Argonne National Laboratory's Froth Flotation Process for Recovering Usable Plastics from Mixed Plastics Waste

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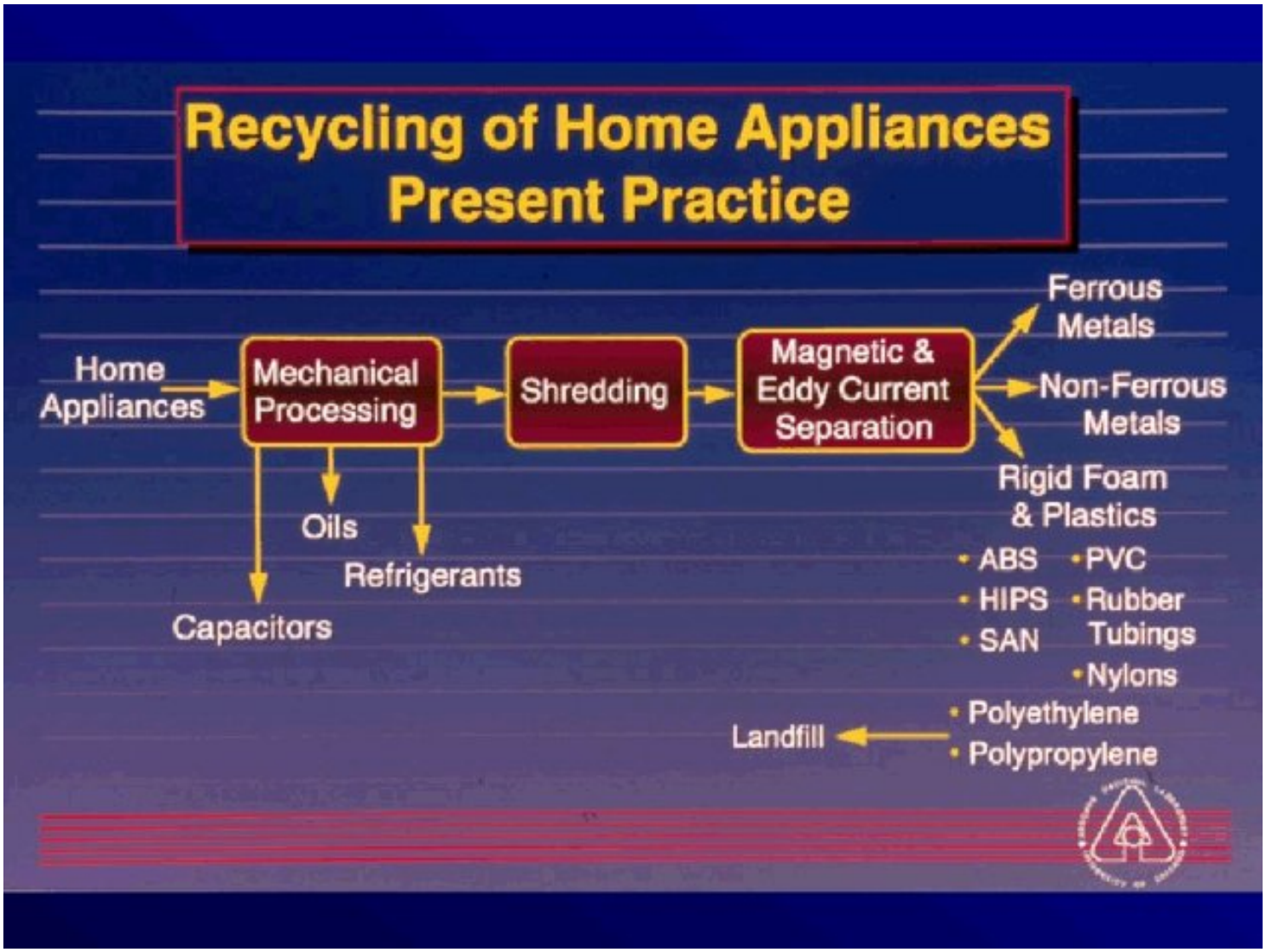
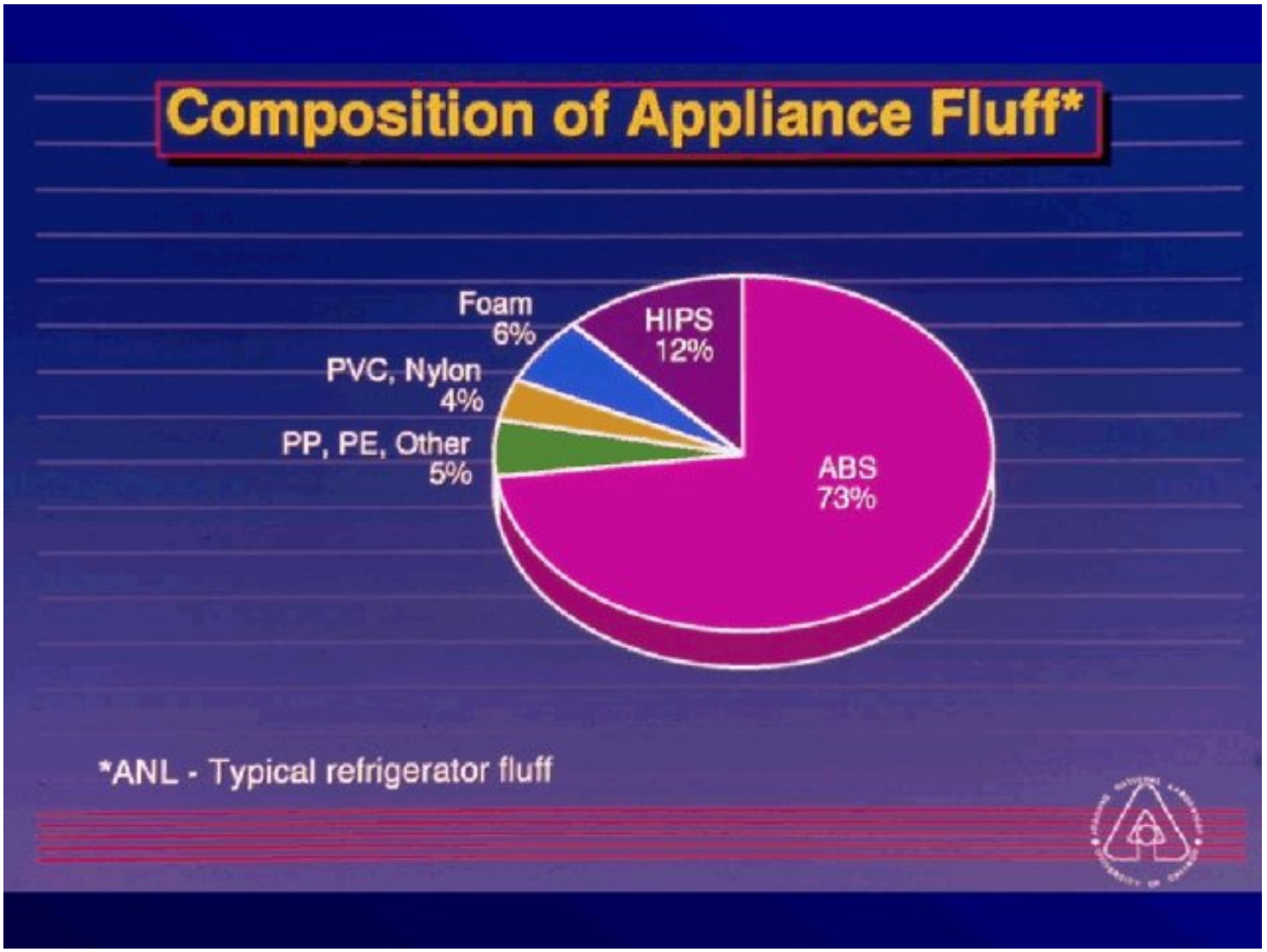
Industrial Collaboration
• Appliance Recycling Centers of America, Inc.
• General Electric Co., Specialty Chemicals Group
• Bayer Co., Polymers Division
• QTR, Inc.
• University of Akron, Polymers Engineering Dept.

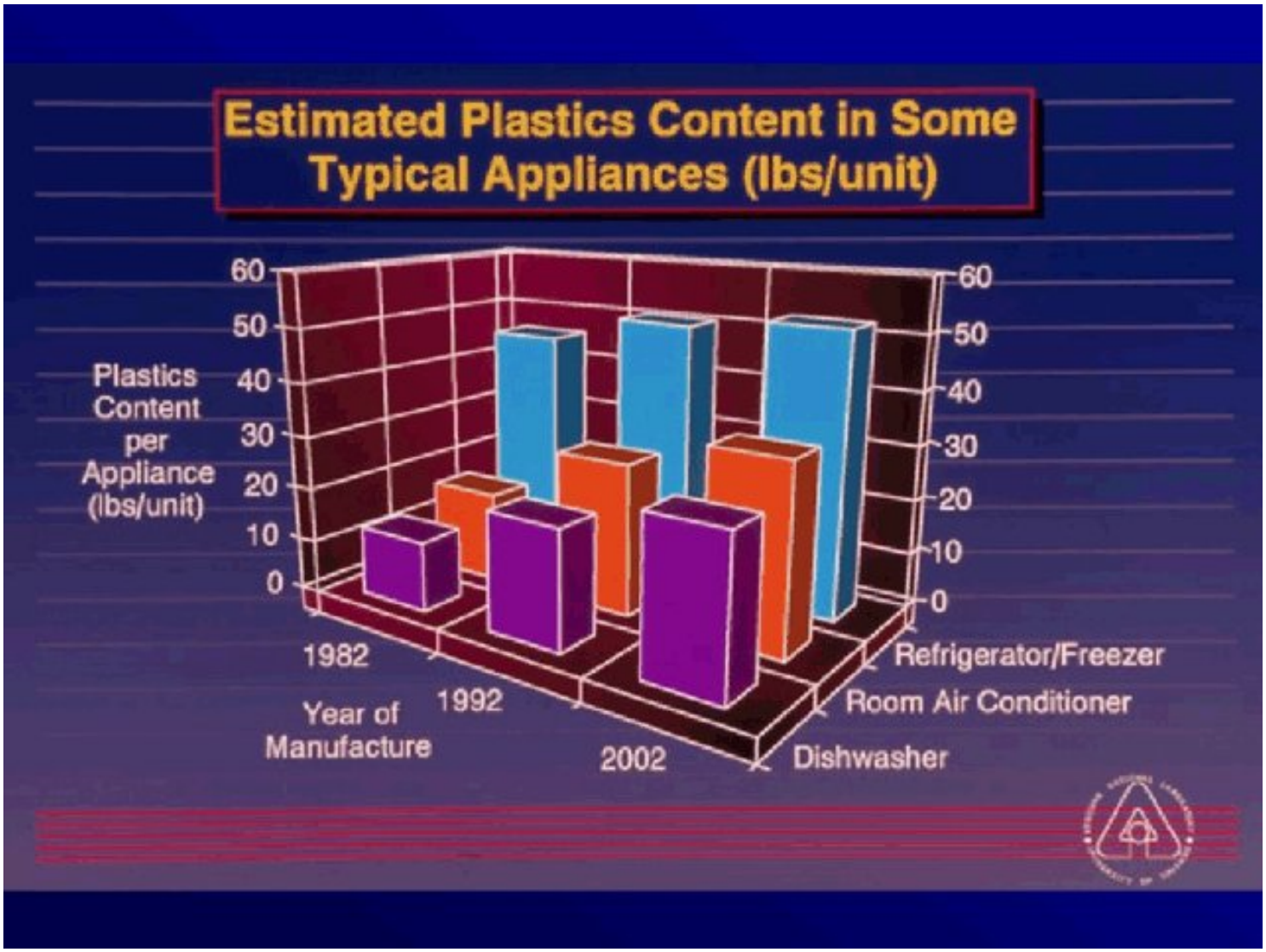
Project Objectives

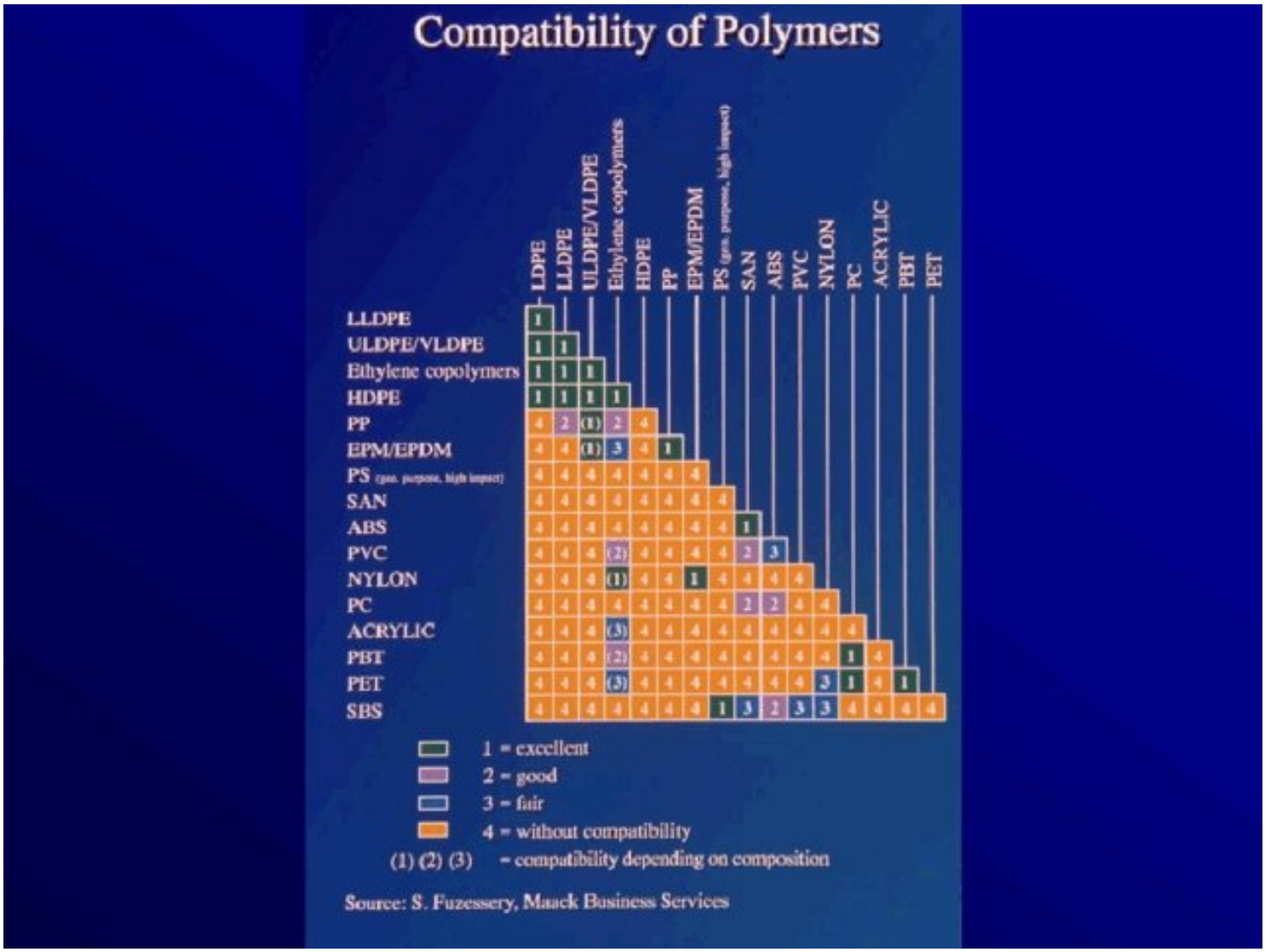
Collaborate with the industry to:

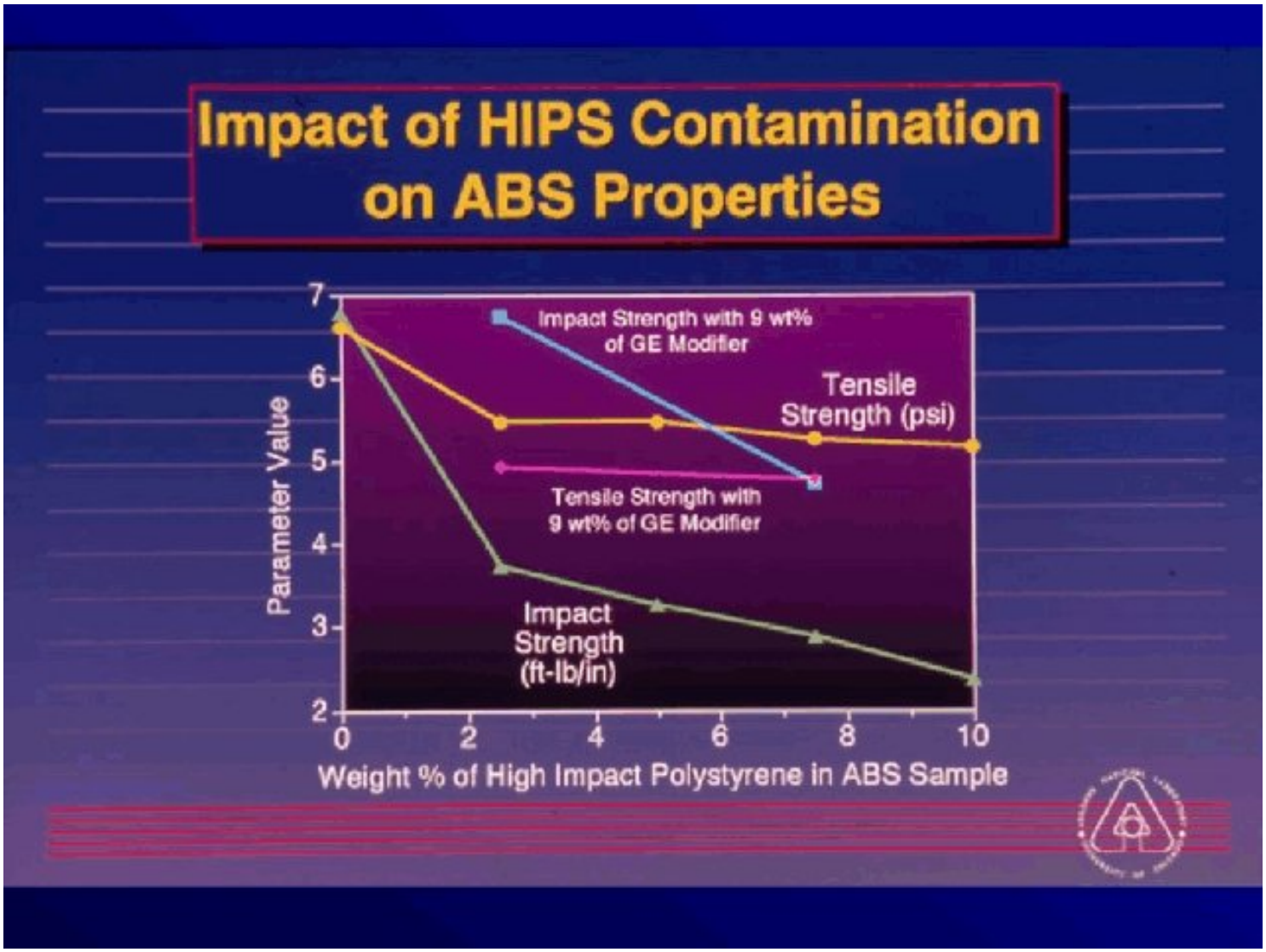
- Develop cost-effective technologies/processes for recovering and reclaiming high purity plastics materials from obsolete appliances;
- Identify high-value applications for recovered plastic materials

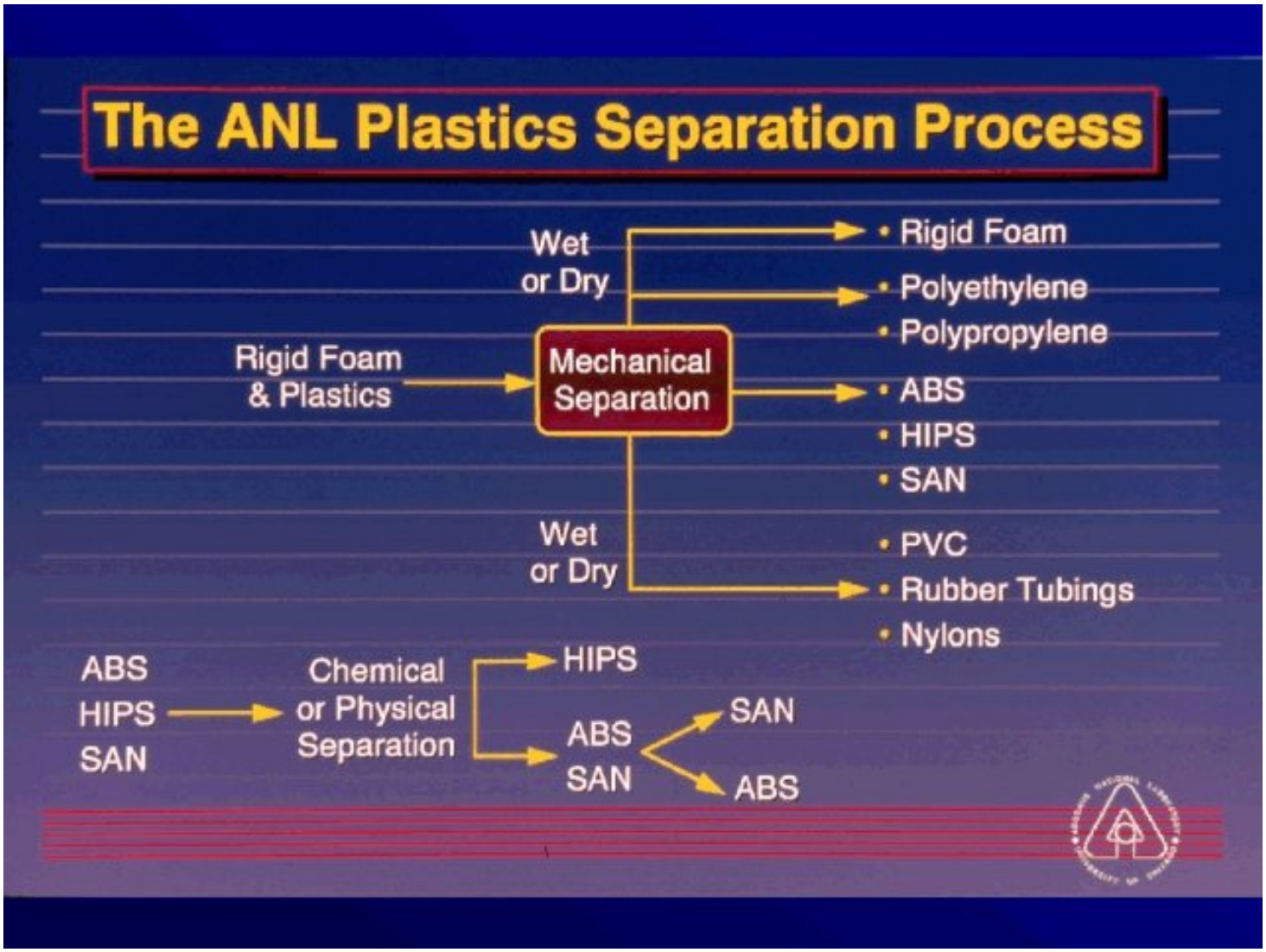

Recycling of Home Appliances
Present Practice
Home Appliances
Mechanical Processing
Shredding
Magnetic & Eddy Current Separation
Ferrous Metals
Non-Ferrous Metals
Rigid Foam & Plastics
• ABS
• PVC
• HIPS
• Rubber Tubings
• SAN
• Nylons
• Polyethylene
• Polypropylene
Landfill
Oils
Refrigerants
Capacitors


Composition of Appliance Fluff*
Foam 6%
HIPS 12%
PVC, Nylon 4%
PP, PE, Other 5%
ABS 73%
*ANL - Typical refrigerator fluff


Estimated Plastics Content in Some Typical Appliances (lbs/unit)
Plastics Content per Appliance (lbs/unit)
60
50
40
30
20
10
0
1982
1992
2002
Year of Manufacture
Refrigerator/Freezer
Room Air Conditioner
Dishwasher

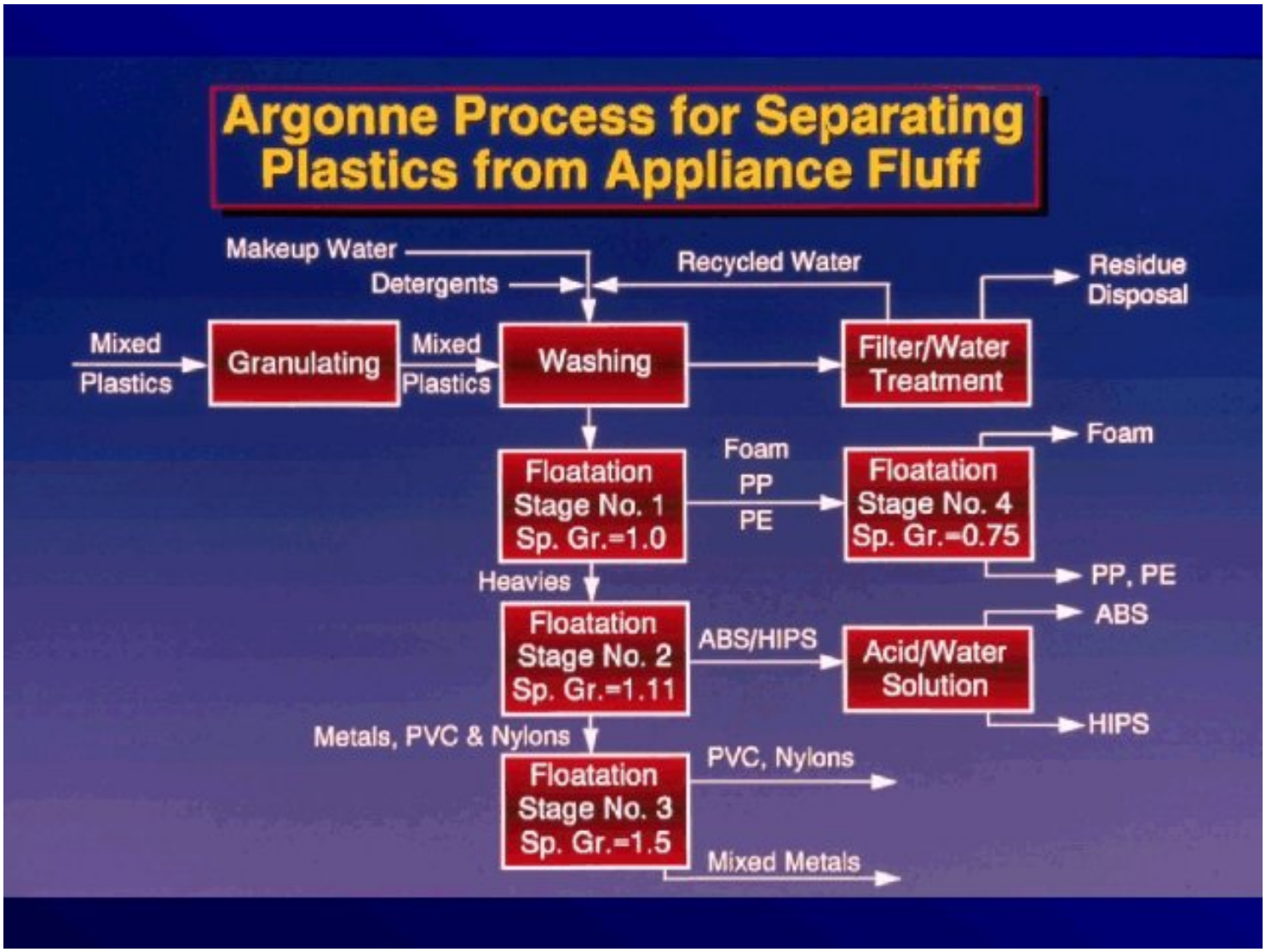

Compatibility of Polymers
LDPE
LLDPE
ULDPE/VLDPE
Ethylene copolymers
HDPE
PP
EPM/EPDM
PS (gen. purpose, high impact)
SAN
ABS
PVC
NYLON
PC
ACRYLIC
PBT
PET
LLDPE
ULDPE/VLDPE
Ethylene copolymers
HDPE
PP
EPM/EPDM
PS (gen. purpose, high impact)
SAN
ABS
PVC
NYLON
PC
ACRYLIC
PBT
PET
SBS
1 = excellent
2 = good
3 = fair
4 = without compatibility
(1) (2) (3) = compatibility depending on composition
Source: S. Fuzessery, Maack Business Services


Impact of HIPS Contamination on ABS Properties
Impact Strength with 9 wt% of GE Modifier
Tensile Strength (psi)
Tensile Strength with 9 wt% of GE Modifier
Impact Strength (ft-lb/in)
Parameter Value
7
6
5
4
3
2
0
2
4
6
8
10
Weight % of High Impact Polystyrene in ABS Sample

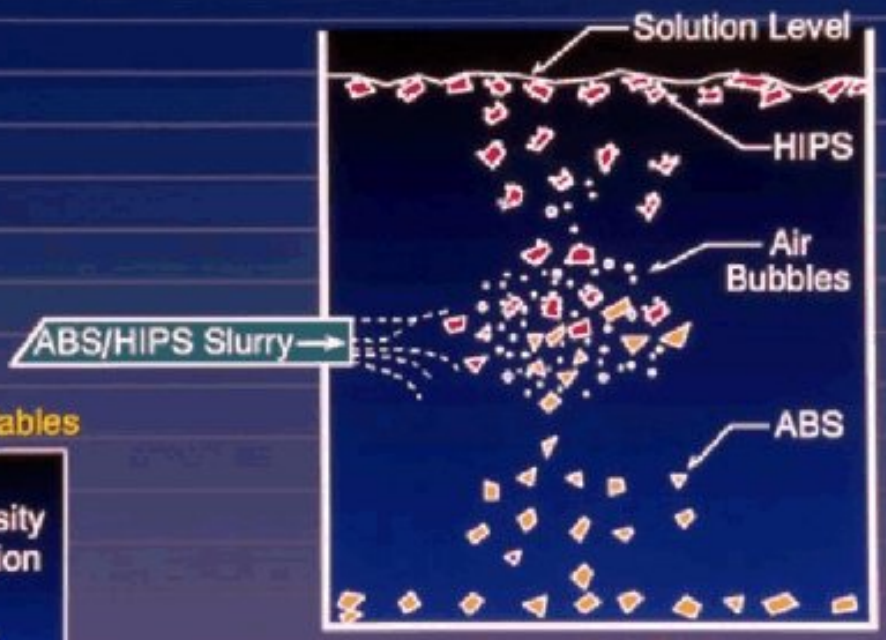

The ANL Plastics Separation Process
Wet
or Dry
Rigid Foam
Polyethylene
Polypropylene
Rigid Foam
& Plastics
Mechanical
Separation
ABS
HIPS
SAN
Wet
or Dry
PVC
Rubber Tubings
Nylons
ABS
HIPS
SAN
Chemical
or Physical
Separation
HIPS
ABS
SAN
SAN
ABS

Density Separation Techniques are Partially Effective for Recovering High-Value Plastics from Appliance Fluff

Plastics	Density (g/cm^3)
PU	0.70
PE	0.90
PP	0.90
ABS	1.04-1.13
HIP	1.02-1.09
PVC	>1.15
Nylon	>1.12

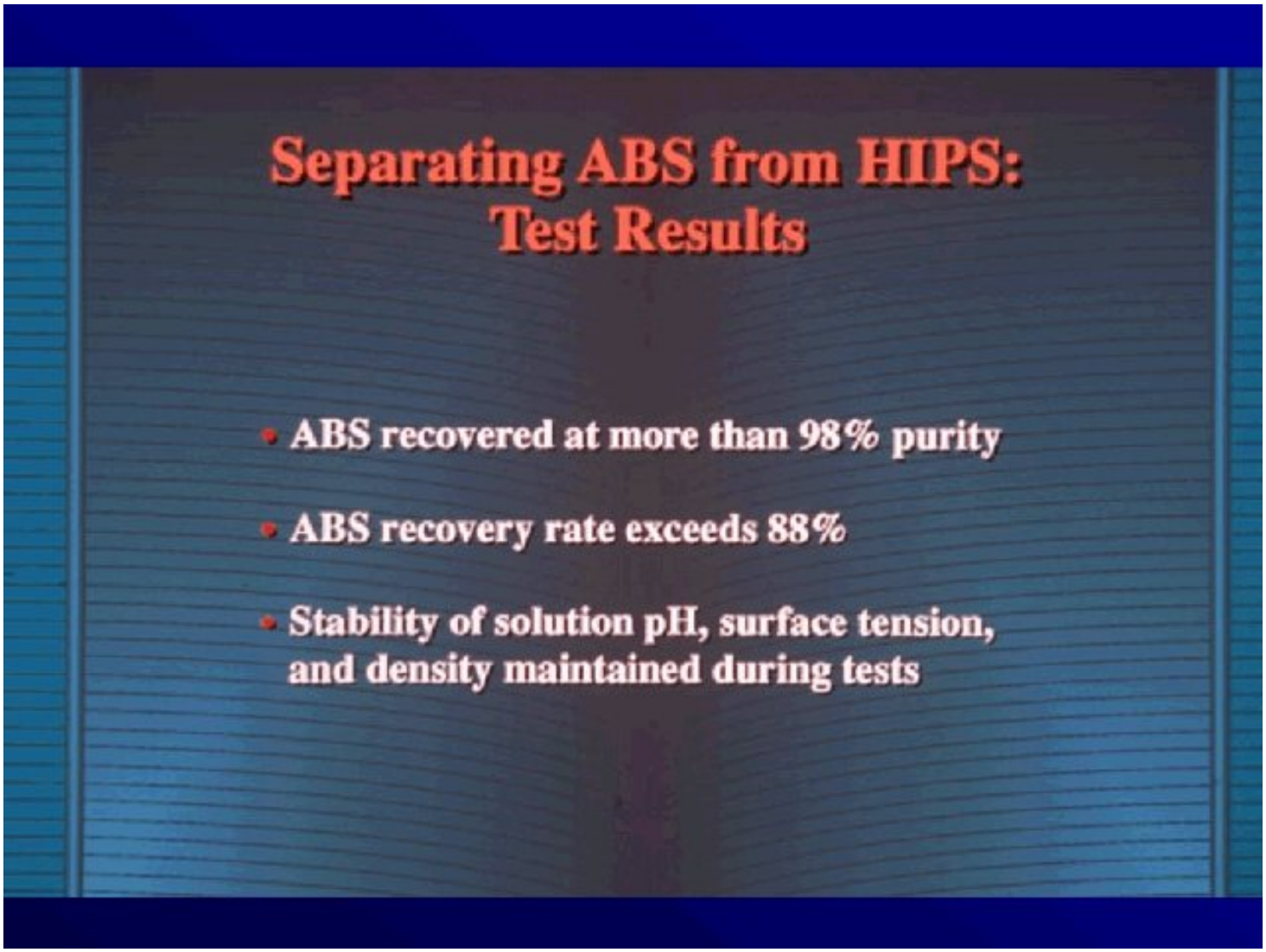

Argonne Process for Separating Plastics from Appliance Fluff
Makeup Water
Detergents
Recycled Water
Residue Disposal
Mixed Plastics
Granulating
Mixed Plastics
Washing
Filter/Water Treatment
Floatation Stage No. 1 Sp. Gr.=1.0
Foam
PP
PE
Floatation Stage No. 4 Sp. Gr.=0.75
Foam
PP, PE
Heavies
Floatation Stage No. 2 Sp. Gr.=1.11
ABS/HIPS
Acid/Water Solution
ABS
HIPS
Metals, PVC & Nylons
Floatation Stage No. 3 Sp. Gr.=1.5
PVC, Nylons
Mixed Metals

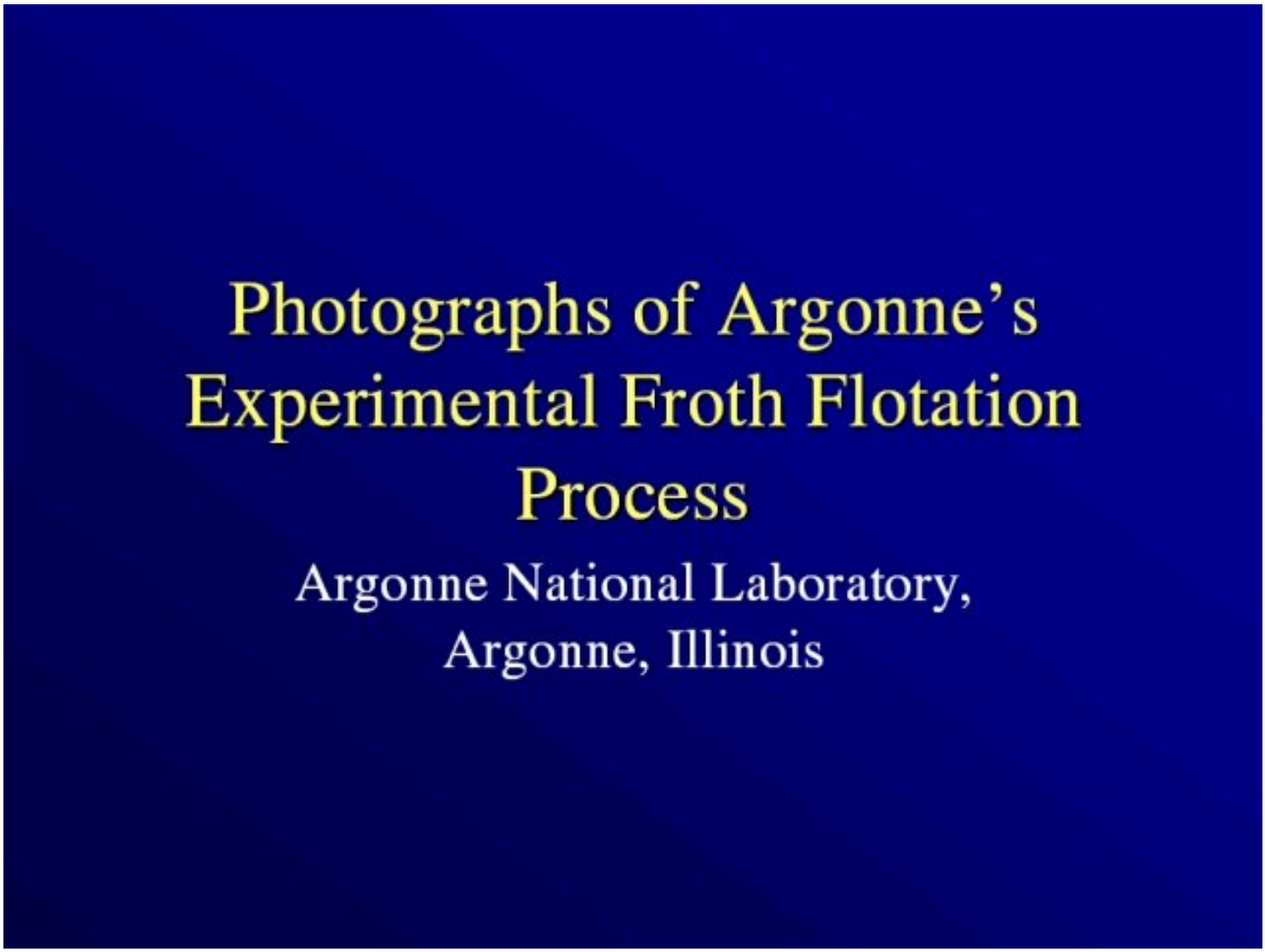
Froth Flotation System for Separating Equivalent Density Materials: Separation of ABS from HIPS



Controlled Variables

- Solution
- Solution density
- Surface tension
- pH
- Material size


Separating ABS from HIPS:
Test Results
• ABS recovered at more than 98% purity
• ABS recovery rate exceeds 88%
• Stability of solution pH, surface tension, and density maintained during tests


Photographs of Argonne's Experimental Froth Flotation Process
Argonne National Laboratory,
Argonne, Illinois

Argonne National Laboratory Physical/Chemical
Plastics Separation R&D Facility

Water and Surfactant

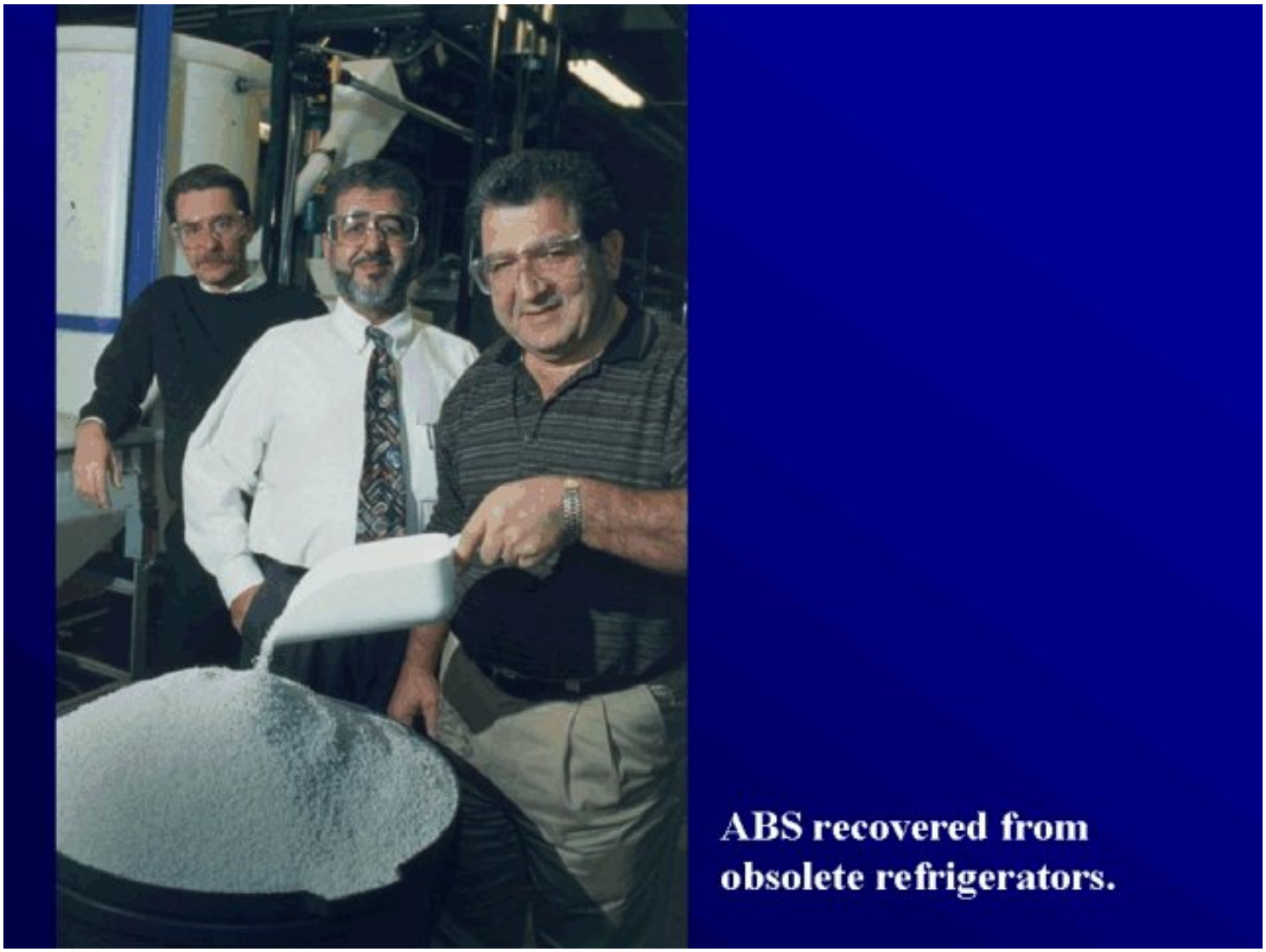
ABS & HIPS

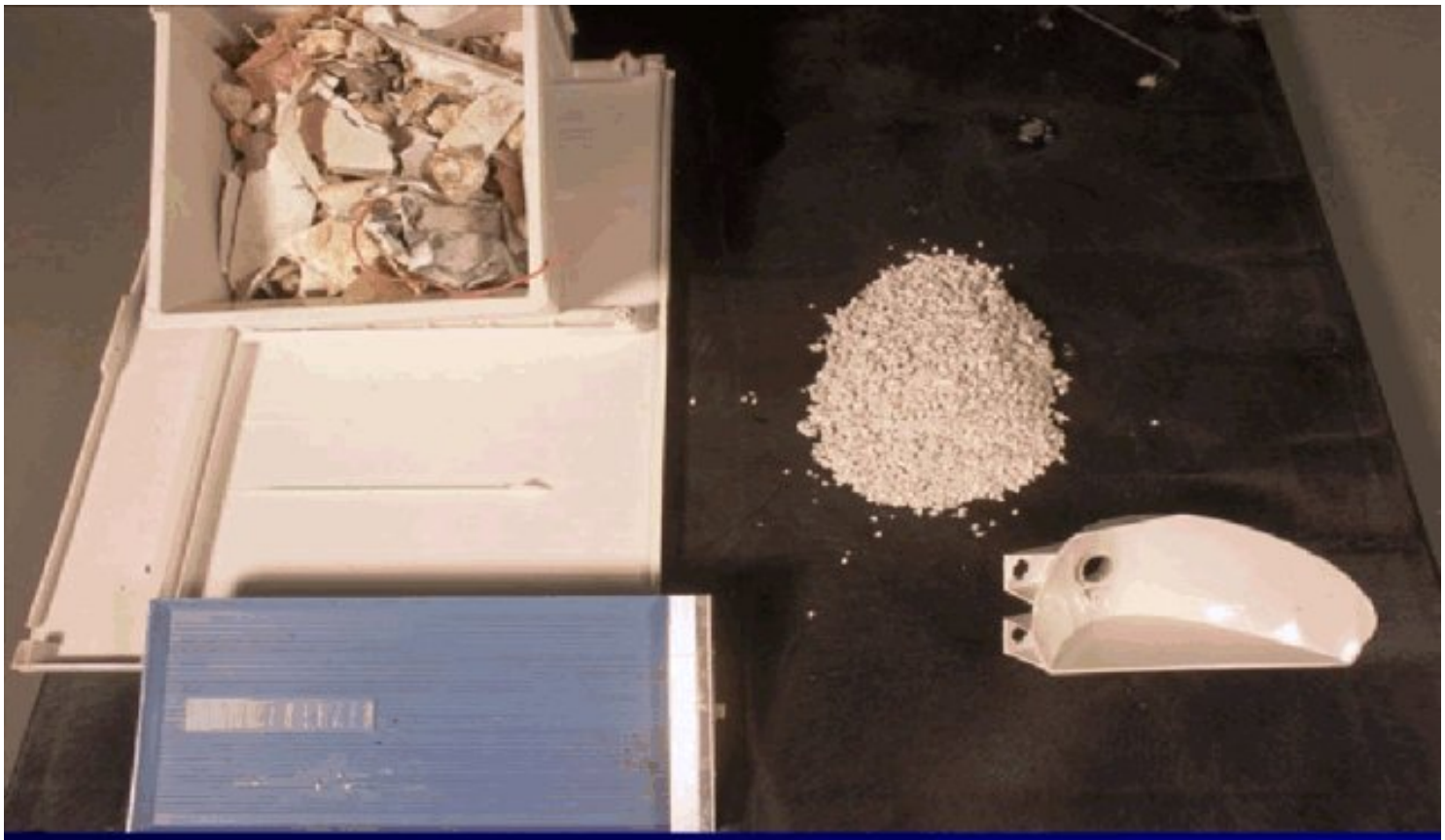
Photographs of Field Test Facility: Continuous Pilot Plant Process

Appliance Recycling Center of America, Minnesota Facility

ABS
HIPS

Photographs of Post-Consumer ABS Re-Used in Auto Parts Test


ABS recovered from
obsolete refrigerators.



Upper left: mixed plastics from obsolete refrigerators. Center: ABS recovered from mixed refrigerator plastics. Lower right: Backcan for auto headlight assembly.

Injection-Mold Tests Confirm Feasibility of Re-Use of 100% Post-Consumer Plastics in Automotive Applications

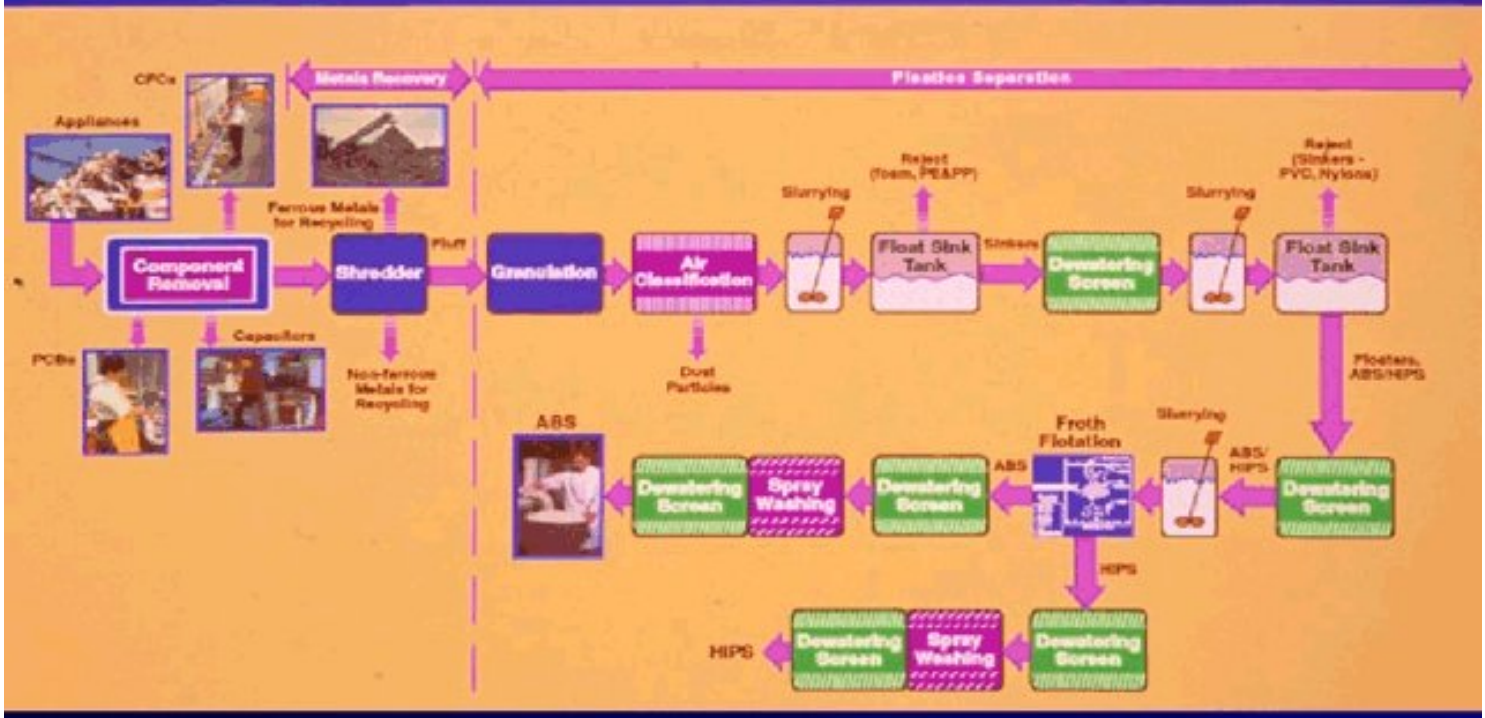
Recovery of ABS from Mixed Plastics Waste Stream

Mixed Waste Plastics

Patented Argonne Plastics Separation Process

Pure
>99% + ABS
Recovered

Recovery/Separation of Materials From Obsolete Appliances



Conceptual design of complete process. Left portion done by appliance recycler. Right portion is Argonne's process.