

PVC RECYCLING - AN OVERVIEW

PRESENTATION TO:  
THE VINYL INDUSTRY TRIPARTITE MEETING  
SEPTEMBER 3-4, 1992  
WASHINGTON, D.C.

F.E. KRAUSE  
DIRECTOR ENVIRONMENTAL SOLUTIONS  
GEON VINYL DIVISION, BFGOODRICH CO.

CTL007168

VINYL TRIPARTITE MEETING  
SEPTEMBER 3-4, 1992  
WASHINGTON, D.C.

PVC RECYCLING - AN OVERVIEW

Good morning. You have already heard a worldwide view on PVC. In 1991, demand for PVC worldwide was 40 billion pounds, making it the second largest selling plastics market. As you have heard from previous speakers, that market and plastics in general are under attack. The public, in a love-hate relationship, loves the utility and convenience of plastics but "hates" to see the material wasted -- that is, not re-used or recycled instead of landfilled. I believe the perception of PVC is our major challenge today and recycling is a key part of the perception issue.

Tony Carbone, Vice President of Dow's Plastic Business and chairman of Partnership for Plastics Progress (P3) Coordinating Committee, put this in perspective very simply in a presentation at the SPE ANTEC this year, the basic issue is economics. In this slide you can see the range of virgin prices for most plastics as well as the estimated costs of recycling those plastics. It clearly shows that engineering plastics selling at greater than \$1 /lbs can be recovered and recycled at a profit. However for commodity plastics, including PVC, the costs of recycling or recovery either overlap or are greater than the selling price for these materials. This is the essence of the problem and the basic reason why recycling is not growing at faster rates, and why

CTL007169

legislators and industry worldwide are struggling with who pays. Ultimately, we hope good economics will prevail, but in the meantime the public almost universally believes recycling is the answer and we as an industry are searching for the best, most economical recycling solution based on the integrated waste management hierarchy of reduce, re-use, recycle, waste-to-energy, and ultimately landfill. As we all know, waste-to-energy or incineration is a logical and likely cost-effective alternative but is almost universally resisted by the public which will not be convinced otherwise until the plastics recycling infrastructure is in place and all the alternatives can be weighed from an economic and environmental point of view. Perhaps we can learn more from our Japanese counterparts who now incinerate more than 70% of their waste.

So what are we as a PVC industry doing to address recycling, including tertiary or chemical recycling? **Packaging** - has been the primary focus, because it is the most visible part of the waste stream, so let me start there and in the U.S. It became very obvious to the Vinyl Institute (VI) VIGOR Group here several years ago that because PVC bottles are used in a broad variety of applications coming in many various shapes and sizes, it is very difficult to sort them manually as soda bottles and milk jugs are -- especially to do it economically. It was obvious that automatic sortation was required. Most of you are familiar with the evolution of

sortation equipment, so I'm going to run through it very quickly.

The Asoma device using x-ray fluorescence to zero in on the chlorine present in PVC was the first detector for single PVC bottles and was developed at Rutgers University. The second generation Asoma model with multiple detectors (shown here) is being used by Magnetic Separation Systems, Inc. (MSS) and I will review that company's work in a moment. National Recovery Technologies Inc. (NRT) -- with support from the VI and U.S.EPA -- developed the first multi detector for separating PVC and PET. This device, which uses electromagnetic radiation, senses the chlorine and sends a signal through a computer to activate an air jet, which ejects the bottle off the conveyor. The non-vinyl continues down the conveyor. NRT now markets three different VinylCycle<sup>TM</sup> models and has sold 16 machines.

Two "next generation" automatic sortation systems have come forward in this last year. Magnetic Separation Systems Inc. (MSS) has developed and commercialized, with support from P3, its modular BottleSort<sup>TM</sup> system to sort all plastic bottles. The base system separates bottles into streams of PVC and PET; unpigmented HDPE and polypropylene; and mixed color HDPE. Additional modules can be added to create a turnkey system producing color-sorted, single resin streams. For example, MSS uses a second generation Asoma unit to separate PVC and PET, and a color detector to separate clear and green

CTL007171

bottles. A complete 5000lbs/hr MSS system has been installed at Eaglebrook Recycling near Chicago and a PVC/PET system has been installed at Environmental Recycling in Raleigh, North Carolina. Automatic Industrial Controls (AIC), again with support from P3, has just started up its Poly-sort bottle recycling system at North American Recycling near Albany, NY. This fully integrated sorting line is running at 1500lbs/hr right next to a manual sorting line. It can identify all major packaging resins, including PET, HDPE, PVC and polypropylene - as well as a myriad of colors. Chamberlain MRC developed the materials handling systems for AIC using its experience in developing materials handling systems for the U.S. Post Office. Over the next year we plan to prove the viability of these systems from both a quality and cost standpoint. We have an excellent video tape showing these two operations that we can view in our meeting later today.

In addition to the technology I've just described, the VI has installed an NRT unit at Clearvue, a small recycler in Amsterdam, NY to both sort and clean PVC bottles. Later, we plan to sort blisters or other containers as well. We have also agreed to install an MSS device for sorting PVC and PET at Waste Alternatives, Inc. a MRF in Ocala, Florida and are exploring the installation of a PVC sorting devices on the West coast near Los Angeles, California.

In Europe, Govani has one of the first automatic sorting

devices for PVC and PET and with the recycling pressure on packaging in Italy are accelerating efforts on their process to include other plastics. For several years, Micronyl in France, Ecoplast in Belgium, and Tecoplast in Italy have been supplying ground vinyl bottles which are being converted into vinyl drain and sewer pipe (as shown in this slide). The collection of these PVC bottles is continuing to expand rapidly, and through programs like Operation Pelican, France will recycle 10,000 tons in 1992. Reprise (EVC) is re-locating its state-of-the-art recycling plant which sorts and recovers vinyl, PET and Polyolefins. EVC's DSR 2000<sup>TM</sup> process utilizes NRT technology for sorting the PET and vinyl. The Japan PVC Recycling Council has recently started up a recycling pilot project to recycle plastic bottles and egg cartons; we should learn more on their progress this week.

In addition to bottle sorting efforts, work is also progressing on the sorting of bottle flake both in the U.S. and Europe. One system, developed by DevTech in the U.S. using proprietary technology, produced excellent results in small-scale testing but ran into some problems when it was used in full-scale testing by CarpcO, Inc. The technology currently is being re-evaluated. Kali and Salz in Germany, a major potash producer, has applied the electrostatic technology for separating inorganic salts to plastics and is continuing large scale trials. Professor Insulet at the

CTL007173

University of Western Ontario in Canada is also continuing work on electrostatic separation of plastics.

Froth Flotation, used for many years in the mining industry, is also being evaluated today for separation of PET and PVC flake. This technology depends on developing an effective emulsifier to preferentially attach bubbles to the PVC flake so that it will float and can be separated by gravity.

GoodYear Tire and Rubber in Akron, and Recovery Processes, Inc. (RPI) in Park City, Utah have both tested such systems. Hoechst-Celanese plans to install the RPI system in its new recycling plant later this year.

Melt Filtration is the final step to get a recycled PVC material which will be acceptable for bottles and for some other applications. Although melt filtration is commonly used for cleaning up recycle polymers such as PET and HDPE, technology to melt filter rigid PVC is just now being commercialized here in the U.S. Oxy has been working with Gneuss and found it is much more difficult to melt filter bottles vs. siding or U.S. bottles vs. European. U.S. bottles tend to contain more impact modifier and are more rubbery, which changes the processing characteristics. In addition, the lower melt viscosity shrinks less than other materials and makes it very difficult to remove from the die and/or breaker plate.

In summary, the technology for bottle separation and cleaning

is here or very close and we should see the commercial realities later this year. The primary issues still to be resolved are economics, quality and end-use applications.

One of the major issues driving packaging recycling today is legislation or the threat of legislation. Again, Germany has taken a lead position with its dual system which requires that 80% of all plastics packaging be collected and 80% of that be recycled by 1996. In other words, the program sets an overall recycle rate of 64%. The law permits material recycling, chemical recycling and export, but not incineration. Without incineration and export the goal is likely not achievable and even now the objections to Germany exporting waste is escalating. This situation has accelerated efforts on chemical recycling which I will discuss later. EEC has issued a proposed directive with more moderate requirements for recycling rate that would even permit some level of incineration. Debate on that directive will start this fall. In the U.S. there are numerous state proposals and some legislation on recycling percentage or rate, but these are contingent on bottle collection rates. Massachusetts has a particularly stringent initiative on the ballot in November which industry is vigorously opposing. Federal legislation on recycling as part of the reauthorization of the Resource Conservation and Recovery Act (RCRA) is not likely to occur during this congressional session. Through P3, the plastics industry has set a 25%

CTL007175

recycling rate goal by 1995 and is aggressively pursuing that target. A key issue still to be resolved is who pays and how.

**DURABLES** - So far, I have talked a great deal about packaging but as all of you know DURABLES are our bread and butter and, as we predicted some time ago, the recycling wave or "ripple effect" is moving in that direction. In the U.S., P3 has organized a Durables Committee with four sub-groups: Automotive, Computers and Business Equipment, Appliances and Construction. All of these groups are just getting started with Automotive leading the way by building on their base provided by the SPI Automotive Committee and the Automotive Marketing Council. Europe, primarily Germany, is leading the efforts on automotive recycling. BMW and Opel have taken an unofficial position, of eliminating PVC from autos. On the other hand, we understand Mercedes likes PVC. Japan's major producers -- Toyota, Honda, and Nissan -- are following Europe's lead and have taken a position of recycling by 1995 or replacing PVC. Their primary concerns are potential toxic gas formation on incineration of PVC and the difficulty in recycling PVC -- specifically the instrument panels. Their impetus is to remain competitive in the Global market.

The automotive industry in the U.S. is rapidly following this trend. The intent is to reduce the number of polymers used in each car and the move is toward designing for

recyclability. BMW has actually established three auto recycling centers here in the U.S. EVC and Hydropolymers are working on a totally recyclable PVC interior car door panel and trim in the U.K. They have produced a prototype from PVC and discussed with two major U.K. car makers. I personally believe PVC now faces de-selection in the automotive market as it did in bottles several years ago. That de-selection is based primarily on environmental perceptions and concern about recyclability.

In other durable applications, Europe has set up a number of Industry coalitions for recycling.

- o Vinyl flooring is being recycled by a vinyl flooring/vinyl industry coalition. That group currently has a capacity of 5000 tons/yr and expects to recycle about 1000 tons in 1992. The recycled material is going back into floor backing material.
- o Rigid blister pack is being collected by the industry in drug stores and hospitals and taken back by members for recycling at about 200 tons/yr.
- o An industry vinyl window take back program operated by Vekaplast is recycling about 5000 tons/year into non-visible window profiles and roof tiles.

The Vinyl Siding Institute in the U.S. had a program to recycle scrap from siding installers, but it eventually ended as the recession drove down virgin prices and cut siding

scrap prices to zero.

Japan has a significant program to recycle about 40% of its PVC agricultural film -- about 100,000 tons/yr -- into floor tiles, footwear, and waterproof sheet. Japan is also recycling about 10,000 tons/yr PVC wire and cable insulation. EVC2 operates a plant in Italy to recycle wire and cable plant scrap into shoe soles and other flexible applications. BFGoodrich has been working with Waxman Ltd., a major wire & cable chopper in Ontario, Canada to start up a recycling plant this fall to recover PVC wire coatings.

In both Europe and the U.S. there is a significant volume of industrial scrap which is recycled but does not get discussed since it is an on-going part of the broker market and many processors use it to improve their competitive position.

A significant amount of effort in Europe, Japan, and the U.S. is moving toward **TERTIARY or CHEMICAL RECYCLING**. The most notable is the alcoholysis or methanolysis of PET to take the polymer or plastic back to its monomer form. Another approach is pyrolysis, where polymers are heated in the absence of air and/or in the presence of catalysts to break polymers down to oily chemical residues or monomers that can be fed to an oil refinery process. Unfortunately, under these conditions, PVC generates HCL, which can be corrosive or potentially inhibit the catalysts present. However, large

scale testing operations are in progress in Europe by PWMI and in the U.S. by P3, and both contend they can handle low levels of PVC in their stream. For example, a 60 ton trial in a German hydrogenation plant using unsorted plastic waste with 10% PVC produced an acceptable oil feedstock for a refinery. These operations will determine the acceptable levels of PVC which can be successfully handled and/or a means to dehalogenate the waste prior to pyrolysis. PWMI has a dehalogenation task group working to find methods to remove PVC prior to pyrolysis. Bruce Bauman at Rensselaer Polytechnic Institute, is continuing solvent extraction of all plastics scrap and currently developing a pilot plant design. Economics is the key issue. The chemical recycling could be an acceptable solution to industry, government, and environmental groups, since part or all of the polymer can be recovered and recycled. However, the time needed to define the economics could be 2-5 years off, so the immediate solution remains direct recycling, hence my emphasis today.

None of the individual segments of the integrated waste management hierarchy are self-sufficient. All, including recycling, must be developed and used as appropriate. Some waste or scrap streams will be easy to process and they are already being handled by the scrap broker market. Others will be more difficult, but economical, and some will never be practical or economically viable. A possible example of this is auto shredder residue, which will likely have to be

incinerated. The key is to define the differences and show the public, government and environmentalists that the balance is reasonable: a noble, expensive, and time consuming goal.

In summary, the recycling or recovery technologies are rapidly evolving to handle recycling of plastics, including PVC. The primary challenges facing us are to:

- o Continue to develop the recycling infrastructure and the technology so all the alternatives (including chemical recycling and incineration) can be weighed from both an economic and environmental view.
- o Implement PVC recycling where practical and economical providing consistent quality materials..
- o Aggressively address the environmental concerns facing PVC and provide visibility for vinyl recycling.
- o Attempt to preempt or influence recycling legislation so it does not disrupt market economics.

FEKrause/Sept.1992

CTL007180

VINYL INDUSTRY TRIPARTITE MEETING

SEPTEMBER 1-3, 1992

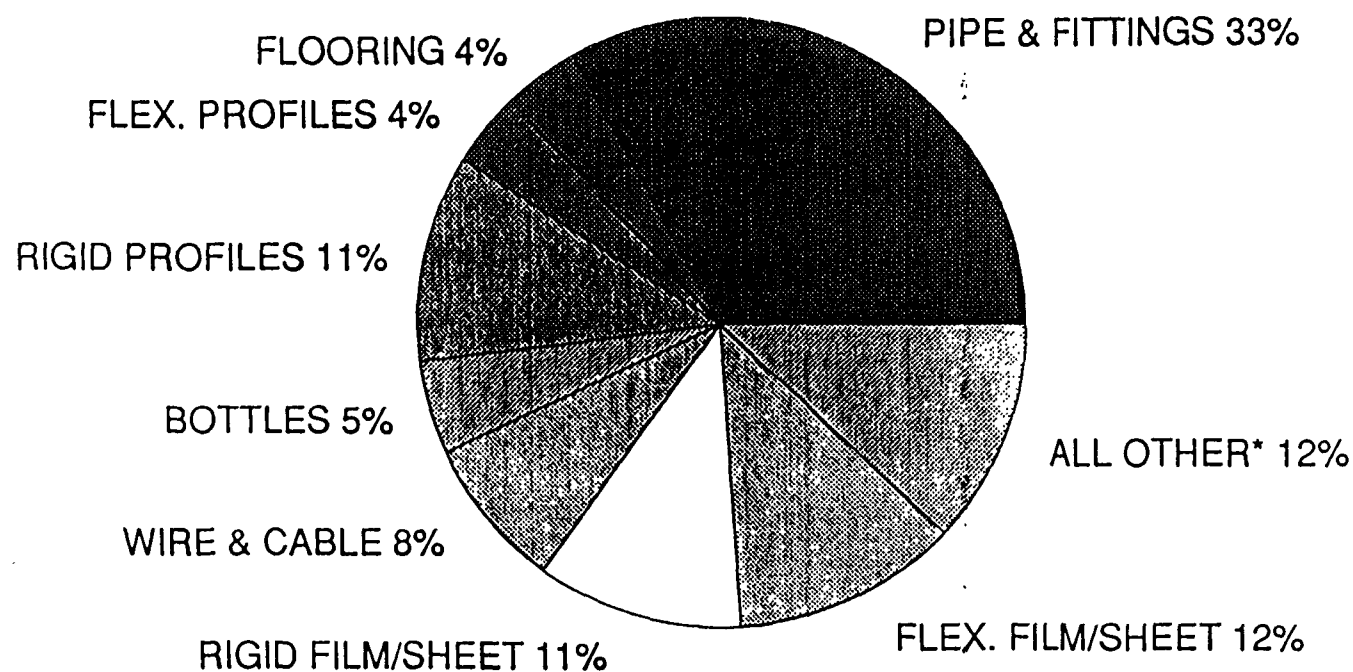
***PVC, It's Recyclable!***



CTL007181

OFFICE OF THE ATTORNEY GENERAL

# WORLD PVC DEMAND BY MARKET 1991



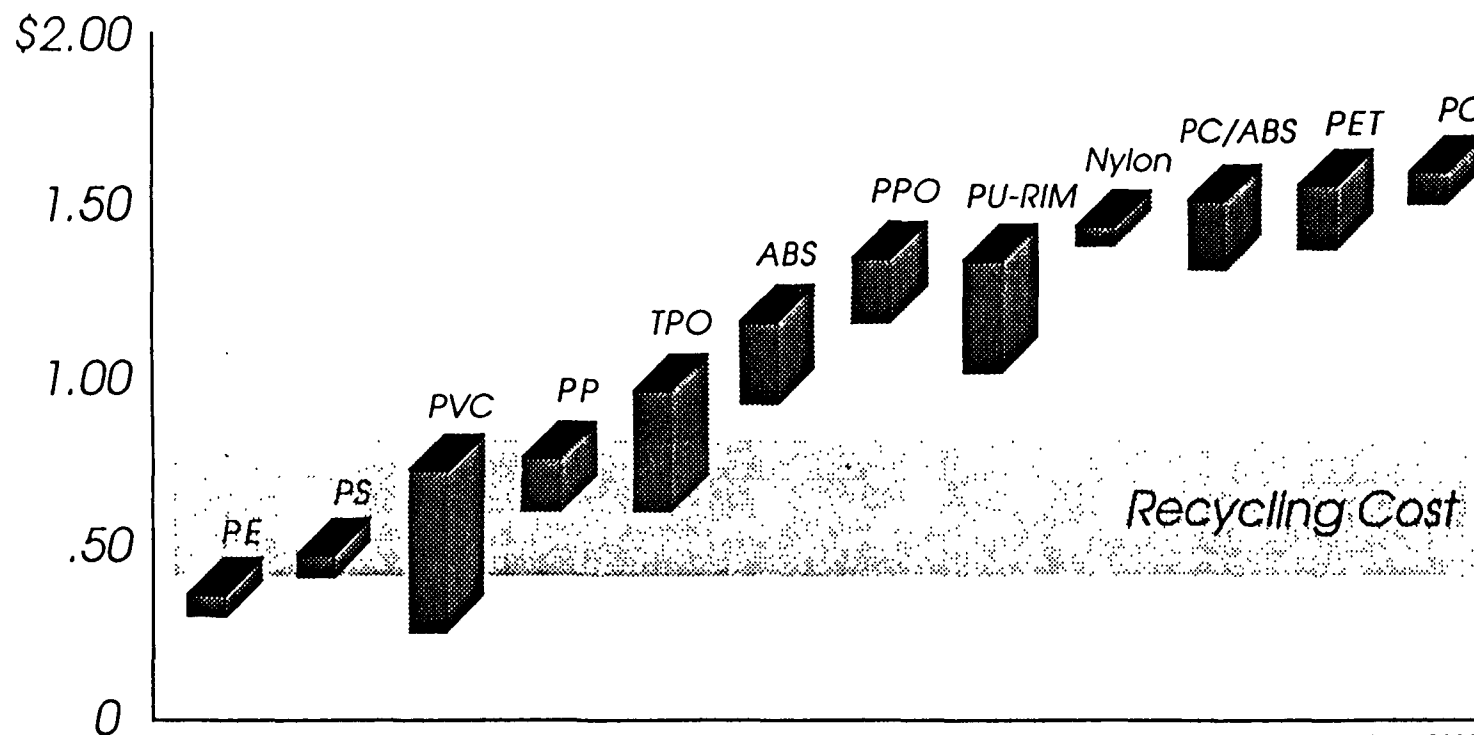
TOTAL = 40 BILLION LBS.

\*Other includes footwear, coated  
fabrics, new applications, etc.  
Source: CMAI, BFGoodrich

CTL007182

# Post-Consumer Resins Recycling Costs vs. Product Value

(\$/Lb.)



Source: Dow - SPE-Antec - 1992



# *Solid Waste Management - Hierarchy*

---

- *Reduce*
- *Re-Use*
- *Recycle*
- *Waste-To-Waste Energy*
- *Landfill*



CTL007184



FIGURE 8  
VINYL BOTTLES  
ASSORTED SIZES AND SHAPES

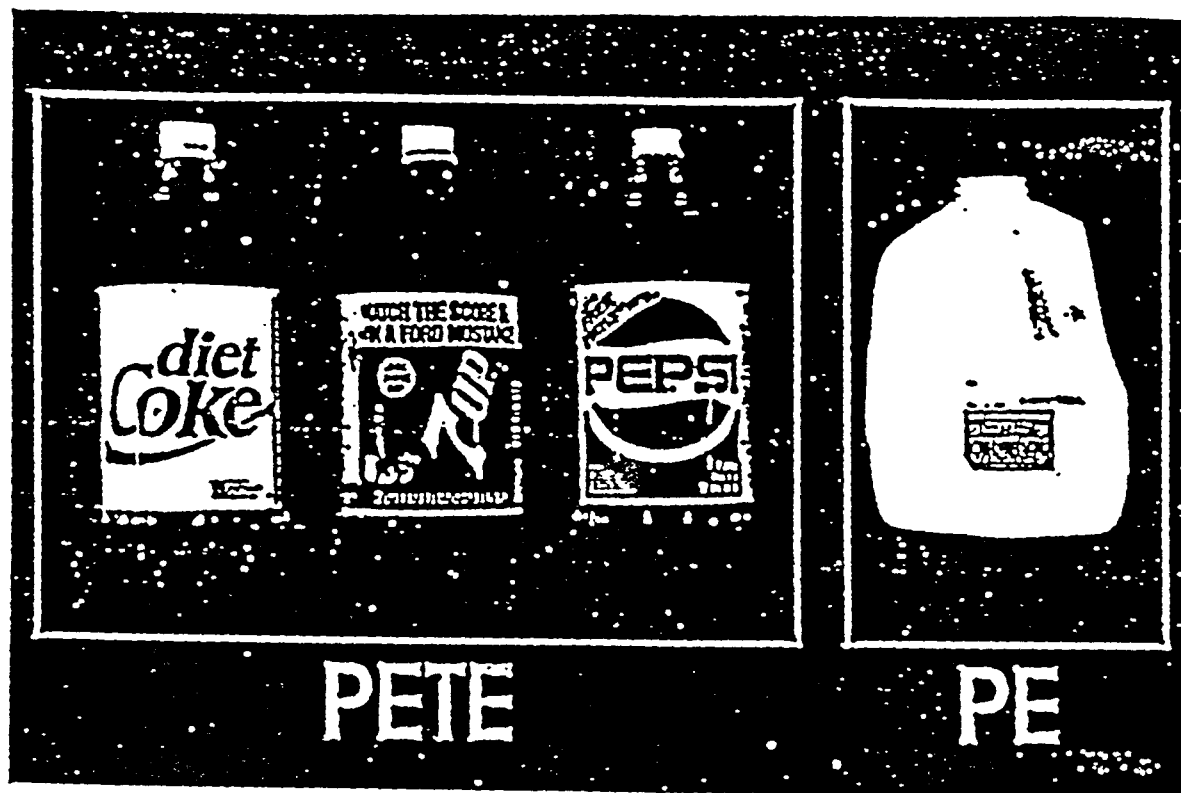
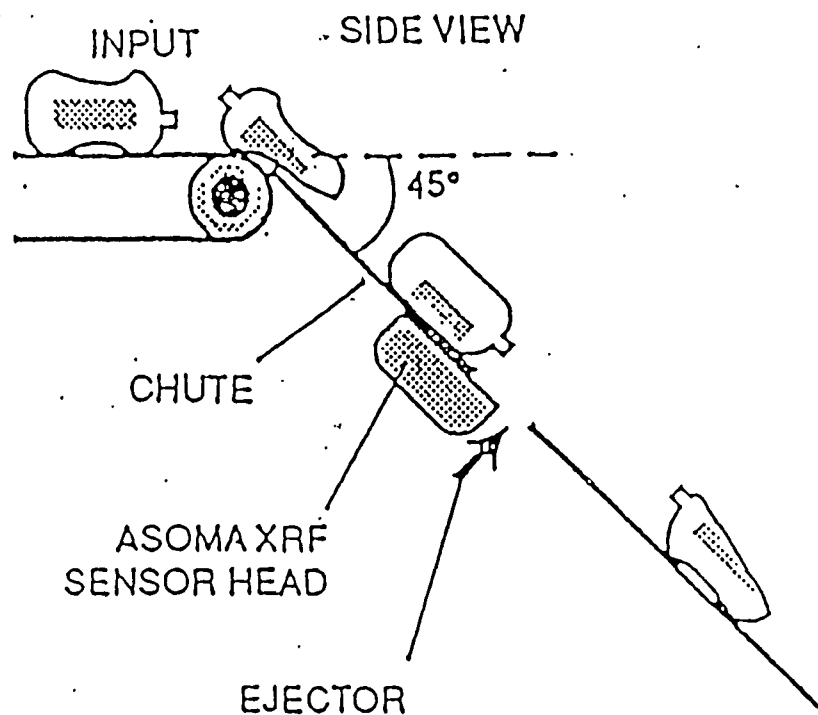


FIGURE 7  
SODA BOTTLES AND MILK JUGS -  
MANUALLY SORTED

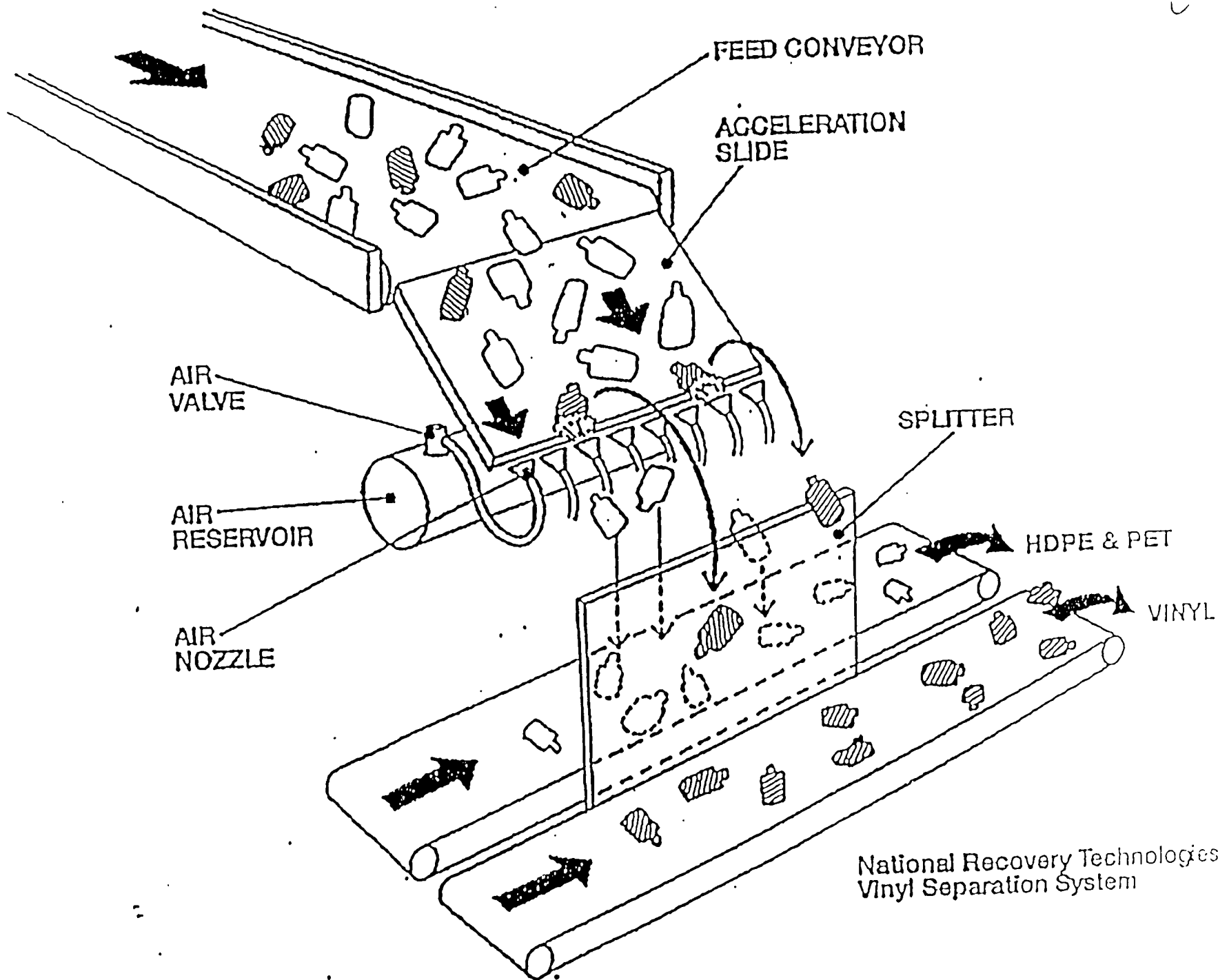
CTL007186

⑦



ASOMA VS-2 Detector

(18)



National Recovery Technologies  
Vinyl Separation System

CTL007188

# *Post Consumer Recycling*

---

## *Next Generation Automatic Sortation Technology*

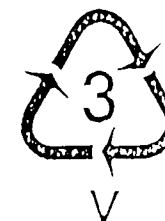
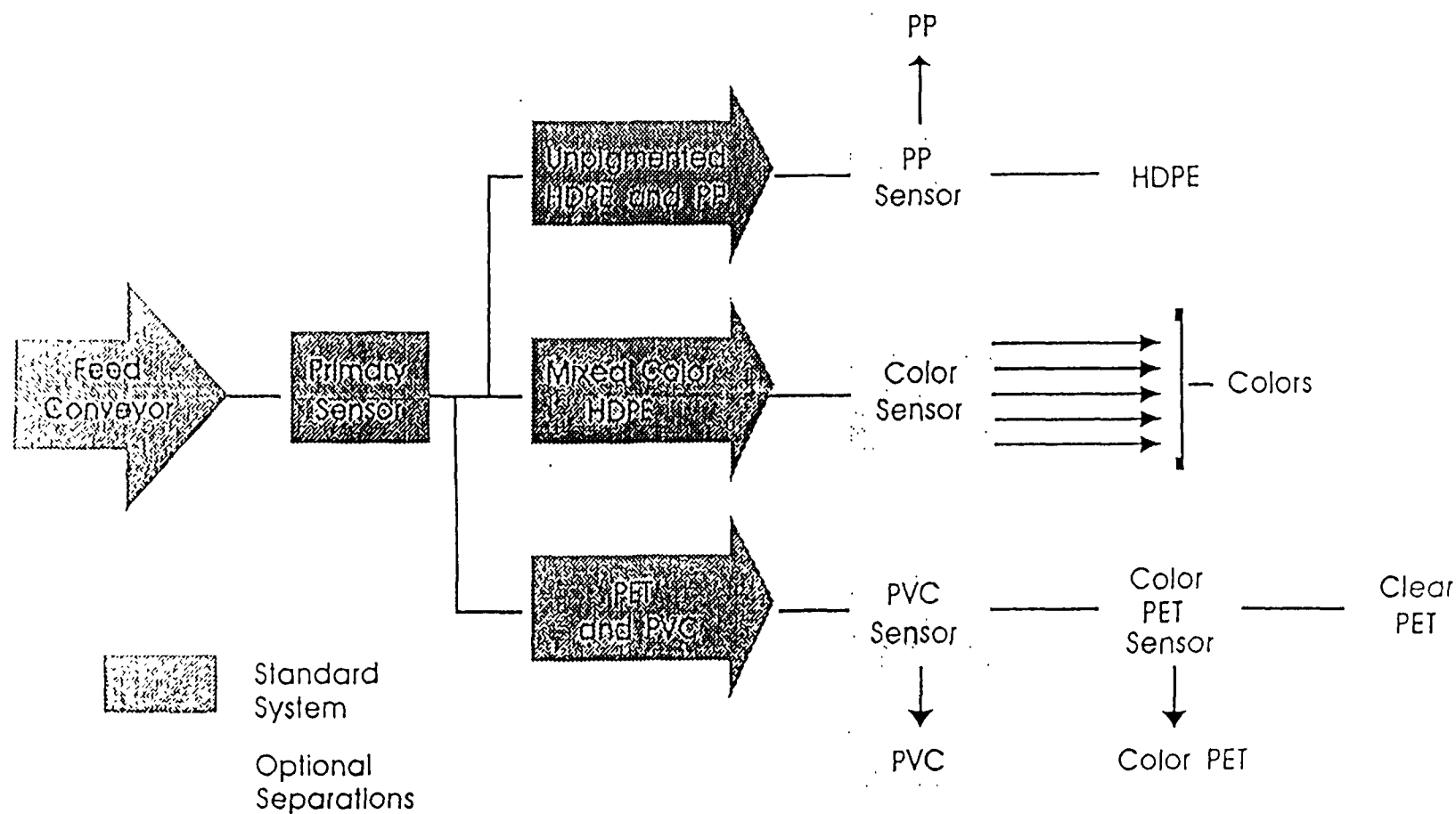
- *Magnetic Separation Systems (MSS) – Eaglebrook*
- *Automation Industrial Control (AIC) – Autosort Demonstration*
- *National Recovery Technology (NRT)*

CTL007189



19

# Magnetic Separation Systems

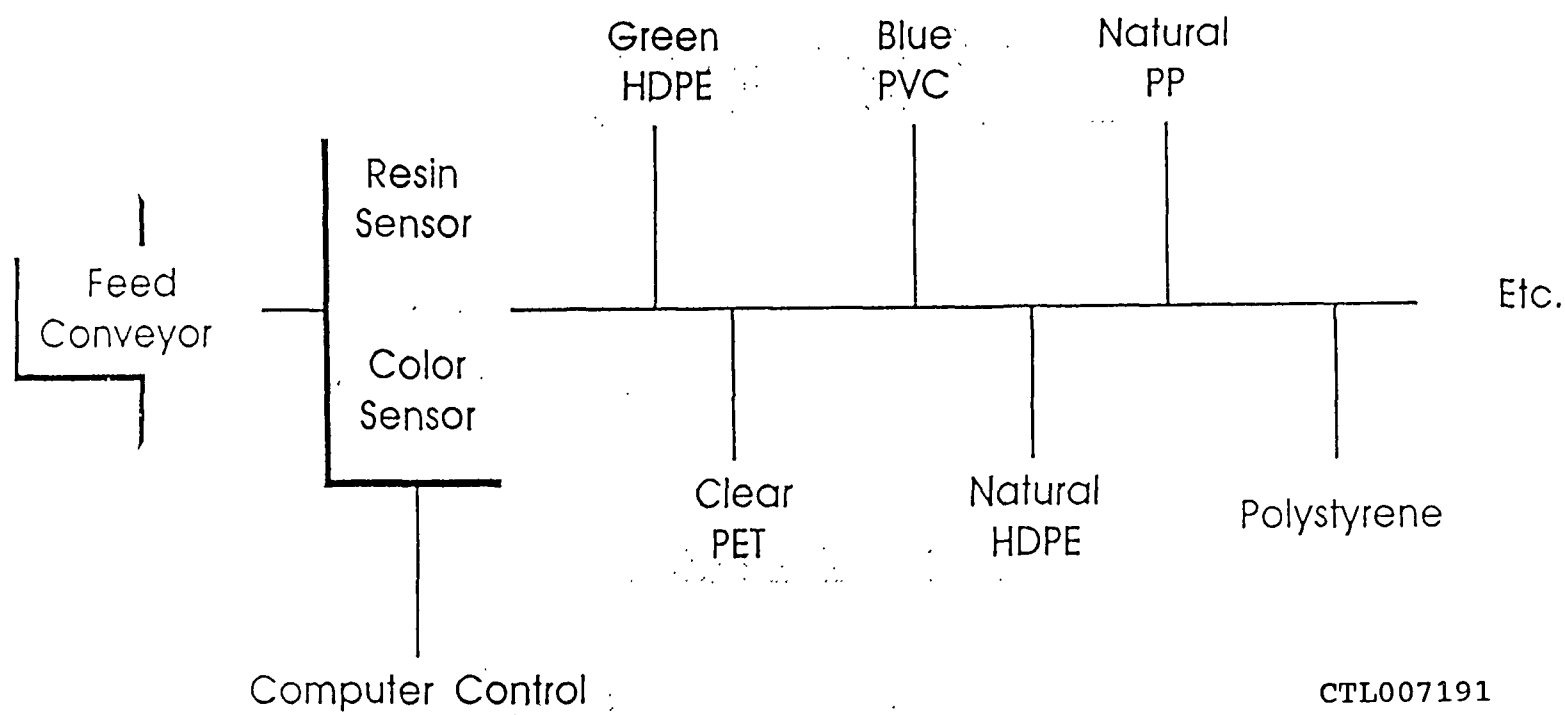


VINYL IT'S RECYCLABLE

CTL007190

10

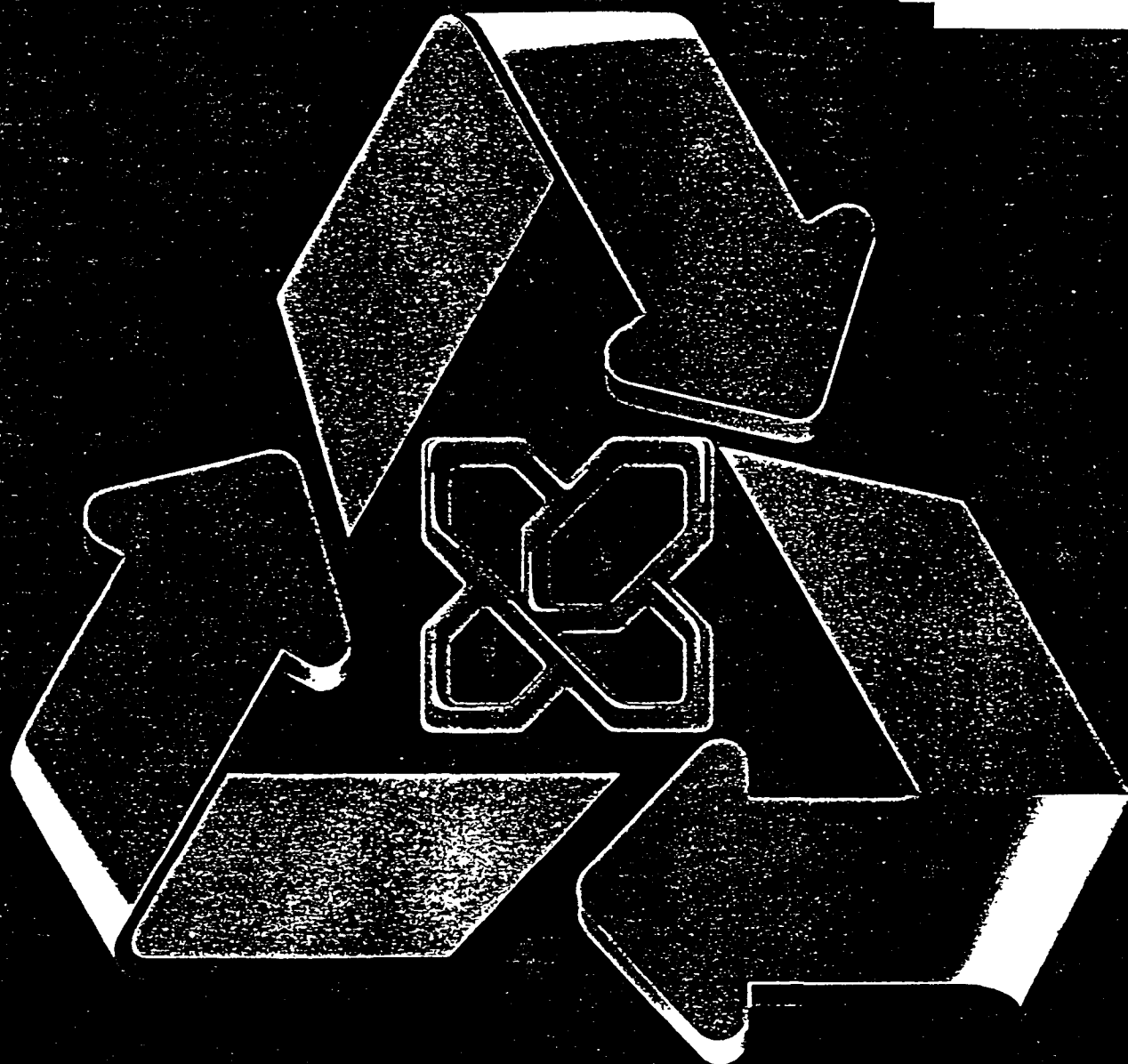
# Automation Industrial Control



CTL007191



VINYL IT'S RECYCLABLE



CTL007192

divisione tecnologie  
ecologiche  
ecological technologies

 **QOVONI**

12

PIPE SAMPLE

11

CTL007193

(13)

DSR-2000

?

CTL007194

# *Post Consumer Recycling*

---

## *Bottle Flake Separation*

- *DevTech*
- *Kali & Salz*

## *Froth Flotation*

- *Goodyear*
- *RPI*



CTL007195

# Post Consumer Recycling

---

## *Melt Filtration*

- *Standard with PET/Polyolefins*
- *PVC Tougher*
- *Commercializing*



VINYL IT'S RECYCLABLE.

CTL007196

# *Post Consumer Recycling*

---

## *Summary*

- *Technology Close*
- Issues*
- *Economics*
- *Quality*
- *Applications*



VINYL IT'S RECYCLABLE.

CTL007197

# Legislation

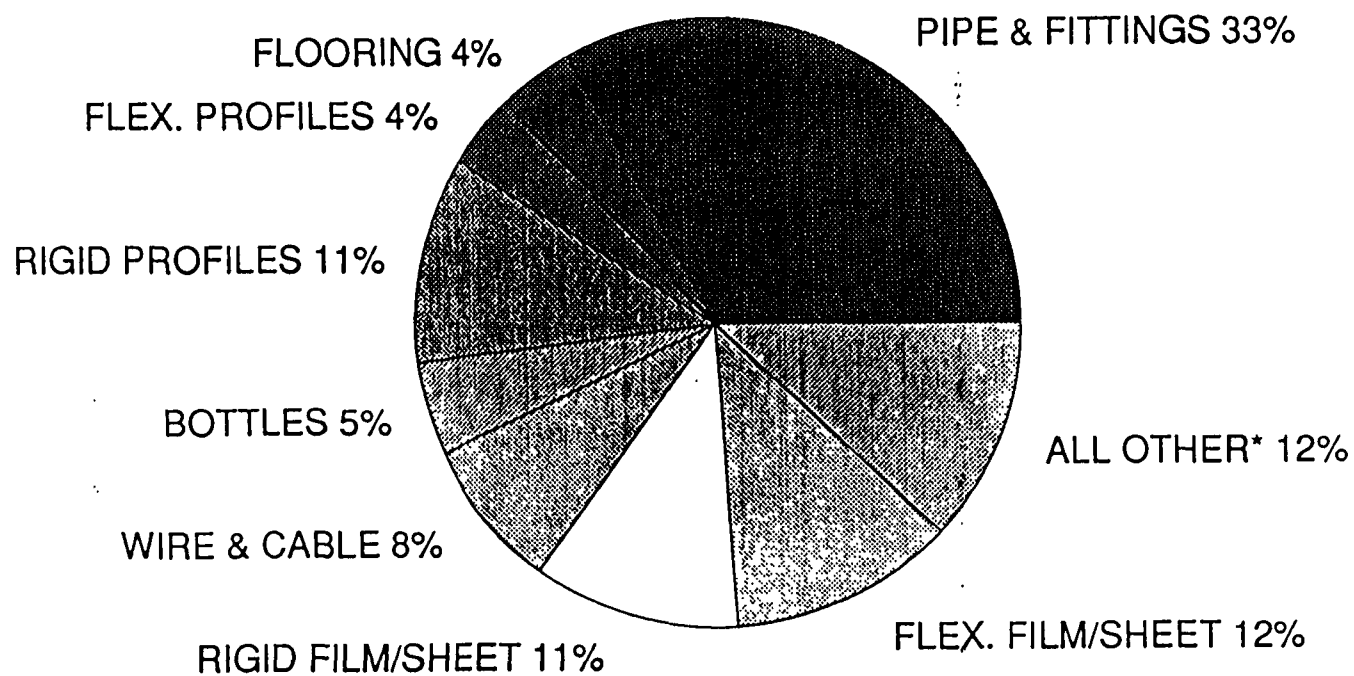
---

- *Germany*
- *EEC*
- *U.S.*
  - *State*
  - *Federal - RCRA*
- *Japan*

CTL007198



# WORLD PVC DEMAND BY MARKET 1991

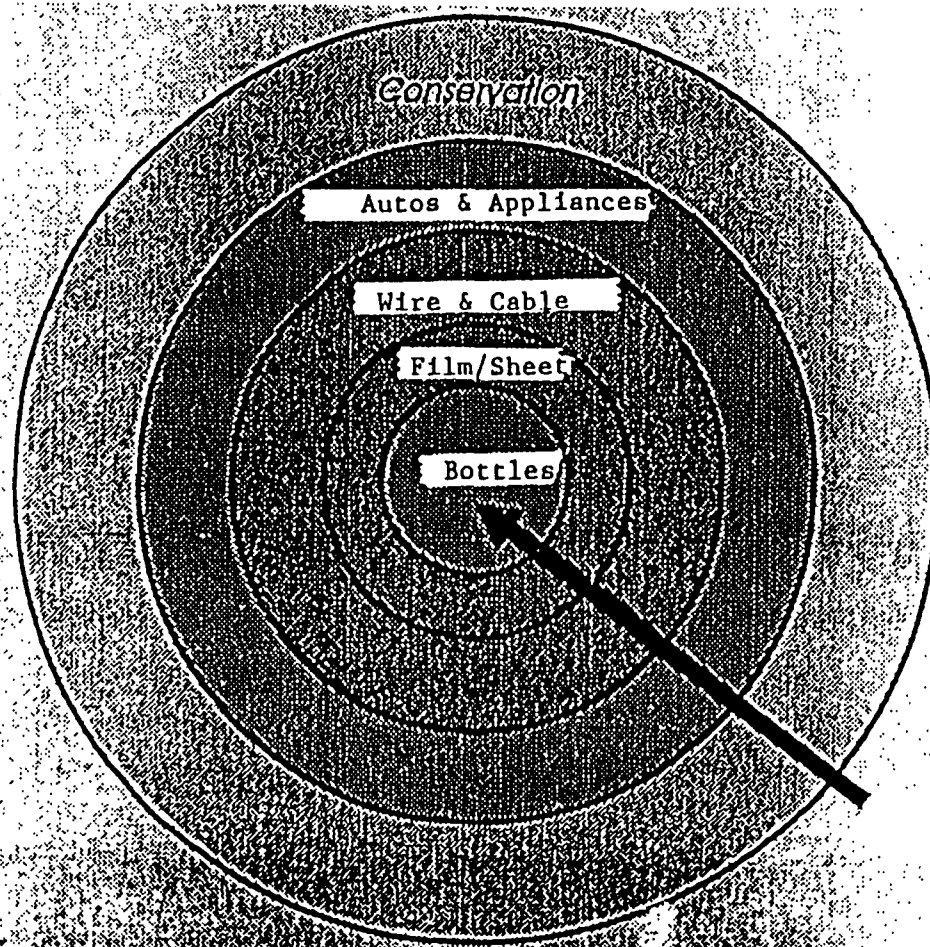


TOTAL = 40 BILLION LBS.

\*Other includes footwear, coated  
fabrics, new applications, etc.  
Source: CMAI, BFGoodrich

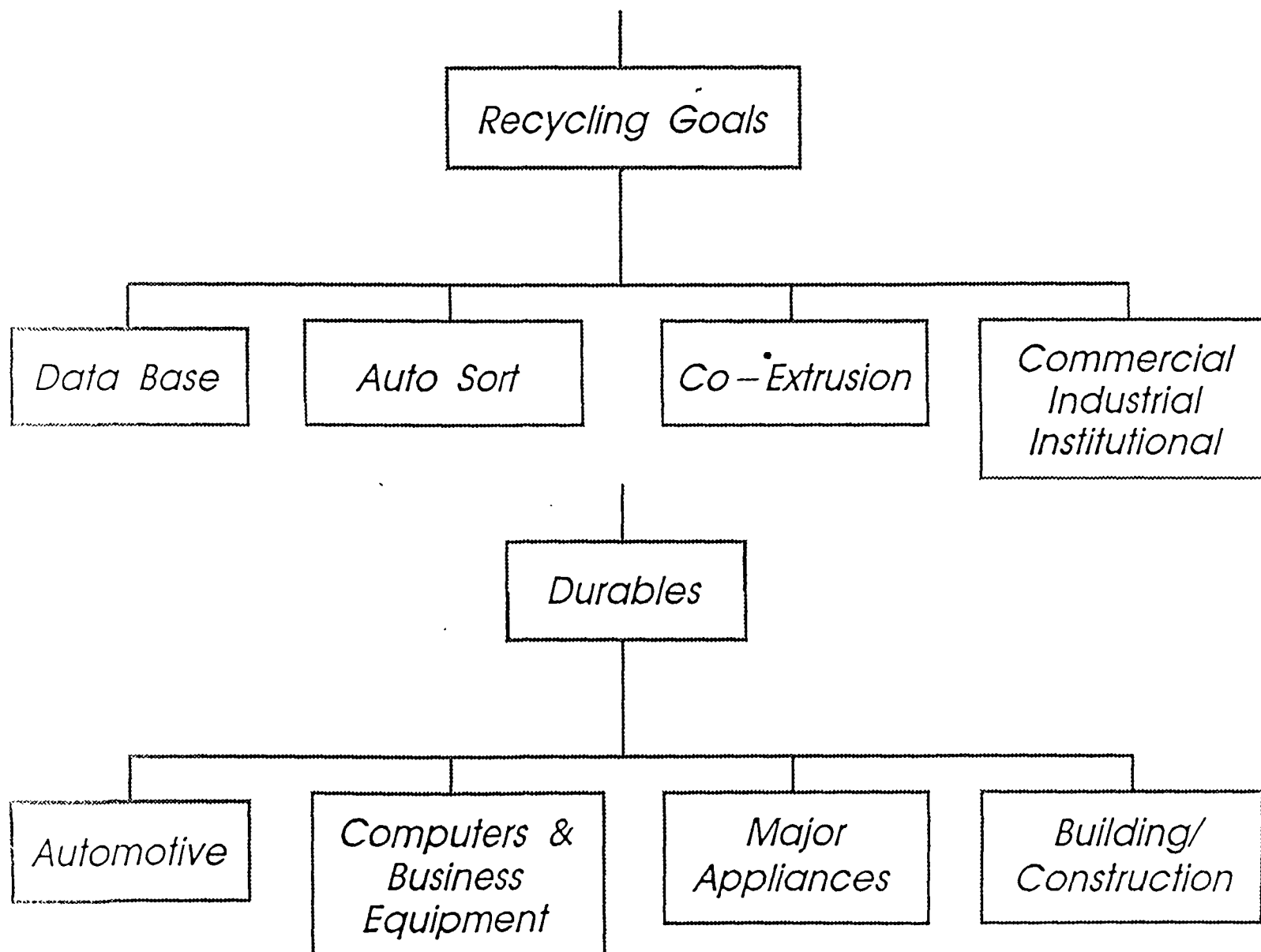
CTL007199

# *Ripple Effect of Solid Waste Issue on Vinyl*



CTL007200

10



CTL007201



# Durables Recycling

---

## Automotive

- Germany
- Japan
- U.S.

## De-Selection



VWYL IT'S RECYCLABLE.

CTL007202

# *Durables Recycling - Vinyl*

---

- *Flooring*
- *Blister Pack*
- *Windows*
- *Siding*
- *Agricultural Film*
- *Wire and Cable*



VINYL IT'S RECYCLABLE.

CTL007203

# *Tertiary/Chemical Recycling*

---

- *Alcoholysis/Methanolysis*
- *Pryolysis*
- *Solvent Extraction*



VINYL IT'S RECYCLABLE

CTL007204

# *Solid Waste Management - Hierarchy*

---

- *Reduce*
- *Re-Use*
- *Recycle*
- *Waste-To-Waste Energy*
- *Landfill*



CTL007205

# Vinyl Recycling

---

## Summary

- *Develop Infrastructure*
- *Implement PVC Recycling*
- *Provide Visibility*
- *Position Legislation*



VINYL IT'S RECYCLABLE

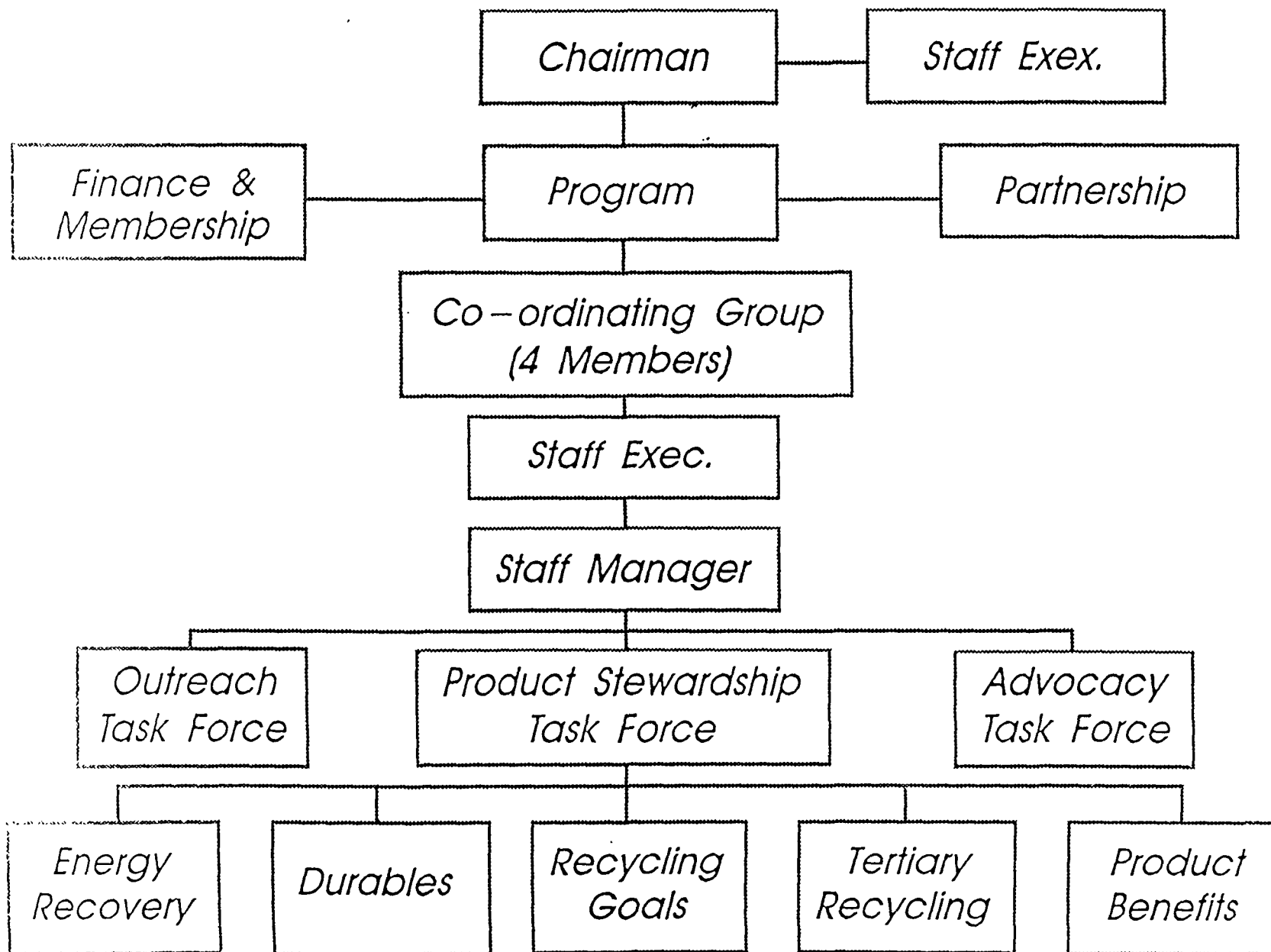
CTL007206



VINYL IT'S RECYCLABLE.

CTL007207

Backed



CTL007208

# REGULATIONS - ENVIRONMENT

omit

## U. S.

- o NO BANS ON PVC
- o STATES VERY ACTIVE
  - CALIFORNIA/OREGON - RECYCLE CONTENT
  - OTHERS CONSIDERING
- o FEDERAL - RCRA RE-AUTHORIZATION

## EUROPE

- o GERMANY - DUALES SYSTEM
- o FRANCE
- o EC

CTL007209