Düsseldorf**

## Laboratory curiosity steps into the limelight

When chemists discovered the first [alkyl polyglycosides](#) (APGs) in 1893 it did not take them long to find out that these products of carbohydrates and vegetable oils exhibited unexpectedly good surfactant properties. At that time, however, no one realized that APGs could be used for a wide variety of applications. Consequently [alkyl polyglycosides](#) were quietly confined to the archives as a laboratory curiosity.

## New interest in familiar chemicals

A century later Henkel rescued them from oblivion, not quietly but in the full glare of publicity. Because this new generation of [surfactants](#) based on renewable raw materials completely satisfies the increasingly stringent ecological demands made on products in our modern world.

APGs are characterized above all by their excellent environmental compatibility. They are readily and completely biodegradable.

And because alkyl polyglycoside [surfactants](#) reinforce the action of other washing active agents, they can be used to reduce the total amounts of [surfactants](#) in, for example, rinsing and cleaning agents. Demand for APGs is now so great that Henkel's second production plant came on line in the Düsseldorf parent plant in April 1995. With the help of Henkel Corporation's plant in Cincinnati, Ohio (which came on line in 1992), the Group can now produce 46,000 tons of APGs per year.

The American and German plants make use of a solvent-free process to produce a variety of alkyl polyglycoside types from [glucose](#), which is obtained from corn starch or wheat and [fatty alcohols](#) based on coconut oil or palm kernel oil. The plants exhibit all the characteristics of state-of-the-art chemical production: they are sparing in their

consumption of energy and raw materials, and they generate scarcely any residual substances. Sophisticated systems are in place to reduce atmospheric [emissions](#) and wastewater pollution. Most of the waste gases are incinerated in the boiler unit. The new Düsseldorf APG plant was not only planned and built in a record time of 24 months but was also approved in record time. Thanks to the close cooperation between official agencies and Henkel's technical departments in Düsseldorf, the licensing procedure for the new plant was completed in just under 6 months. Although the plants in Cincinnati and Düsseldorf are based on the same processes, they are not the same. The plan of the Cincinnati plant was optimized and then adapted to the Düsseldorf site. Specialists from the USA supported the German project team during the construction of the APG plant in Düsseldorf. The first test runs were carried out successfully, producing high quality APG, two months before the plant came on line. The specialists are not resting on their laurels but are now searching for new applications and new ways of optimizing the process. Because yesterday's laboratory curiosity is expected to have a bright future.

**APGs undergo rapid and complete biodegradation**

## **Comprehensive ecological safety assessment**

[Surfactants](#) from detergents, cleaning agents and toiletries usually find their way into wastewater after use. It is therefore important that they should be readily and completely biodegradable, even in the absence of atmospheric oxygen, as is the case in the digester of a sewage treatment plant. Otherwise there is a danger that the [surfactants](#) might enter the environment and, in high concentrations, could have a toxic effect on living organisms.

[Alkyl polyglycosides](#) (APGs) satisfy all the demands made on [environmentally compatible surfactants](#) in our modern world. This has been demonstrated in comprehensive studies carried out by Henkel's ecologists. With the help of internationally recognized test and analysis procedures the experts monitored not only the primary degradation of the APGs but also their final degradation, which is of crucial importance for their long-term effects on the environment.

The degradation studies included screening tests. These are simple but stringent tests which provide conclusive results concerning a substance's effects on the environment. The results were good. APGs are readily biodegradable. Primary degradation of more than 99 percent was measured under realistic conditions in the sewage treatment plant simulation test. About 90 percent of the organic APG compounds were degraded to [carbon dioxide](#) and biomass and therefore returned to the natural material cycle at the sewage treatment plant stage. Nevertheless, this recognized test program was not enough for Henkel. In further complex studies the experts were able to demonstrate that the [surfactants](#) do indeed undergo complete ultimate degradation. This means that no stable intermediate products (metabolites) are produced and that the degradation also proceeds under conditions in which there is no oxygen for the bacteria to use, for example in sewage treatment plant digesters or the sediments of strongly contaminated bodies of water. A test which was developed by Henkel is now used throughout Europe for these studies under [anaerobic](#) conditions. This is the so-called ECETOC Screening Test. APGs also passed these tests. APGs are so [environmentally compatible](#) that the German "Commission for evaluating water pollutants" was able to assign them to the second lowest [water pollution class](#) (class 1). They were the first [surfactants](#) ever to achieve this distinction.

### [Alkyl polyglycosides](#) and their applications

#### From A to Z

Not only do [alkyl polyglycosides](#) (APGs) exhibit excellent technical properties, they also improve the effectiveness of certain other [surfactants](#). This synergetic effect makes them ideal for use in detergents, dishwashing agents, cleaning agents, and cosmetic preparations. They can replace or can be added to most of the petroleum-based [surfactants](#) which are currently in use.

In Germany, half of all [alkyl polyglycosides](#) are used in dishwashing agents, but they also reinforce the action of all-purpose cleaners and glass cleaners, liquid detergents, and industrial cleaners. Other fields of application include gypsum foaming agents, metal cleaners, fire extinguishing foam, shower gels, hair care products, and toothpastes.

In the USA, APGs are already used in more than 80 toiletry products. And the [surfactants](#) based on renewable raw materials are also imparting increasingly better properties to American dishwashing and cleaning agents.

Less [nitrogen oxides](#) from [water glass](#) production

## Crystal clear

[Water glass](#) is one of the oldest Henkel products and is now mainly used as a raw material for [precipitated silica](#), for detergents, and in the manufacture of the phosphate substitute zeolite A (its Henkel brand name is Sasil).

Henkel has produced [water glass](#) since 1884, and at the Düsseldorf parent plant since 1900. [Emissions](#) of dust and [nitrogen oxides](#) used to be an unavoidable accompaniment to the process of manufacturing this unusually versatile product.

## Henkel experts modify the process

Nowadays dust [emissions](#) are no longer a problem. They were reduced by more than 80 percent by the electrofilters which Henkel installed between 1985 and 1987 (see [Dust and nitrogen oxide emissions from water glass production](#)).

From 1996 the nitrogen oxide [emissions](#) from the [water glass](#) factory will also be considerably reduced by a new plant which was installed in the previous year.

"It is planned to reduce the nitrogen oxide [emissions](#) from all [water glass](#) furnaces in future by means of [noncatalytic](#) secondary measures. The preliminary tests have already been concluded." This statement appeared in Environment Report 1993.

At that time the necessary official approval procedures were already under way for modifying the [water glass](#) furnaces, in which pure quartz sand and soda (sodium carbonate) are melted at temperatures of 1200 degrees Celsius to form [water glass](#). The melting furnaces work on the so-called regenerative principle. The combustion air is passed through an ingenious system of pipes in such a way that the energy of the hot waste gases can be reused.

However, the high temperatures cause the nitrogen in the combustion air and the residual oxygen to combine to form nitrogen oxide and nitrogen dioxide.

Tests aimed at preventing the formation of nitrogen oxide by primary measures were only partly successful. The target reduction rates could not be achieved. The use of

catalysts as a secondary measure - catalysts are frequently used in industry to convert [nitrogen oxides](#) - was never a feasible option for Henkel: the temperatures needed for the reaction to proceed are only present in the waste gas before it reaches the dedusting stage, when the high dust content would quickly deactivate the catalysts, thus preventing them from achieving their purpose.

Henkel decided to make use of the SNCR process (selective [noncatalytic](#) reduction). The basic principle is simple: an ammonia solution is sprayed into the waste gas at temperatures of 900 to 1100 degrees Celsius. Ammonia reacts with [nitrogen oxides](#) to form two substances which are also present in the atmosphere: water vapor and nitrogen. In a research project, which received the financial support of the Federal German Ministry for Research and Technology, the suitability of the process for the [water glass](#) melting furnaces was thoroughly tested.

### **Long test series achieve nitrogen oxide reduction**

Long test series were carried out over a whole year with the aim of determining the maximum reduction in [nitrogen oxides](#) under various operating conditions. For example the spray nozzles and their configuration in the regenerative chamber of the melting furnaces were systematically adjusted.

When it had been demonstrated that the SNCR process could bring about a reduction of the order of 50 percent in nitrogen oxide [emissions](#) without damaging the refractory bricks of the regenerative chamber the decision was soon made: the SNCR process would be installed in the [water glass](#) furnaces.

Henkel submitted the approval documents to the local Environment Agency in 1992. They contained all safety and technical data on the storage and injection of the ammonia solution. In 1994 the Agency gave its approval for the modification work to be carried out.

The first furnaces operated in test mode from December 1995, and an independent institute carried out measurements in the plant until April 1996 in order to determine the extent to which nitrogen oxide [emissions](#) could be reduced. Since the spring of 1996 the nitrogen oxide reduction system of the [water glass](#) production line has been in continuous operation.

## Wide range of applications

### Versatile water glass

[Water glass](#) is today used in large amounts in the production of silicic acid and silica gel. These in turn are employed in the production of paints and rubbers, as thickening agents in toothpastes and in textile dyeing processes.

The list of possible uses of [water glass](#), of which Henkel produced 587,000 tons last year alone, is much longer.

It is a component of many products which are used industrially and commercially but also in the home. [Water glass](#) seals landfills, is added to concrete and helps in the recycling of wastepaper.

It is a binder in long-life mineral paints and adhesives for core winding. It is indispensable for the production of visual display units and welding electrodes. And in laundering it not only ensures that the laundry is clean but also protects the washing machine against corrosion.

### New unit separates air

### In-house production

In days gone by, Linde used to send an average of three tankers from Duisburg to Düsseldorf. The tankers contained an extremely cold load: liquid nitrogen at 160 to 180 degrees Celsius below zero, intended for the Düsseldorf parent plant and classified as a dangerous substance. These journeys are no longer needed, because in 1996 Henkel took into operation its own unit for separating air into its individual components by means of the proven Linde process. Nitrogen is one of these components.

Henkel uses nitrogen in many production processes as a protective gas, because it has one special property: it is extremely unreactive. For this reason it is used wherever oxygen has to be kept out of contact with sensitive and reactive substances. It enables production processes to be carried out which would otherwise be disrupted by the reactive oxygen or moisture in the air.

The steadily increasing demand for the protective gas, the cost advantages and the reduction in [emissions](#) due to the elimination of the daily haulages were further good reasons which persuaded Henkel to build an air-separation unit on its premises.

Furthermore, the process requires less energy, because the nitrogen no longer has to be fully liquefied for transportation, as was previously the case.

Henkel had no wish to terminate its relationship with Linde: the Duisburg company operates the new unit and guarantees that its technology and safety are kept up to date.

### **Air-separation unit**

#### **How the Linde process works**

Engineer Carl von Linde's process for liquefying air, which he developed as long ago as 1895, is based on an effect which was first described by the English physicists James Prescott Joule (1818-1889) and William Thomson, later Lord Kelvin (1824-1907). They recognized that strongly compressed gases underwent considerable cooling when they were allowed to expand. In the Linde process, air is compressed to 6 bar. As in a bicycle pump, this generates heat. The heated, compressed air is cooled and then allowed to expand. This causes it to cool still further. If this sequence is repeated often enough the air eventually liquefies.

Liquid air, a thin, pale blue fluid, can be separated into its individual components by passing it through an evaporator.

Air consists of nitrogen (78 percent), oxygen (about 21 percent) and the inert gases neon, argon, krypton and xenon, together with [carbon dioxide](#) and hydrogen, which account for the remaining 1 percent.

### **Tank farm in Fino Mornasco modernized**

#### **Four safety systems**

Henkel Chimica's [ethylene oxide](#) tank farm in the small Italian town of Fino Mornasco, to the south of Como, would probably have functioned perfectly well for many more years. The raw material for [surfactants](#), which was kept there before it was needed for processing, was safe. This was confirmed by a Group-wide risk analysis. Besides Fino Mornasco, another 55 facilities at 23 other locations were included in this safety study (see Environment Report 1995).

### **Planning and implementation in record time**

However, the safety study did draw attention to the fact that not everything in a 30 year-old plant can be completely up to date. This had to be changed. With an eye to the future the Group decided not to make a lot of small changes but elected voluntarily to go for the most comprehensive solution - a thorough modernization of the tank farm.

In record time - only 6 months for the planning and 10 weeks for the implementation - a German-Italian project team erected a new tank farm and fitted it into the existing building. Not only the tank farm is new - so is the extended safety concept that underpins it.

### **Risks are kept to a minimum**

Safety considerations are more central than ever in Fino Mornasco. Henkel Chimica chose a concept which incorporates four protective systems. In this way risks are kept to a minimum, even if a number of operational accidents should occur at one time, each of them potentially critical in itself.

- System 1 is a double shell for each of the three differently sized tanks. This has a cooling function and is surrounded by a 30 cm thick fireproof insulating layer. A number of thick concrete basins prevent [emissions](#) from getting into the soil.
- System 2 incorporates gas detectors. These react automatically to even the tiniest of leaks and signal the alarm, causing all valves to be automatically closed.
- System 3 consists of sprinklers to damp down any clouds of gas which may escape.
- System 4 is the low storage temperatures ([ethylene oxide](#) undergoes polymerization at high temperatures).

And in the process, the Italians also renovated the asbestos-cement roof and replaced ageing pipelines. Now everything possible has been done to ensure the all-round technical safety of the tank farm.

### **[Thermal utilization](#) of wastes**



## Generating energy by incineration

When Henkel's power plant engineers report that they save some 17 million [coal units](#) each year by burning wastes instead of finite fossil fuels such as petroleum or coal, they can be certain that the experts will nod their approval. The man in the street may find this puzzling. After all, he is familiar with grams, kilometers and liters, but what is a [coal unit](#)? In fact 17 million [coal units](#) represent a lot of energy: the equivalent of a freight train 6,000 meters long, carrying 17,000 tons of coal in 570 freight cars!

As many as 23 different types of waste which are generated in the Düsseldorf parent plant and Henkel's German subsidiaries are burned to produce energy ([thermal utilization](#)). They will be joined by a further 16 types of waste in the coming months. Before Henkel could use these substances as power plant fuel it had to carry out numerous gas analyses, which then formed the basis for a comprehensive approval procedure.

Most of the liquid wastes which are used instead of fossil fuels are generated in oleochemical production lines. They used to be mixed with sawdust and then burned in Düsseldorf's municipal waste incineration plant.

The sawdust was added in Henkel's residual substances center to "firm up" the liquids. The fact that this increased the volume of waste had to be accepted.

The thermal energy of the wastes could only be partially utilized in the municipal plant. This is not the case in Henkel's power plant, where almost all the energy contained in the wastes can be exploited because it operates on the principle of [heat-and-power cogeneration](#).

Because the wastes are incinerated at Henkel's own site, they no longer need to be transported by road to the municipal plant. This means less vehicle [emissions](#), less traffic on the roads, and considerable savings in fuel.

### [Heat-and-power cogeneration](#)

## Power plant with 87 percent energy utilization factor

Henkel has generated its own heat and electricity at its Düsseldorf parent plant since the late 1930s. Because Henkel uses heat and electricity simultaneously, they were coupled. Steam is heated in a boiler until it is at a pressure of, for example, 40 bar.

This compressed steam then passes into a turbine, where it expands until it reaches the necessary operating pressure of 4 bar and is used as thermal energy in production and for heating. Generators convert the work performed by the turbine into electricity. This combined heat and power system is especially effective if lots of heat and electricity are used uniformly throughout the year. However, in summer less heat is needed than in winter, and in the past Henkel therefore often had to buy in electricity during the summer and feed its excess electricity into the public grid during the winter.

Technical improvements enabled this climatic dependency to be abolished in 1990: a gas turbine installed upstream of the self-fired high-pressure steam boiler generates electricity independently of the amount of steam being used. The gas turbine draws in air and compresses it. Natural gas is mixed with this air and the mixture is then burned. The mixture subsequently expands and electricity is generated. At the same time the hot waste gases from this process are fed into the steam boiler, where they are used to generate steam and electricity. This technology has an energy utilization factor of 87 percent, depending on demand.

Without cogeneration the maximum which could be achieved would be 63 percent.

## **Wastewater purification in Spain**

### **Multi-phase efficiency**

The requirements of the Spanish authorities in Barcelona were clear: the [organic substances](#) in wastewater had to be reduced by at least 60 percent and the remaining substances had to be readily biodegradable. The reaction of Pulcra, a subsidiary of Henkel Ibérica, was just as clear. After a short period of deliberation the experts at Henkel Ibérica and in Düsseldorf agreed on a procedure which is both effective and cost efficient: multi-phase physico-chemical purification with so-called [dissolved air flotation](#).

The organic components of Pulcra's wastewater include oil and fat residues as well as [surfactants](#), which enter the wastewater during the production of raw materials for detergents, cosmetics, toiletries and leather and textile auxiliaries.

The wastewater was previously collected, neutralized, separated from free oils and fats, and discharged into the municipal main sewer. This form of disposal reached its limits in 1995. On the one hand, increased production volumes were resulting in

increased volumes of pollutants in the wastewater, while on the other, environmental legislation was becoming much stricter. The fact that the organic load of Henkel Ibérica's wastewater is now well below the legal maximum, so that it can be discharged into the municipal main sewer, is attributable to the multi-phase physico-chemical purification which it undergoes. Before this process could work efficiently the capacity of the equalization tanks at the Pulcra plant had to be expanded to allow the various wastewater streams to be properly mixed.

Iron salts and milk of lime are added to cause the emulsified or dispersed substances in the water to flocculate.

In the subsequent solid/liquid separation - referred to as [dissolved air flotation](#) - air is passed into the water.

The air bubbles attach themselves to the sludge flocs, causing them to rise to the surface, where they are removed.

The residual clear water flows into the sewers together with water from sanitary facilities and rain water.

The new plant has been in operation since September 1995. All those involved are satisfied: the authorities because their demands have been met, and the management of Pulcra because the company can comply with the limiting values even though the wastewater load at the site is increasing.

## **Wastewater treatment in Italy**

### **Long search bears fruit**

Just as in Spain, the management of Henkel S.p.A. in the Italian town of Fino Mornasco, south of Como, needed a process for removing [organic substances](#) - above all anionic and [nonionic surfactants](#) - from its wastewater. It had been looking for a solution to this problem since 1993 because there was a danger that the town's municipal sewage treatment plant, into which the works' wastewater ultimately flows, would not be able to guarantee that it could comply with the limiting values for wastewater pollution.

In order to determine the most economical process, a variety of chemico-physical purification methods were comprehensively studied in the laboratory and a biological method was subjected to a three-month trial in a test plant. Although a chemico-physical method yielded good results and less investment would have been needed

to construct a suitable plant, it was rejected as a sole treatment method. In Italy the costs of sludge disposal are very high and any initial financial benefit would therefore soon have been eroded.

### **Thorough purification in three stages**

The experts opted for a biological purification process. This consists of a two-part aeration tank and a connected final clarifier. Membrane aerators provide the bacteria in the 600 cubic meter aeration tank with the air they need to biodegrade the [organic substances](#). In the clarifying stage the bacteria are separated from the clear, purified wastewater by [sedimentation](#).

Most of the separated activated sludge is returned to the aeration tanks. The excess is dewatered in a filter press and disposed of by landfilling. The clarified water is subsequently channeled into the municipal sewage treatment plant. There is no possibility that biocidal or poorly biodegradable substances can enter the biological purification tanks, because they are eliminated by a preliminary chemical treatment. On cost grounds this chemical treatment is only carried out if needed.

Since January 1996 the new system has been able to purify about 400 cubic meters of waste-water each day.

The operating results show that the objectives set by Henkel S.p.A. have been achieved: a considerable reduction in the burden on the municipal sewage treatment plant without any impairment of production flexibility.

### **French sewage treatment plant successfully extended**

#### **Drastic reduction in COD**

In 1994 Henkel's French subsidiary Sidobre-Sinnova in Meaux (40 kilometers east of Paris) extended its biological sewage treatment plant, which had originally been built in 1981 (see Environment Report 1995). Almost 18 months later the plant's figures show an impressive improvement.

## **Residual organic load reduced by 75 percent**

During this period, the residual organic load discharged into the Marne was reduced by 75 percent to 60 kilograms per day. This corresponds to a [chemical oxygen demand \(COD\)](#) of 200 kilograms per day (see chart).

This was brought about not only by the sewage treatment plant, whose efficiency in degrading the [organic substances](#) present in wastewater has increased to 95 percent since the second biological stage was taken into operation, but also by a considerable reduction in water consumption.

This is attributable to the efforts of employees, who are very aware of the need to conserve resources, and the introduction of closed cooling cycles and other technical improvements which have reduced the demand for fresh and process water.

## **Water consumption reduced by a quarter**

Anyone who thinks that only major changes can have a beneficial effect on the environment should study the example of Henkel S.A. Indústrias Químicas in Jacarei (Brazil), where a lot of small measures have been implemented to save a lot of water. Inventive employees improved production processes and modified purification procedures, e.g. for reactors, so that the plant now needs much less water. In addition the employees recognized that wastewater from the gas scrubber of the sulfonation plant could be fed back into the plant's production cycle rather than discharged.

## **25 percent less water consumption**

As a result of these and similar steps, Henkel S.A. Indústrias Químicas in Jacarei used a quarter less water in 1995 than in the previous year.

Another big step toward the preservation of natural resources.

**American Environmental Protection Agency honors Henkel Corporation**

## Environment award for dedicated team

Dedicated but voluntary commitment to solving major problems deserves its reward. In 1995, in New York, Henkel Corporation was honored with the Environmental Champion Award of the American Environmental Protection Agency for its significant reduction of environmental pollution.

### Emissions reduced by half

The prize is part of the American government's nationwide 33/50 program. The 33 and 50 stand for the targets set by the Environmental Protection Agency for 1,300 companies, who voluntarily took up the challenge to reduce [emissions](#) of 17 environmentally polluting substances such as [heavy metals](#) and [chlorinated hydrocarbons](#) by 33 percent between 1988 and 1992 and 50 percent by 1995. The Henkel Corporation companies, which only emit eight of the 17 substances, achieved their objective: by 1995 they had reduced their [emissions](#) by more than half. A comparison of the individual subsidiaries shows that the plant in Charlotte, North Carolina, has been the most successful.

In Charlotte, Henkel produces specialty chemicals for the textile and paper industries. One of the waste substances is the organic compound [toluene](#). Since this has been recycled or thermally utilized, [emissions](#) have been reduced by 72 percent.

These good results were facilitated by the close cooperation between employees from Charlotte and the other Henkel Corporation companies, where safety, health and environmental protection are given high priority.

The successes are a further token of Henkel's commitment to the [Responsible Care®](#) initiative of the chemical industry worldwide.

Of all the companies which took part in the American government's program, only 20 were designated Environmental Champions. At the award ceremony, Vice President Al Gore emphasized that industry and federal government could work together to protect public health and safety without additional burdensome regulations; the success of the program has very clearly demonstrated this.

## Henkel Corporation cuts waste mountains

### Recycling made in the USA

How can we use less raw materials in our production processes? The employees of the Henkel Group's U.S. subsidiary Henkel Corporation at the Los Angeles (California), Cedartown (Georgia) and Mauldin (South Carolina) production sites are always on the lookout for new ways of achieving this objective. Their commitment to avoiding, reducing and recycling wastes is a fine illustration of their steadily developing environmental awareness.

#### Californian Waste Reduction Award

In 1994, the 100 Emery Group employees at the Los Angeles plant, where oleochemical products are manufactured, started to recycle wastepaper. One year later not only 1.5 tons of paper but also 2.25 tons of cardboard, 2.5 tons of wood, 17 tons of scrap metal and 454 kilograms of glass had been recycled. That is 220 kilograms of waste per employee. The employees' efforts did not go unnoticed, and in 1995 the company was conferred the Californian Waste Reduction Award.

The 120 Henkel employees in Cedartown, a small town near Atlanta, also ensure that waste materials such as paper, glass, wood, plastics, cardboard and aluminum cans are processed and recycled. The same applies for oil and [methanol](#), which accumulates during the production process. In this way the amount of waste was reduced by nine percent in comparison with the previous year in Cedartown, where organic products are manufactured.

The emphasis at Henkel Corporation's Mauldin plant is slightly different. The 95 employees have been asked to avoid creating waste. In order to achieve this objective the plant, where oleochemical [derivatives](#) are produced, works closely together with the "Center for Waste Minimization." This government agency advises companies about problems associated with waste. Henkel channels used units such as steel and fiber drums, but also paper, cardboard, plastics and metals, to government supervised recycling companies.

The employees at the Mauldin plant have set themselves another objective for 1996. Despite increased production volumes, the plant aims to reduce its waste by ten

percent. Employee training courses, teamwork and process modifications will help to reach this target.

### **Helping the needy**

### **Recycling for a charitable purpose**

The production sites of Henkel's U.S. subsidiaries in Los Angeles (California) and Cedartown (Georgia) have found a way of allying environmental protection work with the provision of help to those in need. The Emery Group's Los Angeles plant, which has belonged to the Henkel Group since 1989, gives its waste glass to a charitable organization, which sells it and uses the proceeds to finance the distribution of food to the city's homeless. In Cedartown, the money raised by the sale of aluminum, old newspapers and periodicals and cardboard is presented to a non-profit organization, which uses it to support those in need.



## Environmental objectives

### Improved environmental protection and safety in the Henkel Group starts at the individual plants

#### Cincinnati, Ohio, USA

Reduction of atmospheric emissions of organic substances by approximately 50 percent (voluntary participation in Ohio's emission reduction program)	Expected to be achieved by the end of the year 2000
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#### Düsseldorf-Holthausen, Germany

Compilation of a wastewater register for AOX loads	1995 objective achieved
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Reduction of AOX load in plant wastewater to less than 3.5 kilograms per day	By end of 1997
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Reduction of average daily wastewater volume to 11,000 cubic meters	By end of 1997
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Construction of a new emergency management center	Approved by the authorities in October 1995 Completion by end of 1996
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Voluntary fire-protection inspections in 20 percent of all buildings	Implemented in 1995 for the first time Will be carried out annually in future
--	--

Minimization of the amount of substances that can escape during an operational accident	Survey and assessment concluded Schedule of measures drawn up, measures implemented
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Environmental protection courses for 1,600 employees in 1995	1995 objective achieved
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#### Hoboken, New Jersey, USA

Reduction of the amount of anionic surfactants in wastewater by about 80 percent	By end of 1997
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#### Kankakee, Illinois, USA

Reduction of more than 80 percent in atmospheric emissions of organic substances which the US Environmental Protection Agency has categorized as being subject to a monitoring requirement	By end of 1997
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#### Little Island, Cork, Ireland

Reduction of <a href="#">sulfur dioxide emissions</a> by about 40 percent	By end of 1998
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Reduction of <a href="#">nitrogen oxide emissions</a> by about 25 percent	By end of 1998
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Reduction of <a href="#">carbon dioxide emissions</a> by about 25 percent	By end of 1998
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## Mauldin, South Carolina, USA

Reduction of 10 percent in wastes, for example by modifying production processes, despite a planned increase of 30 percent in production By end of 1998

## Environmental data of the Henkel Group

The published data on the Henkel Group relate to [energy consumption](#) (in general the use of fossil sources of energy) and the associated emissions of the greenhouse gas carbon dioxide.

Sulfur dioxide and nitrogen oxides are the main causative agents of acid rain. [Dust emissions](#) are an important parameter for assessing possible nuisance in the vicinity of the production sites. Henkel has not used chlorofluorocarbons, which damage the ozone layer, since 1989. Only a fraction of the chlorinated hydrocarbons which are used escape into the atmosphere, because most industrial plants which use these compounds are fitted with waste gas cleaning systems.

The data in the following five charts represent aggregate values from 31 sites which are of special importance for the Henkel Group. These sites are located in Austria, Belgium, Brazil, France, Germany, Ireland, Italy, Mexico, the Netherlands, Poland, Portugal, Slovenia, Spain, Turkey and the USA.

The data have been collected since 1992 and are representative of the whole Henkel Group. In future even more sites will be included and the environmental indicators will be extended to include waste-water and waste.

### Expenditure on environmental and consumer protection

In-plant environmental protection investments fluctuate widely from one year to the next, depending on the implementation of specific measures.

### Energy consumption

Despite increased production, energy consumption has decreased. This is partly attributable to the construction of new energy production plants with heat-and-power

cogeneration.

### **Sulfur dioxide emissions**

The reduction in sulfur dioxide emissions in 1993 is largely attributable to the coming on line of the new energy production plant at the eastern German site Genthin, which was taken over by the Henkel Group in 1990.

### **Nitrogen oxide emissions**

The reduction in nitrogen oxide emissions in 1993 is largely attributable to the coming on line of the new energy production plant at the eastern German site Genthin, which was taken over by the Henkel Group in 1990.

### **Dust emissions**

The decrease in dust emissions is mainly attributable to dedusting measures at production sites in eastern European countries.

### **Carbon dioxide emissions**

Carbon dioxide emissions have decreased despite an increase in production. The data shown in the chart include carbon dioxide formed during the generation of bought-in, i.e. externally generated, electricity. The amount of such carbon dioxide was estimated with the help of a recognized factor which assumes relatively high carbon dioxide emissions per unit of generated power. Because the Henkel Group's consumption of externally generated power is increasing, the decrease in carbon dioxide emissions does not exactly correspond to the reduction in [energy consumption](#).

## **Consumption of chlorinated hydrocarbons**

The increase outside Germany in 1990 is attributable to the acquisition of new companies, such as the largest British manufacturer of pickling agents, which previously contained chlorinated hydrocarbons. On European markets outside Germany, acceptance of alternative products without chlorinated hydrocarbons has not matched expectations. The increased consumption of chlorinated hydrocarbons since 1994 is attributable to stronger demand from picklers in a number of European countries.

## **Environmental data - Henkel KGaA**

### **Detergent dosages, e.g. Persil**

By developing ever more efficient detergent formulations and dispensing with fillers and auxiliaries as far as possible, considerable reductions have been achieved in the recommended detergent dosage per wash cycle. This means that the chemical pollution of domestic wastewater has also been reduced. In 1994 the recommended dosages for normal product and concentrate had to be increased slightly for technical reasons.

### **Environmental protection courses**

Since mid-1990 employees have undergone systematic target-group-specific training in a systematic program of seminars and have been made more aware of the importance of environment and safety questions. In 1995 these training courses were extended to employees of contractors which carry out work at the Henkel parent plant, and to other Group companies. In addition, discussions on environmental protection and safety are also held at least twice yearly in the various departments. For many years environmental protection seminars, which are open to all, have been held in the context of advanced training, and management personnel have been able to attend special advanced training courses on environmental subjects.

# **Environmental data - Henkel-parent plant**

## **Production**

The decrease in production is largely attributable to the manufacture of concentrated products, e.g. compact detergents instead of standard forms, and to a switch of types within the water glass range of products.

## **Sulfur dioxide and nitrogen oxide emissions**

The emissions are largely caused by the power plant and the water glass factory.

## **Emissions of organic substances and dust**

The increase in emissions of organic substances in 1995 resulted from considerably increased plant exploitation and changes in formulations. Henkel aims to reduce these emissions.

## **Power and steam consumption**

The Henkel power plant works on the principle of heat-and-power cogeneration. Steam, after passing through the turbines to generate electricity, provides heat to the production lines. Cogeneration is much more efficient in terms of energy utilization than simple power generation. Excess power produced by cogeneration can be fed into the public electricity supply.

## **Sulfur dioxide and nitrogen oxide emissions from the Henkel power plant, Düsseldorf**

Sulfur dioxide emissions were reduced considerably in mid-1991, when the flue gas desulfurization plant came on line. Nitrogen oxide emissions have been reduced by the step-by-step introduction of the HERENOX process.

## **Dust emissions from the Henkel power plant, Düsseldorf**

The reduction in dust emissions is attributable to shutting down an old boiler unit and to dust separation in the flue gas desulfurization plant.

## **Wastewater**

Daily wastewater volume, excluding water from atmospheric precipitation. Henkel has a completely mixed sewage system. Atmospheric precipitation, cooling water, process water and water from non-industrial activities are jointly discharged and fed into the Düsseldorf-South municipal sewage treatment plant. Process water is generally used in the plant. Potable water is only used for non-industrial activities, and in the administration building and the employee facilities. Further reductions in wastewater are planned.

## **COD and sulfate loads in wastewater**

Because Henkel, as an indirect discharger, feeds its wastewater into the Düsseldorf-South municipal sewage treatment plant, the given COD loads do not find their way into the environment. Studies in model sewage treatment plants have demonstrated that some 90 percent of the COD load is eliminated. Sulfates are formed when sulfuric acid is used, and this is followed by neutralization with sodium hydroxide. They are not critical from an environmental point of view, but in high concentrations they attack concrete sewage pipes. However, such critical concentrations are not found in Henkel wastewater. From 1995 the sulfate loads will no longer be expressed as sodium sulfate but as sulfate ( $\text{SO}_4^{2-}$ ).

## **Nickel and AOX loads in wastewater**

Nickel is used as a catalyst in some production processes, and traces of it are transferred to wastewater during product purification. As a result of specific process changes, nickel loads have been considerably reduced. A plant for purifying nickel-

polluted wastewater streams has been in operation since 1993. This resulted in a considerable reduction of the nickel load in 1993. Increased production of oleochemical products resulted in an increase in the nickel load in 1994 and 1995. Measures have been initiated to achieve a reduction in nickel emissions. A number of measures were initiated in response to the increase in the AOX load in 1993.

## **Copper and chromium loads in wastewater**

Copper and chromium are used as catalysts in the hydrogenation of fatty acid methyl esters. The small chromium load is largely attributable to unavoidable plant corrosion. Another hydrogenation plant came on line in 1994, causing an increase in the copper load. In 1995 the catalyst production's wastewater treatment plant started its period of trial operation. This resulted in a decrease of about 45 percent in the copper load. A further decrease is expected.

\* No comparable chromium data available before 1989.

Other heavy metals - especially ecologically suspect cadmium and mercury - are not used or processed in the production facilities at the Henkel parent plant in Düsseldorf.

## **Waste balance, 1995**

### **Henkel-parent plant, Düsseldorf**

Some newly defined terms are used in the Environment Report 1996 in the wake of newly introduced legislation in Germany. The term "residual substances" has been replaced by the term "waste".

## **Non-utilizable wastes and methods of disposal**

A comparable waste statistic, distinguishing between wastes which are disposed of and wastes which are utilized, is not available for the year 1988. The individual methods of disposal have been recorded since 1991. From 1992 the waste figures

include excavated soil.

### **Noise emission trend**

A comparison of the years 1987, 1992 and 1995 shows the improvement in the noise situation around the parent plant. The noise level of 50 decibels (A) is comparable with a normal conversation in a room.

In 1995 only one complaint was received concerning noise.

### **Odor emissions, 1995**

In by far the most instances no odor was detected. Strong to extremely strong odors were not detected during any of the inspections.

### **Reportable occupational accidents**

At the time of going to press, no figures for 1995 were available from the Federation of Workers' Compensation Insurances and the Workers' Compensation Insurance of the Chemical Industry.

### **Water glass production**

The decrease in production volumes is mainly attributable to a switch of types within the range of water glass products.

### **Dust and nitrogen oxide emissions from water glass production**

The reduction in dust emissions from [water glass production](#) is mainly attributable to the use of electrofilters to purify the waste gases since 1988. The nitrogen oxide emissions from the water glass furnace have been reduced by improving the firing technology. An efficient nitrogen oxide limitation system came on line in late 1995. This will bring about a considerable reduction in nitrogen oxide emissions in future.



## **Solvent consumption in adhesives production**

Years of intensive efforts aimed at finding substitutes for organic solvents have brought about considerable savings, especially of the critically regarded aromatic and chlorinated solvents. Because not all adhesive systems can be switched to an aqueous basis, consumption of some of the less critical solvents has increased in some cases.

## **Environmental monitoring - surfactants in the Rhine**

Since 1958 Henkel has carried out systematic analyses of the concentration of anionic surfactants in the Rhine and its major tributaries. After nonionic surfactants started to be used on a large scale in detergents and cleaning agents, in 1972 the analyses were also extended to include this product group. The latest increase in the average concentration of non-ionic surfactants was caused by temporary peak concentrations of BiAS of unknown origin. This development will be monitored closely. The possibility that nonionic bismuth active substances are influencing the figures cannot be excluded.

## **Environmental monitoring - boron and phosphate in the Rhine**

Although Henkel had switched to phosphate-free formulations for all its detergents in Germany by 1989, it still monitors the phosphate content of surface water. Boron is present in many detergents in the form of the bleaching agent sodium perborate.

# Glossary of chemical terms

## Additives

([Oleochemicals/Care Chemicals](#), [Organic Specialty Chemicals](#), [2,000 hectares of arable land for a pilot project](#))

Substances that are added for the purpose of imparting specific properties to a product.

## Aerobic

([Industrial Adhesives](#))

Environment characterized by the presence of free oxygen.

## Aerosols

Finely distributed solid or liquid particles suspended in air or other gases, e.g. smoke or fog.

## Alcohols

([Esters](#), [Fatty acid esters](#), [Fatty alcohols](#), [Methanol](#), [Transesterification](#))

Organic compounds whose molecules contain one or more OH-groups. This makes them more soluble in water than the hydrocarbons from which they are derived.

## Alkyl polyglycosides(APG®)

([Laboratory curiosity steps into the limelight](#), [Comprehensive ecological safety assessment, From A to Z](#))

[Surfactants](#) made only from natural raw materials such as starch, sugar and [fatty alcohols](#).

## Amino acids

([Polypeptides](#))

Naturally occurring nitrogenous organic acids found in proteins, etc.

## Amylase

([A new production process for detergents](#))

An enzyme which breaks down starch.

## Anaerobic

([Industrial Adhesives](#), [Comprehensive ecological safety assessment](#))

Environment characterized by the absence of free oxygen.

## Anionic surfactants

([MBAS \(Methylene Blue Active Substance\)](#), [Sulfation](#))

[Surfactants](#) that break down into electrically charged [ions](#) in aqueous solutions, and whose special surfactant properties are attributable to the negatively charged [anions](#).

## Anions

([Anionic surfactants](#))

Negatively charged [ions](#).

## AOX load

Measure of the sum of the organic halogen (especially chlorine) compounds in wastewater.

## Aromatics

([Benzene](#))

Class of organic compounds derived from [benzene](#).

## Barium sulfate

([Dedicated search for alternative products](#))

Poorly soluble inorganic salt.

## Benzene

([Aromatics](#), [Toluene](#))

The ring, consisting of six carbon atoms, is characteristic. Benzene is the simplest representative of the class of substances known as [aromatics](#).

BiAS (Bismuth Active Substance)

An analytical parameter for complete determination content of [nonionic surfactants](#).

Biocides

Compounds which have a toxic effect on microorganisms, e.g. on useful bacteria in sewage treatment plants.

Business Charter for Sustainable Development

([How we interpret our responsibility](#), [Commitment to social responsibility](#), [Tree nursery on factory site](#))

Charter agreed at WICEM II (Second World Industry Conference of Environmental Management) in Rotterdam in April 1991. It formulates principles of environmental management. WICEM II was organized by the International Chamber of Commerce (ICC) in cooperation with the United Nations Environment Programme (UNEP) and the UN Conference on the environment and Development (UNCED).

Carbon dioxide

([Comprehensive ecological safety assessment](#), [How the Linde process works](#), [Primary and ultimate degradation](#))

Gaseous combustion product of all [organic substances](#) that contain carbon. Carbon dioxide contributes considerably to the greenhouse effect. The most important source of carbon dioxide is the exploitation of fossil raw materials such as coal and mineral oil (mainly for energy production or vehicle traffic).

Catalyst

([Noncatalytic](#))

Special substance that accelerates a chemical reaction while itself remaining unchanged.

Cations

Positively charged [ions](#).

Chemical oxygen demand (COD)

([Residual organic load reduced by 75 percent](#), [COD loads](#))

Measure of the sum of all [organic substances](#) in wastewater, including those which are poorly degradable. The COD serves to quantify the organic pollutants in wastewater. It indicates how much oxygen is needed to oxidize these substances completely.

Chlorinated hydrocarbons

([Emissions reduced by half](#))

Organic [solvents](#) with incorporated chlorine, as a result of which they are not flammable. This means that they are safe to handle, but this advantage is offset by disadvantages in the fields of health and environmental protection.

Coal unit

([Generating energy by incineration](#))

A unit of measure for energy. Frequently used in the context of power plant engineering. One coal unit corresponds to the average energy content of one kilogram of bituminous coal.

Combing lubricant

([Practical tests in the mine](#), [Wool flocks sprayed with combing lubricants](#), [Technical and ecological advantages](#))

An [emulsion](#) which is sprayed on cleaned wool flocks to increase their lubricity and protect the wool fibers during combing.

Derivatives

[\(Oleochemicals/Care Chemicals, Product characteristics are not easily transferable, Californian Waste Reduction Award, Fatty acids\)](#)

Chemical compounds obtained from another substance.

#### Dispersion

[\(Metal Chemicals, Industrial Adhesives, Product characteristics are not easily transferable, Emulsion\)](#)

Finely distributed undissolved particles in water.

#### Dissolved air flotation

[\(Multi-phase efficiency\)](#)

A physical method of separating solids and liquids. Gas bubbles are introduced to carry the solids to the surface.

#### Emissions

[\(On an international course, Specialist in Applied Chemistry, Production, Environmentally compatible, Clear facts facilitate evaluation, Test with more spacious freight cars, Laminated film refills, More boxes per pallet, Production, New interest in familiar chemicals, Crystal clear, Henkel experts modify the process, Long test series achieve nitrogen oxide reduction, In-house production, Risks are kept to a minimum, Generating energy by incineration, Emissions reduced by half, Immissions\)](#)

Gaseous, liquid or solid substances that enter the atmosphere from industrial production plants, motor vehicles with internal combustion engines, domestic heating systems or during the course of other industrial processes.

#### Emulsifiers

Substances that support the formation of stable emulsions.

#### Emulsion

[\(Silicone emulsion for impregnating facades, Combing lubricant\)](#)

[Dispersion](#) of fine drops of a liquid in another liquid, for example water in oil, or oil in water.

#### Enzymes

[\(A new production process for detergents\)](#)

High-molecular proteins that function as bio-catalysts. Certain enzymes are included in detergents to remove stubborn stains because they accelerate their decomposition.

#### Erucic acid

[\(2,000 hectares of arable land for a pilot project\)](#)

A long-chain unsaturated fatty acid.

#### Esters

[\(Product characteristics are not easily transferable, Fatty acid esters, Methyl esters\)](#)

Class of compounds formed by reactions between [alcohols](#) and acids. Esters are not only valuable intermediate products for chemical syntheses but are also used directly for a large number of purposes.

#### Ethylene oxide

[\(Four safety systems, Risks are kept to a minimum\)](#)

[Reaction product](#) obtained from ethylene and used in the manufacture of [nonionic surfactants](#).

#### EU Eco Management and Audit Scheme

[\(Preparation for EU Eco Audit\)](#)

Regulation adopted by the European Union (EU), providing for voluntary eco auditing and certification of companies.

#### Eutrophication

[\(Phosphates\)](#)

The introduction of excessive amounts of nutrients into bodies of water promotes increased growth of algae and aquatic plants. This can lead to temporary

oversaturation of the water with oxygen. When the plants die, however, large amounts of oxygen are consumed during their decomposition in deeper layers of the body of water. This can lead to an acute shortage of oxygen in the water and bring about a massive disturbance of the biological equilibrium.

#### Extrusion

([A new production process for detergents](#))

Technical process, which works on principles similar to a meat mincer, for manufacturing highly concentrated mixtures of substances, e.g. the Megaperls® generation of detergents.

#### Fatty acid esters

([Fatty acid methyl esters](#), [Transesterification](#))

Reaction products obtained from [fatty acids](#) and [alcohols](#). The best known fatty acid [esters](#) are the natural oils and fats. Other fatty acid [esters](#) are intermediate and end products in the widely branching field of oleochemistry.

#### Fatty acid methyl esters

([Fatty alcohols](#), [Methyl esters](#), [Rapeseed methyl ester](#))

[Fatty acid esters](#) with [methanol](#); intermediate product in the manufacture of [fatty alcohols](#).

#### Fatty acids

([Oleochemicals/Care Chemicals](#), [Fatty acid esters](#), [Fatty alcohols](#))

Class of substances that are found - bonded to [glycerine](#) - in all vegetable and animal fats and oils. Important starting materials for numerous oleochemical [derivatives](#).

#### Fatty alcohol sulfates (FAS)

([Environmentally compatible](#), [Clear facts facilitate evaluation](#), [Wastewater purification in small sewage treatment plants](#), [Sulfation](#))

Important group of [surfactants](#) based on [fatty alcohols](#).

#### Fatty alcohols

([Oleochemicals/Care Chemicals](#), [New interest in familiar chemicals](#), [Alkyl polyglycosides\(APG®\)](#), [Fatty acid methyl esters](#), [Fatty alcohol sulfates \(FAS\)](#))

Long-chain [alcohols](#), which Henkel obtains from [fatty acid methyl esters](#) or directly from fats by reacting them with hydrogen ([hydrogenation](#)). [Fatty acids](#) are important raw materials for the manufacture of [surfactants](#).

#### Flue gas desulfurization

([Sulfur dioxide](#))

Process for removing [sulfur dioxide](#) from the flue gases emitted by power plants and other firing plants.

#### Glucose

([New interest in familiar chemicals](#))

Also known as dextrose. Present in almost all sweet fruits.

#### Glycerine

([Oleochemicals/Care Chemicals](#), [Fatty acids](#))

One of the two main components of all oils and fats; serves as a solvent and as an intermediate product in the manufacture of numerous other substances.

#### Heat-and-power cogeneration

([Generating energy by incineration](#))

Name for the combination of electricity production and utilization of the heat which is simultaneously generated. If the large amounts of waste heat generated during electricity production can be utilized for heating purposes - e.g. as process heat on production lines - this can result in considerable savings in primary energy (fuel) and therefore in higher levels of efficiency.

#### Heavy metals

[\(Emissions reduced by half\)](#)

Metals with a density greater than 4 grams per cubic centimeter. Because many heavy metals and their compounds are toxic and environmentally hazardous, they are the subject of critical attention. There are, for example, strict limits on the amounts of heavy metals in drinking water and food, arable soil, and wastewater discharged into sewage treatment plants or bodies of water.

HERENOX®

Name for a process developed by Henkel to reduce the amount of [nitrogen oxides](#) (NO<sub>x</sub>) in flue gas. The firing system of the power plant incorporates engineering features which prevent the oxidation of atmospheric nitrogen to [nitrogen oxides](#). This makes downstream denitrification measures redundant.

Hydrogenation

[\(Fatty alcohols\)](#)

Chemical reaction with hydrogen.

Immissions

[\(Specialist in Applied Chemistry\)](#)

Effects of atmospheric pollution, noise, vibration or radiation on humans, animals, plants or objects. In the context of clean air legislation it refers to the [emissions](#) absorbed by the atmosphere and distributed up to a certain concentration.

Inhibitors

[\(Metal Chemicals, Other detergents in the form of Megaperls, Dedicated search for alternative products, Practical tests in the mine\)](#)

Substances which curb or prevent an undesirable process, e.g. precipitation.

Inorganic compounds

Substances that, in contrast to organic compounds, are not based on the key elements carbon and hydrogen. Inorganic compounds include, for example, minerals, acids and salts.

Ions

[\(Anionic surfactants, Anions, Cations, Nonionic surfactants, Zeolites\)](#)

Electrically charged particles.

MBAS (Methylene Blue Active Substance)

An analytical parameter for complete determination content of [anionic surfactants](#).

Methanol

[\(Californian Waste Reduction Award, Fatty acid methyl esters, Methyl esters, Rapeseed methyl ester\)](#)

Simplest compound in the group of substances known as [alcohols](#). Toxic, flammable, readily biodegradable liquid, which is miscible with water.

Methyl esters

[Esters](#) that contain [methanol](#) as their alcohol component ([fatty acid methyl esters](#)).

Native

[\(Tree nursery on factory site, Product characteristics are not easily transferable\)](#)

Natural, e.g. native substances = substances which occur in nature.

Nitrogen oxides

[\(From A to Z, Crystal clear, Henkel experts modify the process, Long test series achieve nitrogen oxide reduction, HERENOX®\)](#)

Compounds of nitrogen and oxygen, formed for example from atmospheric nitrogen during all combustion processes. In order to keep the atmosphere clean, the permissible concentration of nitrogen oxides in exhaust gas is limited.

Noncatalytic

[\(Henkel experts modify the process\)](#)

A chemical reaction which proceeds without a [catalyst](#).

#### Nonionic surfactants

([Long search bears fruit](#), [BiAS \(Bismuth Active Substance\)](#), [Ethylene oxide](#))

Group of [surfactants](#) that do not form [ions](#) in aqueous solutions and are surface-active in both acid and alkaline environments.

#### Oleochemicals

([Technical and ecological advantages](#))

By analogy to petrochemicals, collective term for industrial chemicals based on oils and fats from renewable raw materials.

#### Organic substances

([Multi-phase efficiency](#), [Long search bears fruit](#), [Thorough purification in three stages](#), [Residual organic load reduced by 75 percent](#), [Carbon dioxide](#), [Chemical oxygen demand \(COD\)](#))

Substances whose characteristic main elements are carbon and hydrogen. Organic substances occur naturally, but can also be manufactured synthetically, for example from coal or mineral oil.

#### Petrochemical products

Collective name for substances that are obtained from mineral oil or natural gas by chemical synthesis.

#### pH

([Wastewater data on tap](#))

A measure of the basic (alkaline), acidic or neutral character of aqueous solutions. pH 7 is neutral; alkaline solutions have a pH greater than 7; acidic solutions have a pH lower than 7.

#### Phosphates

Salts of phosphoric acid. They are essential plant nutrients, but their presence in too high concentrations in bodies of water can cause overfertilization ([eutrophication](#)).

The main sources of phosphates in bodies of water are faeces and fertilizers. Substitute substances are now used instead of the phosphates that were previously present in detergents.

#### Polyethylene

([Laminated film refills](#))

Plastic manufactured solely from ethylene. Used for consumer articles and packaging materials.

#### Polymers

Substances that are composed of a large number of repeated basic units, for example plastics.

#### Polypeptides

([Dedicated search for alternative products](#))

Polymeric substances whose basic units are [amino acids](#).

#### Polypropylene

([Laminated film refills](#))

A widely used polymeric substance which contains no chlorine.

#### Precipitated silica

([Crystal clear](#))

Especially finely grained silica, which is formed by precipitation.

#### Primary and ultimate degradation

Biodegradation is a multistage process which is initiated by bacteria. These microorganisms convert the initial compound into a first degradation product. This primary degradation, during which a surfactant loses its surface activity, usually proceeds in the presence of atmospheric oxygen. It is followed by further stages. At the end of the total degradation sequence the original compound has been completely

mineralized: the surfactant is broken down into [carbon dioxide](#), mineral substances and biomass.

Rapeseed methyl ester  
([Small flower, plenty of power](#))  
Manufactured from rapeseed oil by [transesterification](#) with [methanol](#). Mixture of different [fatty acid methyl esters](#).

Reaction product  
([Ethylene oxide](#))  
Product created by a chemical transformation.

Responsible Care®  
([How we interpret our responsibility](#), [Products](#), [Emissions reduced by half](#))  
A worldwide initiative developed by the chemical industry. It stands for commitment to continuous improvement in safety and the protection of health and the environment, independently of legal requirements. The program is identified worldwide by the same logo. Responsible Care® is a registered trademark.

Sedimentation  
([Thorough purification in three stages](#))  
Settling out of insoluble substances in a liquid.

Solvents  
([Chlorinated hydrocarbons](#))  
Substances in which high concentrations of other substances can be dissolved. Often understood to refer only to organic solvents, although water is frequently used as a solvent.

Sulfates  
Salts of sulfuric acid.

Sulfation  
Process for manufacturing [anionic surfactants](#) that contain sulfate or sulfonate groups (for example [fatty alcohol sulfates](#) or alkylbenzene sulfonate).

Sulfur dioxide  
([Flue gas desulfurization](#))  
Gaseous combustion product of sulfur and its compounds. Because sulfur is present in coal and fuel oil, sulfur dioxide is present in the flue gases of these products. In order to keep the atmosphere clean, this sulfur dioxide must be removed in [flue gas desulfurization](#) plants.

Surfactants  
([Environmentally compatible](#), [From the cradle to the grave](#), [Small flower, plenty of power](#), [A new production process for detergents](#), [New interest in familiar chemicals](#), [Comprehensive ecological safety assessment](#), [From A to Z](#), [Four safety systems](#), [Multi-phase efficiency](#), [Alkyl polyglycosides\(APG®\)](#), [Anionic surfactants](#), [Fatty alcohol sulfates \(FAS\)](#), [Fatty alcohols](#), [Nonionic surfactants](#))  
Surface-active substances that reduce the surface tension of water.

Thermal utilization  
([Risks are kept to a minimum](#), [Generating energy by incineration](#))  
Utilization of the energy content of residual materials by burning them.

Toluene  
([Emissions reduced by half](#))  
Aromatic organic compound derived from [benzene](#).

Transesterification  
([Rapeseed methyl ester](#))  
Conversion of fats and oils to [fatty acid esters](#) with the help of [alcohols](#).

Water glass



([Inorganic Products](#), [From A to Z](#), [Crystal clear](#), [Henkel experts modify the process](#), [Long test series achieve nitrogen oxide reduction](#), [Versatile water glass](#))

Alkaline silicon compound that is soluble in water. Important intermediate product in inorganic chemistry, but also a corrosion-inhibiting component of detergents.

Water pollution class

([Comprehensive ecological safety assessment](#))

Categorization introduced in Germany. The water pollution potential of chemical substances and products is assessed on the basis of their toxicological and ecological test data, and each substance is assigned to one of four classes (0 to 3). The worst pollutants are assigned to class 3.

Zeolites

Sodium aluminum silicates whose three-dimensional structure contains cavities, enabling them to combine with [ions](#) of hardness elements in water.