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The
Plastics
Industry
Trade
Association

46pp

April 24, 2001

AR 226

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Tracy G. Williamson, Ph.D.
Chemist, Industrial Chemistry Branch
Office of Pollution Prevention and Toxics (OPPT
US Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Dear Dr. Williamson:

On behalf of the Fluoropolymer Manufacturers Group (FMG), I would like to extend my appreciation to you and your associates for the opportunity to continue the dialogue on fluoropolymers and APFO.

1. As we promised during our meeting, I have included in this package copies of our presentation slides.
    a. One copy is marked "Company Sanitized, Does not contain TSCA CBI."
    b. The other copy is marked "Contains TSCA CBI" and is contained in an inner envelope marked "Company confidential, contains CBI." This inner envelope is addressed to you.
2. Please note this letter does not contain confidential business information.

I hope that this information is sufficient for your needs as this time. If there are any other questions, please do not hesitate to contact the Society of Plastics Industry. We are committed to working with the EPA in this important matter.

Sincerely,

Allen Weidman
Executive Director
Fluoropolymer Manufacturers Group

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EPA/SPI-FMG/DuPont

Fluoropolymers and APFO: Discussion of Value in Use

April 23, 2001

Washington D.C.

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DuPont/SPI Participants

Don Duncan: President, Society of the Plastics Industry

Subhash Gangal: Global Technology Manager, DuPont

Dave Rurak: Global Business Manager, DuPont

Meeting Goals

- Recognize the technological and societal benefits of fluoropolymers.
- Provide a clear understanding of the fluoropolymers manufacturing process, critical technical issues and the role and importance of fluorosurfactants.
- Share work DuPont has done over the past 30+ years to identify and evaluate non-APFO surfactants, and why no suitable replacements have been found.
- Clarify industry needs to maintain APFO use and develop new supply.

Agenda

- Follow-up from March 7 Meeting
- Value of Fluoropolymers
- APFO Substitution Efforts
  - Business Incentive
  - Technical Discussion
- Industry Needs Going Forward

Follow-up from March 7 Meeting

EPA Requests:

- Discussion of Possible APFO Substitutes
- Discussion of Bio-monitoring
- Additional Sharing on Containment and Exposure
  - APFO Risk vs. Benefits

Fluoropolymers: Value to Society Through Unique Properties in Critical Uses

Don Duncan

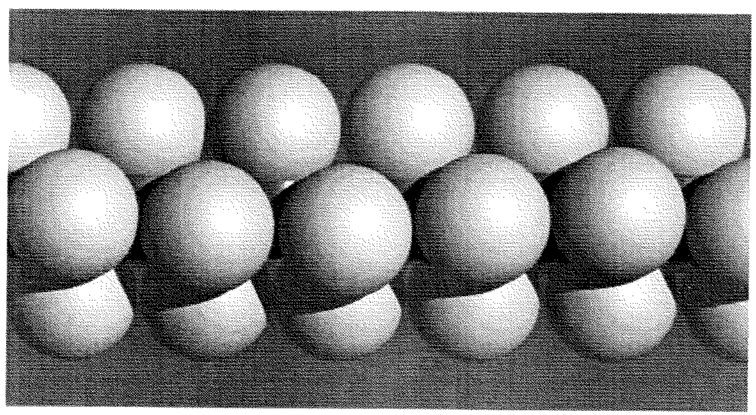
President, SPI

History of Fluoropolymers

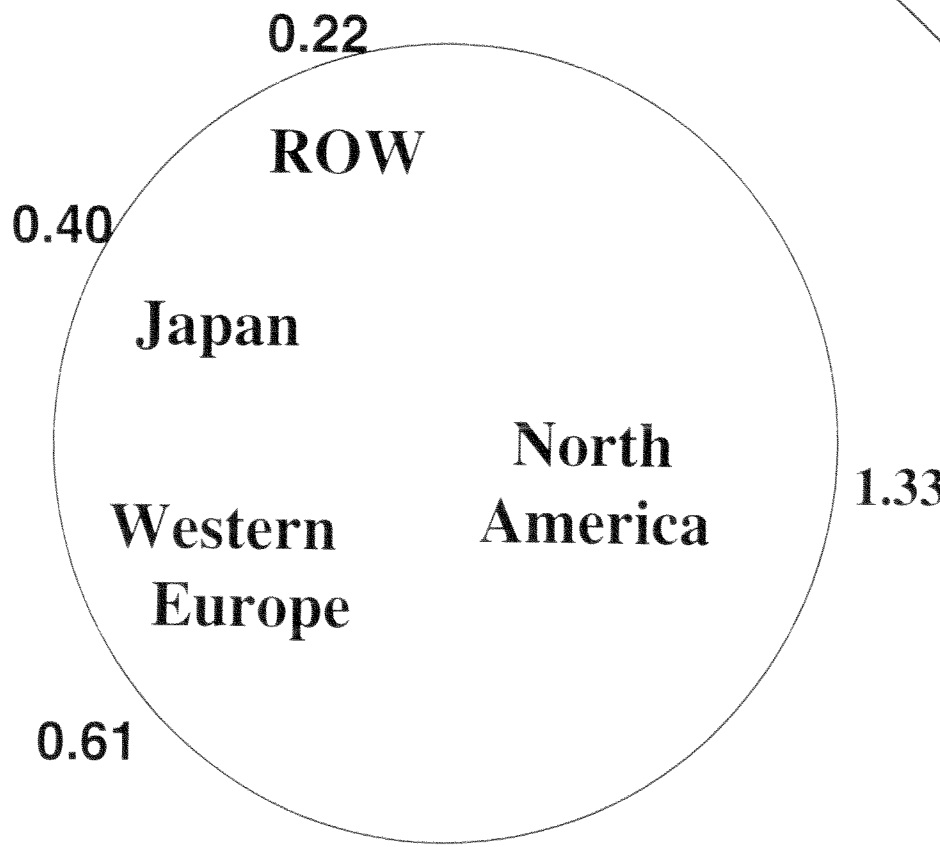
- Discovered by "serendipity" in 1938
- Limited use in aerospace/military during World War II
- Cookware first major use in early 1960s
- Primary use today in industrial markets
- Advance technology and system performance wherever they are used

Fluoropolymers: "Super" Polymers

- Chemical resistance across broad temperature range
- "Slipperiest substance known to man"
- Unique properties/High value in use



Fluoropolymers – 2000 Global Market Demand ($Billions)



Total Demand $2.5 billion

Fluoropolymers:
A Diverse Portfolio

- PTFE Homopolymers
- Melt Processible Copolymers
- Fluoroelastomers and Perfluoroelastomers

PTFE Homopolymers

- Highest performance materials
- About 35% of total market
  - Granular: molded parts, thick extruded tubing
  - Fine Powder: thin extrusion
  - Dispersion: coatings, fabric impregnation

Copolymers

- About 40% of total market
- Melt-processible
- Can be molded or extruded
  - FEP
  - PVDF/PVF
  - PFA/MFA
  - ETFE/ECTFE/PCTFE
  - CTFE-VDF

Fluoroelastomers

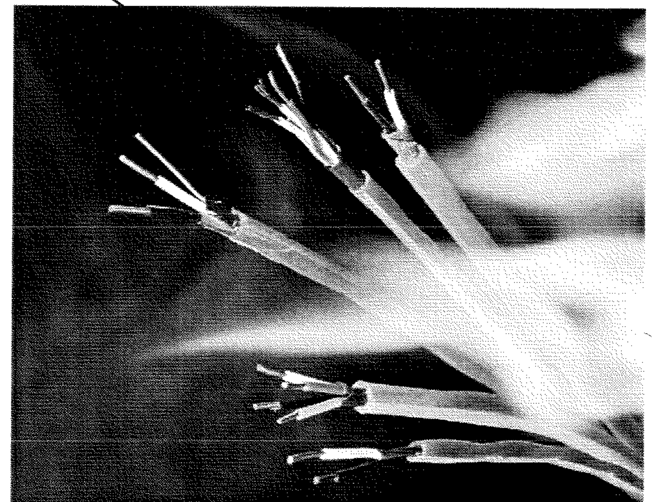
- Introduced in 1955
- About 24% of total market
- Products sold raw or cured
- Three basic chemistries
  - vinylidene fluoride (VF2)
  - hexafluoropropylene (HFP)
  - tetrafluoroethylene (TFE)

Major Industries Served by Fluoropolymers/elastomers

- Aerospace/Military
- Automotive/Transportation
- Chemical/Petrochemical Processing
- Semiconductor/Electronics Manufacturing
- Telecommunications
- Power Generation/Pollution Control
- Consumer Housewares

Aerospace/Military

<u>Key requirements</u>: Temperature and chemical resistance; electrical performance; low flammability



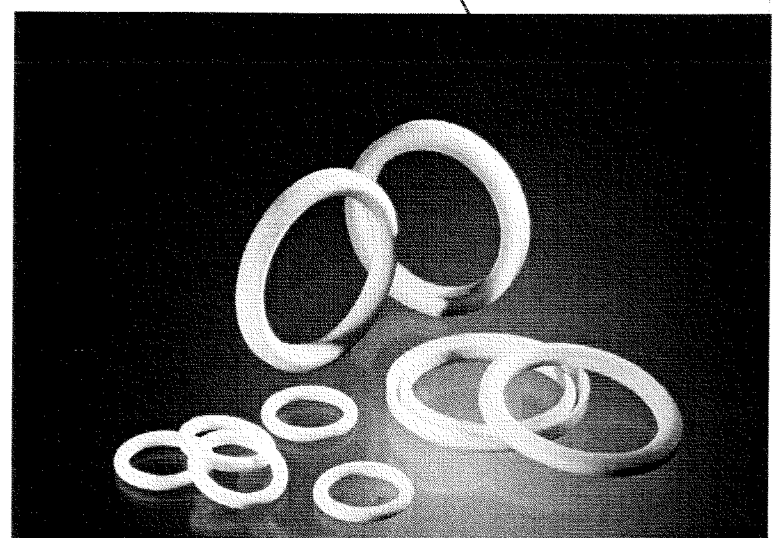
<u>Major uses</u>:

Wire and cable insulation

Fuel and hydraulic hoses

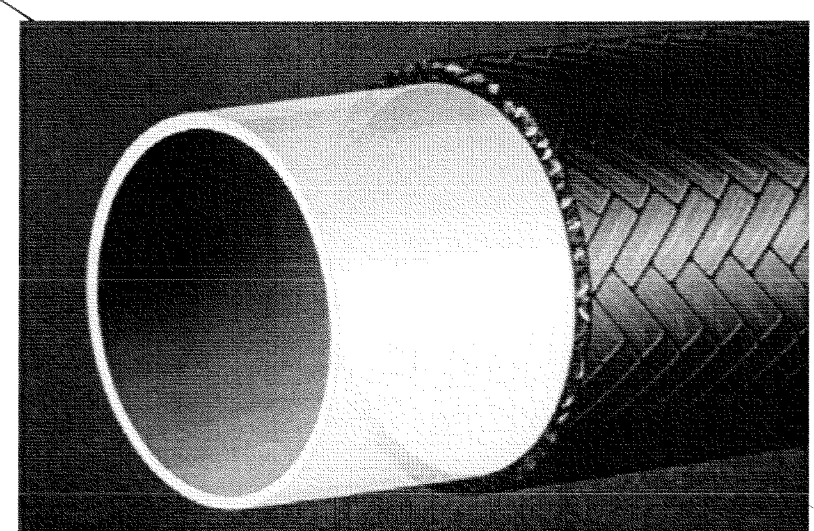
Seals/bushing

Space apparel



<u>Societal Benefits</u>: Passenger protection; aircraft reliability

Automotive/Transportation

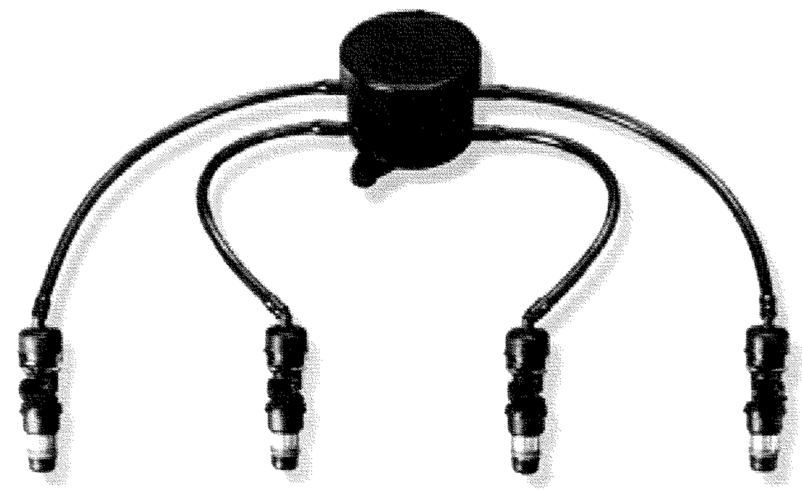


Key requirements: Chemical and temperature resistance; electrical performance; lubricity

Major uses:

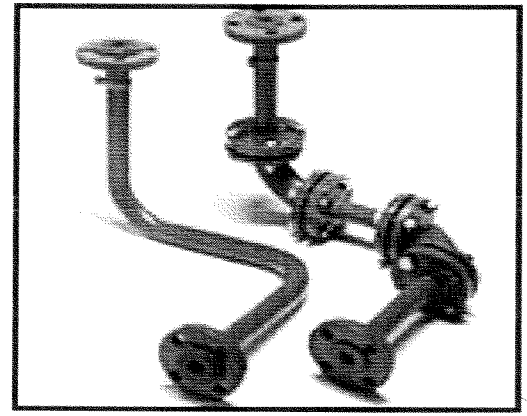
- Seals,bushings
- Fuel and brake hoses/tubing
- Control cables
- Underhood wire

Societal Benefits: Lower vehicle weight and emissions; reliability



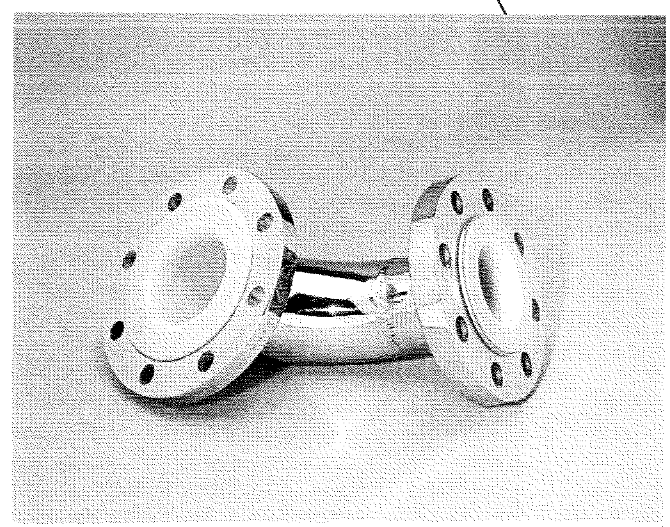
Chemicals/Petrochemicals

Key requirements: Chemical and applications temperature resistance; non-stick



Major uses:

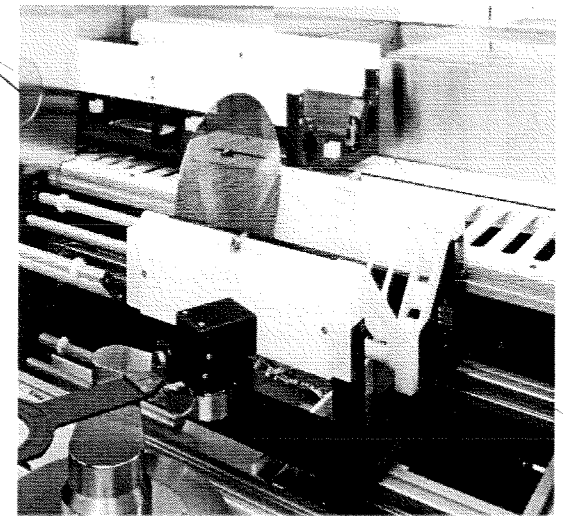
- Lined pipes,valves, pumps
- Tank and reactor linings
- Gaskets, seals
- Wire insulation



Societal benefits: Worker and public safety; industry productivity

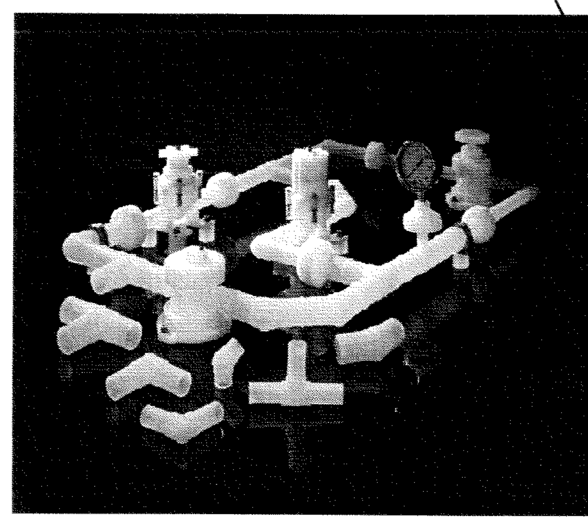
Semiconductor/Electronics

Key requirements: Chemical and temperature resistance; purity; electrical performance



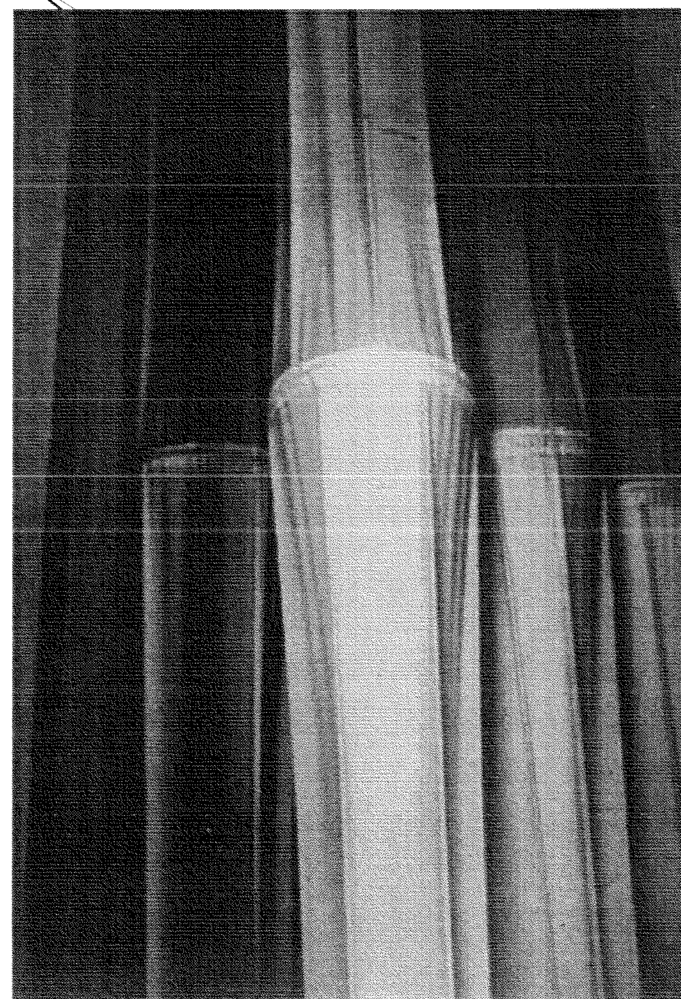
Major uses:

- High-purity fluid handling equipment
- Silicon wafer carriers
- Clean room garments



Societal benefits: Consumer product quality and cost; industry productivity

Power Generation/ Pollution Control



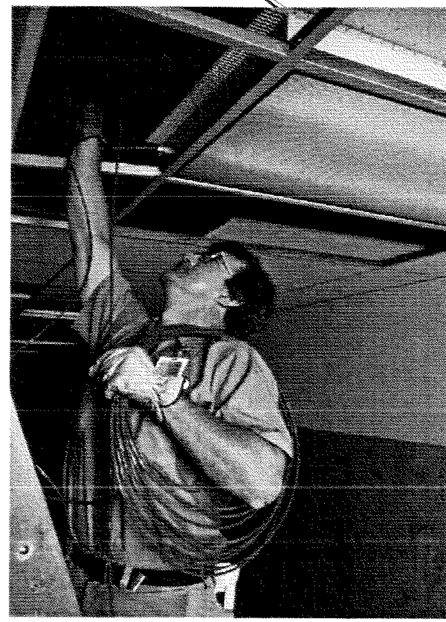
Key requirements: Chemical and temperature resistance; flexibility

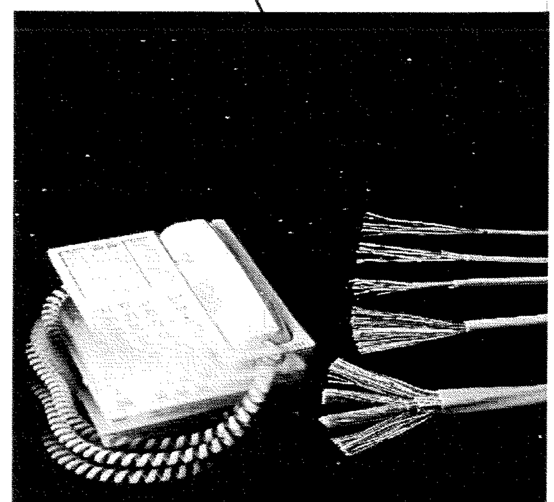
Major uses:

- Acid resistant filter bags
- Radiation resistant wire insulation
- Expansion joints

Societal benefits: Fewer emissions to the environment; worker and public safety; process reliability

Telecommunications





Key requirements: Electrical performance; fire resistance; optical properties

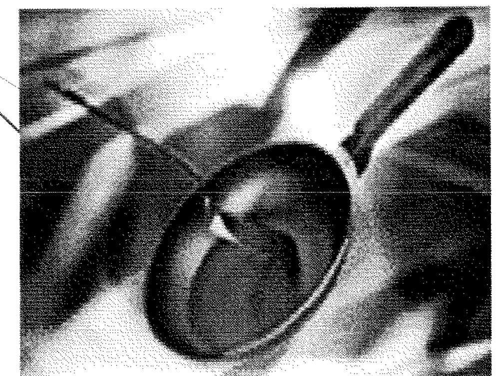
Major uses:

- LAN Cable
- Mainframe wiring
- Satellite wiring
- Fiber optic cladding and cable

Societal benefits: Public safety; critical systems reliability

Consumer Housewares/Apparel

<u>Key requirements</u>: Non-stick; temperature resistance; easy to clean; hydrophobic



<u>Major uses</u>:

- Non-stick cookware and bakeware
- Waterproof/breathable clothing
- Appliance wiring

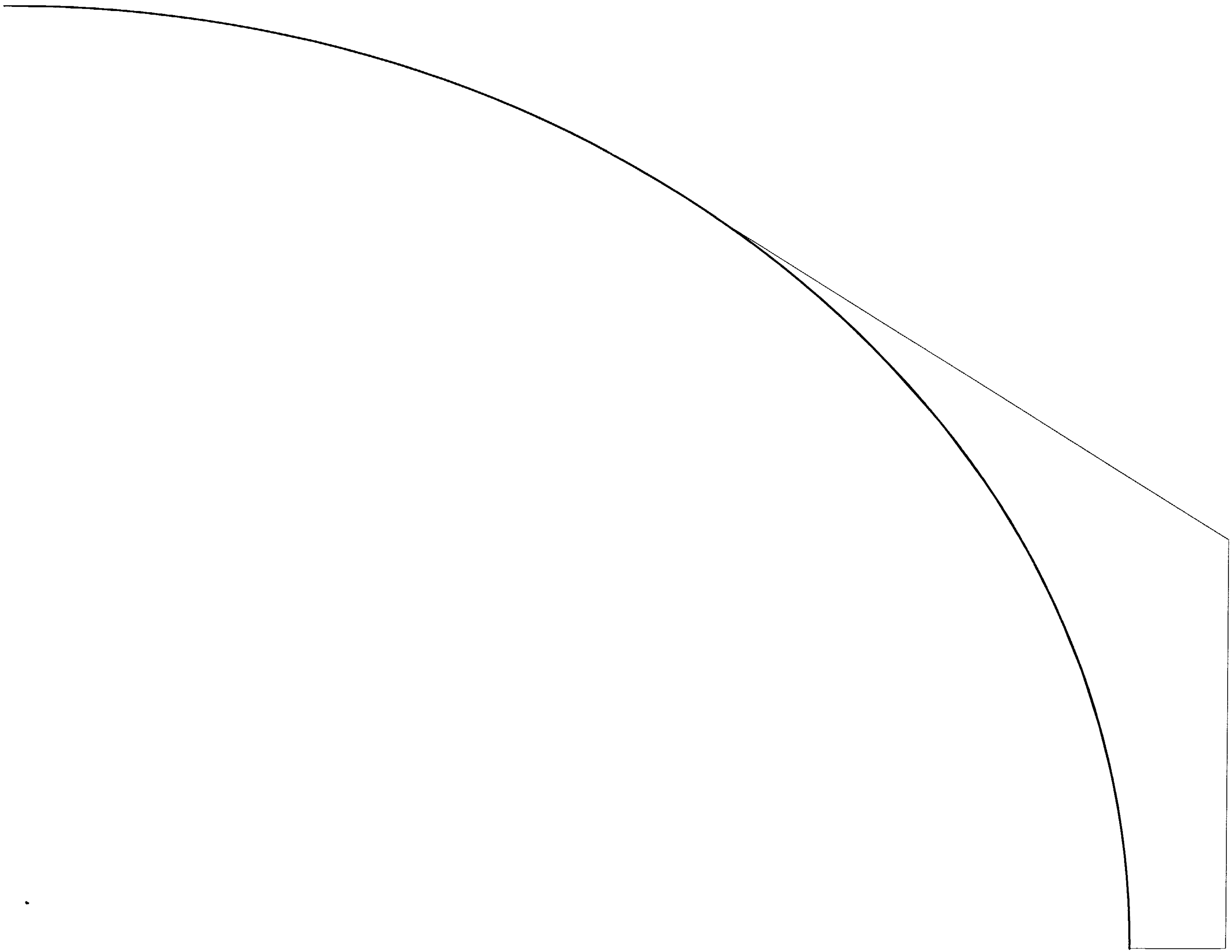
<u>Societal benefits</u>: Enables low-fat cooking; supports healthy lifestyle; consumer convenience

Fluoropolymer Applications Summary

- Fluoroplastics and fluoroelastomers provide unique and critical performance properties in "system critical" applications that protect and benefit people and the environment.
- For virtually all applications, fluoropolymers are the only materials that meet system performance needs.
- Application design and best-available technology based on fluoropolymers.

Fluoropolymer Applications Summary (contd.)

- OEM technology and investment based on fluoropolymers.
- Fluoropolymers have high value-in-use; are only used where there are no other options.
- Not-in-kind technologies for some applications have negative environmental impact and/or are cost prohibitive.



Business Incentive to Replace APFO

- Very Few Suppliers
- High Raw Material Cost
- Manufacturing Complexity

Importance of APFO in Dispersion Polymerization and DuPont Research on Alternatives

Subhash Gangal
Global Technology Manager, DuPont

AGENDA

- Background - Commercial Fluoropolymers, processes used to produce them and major applications of each family of products.
- Dispersion Polymerization Process and why it is important.
- Sequence of events in the Dispersion Polymerization Reactor.
- Classes of Surfactants and limitations of their use in Perfluoropolymerization.
- Efforts to replace APFO
  - Incentives
  - Evaluation Procedure
  - Research Efforts

FLUOROPOLYMERS, POLYMERIZATION PROCESS AND APPLICATIONS

DISPERSION POLYMERIZATION PROCESS

INGREDIENTS

- Monomer(s) with extremely high purity
- Water (demineralized)
- Initiator (an oxidizing agent with high purity)
- Surfactant (non-telogenic, high purity)
- Optional other ingredients

EQUIPMENT

- Gently stirred heated reactor

IMPORTANCE OF AQUEOUS DISPERSION POLYMERIZATION

- **Very high heat of polymerization requires rapid heat removal capability.**
- **An ability to develop a specific particle architecture for a particular application.**
- **An ability to maintain individual particle identity for fine powder applications.**
- **Ease of availability of pure water.**

KEY POLYMER CHARACTERISTICS
TAILORED FOR SPECIFIC APPLICATIONS

Dispersion particle size and its morphology

Particle architecture

Molecular weight and its distribution

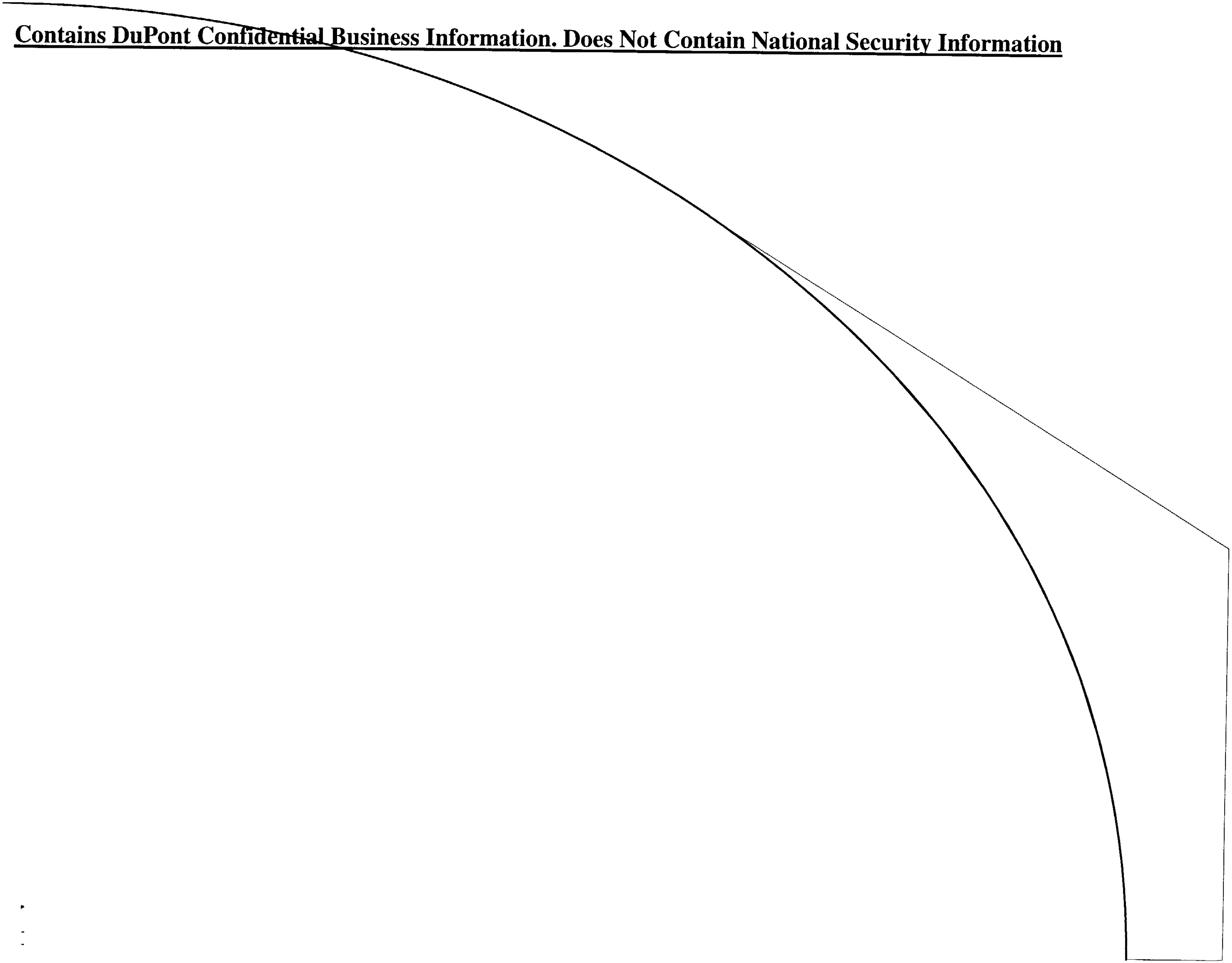
Comonomer content and its distribution

High to extremely high molecular weight

SEQUENCE OF EVENTS IN THE REACTOR

POLYMERIZATION MODEL

EFFECTS OF TELOGENS (COMPOUNDS THAT LOWER MW)



SURFACTANTS FOR POLYMERIZATION

Ionic

Typically salts with a hydrophobic segment (hydrocarbon or fluorocarbon organic chain segment) and hydrophilic anion.

e.g., $R - CH_2COO^- NH_4^+$

The dispersion stability is achieved by the particle to particle repulsion due to electrical charge.

Non-Ionic

Typically alcohols with a hydrophobic segment (hydrocarbon, silicon or fluorocarbon chain segment) and hydrophilic segment made up ethoxylates which extend into water phase.

The dispersion stability is achieved by the steric balance between hydrophobic and hydrophilic segments. The ethoxylates having number of hydrogens in the segment have telogenic effect on the molecular weight, and therefore, adversely affect the molecular weight.

EFFORTS TO REPLACE APFO

SURFACTANT EVALUATION PROCESS

POTENTIAL SURFACTANT CANDIDATES EVALUATED

(1971-1999)

POTENTIAL SURFACTANT CANDIDATES EVALUATED (contd.)

(1971-1999)

Technical Summary

- The majority of DuPont's products are dispersion polymerized and require very pure ingredients, including the surfactant, to achieve high molecular weight.
- Impurities containing hydrogen cause a significant reduction in molecular weight.
- All of the above create a limit in the choice of surfactant.
- Over the last 30 years, DuPont has invested substantial resources to find an alternative to APFO but has been unsuccessful.

Meeting Goals

- Recognize the technological and societal benefits of fluoropolymers.
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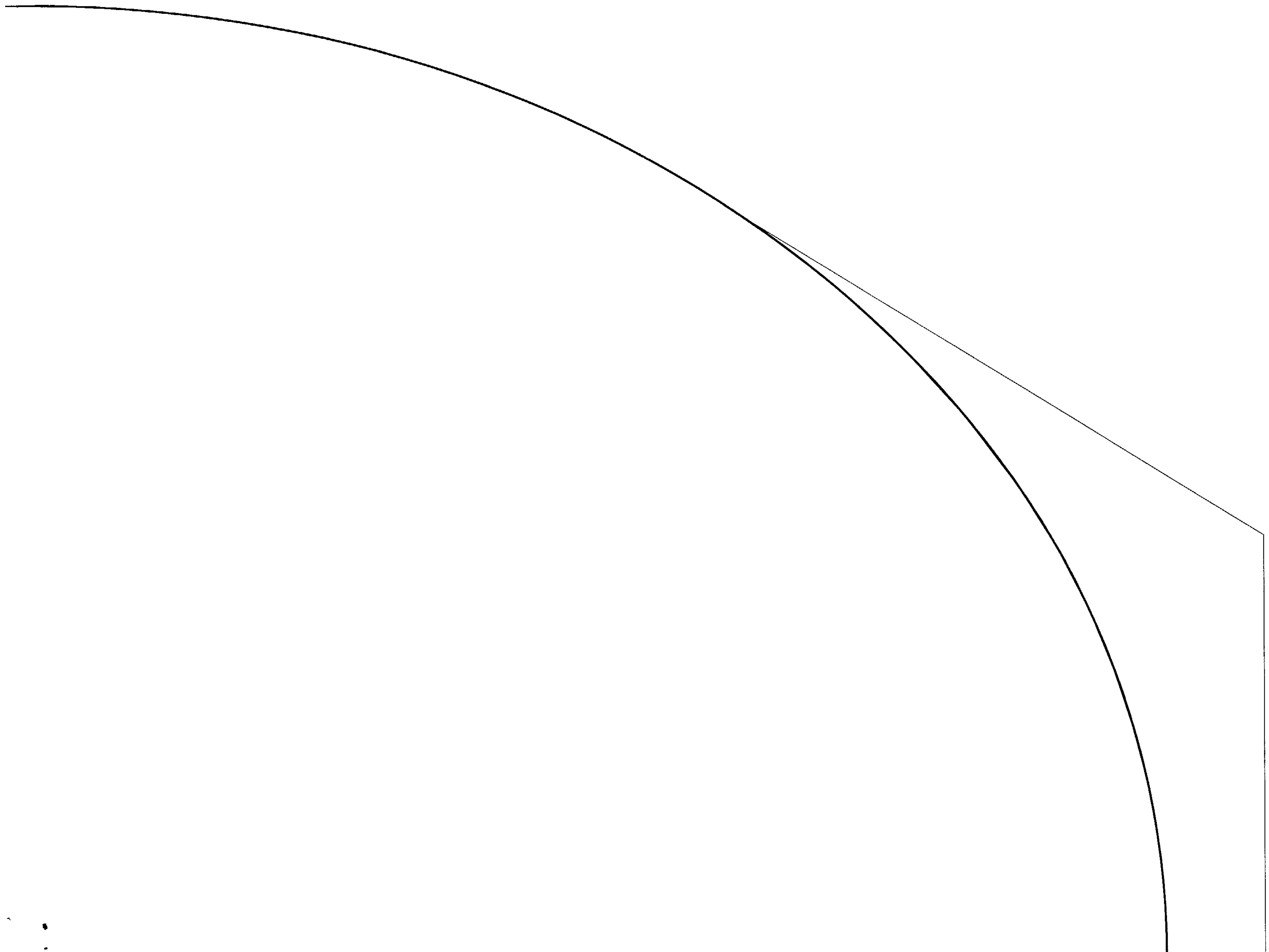

Alternative Supply