

"PHOSPHORUS AND INDUSTRY :
PRESENT SITUATION & TRENDS IN EUROPE"

by

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"PHOSPHORE ET INDUSTRIE : SITUATION ET TENDANCE EN EUROPE"

OR

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ENGLISH ABSTRACT

A short history of the development of phosphoric acid and other processes associated with the production of phosphatic chemical fertilisers. This includes reference to the developments for the production of higher strength acids in an attempt to reduce energy costs and the measures implemented to reduce environmental impacts.

Reference to the precipitation methods for the production of an improved grade of acid for the manufacture of Sodium Tri-PolyPhosphate (STPP) and the defluorination/dearsenification processes used for the production of Feed Grade Phosphates such as Mono-calcium Phosphate and Di-calcium Phosphate.

Reference to the Thermal Route for the production of Yellow Phosphorus, Thermal Phosphoric Acid and Feed & Industrial Phosphates.

Description of how Purified Wet-Process Acid - PWA (solvent extracted fertiliser acid) has in a great part substituted thermal acid for the production of Feed and Industrial Phosphates and how the STPP produced from PWA has great advantages over that produced from acid purified by precipitation.

Review of the past and present Production and Marketing structure of Phosphates, Phosphate Fertilisers and Phosphoric Acid. Description of the products that can be produced from purified acid and their uses. A comparative study of the Production and Marketing strategy for Technical and Food Grade Phosphates. Brief discussion of the advantages of STPP and Zeolites for use in Detergents.

Production and Marketing Strategy of Phosphates and Phosphoric Acid, possible changes for the 21st Century.

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SECTION 1

A BRIEF HISTORY OF THE TECHNOLOGIES USED

1.1 SHORT HISTORY OF FERTILISER ACID PRODUCTION METHODS

Originally fertiliser grade phosphoric acid was made by mining engineers using extractive metallurgical techniques such as Double-decantation. This technique used a counter-current leaching process, Phosphate being fed at one end of the circuit and sulphuric acid at the other end. Obviously the acid strength and recovery of this type of process was limited and other processes were developed with batch-wise attack of the phosphate followed by filtration with the recycle of wash liquors and the addition of sulphuric acid. Filter presses were used to separate the precipitated gypsum and they also enabled the gypsum to be washed thus improving the efficiency.

The disadvantages of this type of process were clear, both produced a very weak acid, 15-20 % P_2O_5 , and had low efficiencies. The first attempt at a continuous process for strong phosphoric acid production was made in the 1930's by Dorr-Oliver, a mining engineering company at the Cominco plant in Trail, Canada. This process used large drum filters for the filtration step and as the $CaSO_4$ gypsum was precipitated in the Hemihydrate form there were several problems. The process did not work as envisaged and the acid strength had to be reduced to allow dihydrate precipitation and evaporators installed to concentrate the acid from what was still a reasonable 28-30 % P_2O_5 . With the introduction of this continuous process, with continuous gypsum separation, the basis of today's process technique was developed.

After the eventual solving of the problems at Trail, the construction of other units awaited a solution to the problem of filter design and Dorr-Oliver later used the Giorgini travelling pan vacuum filter. This was a straight-line filter with a number of pans travelling along the filtration surface undergoing the progressive steps of the filtration cycle. For people who have not seen one the most similar equipment in frequent usage today is the metallic travelator or moving walkway. At the end of the cycle after the counter-current washing the pan was tipped and returned inverted to the starting point. One of the main problems with this design of filter was the limitation in size and for a 50 mtpd P_2O_5 unit two filters in parallel were used.

At this time, the early 1940s, Prayon was operating a batch-wise process with filter presses but dissatisfied with the recovery they attempted to use a continuous attack section with flash-cooling, a feature of the Prayon processes to this day, followed by a German design "Gropel" rotating table filter with cake discharge by a screw. Results were not promising with difficulties in cloth washing and the tearing of the cloth by the screw and so they decided to design their own filter to overcome these difficulties.

Thus Prayon embarked on the development of their own filter a horizontal rotary tilting-pan vacuum filter. This equipment was initially built with the wetted parts in lead. However with the cells and the central distributor in lead the size and speed was limited. Once stainless steels became readily available the materials of construction could be adapted and the maximum size of units soon reached over 100 m² enabling plants of 400 mtpd P₂O₅ potentially to be built. There was however still a big drawback regarding reactor design. In the early 1950s Prayon began selling their Process and Filtration equipment throughout the world, the first being a 40 mtpd P₂O₅ unit sold in 1953 to Smith Douglass for their plant in Streator, Illinois, USA. But it was in the early 1960s when Prayon was intending to expand their own facilities that the next critical change in phosphoric acid equipment was to be developed. The design of reactor up to that time had been developed from the old lead-lined wooden vats to rubber and carbon brick-lined carbon steel reactors but still there were considerable size limitations to the agitators and multi-tanks were very expensive. Prayon broke tradition once again by developing the multi-compartmented monolithic concrete tank lined with rubber and carbon bricks. Progressive development to the Prayon design means that today there are three units in the USA producing over 2000 stpd P₂O₅ in a single train with a single filter. Over 60 % of the World's phosphoric acid capacity is produced in units designed according to the Prayon process.

In the past the plants were built in the fertiliser consumption areas but economics have tended to dictate that present day units should be built either at the phosphate mine or at the source of sulphur or sulphuric acid; this is discussed in Section 2. However several producers have tried to improve their production economics by going away from the traditional dihydrate process and revamping or replacing units with higher strength and/or higher efficiency processes. These processes, based on their consumption figures, have a potential to reduce production costs by the production of higher strength acid, giving lower utility consumption costs. In the case of the two-stage processes also reducing raw material consumption by having higher efficiencies. However the results seem to have demonstrated that these potentials are not necessarily tangible when plant down-time and overall efficiency is taken into account. In fact, many units that have selected these newer technologies have either not been built, have not lived up to their expectation or have had to shut-down after very few years of operation. Plants that can be included in the list are : RMHK Trepca (Kosovo, YU), Hellenic (Cyprus), Royster (Florida, USA), Narmada Emirates (Dubai), Queensland Phosphates (Australia), CSBP (Australia), PIVOT (Australia), Albright & Wilson (Whitehaven, UK), Supra (Landskrona, Sweden), Boliden (Helsingborg, Sweden). Although some of these units have claimed that the closure has been partially due to environmental reasons. Environmental pressures in highly inhabited sites have also put pressure onto the construction of units close to the mine site in zones with a relatively low population density. Although processes to reduce fluorine emissions have been developed to create plants with minimal environmental impact, the big environmental "white elephant" is the gypsum stack.

Although processes have been developed that can produce a marketable gypsum, the basic problem is that the market for gypsum is small compared with that for phosphates and the "fatale" production of gypsum is many times greater than the quantity that the gypsum market can consume. At the Prayon unit in Engis in Belgium, the production of 400 mtpd P_2O_5 produces about 2000 mtpd of gypsum of which about 60-70 % is sold for plaster production at a local site or as a cement retarder in units not too distant from the site. Until only a few years ago, the Puurs site of Prayon also purified 100 % of the gypsum for resale but the market for this product previously sold to the Dutch construction industry declined and at the present time difficulties are being experienced with the disposal of what is even declared by the local authorities to be a "non-toxic waste" which will probably cause the shut-down of this unit during 1992.

1.2 PRODUCTION OF YELLOW PHOSPHORUS AND THERMAL ACID.

For many years the only other technique for phosphoric acid production was the thermal route via elemental or "Yellow Phosphorus".

This process is suited to some low grade phosphates (c. 17 % P_2O_5) as a high silica to phosphate ratio is desirable in the charge. In fact higher grade beneficiated phosphates can be less interesting as a fine phosphate would need to be pelletised or granulated to produce an acceptable charge. Volatiles such as CO_2 are deleterious. However the basic inconveniences of this process are the high capital cost of the furnaces, the high electrical energy consumption and the disposal of "phossey water" a contaminated stream from the furnace scrubbers.

These units consist of a raw material pre-treatment section where the phosphate, silica and carbon are prepared into a charge. This section is followed by the furnace itself. The furnace, which is a refractory and carbon brick-lined vessel with a number of carbon cathodes situated immediately above the charge. The electrical current melts the charge and vaporises the phosphorus. The melt separates into two liquid phases, the slag and the ferro-phosphorus. The slag is tapped from the furnace discontinuously into a sluice channel where it is quenched with water. Ferro-phosphorus is separately tapped into a ladle and cast into ingots. On leaving the furnace the phosphorus vapour is condensed in a direct contact spray condenser, the liquid phase phosphorus is heavier than the water and decants out in an acid-brick lined concrete sump. After decantation the liquid phosphorus is pumped to storage. The phosphorus can be stored as a liquid in heated tanks but contact with the air is prevented by a water blanket. Alternatively the phosphorus can be solidified for storage and transportation in drums or ISO-containers; in both cases water is again used to prevent contact with the air.

The liquid Yellow Phosphorus can be "burnt" to phosphoric acid at the same site or the solid phosphorus after transport to another site can be melted in a hot water bath prior to acid production. Transport of elemental phosphorus is extremely economic due to its high concentration. Thermal acid production is the controlled oxidation of the phosphorus and the recovery of the Phosphorus Pentoxide in acid solution. The liquid phosphorus is pumped to a water cooled jacketed burner where it is atomised with an excess of air to produce the oxide. In the second stage, the hydrator, the gases are absorbed in a co-current acid scrubber. The absorbing solution is a mixture of 100 % H_3PO_4 and weaker acid. At the base of the tower the solution is captured in a large acid-brick lined sump fitted with agitation and cooling coils. The efficiency of the first stage hydrator is limited due to the formation of acid mist and this is removed in the second stage, a weak acid irrigated venturi scrubber fitted with a cyclonic separator. Almost all parts of the "burner" are constructed of stainless steel but requires to be water jacketed to keep the temperature down thus reducing corrosion rate. Although relatively pure, the thermal acid contains Arsenic, Lead and Fluorine. These and other contaminants may require further purification for some uses. The off-gases contain little phosphorus but the waste streams from the scrubbers have to be treated to neutralise fluorine and other compounds before being safe for disposal.

The main drawback to the thermal route is the high consumption of electrical energy, the remaining units for Yellow Phosphorus production are in areas where cheap electrical power is available, normally hydro-electric, or in centralised economies where the cost of energy is not necessarily computed at a real value. In fact many furnaces are continuing operation under the threat of closure, the cost of re-lining the furnace being difficult to justify in economic terms. It is considered that many thermal acid producers are just "milking the cow".

1.3 BRIEF DESCRIPTION OF PURIFICATION BY PRECIPITATION.

For many years the option of up-grading fertiliser acid to substitute thermal acid has been an attractive alternative due to the price differential. Many methods have been used but normally they are linked to a specific product.

In the past, Animal Feeds were produced using thermal acid but the rise in energy cost made this prohibitive. Two techniques were developed to produce a purified animal feed from fertiliser grade acid : the first by partial precipitation of Di-calcium Phosphate, or Mono-ammonium Phosphate leaving the impurities in solution to be used in the production of fertiliser products, the second by acid defluorination to produce a ratio of P/F of greater than 100. Nowadays the reduction of Arsenic and Cadmium is also sometimes required. This defluorination process can be by batch stripping using air or steam; in both cases active silica is normally added to facilitate the defluorination.

The actual acid analysis defines the relative ease or difficulty of the task. Acids with high levels of Aluminium and Magnesium are more difficult to treat as both these elements form less volatile complexes with the fluorine and slow down the defluorination process. These defluorinated acids can be used to produce Feed Grade (Animal Feed Grade) products such as Di-calcium Phosphate and Mono-ammonium Phosphate.

Other precipitation methods were developed to produce feedstock for STPP (Sodium Tri-polyphosphate) by reducing the level of Organics, Iron and Aluminium and the reduction of the fluorine content by precipitation of Sodium Silica-fluoride but more recently the additional reduction of heavy metals contents has also become important.

The precipitation purified acid produced an STPP of inferior quality and whiteness to that produced from thermal acid but the greatly reduced production cost made this product of interest to the detergent manufacturers in an effort to keep prices down in this competitive market, the slightly greyer colour being compensated for by the addition of blue or green dye to the final detergent product.

1.4 DESCRIPTION OF PURIFICATION BY SOLVENT EXTRACTION.

Initially most of the units, and almost all of the technology, was of European origin but in the recent past there has been a world-wide evolution in the use of this technology. These processes differ in the selection of solvent and the form of the extractors but all the processes generally have the same steps as the Prayon process, which was developed "in house" during the 1970s, and a description of the Prayon process follows.

The Prayon Process for Wet Process Acid Purification was developed during the 1970s, the first unit being built at the Prayon site in Puurs, Belgium in 1976. This pioneer unit produced all grades of purified acid known at that time from the simple pre-purified acid through the various grades of solvent extracted acid up to the pharmaceutical grade "Codex". A second unit of a similar size but with different process features was built at the site of the Head Office of Prayon in Engis, Belgium in 1982. This unit had no defluorination section nor a "Codex" section.

Besides these two units, three others have been built in Brazil, Indonesia and Korea. Each unit has been based on different raw acid specifications and product ranges. These local conditions affect the process design of units, due to changes in the quality of the feedstock and the quality requirements of the product. These requirements dictate the levels of Pre-treatment prior to and the Post-treatment after the Solvent Extraction section (Flowsheet 1). The raw acid quality varies considerably; from Jacupiranga (that can be considered one of the purest fertilizer grade acids in the world) to Florida (one of the most impure).

Experience gained from the Uranium Extraction process developed by Prayon enabled the techniques of acid Pretreatment to be developed and allowed a fuller understanding of the essential criteria linked to the selection of a solvent for phosphoric acid treatment. After pretreatment to produce an acid quality compatible with the requirements of solvent extraction the wet process fertilizer grade acid is introduced into the Solvent extraction process. Steps in this Pre-treatment process may include Defluorination, Dearsenification, Desulphation, Removal of Organics and Concentration.

The outlines of the basic Prayon solvent extraction process are shown in Flowsheet 2 and does not vary in principle for each of the above cited cases except in the number of stages used for each of the extraction items, extractor, washer and re-extractor. The solvent selected by Prayon was a mixture of DIPE (Di-iso propylic ether) and TBP (Tri-butyl phosphate). This selection being made due to four main characteristics :

- * A resistance to "crud" formation
- * A rapid and efficient phase separation
- * A low boiling point aiding stripping
- * A low latent heat reducing production cost

The basic process consists of three stages; Extraction, Washing and Reextraction.

The Pretreated acid which has been cooled and decanted to remove the final traces of solids is fed to the top of the Extractor and flows down the column through the various stages of Mixing/Settling counter-current to a flow of solvent which rises through the column due to the density difference. The solvent is introduced at 5 degrees Centigrade and the column is cooled by internal cooling coils. Under these conditions the HPO_4^- ion is extracted into the organic phase leaving the metallic ions in aqueous solution. The acid leaving the bottom of the column under interface level control, called the Raffinate, has essentially all the impurities whilst the solvent leaving the top of the column, the Pregnant Solvent, contains essentially only the HPO_4^- ions. The Raffinate should normally be used for the production of Solid Fertilizers and normally does not represent a reduction in quality or value of this product. This Raffinate is stripped of ether in an agitated tank fitted with steam coils prior to being recycled to the Fertilizer operation. One of the main features of this process is the very low residual organics content of the Raffinate, a feature of the excellent separation characteristics which result in a very low solvent consumption.

The pregnant solvent overflows by gravity to the base of the second column, the Washer. Here the solvent rises counter-currently to a flow of water that removes most of the metal ions present in the solvent and also acts as a safety net for any entrainment of aqueous phase from the extractor. The washings leaving the bottom of the column are recycled to the middle of the Extractor under interface level control. The organic phase overflows by gravity from this column to the final column the Re-extractor.

In the Re-extractor the temperature is increased by the introduction of live steam and the organic phase rises counter-currently to a flow of demineralised water or condensate. The hot stripped solvent exits the top of the column and overflows to the solvent buffer tank where recirculation pumps transfer the solvent via coolers to the beginning of the cycle the Extractor. The aqueous phase leaving the bottom of the Re-extractor, containing about 40 % P₂O₅, is stripped of solvent in a falling film stripper and fed to the Post-treatment sections.

During the past 20 years the equipment has been progressively improved and although the process is relatively simple, the developments in detailed equipment design based on 20 years of in-plant development and plant experience that have made most outstanding improvements in the economics.

The acid quality at various stages of production in the case of the FOSBRASIL, Brazil unit are shown in Table 1.

TABLE 1

**Analyses of Feed and Product Acids
Based on FOSBRASIL Data**

Element	Fertilizer Grade Acid	Industrial Grade Acid	Food Grade Acid	"Codex" Grade Acid
P ₂ O ₅	46.0 %	59.0 %	61.5 %	61.5 %
SO ₄	2.8 %	0.5 %	0.04 %	0.04 %
CaO	0.6 %	500 ppm	1 ppm	5 ppm (max)
MgO	2.0 %	1.2 %	12 ppm	12 ppm
F	0.8 %	0.2 %	9 ppm (max)	9 ppm
Fe ₂ O ₃	0.3 %	0.2 %	20 ppm	20 ppm
Al ₂ O ₃	0.4 %	0.4 %	5 ppm	5 ppm
As	2 ppm	2 ppm	0.5 ppm	0.5 ppm
Solids	1.4 %	0.05 %	-	-
Heavy Metals	n/d	n/d	9 ppm	9 ppm
Colour (APHA)	n/d	n/d	20	10

n/d = not determined

The overall block diagram Flowsheet 1, shows the relative weight of the pre-treatment and post-treatment sections compared with the solvent extraction process itself. It is clear that the qualities of the feed acid used and of the products required considerably affect the total investment cost of such a unit.

1.5 QUALITY OF PURIFIED ACID AND ITS PRODUCTS.

The full range of products made with thermal acid can be made from solvent extracted purified wet-process acid (PWA) but different degrees of post-treatment are required.

For STPP the main criteria are the Organics content; the metals and heavy metals content and the sulphate content. The strength of the PWA being above 40 % P_2O_5 is sufficient to be used directly as feedstock for the production of STPP without further evaporation.

Technical Grade acid requires lower Fluorine content and has more stringent requirements on metallic impurities than that for STPP. the acid is also marketed at 54-62 % P_2O_5 so additional concentration is required.

Food Grade acid has additional requirements on the Arsenic level that can be tolerated.

Codex Grade acid (Pharmaceutical Grade Acid) is used for pharmaceutical preparations and also as an acidifying agent for soft drinks amongst which the best known are Coca-Cola and Pepsi-Cola.

Electronic Grade acid has differing specifications depending on the downstream consumers requirements.

SECTION 2

WESTERN EUROPEAN PRODUCTION AND MARKETS

2.1 FERTILISER ACID PRODUCTION AND FERTILISER CONSUMPTION.

The production of Fertiliser Grade Phosphoric Acid in Europe is in rapid decline. The production capacities are set out in Figure 1 and it can be clearly seen that the production capacity at the end of this year, being 2.1 Mio tonnes P_2O_5 , will be less than half of the 4.8 Mio tonnes produced in 1980. The number of plants being reduced from 60 to 21 and as this is mainly due to the closure of the smaller units the average plant size has gone up from 80,000 to 176,000 mtpa P_2O_5 .

The fertiliser consumption, as shown in Figure 2, has decreased marginally from the 5.4 Mio tonnes P_2O_5 in 1980 to the 4.3 Mio tonnes in 1991.

Thus the general trend is an increase in the importation of phosphate fertilisers obviously from the mine site production units in North Africa and Florida. The reasons for this tendency are clear, the economics are favourable and the acceptable sites for gypsum disposal can be more easily found in less densely populated areas. Often, as in Florida, mined-out areas can be filled with gypsum to effect land reclamation. The imports of merchant grade acid have risen four-fold from 0.6 Mio tonnes P_2O_5 in 1980 to 2.4 Mio tonnes in 1991.

2.2 STPP CONSUMPTION AND EFFECT ON W. EUROPEAN PRODUCTION.

It can be clearly seen that the consumption of STPP in Western Europe has been in decline since the 1 Mio tonnes consumed in 1980. Initially the decline averaged about 32,000 tonnes per year due to the impact of "Green" orientated advertising and the introduction of legislation in a small number of European countries. The average descending trend since 1984 accelerated to about 70,000 tonnes but the yearly decrease has shown a tendency to reduce and it is expected to stabilise at just under 400,000 tonnes. This value signifies a drop of 60 % compared with the value in 1980. Studies have shown that phosphate based detergents can be considered more environmentally friendly than zeolite based products. Phosphates have a better performance and the effluents from phosphate sources are bio-degradable, in fact fish need phosphate in the water to attain normal levels of growth. Zeolites have been shown to damage fabrics and the effluents are not bio-degradable. However despite these facts it is unlikely that the downward trend in STPP consumption will be reversed due to the false "Anti-Green" image that has been attached to phosphates by the producers of zeolites.

This decline has had a significant impact on the STPP factories and Figure 4 shows that the 1992 nominal production capacity is almost half of its value in 1980, from 1.79 Mio to 0.97 Mio tonnes, a reduction of about 45 %. However many plants are operating at less than nominal capacity as the export market is not capable of absorbing the difference.

This reduction in production capacity has been caused by the closure of 8 units in Western Europe, the average size of the units being unchanged as the size criteria is mainly due to the economic calciner capacity.

2.3 THE DECLINE OF THERMAL ACID PRODUCTION IN W. EUROPE.

Higher energy costs have had a marked effect on the economics of thermal acid production and it can be clearly seen in Figure 5 that since 1980 five of the smaller units have closed down and the production capacity has been reduced from 420,000 tonnes in 1980 to 162,000 tonnes in 1992. The largest production site remains at Vlissingen in Holland which accounts for almost 90 % of the total Western European capacity. The energy policies of some of the European governments have modified the electricity price such that of the 7 countries producing thermal acid in 1980 there will only remain 3 by the end of 1992. The fate of the ex-Eastern European Phosphorus burners based on the Yellow Phosphorus produced in Kazakhstan is also questionable and this may be one of the greater influences on the future of the market. If the electrical price in Kazakhstan increases significantly, as is expected, the future of all these down-stream users could be bleak.

2.4 TECHNICAL GRADE ACID PRODUCTION BY SOLVENT EXTRACTION.

The tendency for the market in technical grade acid to decrease is not followed by the solvent extraction based purified acid plants. Although the actual number of units operating in Western Europe has decreased by one the total capacity as can be seen in Figure 6 has increased. This has essentially been effected by the de-bottlenecking of existing units.

The total Western European capacity has increased from 470,000 tonnes P_2O_5 in 1980 to 550,000 tonnes in 1992, an increase of 17 %.

2.5 THE WESTERN EUROPEAN TRENDS IN TECHNICAL ACID.

Economics have had a very big impact on the production route for technical grade acid. Figure 7 shows how the Western European production of purified acid has taken over from the thermal route since 1980. The production capacity has reduced by 20 %, from 892,000 tonnes in 1980 to 712,000 tonnes in 1992. The impact of energy costs has caused the proportion of thermal acid to be reduced from 47 % in 1980 to 23 % in 1992 but the production capacity by the thermal route has been reduced by an even greater proportion from 422,000 tonnes in 1980 to 162,000 tonnes in 1992 a reduction of 60 %. The production capacity of the purified acid increasing by almost 20 %.

The expected 1992 consumption of phosphates, both Worldwide and in Europe, is set out according to usages in Figure 8. By far the largest tonnage both Worldwide and in Western Europe is in fertilisers accounting for 87 % and 78 % respectively. The next and only significant single big consumer is animal feeds that accounts for 5 % and 8 % respectively. Technical grade acid, with the multiplicity of products, only accounts for 8 % Worldwide and 13 % in Europe, but the decline of consumption in STPP will have a big effect on the European figure during the next few years.

The relative size of these markets for 1992 can be seen in Figure 9. The Western European market of all phosphates is of the order of 5.5 Mio tonnes, of which 78 % is fertilisers, about 4.3 Mio tonnes P_2O_5 . The animal feed market accounts for about one tenth of this at about 460,000 tonnes. The total technical grade acid market is about 700,000 tonnes.

The STPP and other large quantity alkaline phosphates markets linked to detergents account for 75 % of this market or about 525,000 tonnes, this is a market in decline. The remaining market of 175,000 tonnes is distributed between the myriad of small scale consumptions with specific requirements as shown in Figure 10.

2.6 PHOSPHATES IN EUROPE - THE FUTURE.

What are the main trends to be expected for the European phosphates industry for the future.

Economic and environmental pressures will cause the progressive closure of both phosphoric acid and phosphate fertiliser plants and this will be offset by the importation of fertiliser grade acid and phosphate intermediates mainly from the mine site units.

Production of solvent extraction purified wet process acid will continue but due to the reduction in demand for STPP some of this type of purified acid for other uses. Lower grade STPP produced from precipitation purified acid will become extinct as prices of the purer product fall.

Thus discounting the effects of changes in the production and of markets in the ex-Eastern European countries there is little reason to expect much growth in the solvent extraction purified acid market and there could well be oversupply in the medium term, not only in Europe but also Worldwide.

The lack of European demand for STPP and other Alkaline phosphates will force this product onto the export market at very competitive prices.

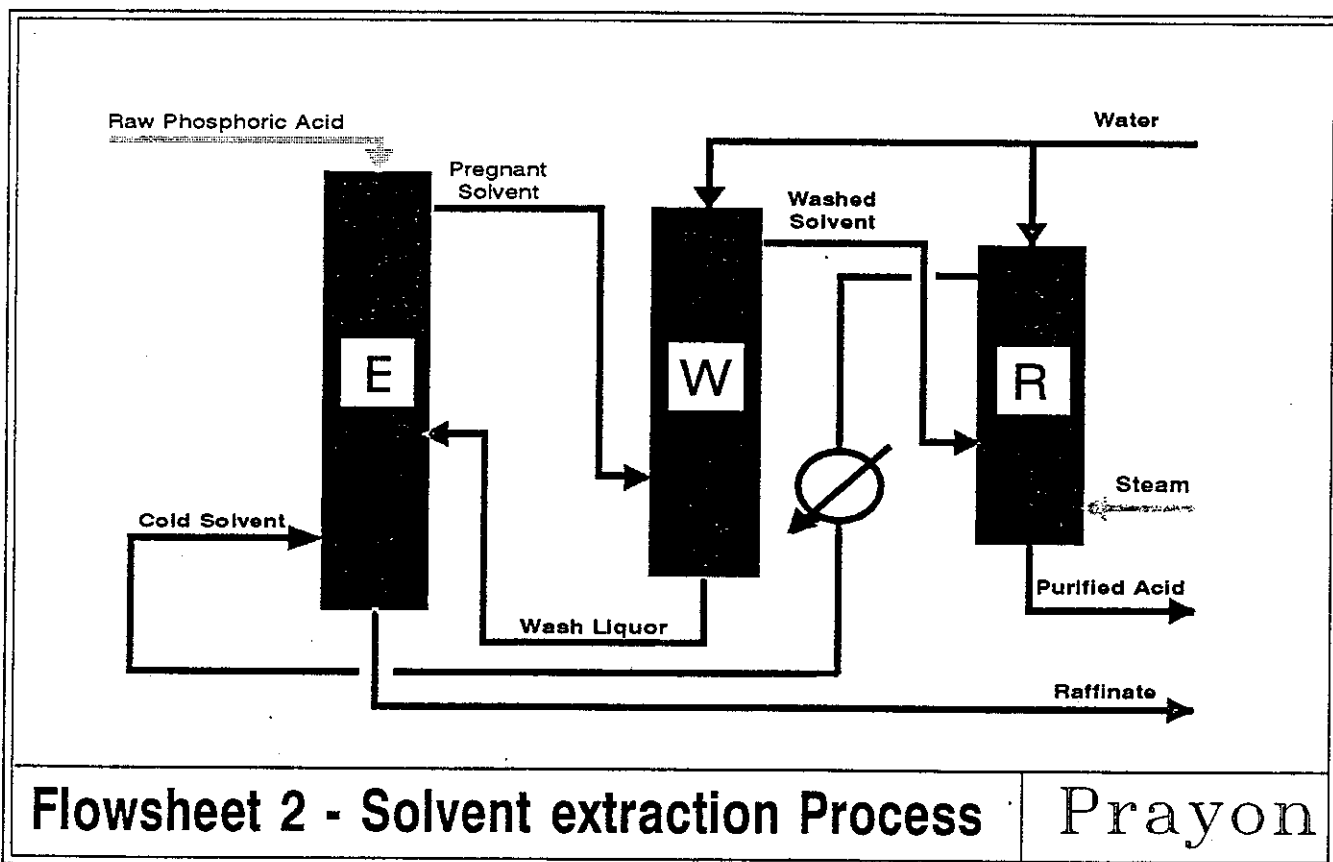
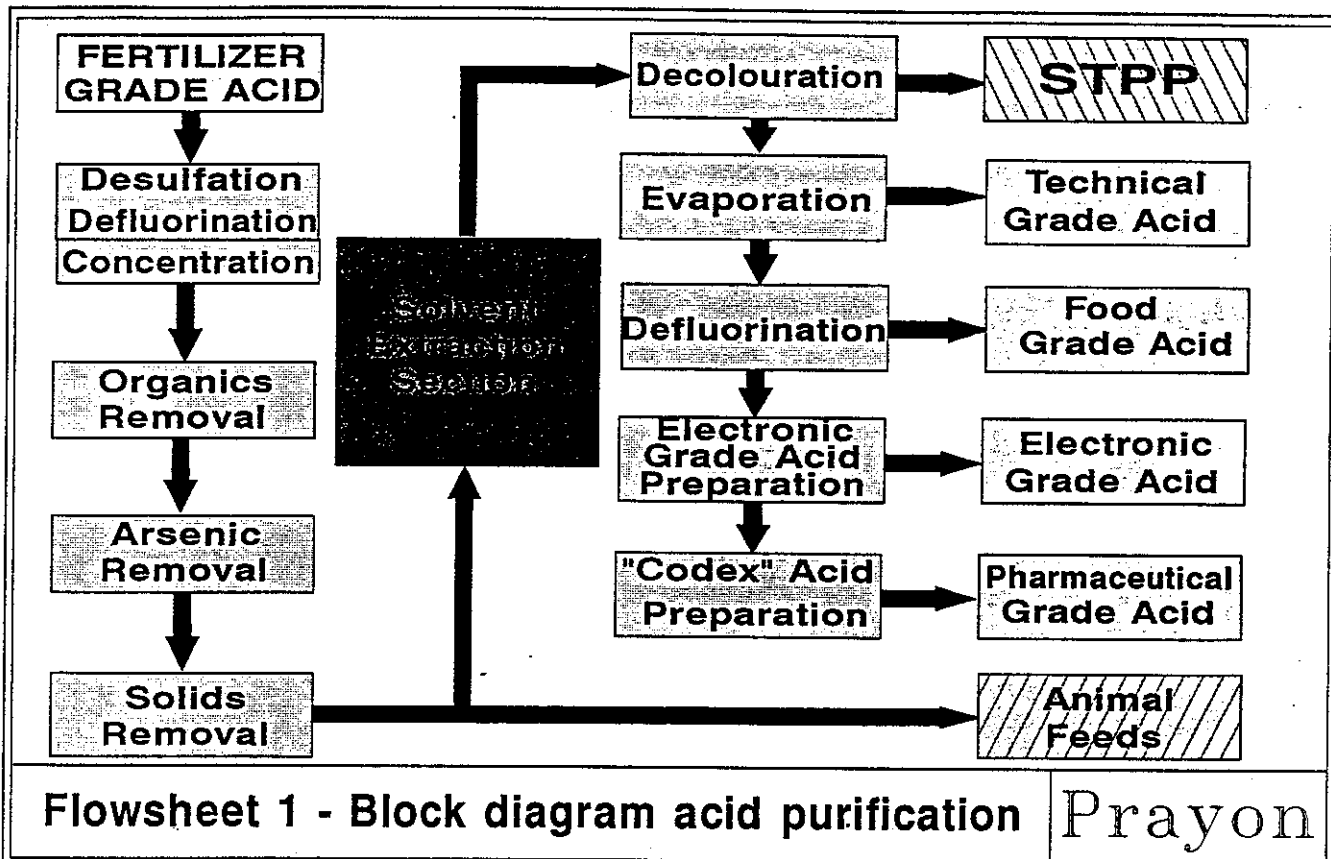
In review the prospects for the European phosphate industry are not very bright. There will be a progressive switch to importation of partially elaborated intermediates from sites with either the phosphate or sulphur source. Despite the advantages of STPP over Zeolites there will still be a decline in STPP consumption. The production of the myriad of small volume phosphate salts will however remain in Europe due to the diverse detailed specifications and the close relationships that exist between the supplier and the consumer.

ACKNOWLEDGEMENTS

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WET PROCESS ACID

West European Production - 1980/1992 (tonnes P2O5)

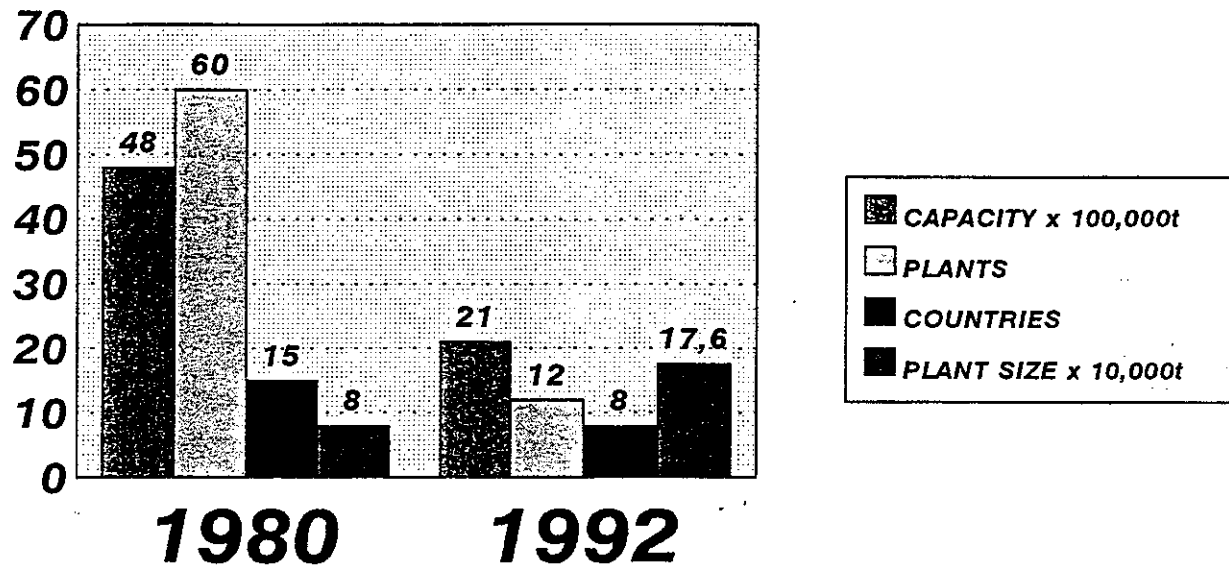


Fig. 01

FERTILISER CONSUMPTION

Western Europe - Mio. tonnes P2O5

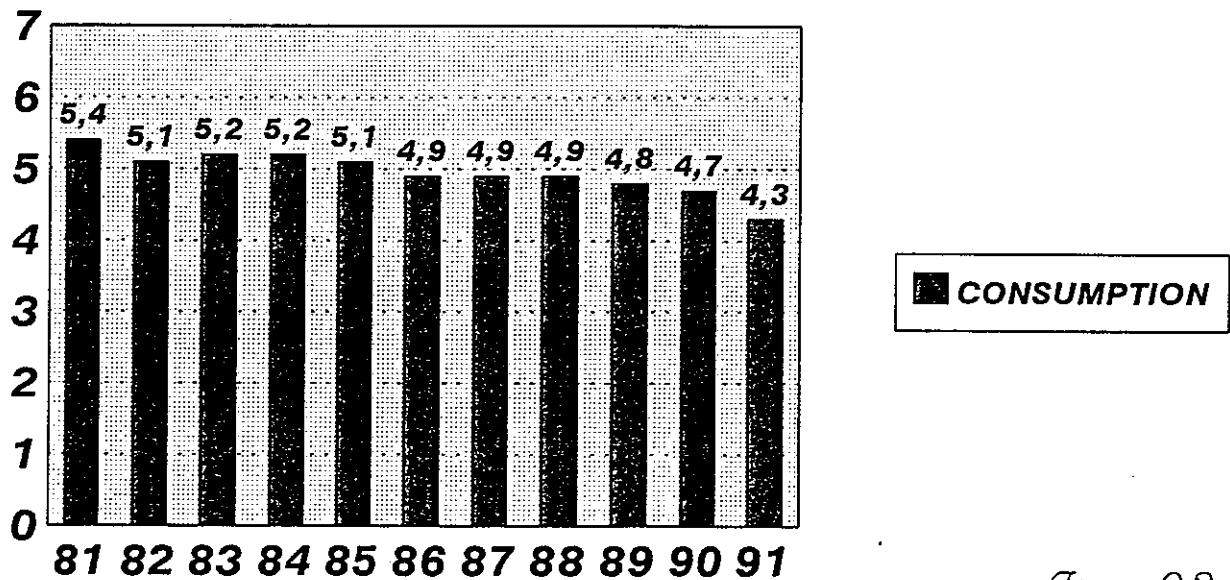
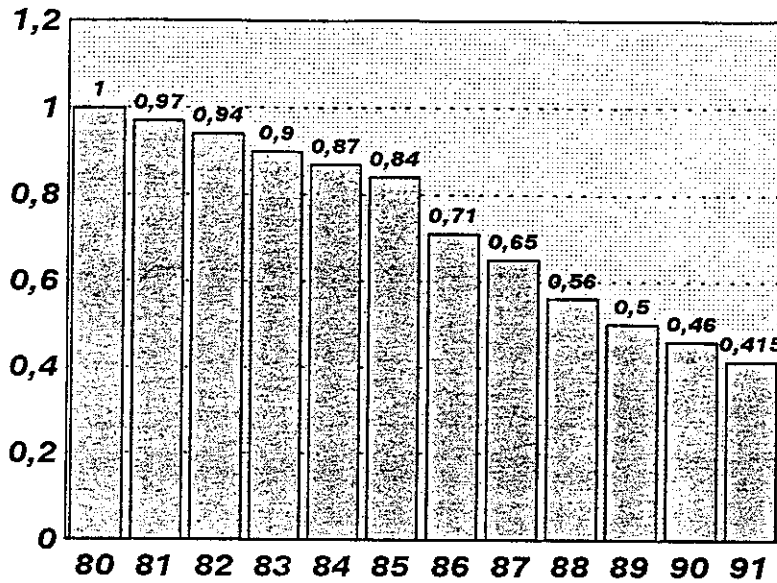


Fig. 02

STPP CONSUMPTION

Western Europe - Mio. tonnes

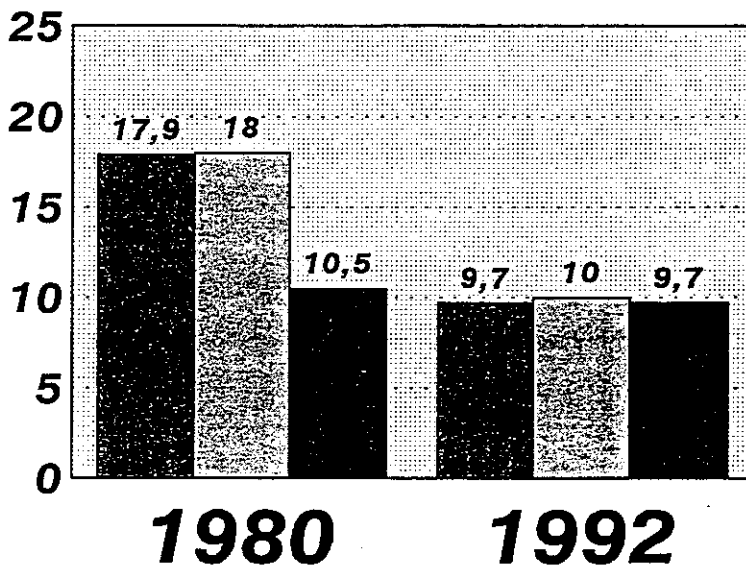


CONSUMPTION

Fig. 03

STPP PRODUCTION

West European Production - 1980/1992



CAPACITY X 100,000t
PLANTS
PLANT SIZE X 10,000t

Fig. 04

THERMAL PHOSPHORIC ACID

West European Production - 1980/1992 (tonnes P₂O₅)

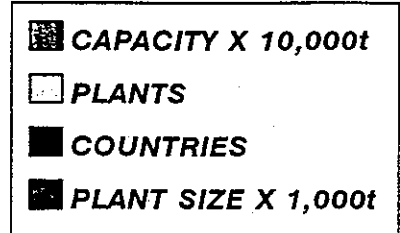
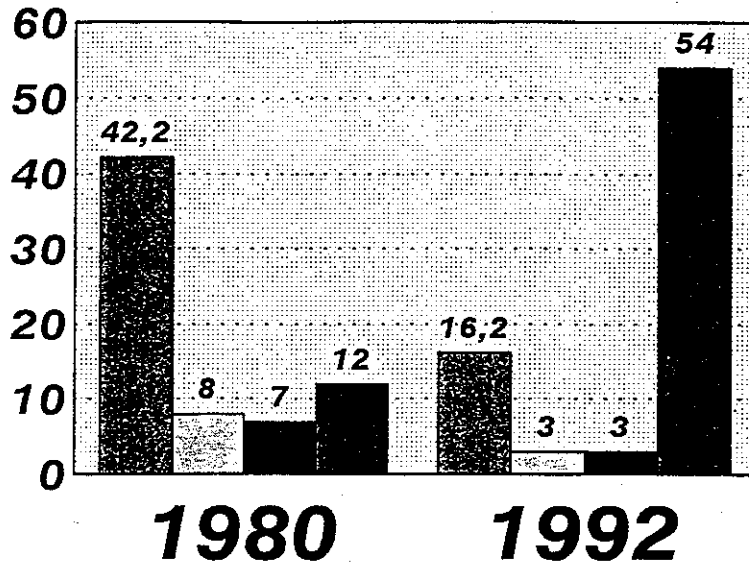


Fig. 05

PURIFIED PHOSPHORIC ACID

West European Production - 1980/1992 (tonnes P₂O₅)

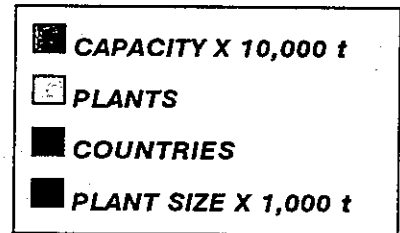
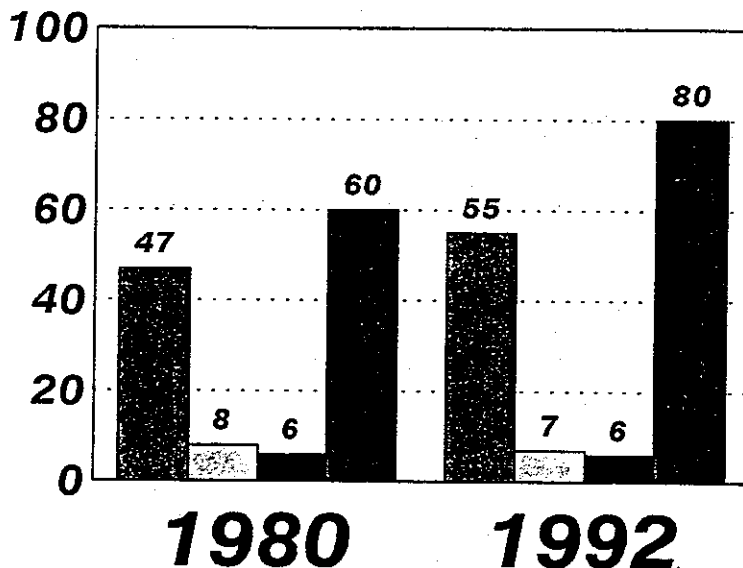
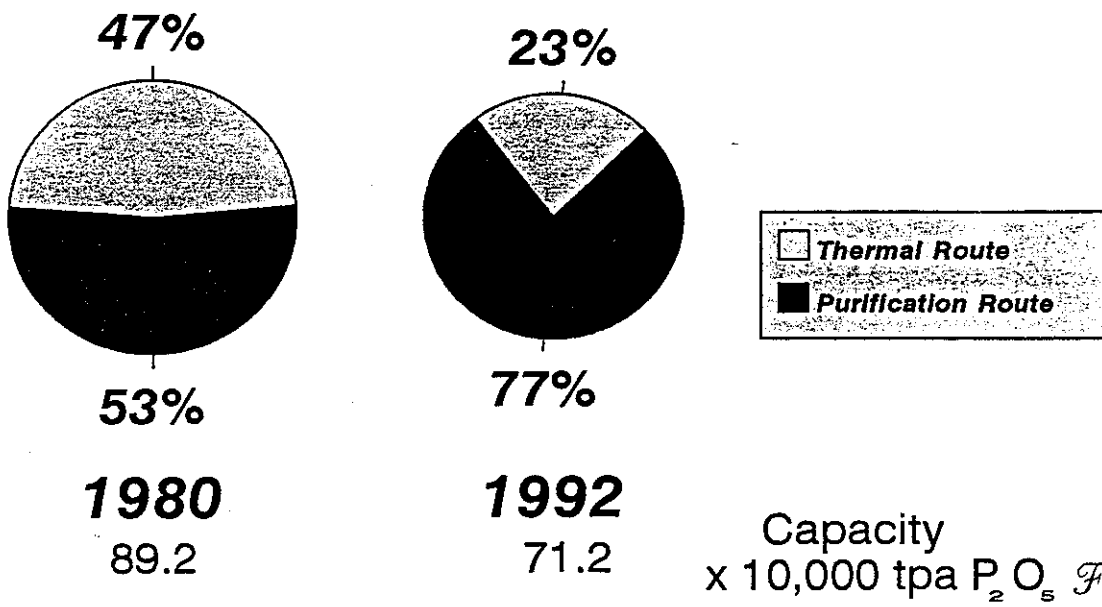


Fig. 06

TECHNICAL ACID PRODUCTION

Thermal v. Purified (Western Europe)



PHOSPHATES CONSUMPTION

Estimate for 1992 - (World / Western Europe)

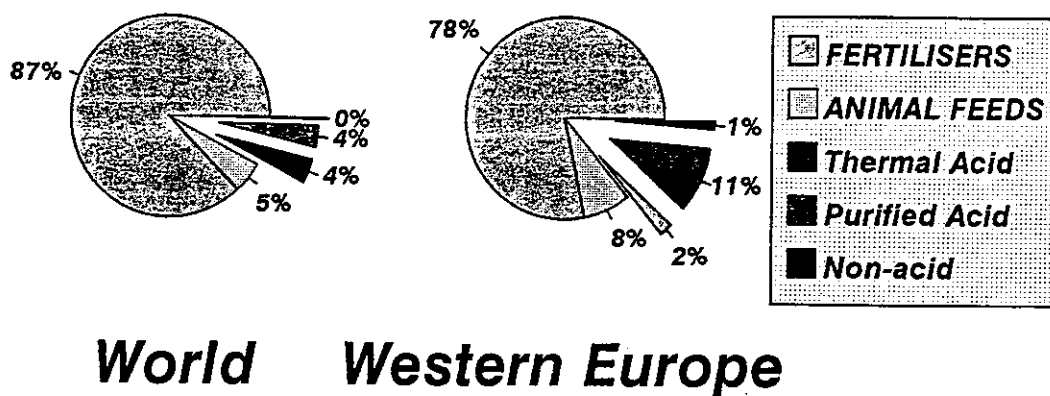
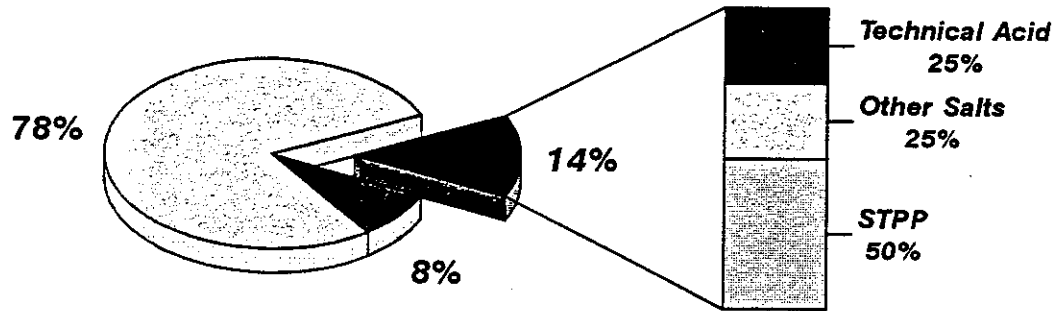


Fig. 08

USES OF PURIFIED ACID

WESTERN EUROPE

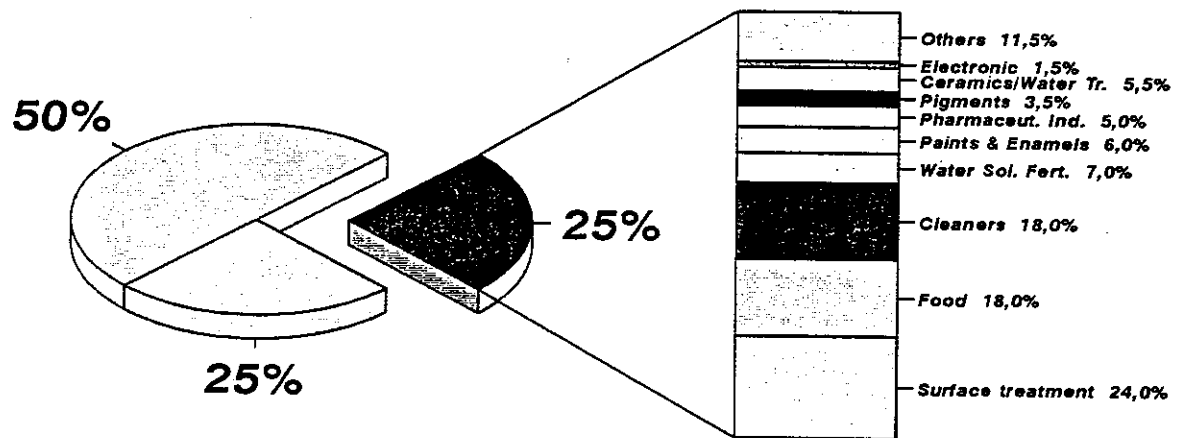


FERTILISERS
 ANIMAL FEEDS
 TECHNICAL ACID

Fig. 09

USES OF TECHNICAL ACID

WESTERN EUROPE



STPP
 OTHER SALTS
 TECHNICAL GRADE ACID

Fig. 10