Applied Polyethylene and Polyvinyl Chloride Production Technologies

Presented By

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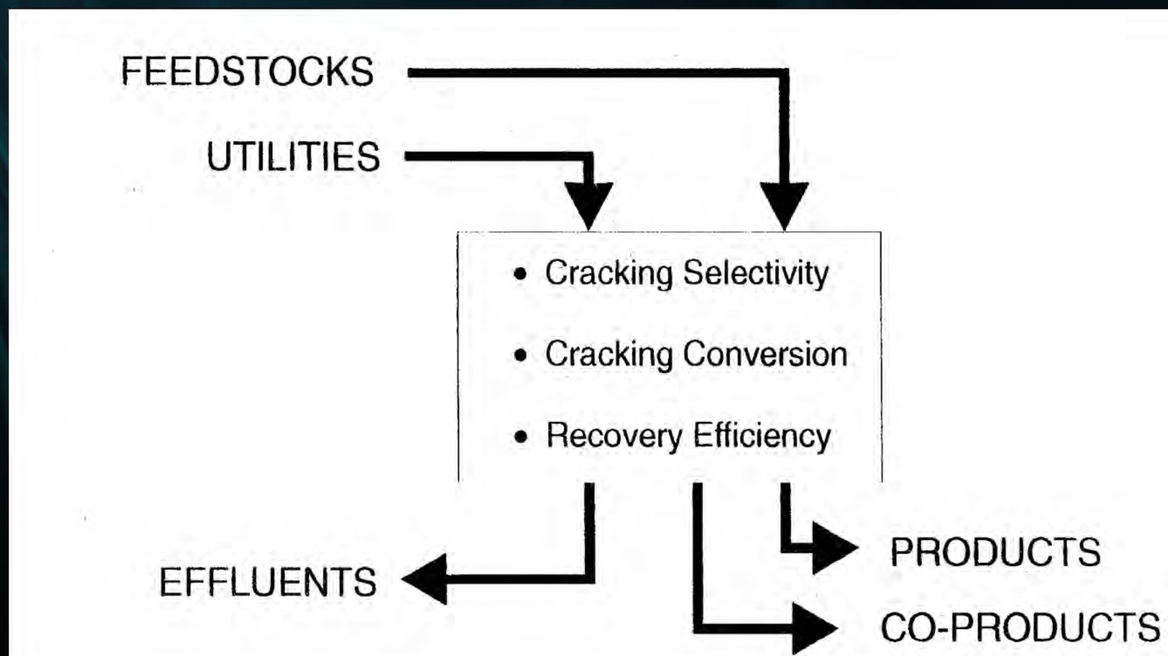
Contents

Ethylene Plant

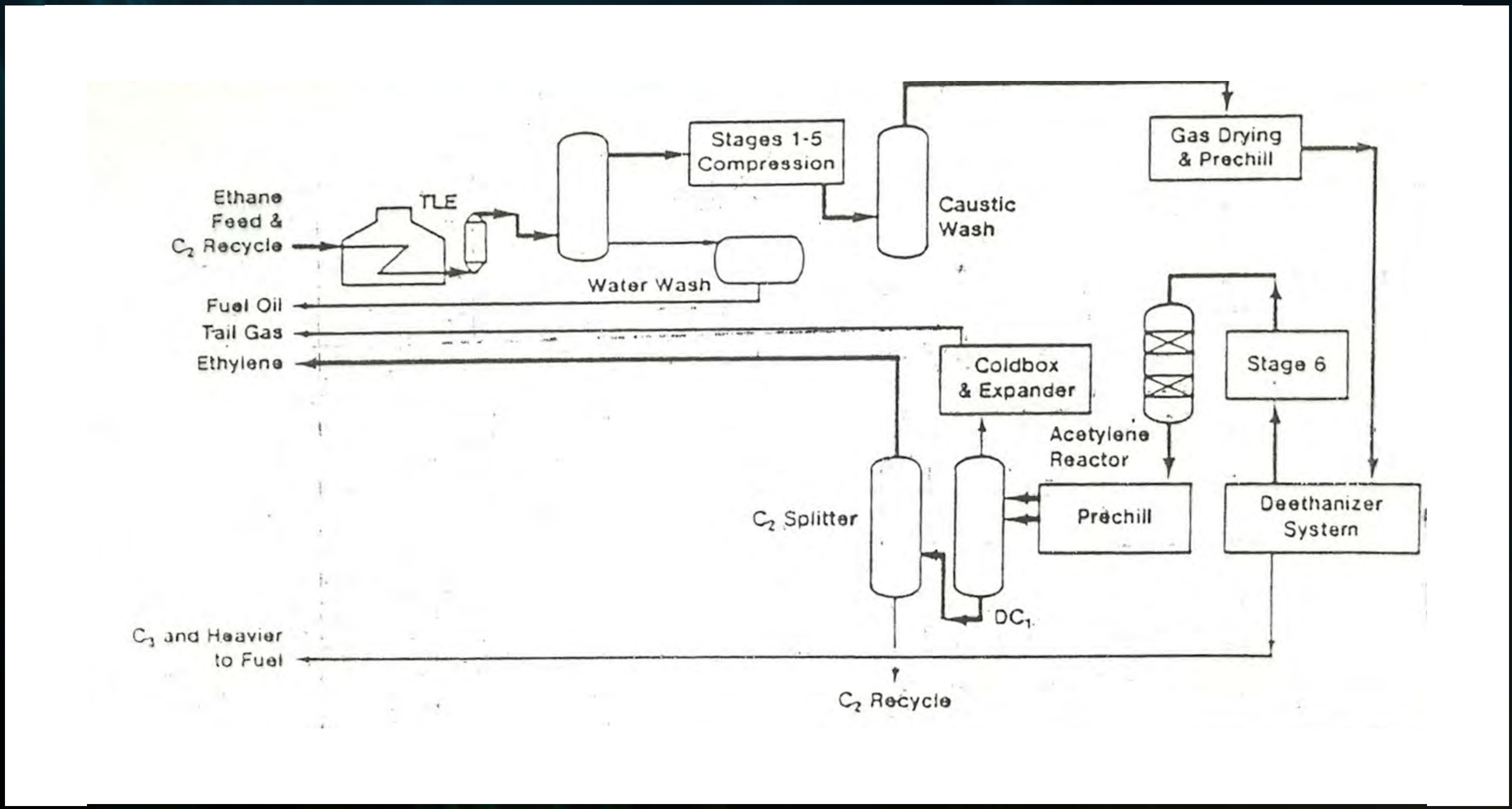
Ethylene Cracking Consideration

1. **Basic scheme**



Ethylene Cracking Consideration (Cont.)

2. **Block flow diagram**



Ethylene Cracking Consideration (Cont.)

3. **Environmental:**

   - Latest burner technology (min. NOX, CO).
   - Standard NOC regulation practice, de-coke to firebox.
   - Minimum quench water blow down with no benzene.
   - Segregated contaminates and only water effluent system.

Ethylene Cracking Consideration (Cont.)

4. **Advanced Control:**

- Advanced regulatory control in DCS.
- Multi variable control.
- Linear and non-linear equation based optimization
  - Online, continuous optimization.
  - Offline, process analysis.

Ethylene Cracking Consideration (Cont.)

5. **Quench:**
   - Secondary oil removal.
   - Dilution steam operation.
   - Min. waste heat rejection.
   - Ripple trays, cost effective, self cleaning vapor/liquid action.

Ethylene Cracking Consideration (Cont.)

6. **Cracked Gas Compressor:**
   - Multistage based on the limitation of max. discharge temperature (90-100C) which depends on diene's content.

Ethylene Cracking Consideration (Cont.)

7. **Primary fractionation:**

- One tower, good wasting of trays to avoid excessive cooling of the column.
- Front end demethanizer.

Ethylene Cracking Consideration (Cont.)

- **De-methanizer, front end**
  - Lower compressor power
  - Lower investment
  - Improved fractionation efficiency
  - Pressure = 31 bar
  - Top temp. = -98C
  - Bottom temp. = 10C

Ethylene Cracking Consideration (Cont.)

- **De-ethanizer:**
  - Reflux condenser at low temp. due to the presence of hydrogen in the over head.
  - Use propane refrigerant to condense and reboil the tower side reboiled tower with ethylene (open loop power advantage).
  - Pressure = 25 bar, Top temp. = -15C, Bottom temp. =70C.

Ethylene Cracking Consideration (Cont.)

8. **Acetylene hydrogenation, back end reaction selective hydrogenation of acetylene (adiabatic reaction).**

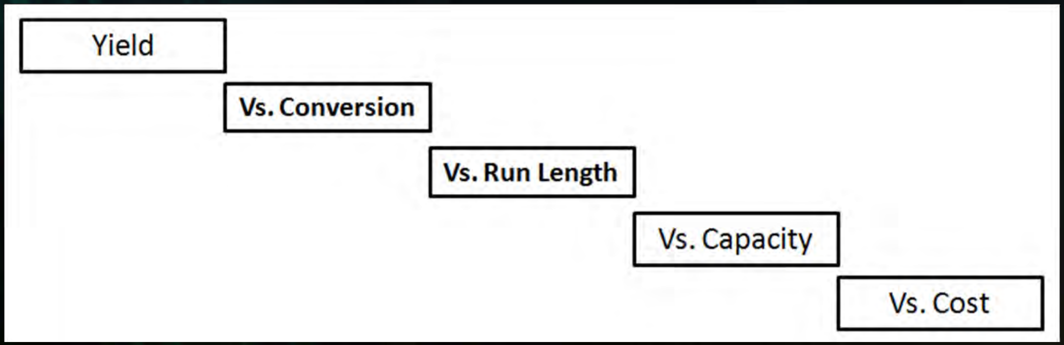
   For high severity, we need reactor feed dilution with de-ethanizer reflux.

   CO is injected as a moderator.

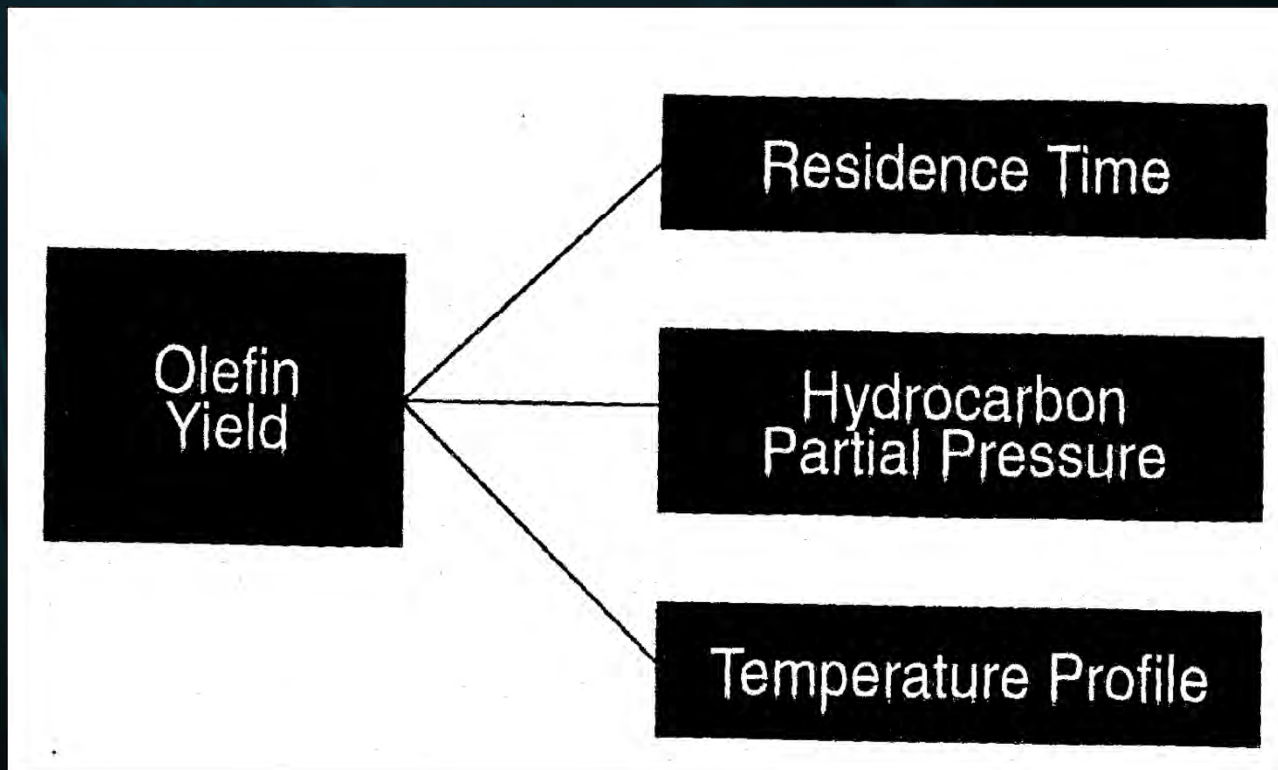
Pyrolysis

Pyrolysis Decisions

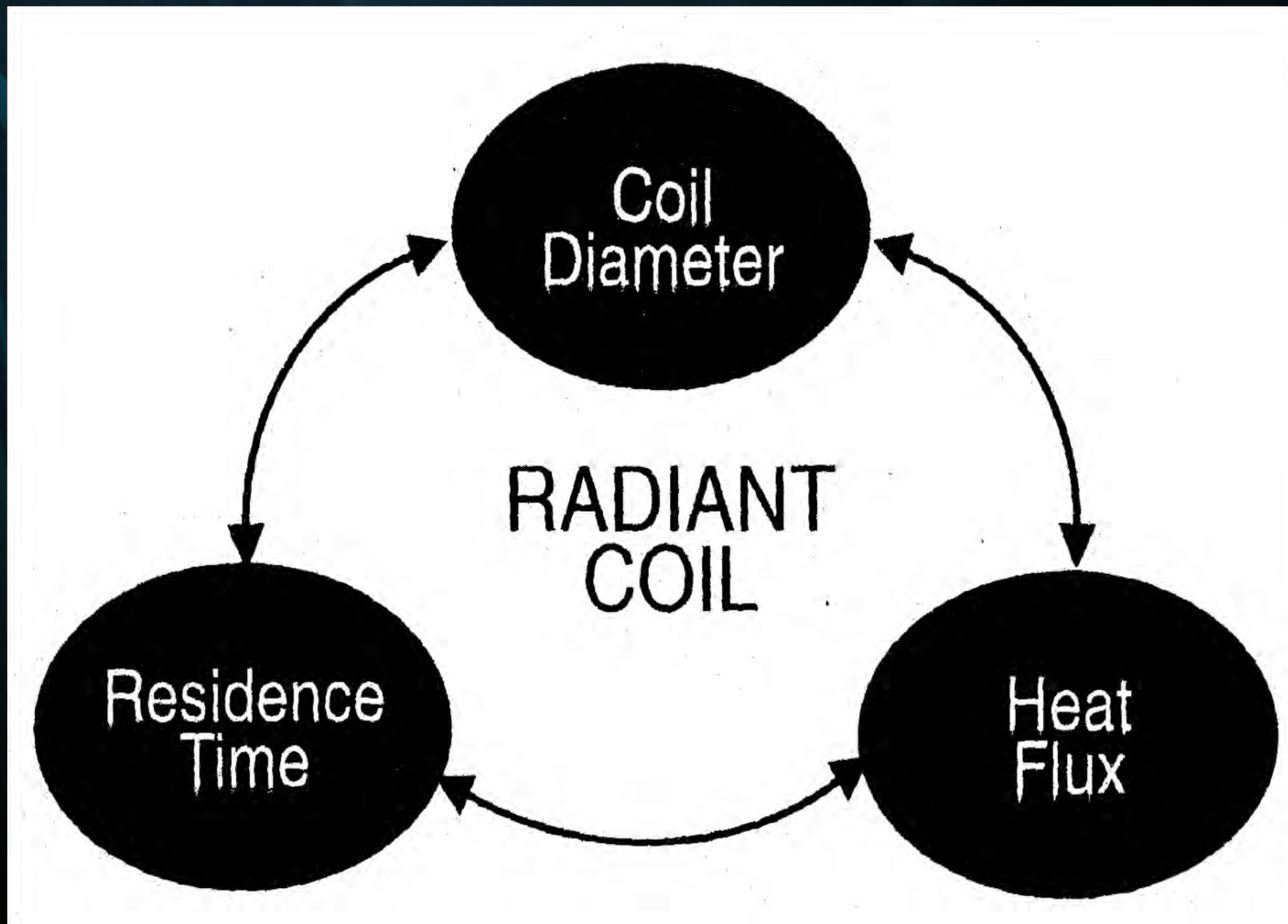
1. Simple coil design, proven mechanical reliability.
2. Should combines best of 2 concepts.
   a) Small diameter inlet tubes for high heat transfer/ low residence time.
   b) Large diameter outlet tube for minimum coke/ effect on yield.



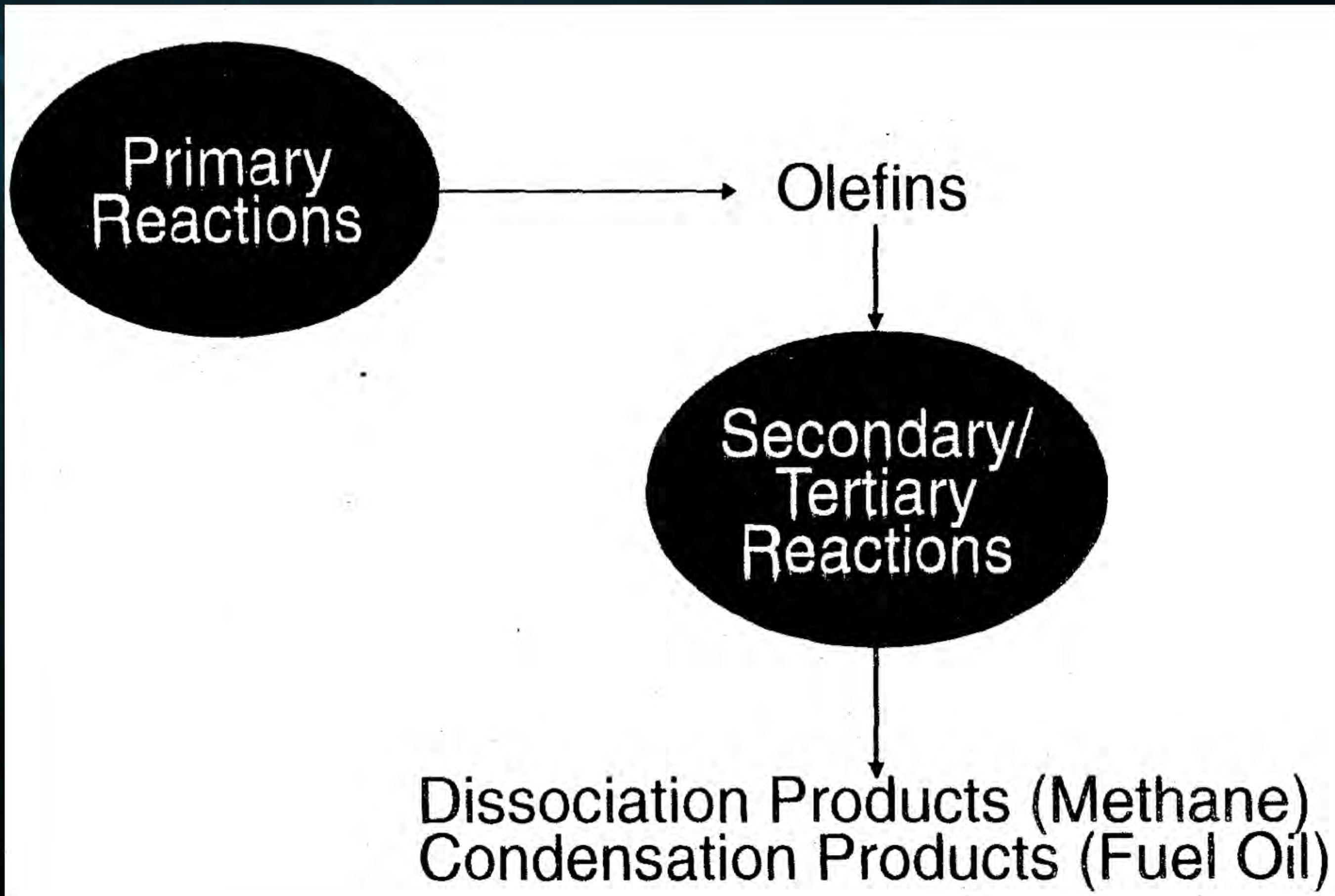
Yield Parameters



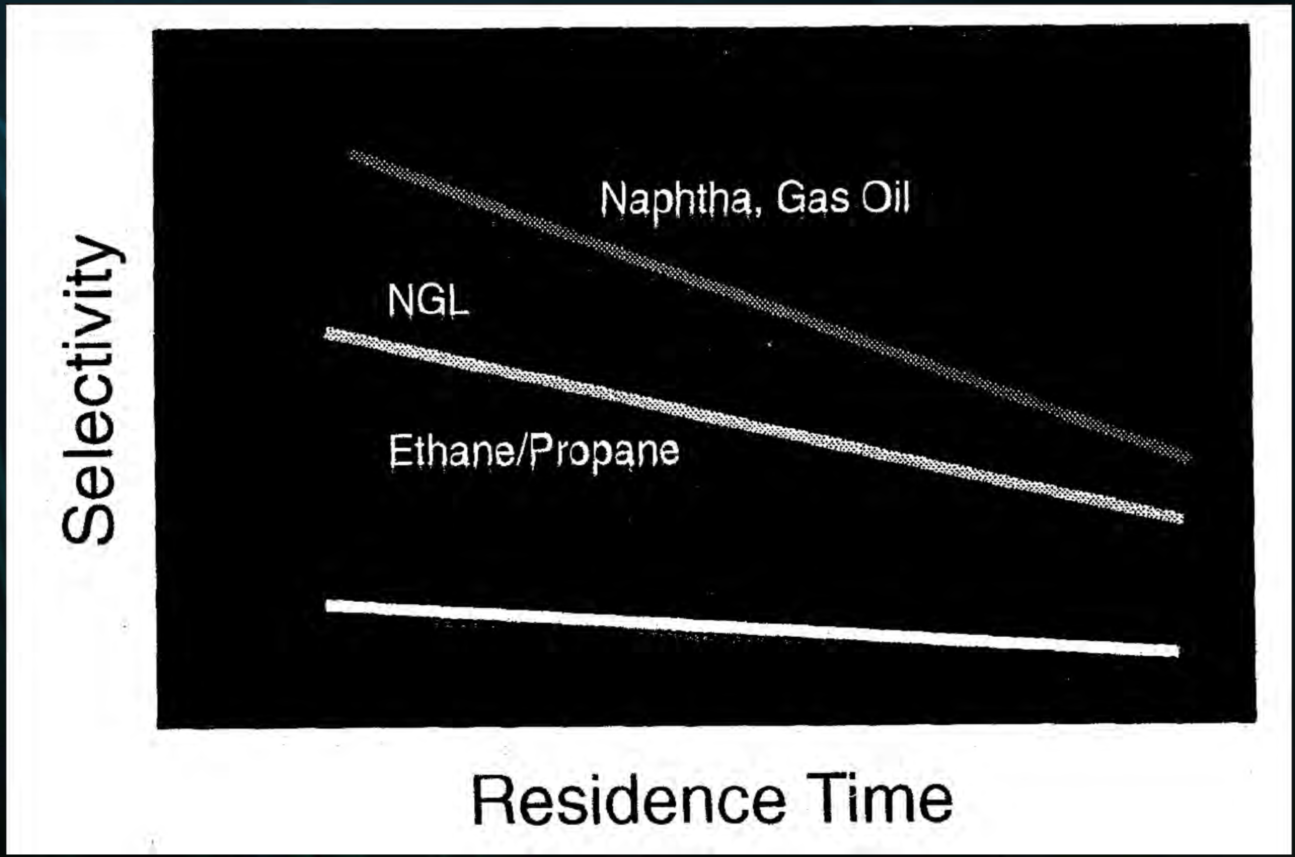
Radiant Coil Relationships



Kinetic Reactions



Selectivity Comparison



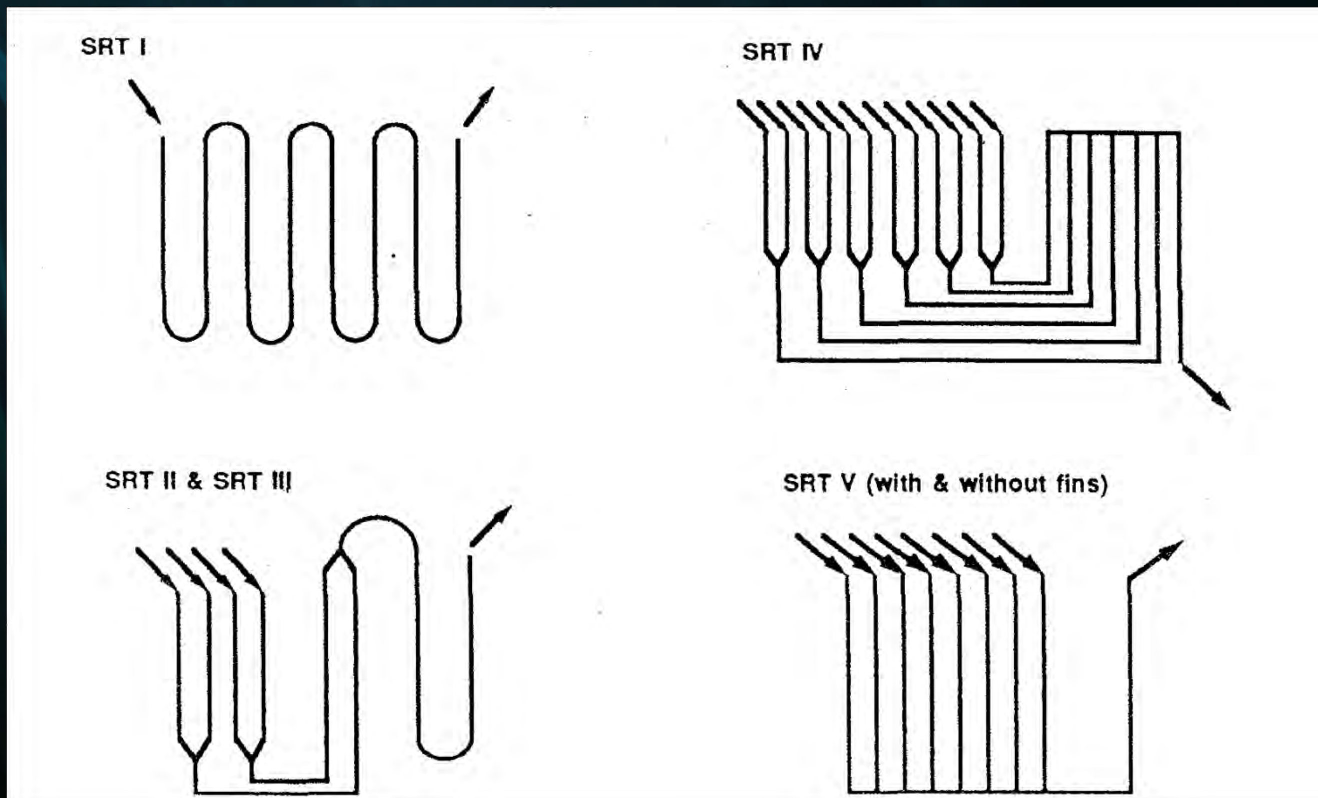
Selectivity Increase

- **Short Residence Time:** shorter coil , heat flux limitations.
- **Higher Temp.:** Metallurgical limits, Shorter Run Length.
- **Steeper Temp. profile :** Small Coil Diameter.
- **Lower HCPP:** Larger coil diameter, higher steam dilution.

Radiant Coils Selection

- High selectivity cracking are not feed flexible .
- Ultra short residence time/ single-pass coil achieves run length 5 to 10 d . it exhibits significant increases in pressure drop throughout the run which is detrimental to yield .
- The moderate short residence time, split coil design, has improved the selectivity to olefins and at the same time, maintained long run lengths, more than 60 days run length at high severity (65-70% ethane conversion).

Radiant Coil Designs



Coking

1. Surface reactions:

- Unwanted coking reactions occur. Hence, increasing the surface area increases the coking rate and decreases the run length. Therefore, an optimum exists for each feed stock.

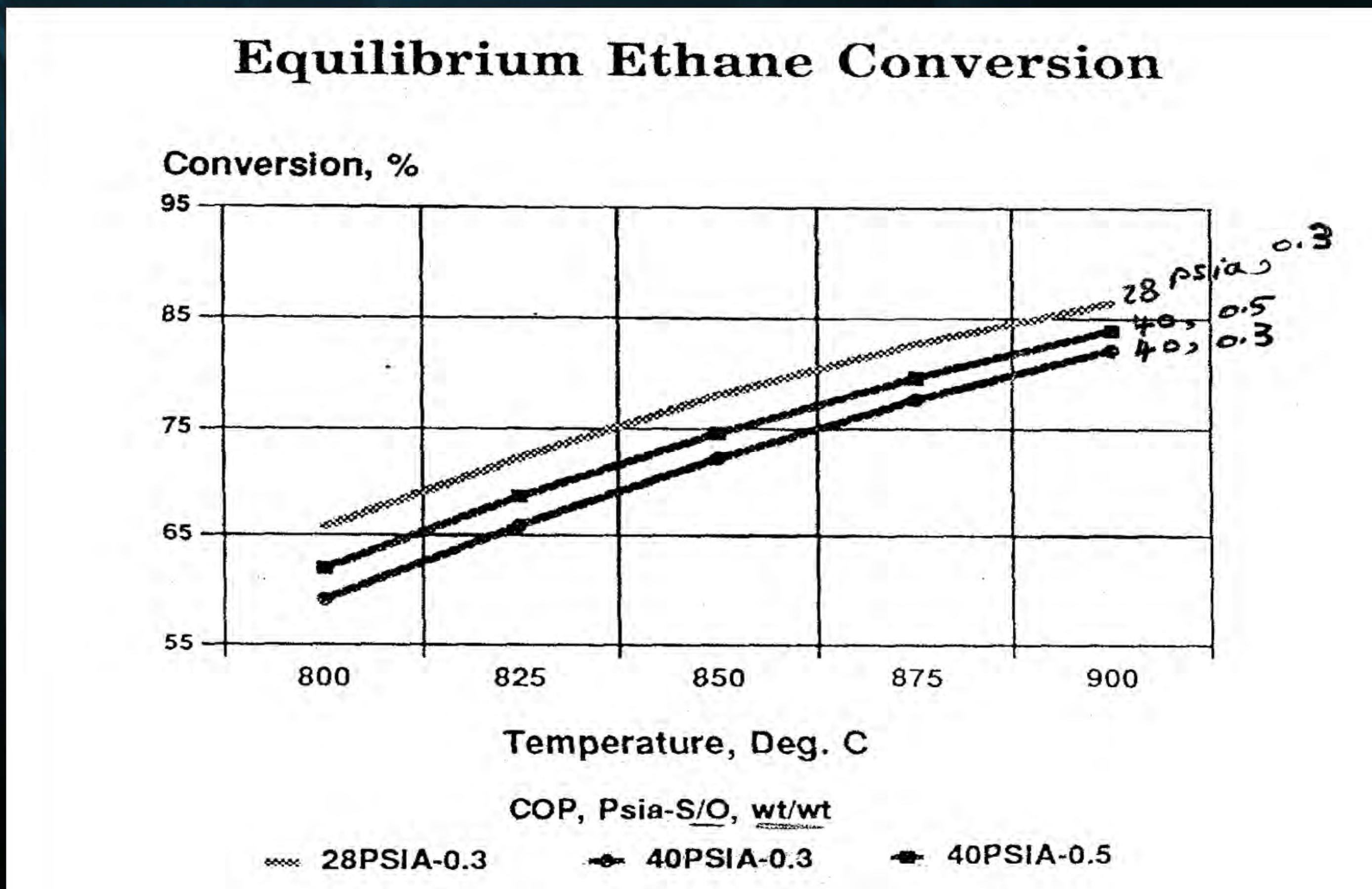
Coking (Cont.)

2. Equilibrium Limitations Accelerate Coke Deposition

- It is known that ethane cracking to produce ethylene may be thermodynamic equilibrium limited. In Figure 2, equilibrium conversions as a function of coil outlet temperature and steam-to-oil ratios are shown.

$$C_2H_6 \longleftrightarrow C_2H_4 + H_2$$

Coking (Cont.)



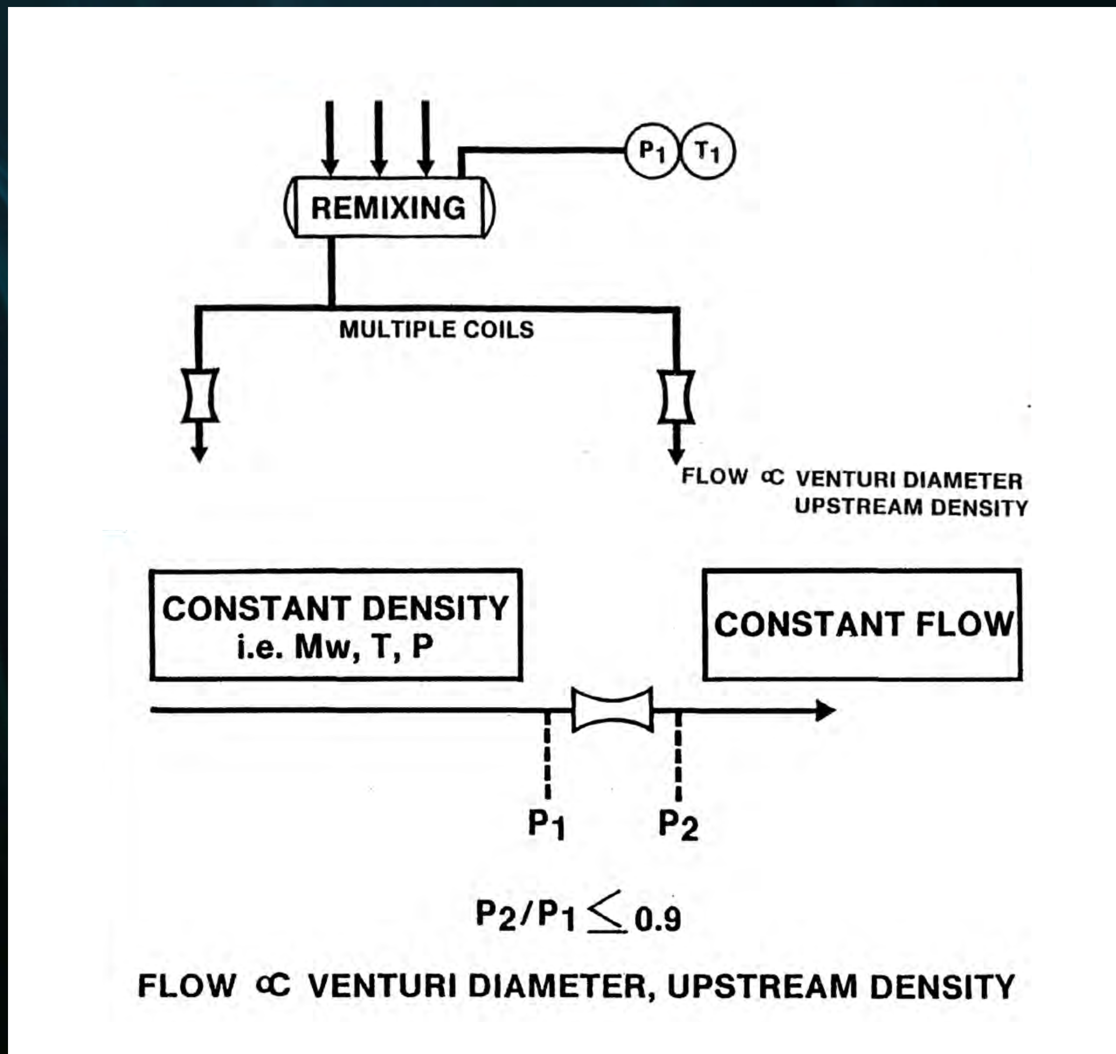
Equilibrium Ethane Conversion
Conversion, %
95
85
75
65
55
800
825
850
875
900
Temperature, Deg. C
COP, Psia-S/O, wt/wt
28PSIA-0.3
40PSIA-0.3
40PSIA-0.5
28 psia, 0.3
40, 0.5
40, 0.3

Coking (Cont.)

3. Flow Distribution

a) A single manifold feeds many single pass coils with many parallel tubes in the first pass. The flow to each tube is controlled by the pressure drop in that tube. For a long coil, the pressure drop in each tube of the first pass is significant and the coke deposition is very small from start of run (SOR) to end of run (EOR) to low ethane conversion (<15%) in that pass. Where coke deposition is significant, (large tube) is used.

Uniform Flow Venturi Principle



Coking (Cont.)

b) Contaminants in the ethane feed like green oil can increase the coking rate near the inlet of the coil, therefore, for a successful ethane cracking, no green oil should be present.

c) Short run length for ethane cracking has been attributed to iron and chromium migration, plays some role in coke formation.

Quench Exchanger

- Rapid quenching to achieve high heat transfer and reduce the secondary reactions.
- Coking rate reduction.
- Online decoking.
- Stage wise diameter increase throughout the radiant coil – transfer line exchanger – to accommodate thermal and molecular expansion and coke lay down.

Quench Exchanger, (cont.)

- A single stage shell and tube heat exchanger is used to cool the heater effluent rapidly. During this process, high pressure steam is generated.
- Coking in the radiant coils and in the transfer line exchangers (TLE) cannot be avoided. But the rate of deposition can be controlled by proper design.

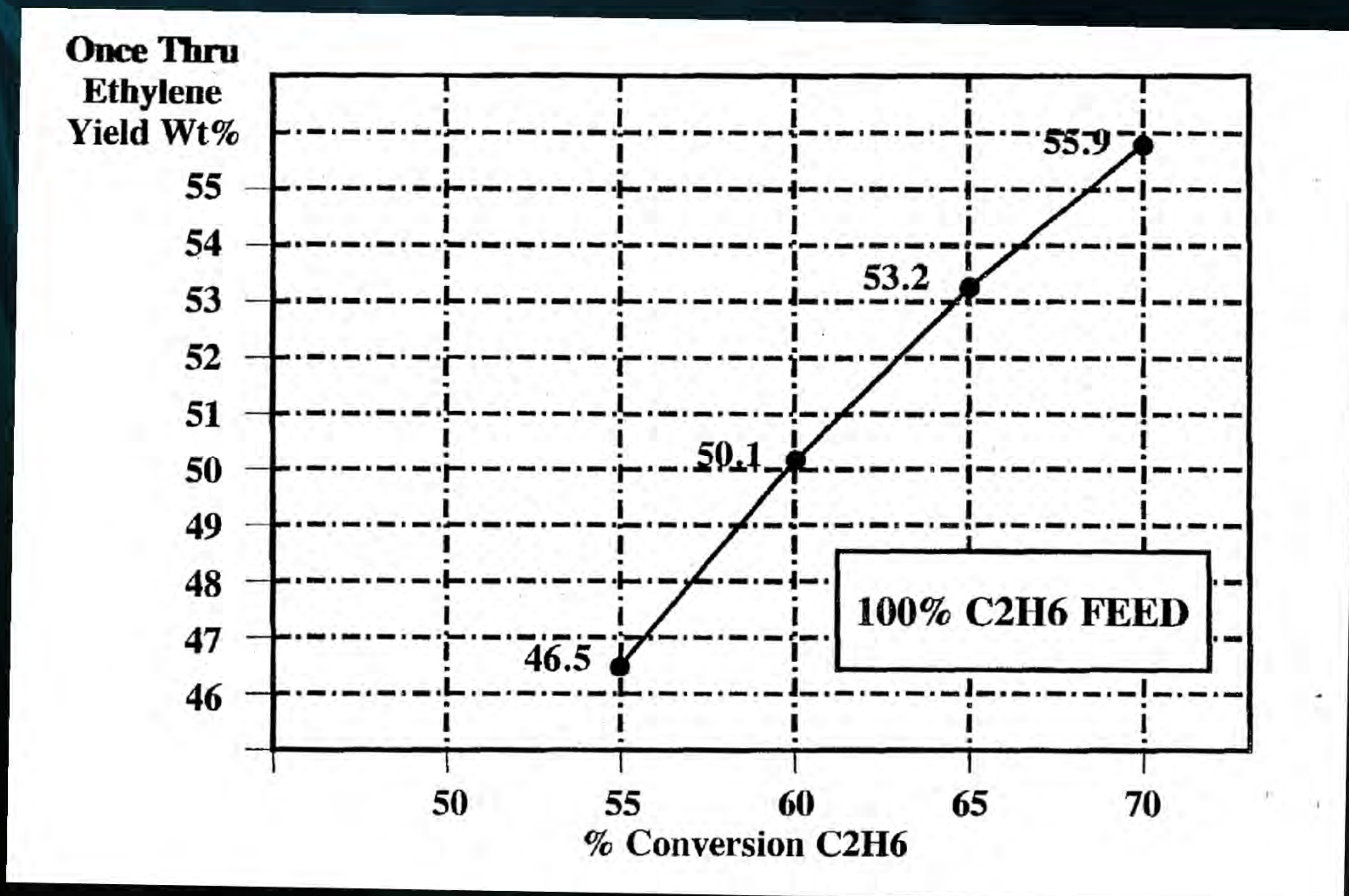
Economic Design Aspects

Economic Definitions

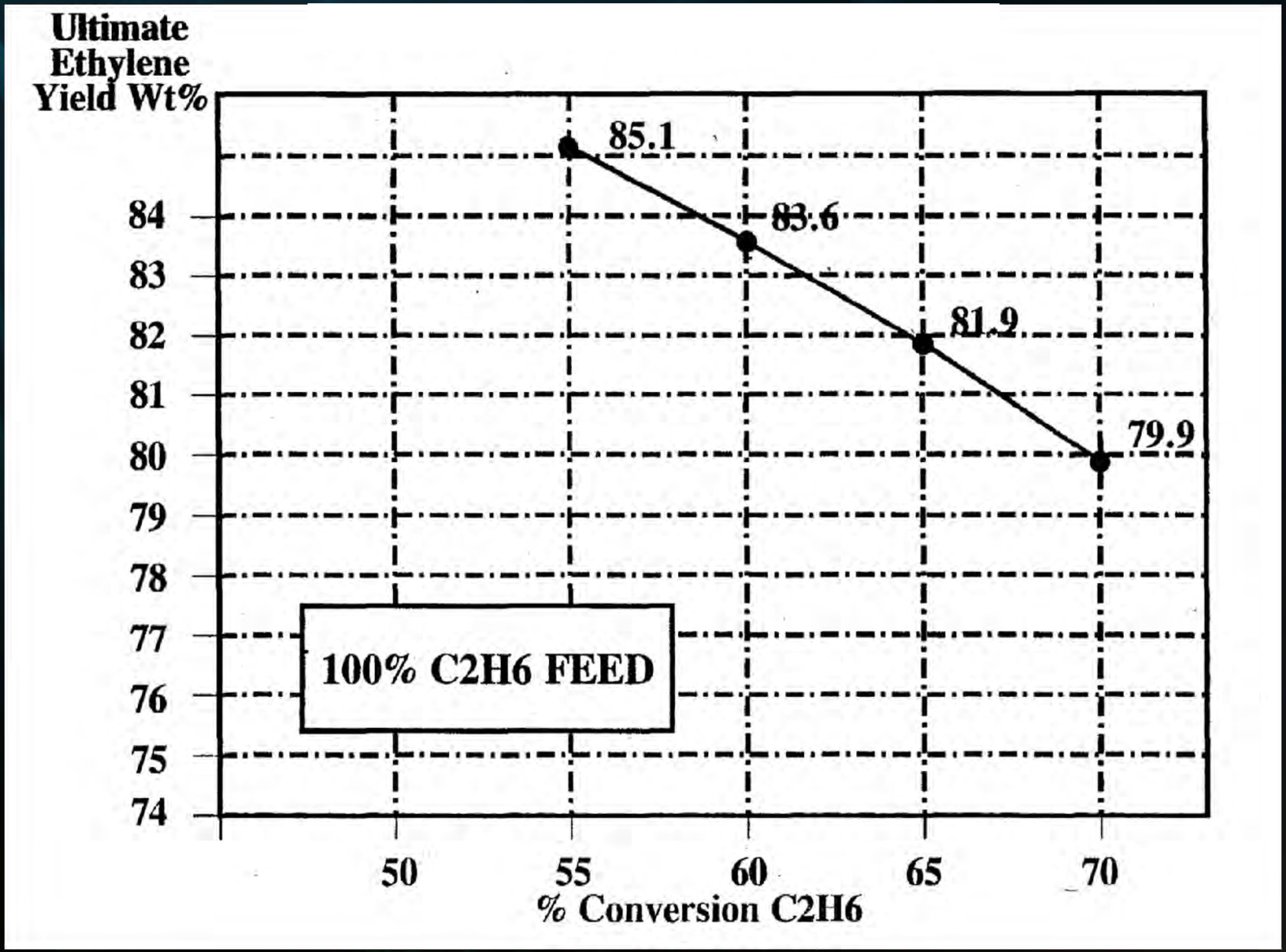
- ***Selectivity:*** ∑ (Ethylene + Propylene + Butadiene) produced at constant severity (conversion).
- ***Severity:*** % of Feedstock converted to cracked products.
- ***Specific Energy Consumption:*** Total Net Energy to produce unit quantity of Ethylene

  No G.T = 3300 kCal/ kgC_2H_4
- ***Specific Power Consumption:*** ∑ Compressor Power per unit quantity of Ethylene, Ranges from 0.55 – 0.62 KW/ kgC_2H_4

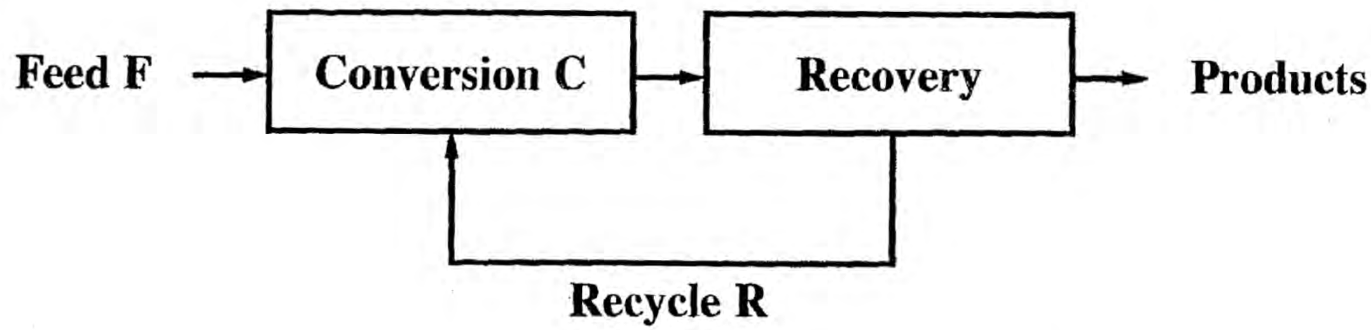
Once thru ethylene yield vs. % Conversion



Ultimate ethylene yield vs. % Conversion



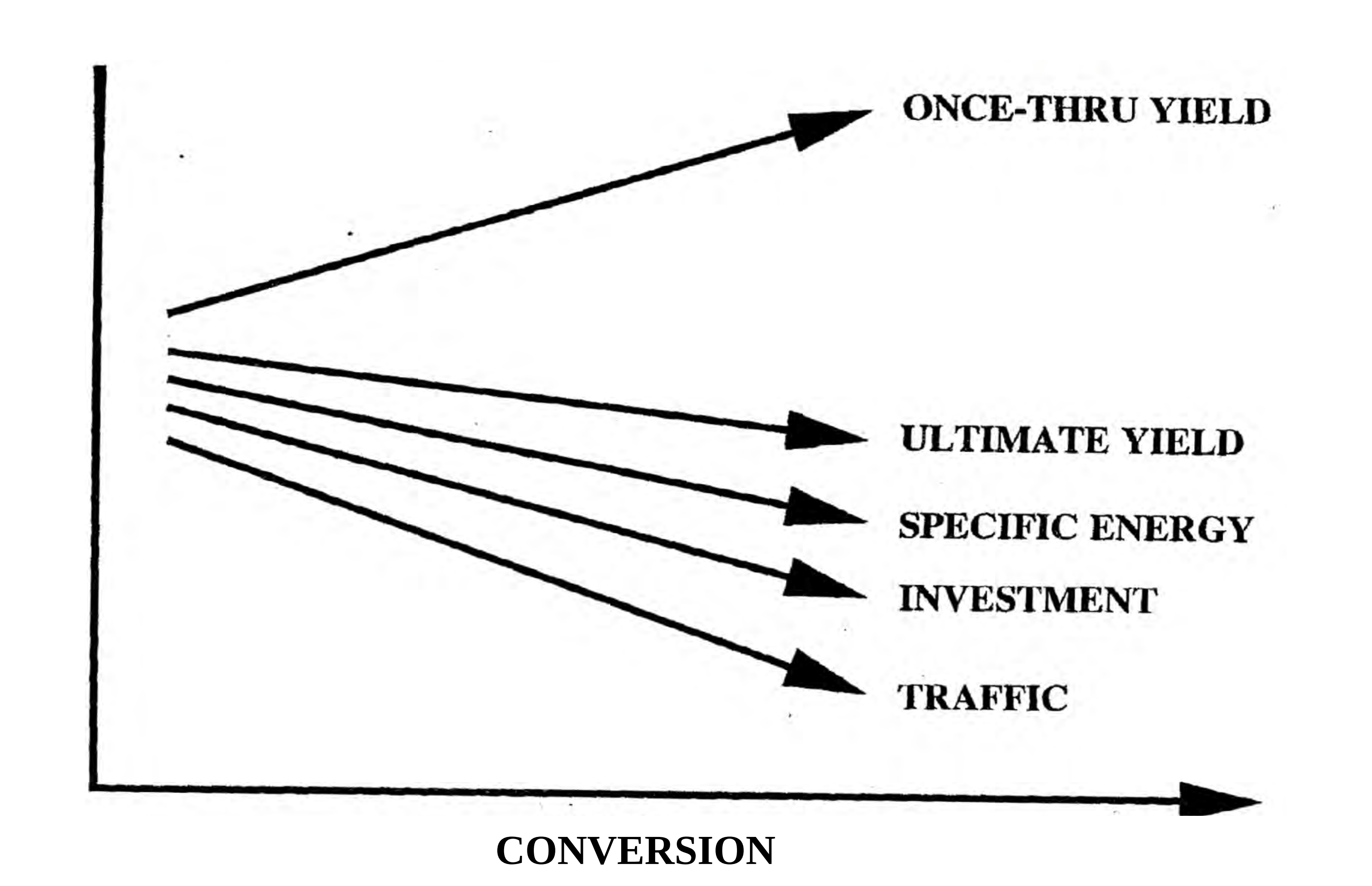
Ethane Traffic vs. Conversion



$$R = F \cdot \frac{I - C}{C}$$

C	R+F	RATIO
.70	1.43	BASE
.65	1.54	1.08
.60	1.66	1.16
.55	1.82	1.27

Ethane Conversion Optimization



Operating Parameters

Operating Parameters

- Olefin production is promoted by high temp. and short residence time and cracking pressure.
- Cracking pressure is controlled by the suction pressure of compressor and ΔP between outlet of furnace and the compressor.

  If cracking pressure decreases: olefin yield increase, furnace and quench boiler coking decrease.

Operating Parameters (Cont.)

- High pressure steam generation:
  - At the outlet of the furnace, effluents are cooled down to 350-400 C in a quench boiler (double pipe exch.) with generation of high pressure steam 120 bar.

Table 1

Design and Operating Conditions for Ethane Cracking

	Design	Operation Average	Operation (Min. - Max.)
Feed, Mol%			
CH_4	1.5	0.95	(0.76 - 1.38)
C_2H_6	97.0	97.4	(95.7 - 98.5)
C_2H_4	-	1.04	(0.01 - 3.0)
C_3H_8	1.5	0.6	(0 - 0.95)
S/O ratio, wt/wt	0.30	0.303	
COT, deg.F	1521	1540	(1531 - 1560)
Conversion, %	65	64	(59.8 - 68.9)
TLE outlet temp.,F	533	530	(525 - 533)
HP steam, lb/h	37367	37350	(35216 - 38537)
Run length, days	70	72	

Technology Improvements

Technology Improvements

1. **Reduction of Energy consumption**

    a) Improve furnace thermal efficiency more than 95%.

2. Reduction of steam demand by reducing compressor power required per ton ethylene, less than 650 kWh/t/h.

3. **Tertiary refrigerant application.**

4. **High capacity pyrolysis heaters with high selectivity.**

5. **Pyrolysis radiant coil modification**

Technology Improvements, (Cont.)

6. Ethylene Feed Pretreatment:

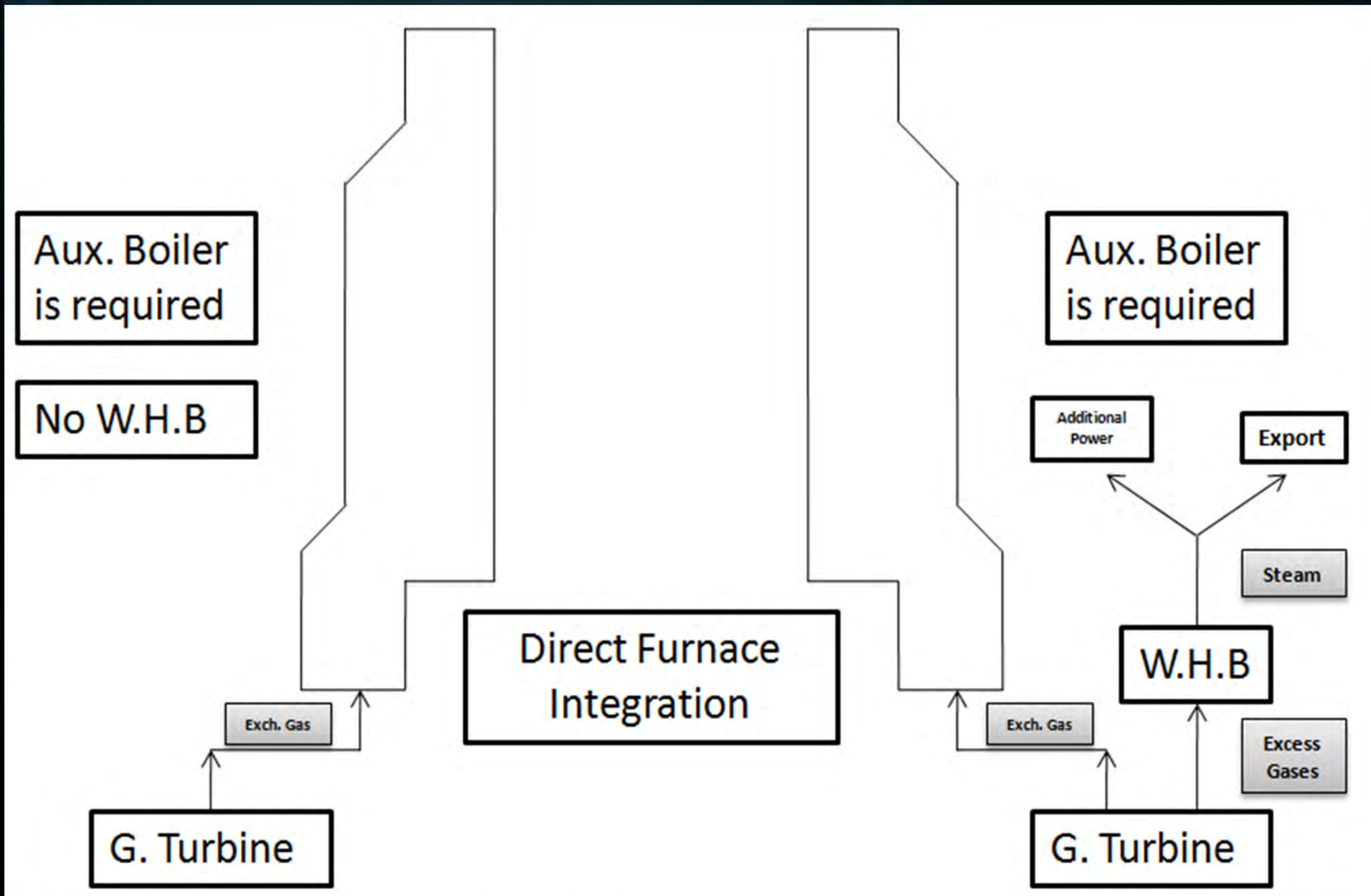
- Mercury removal
  RAM Process:
- 2 catalytic reactors, to trap Hg
- 1st reactor :Organometallic Hydrogenolysis of Hg To elemental Hg
- 2nd reactor: Mercury trapping medium

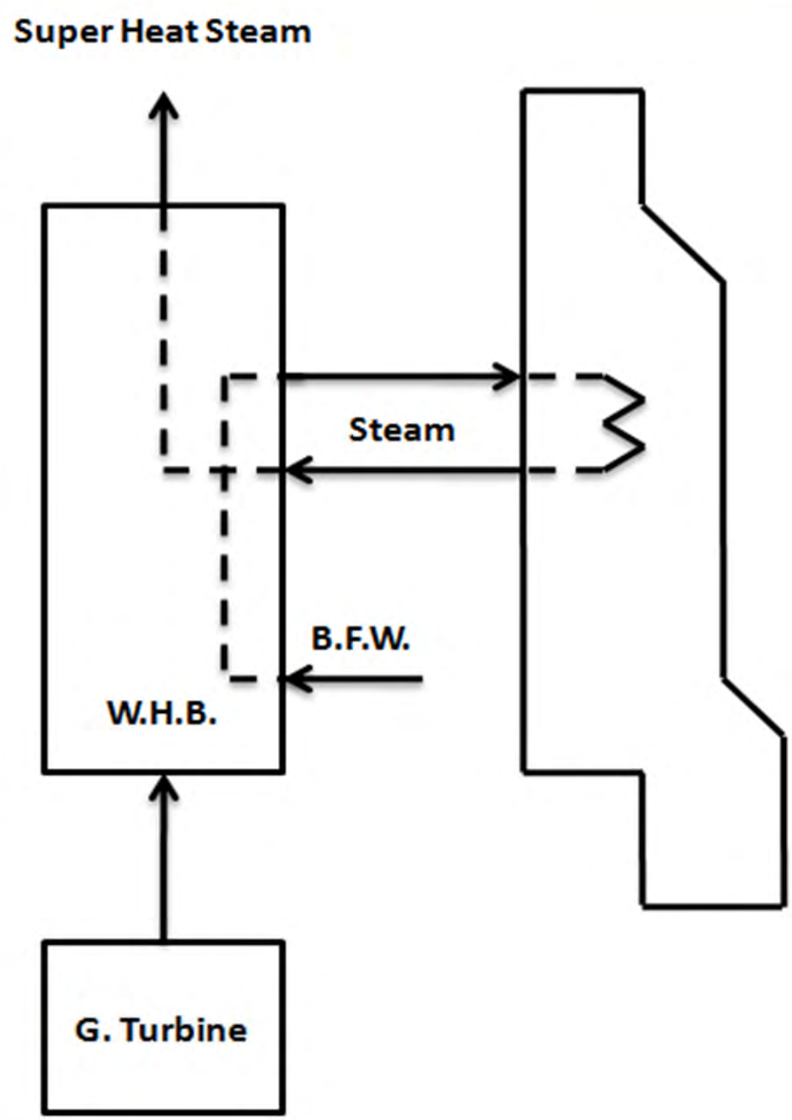
Technology Improvements (Cont.)

7**. Integration of a gas turbine driver and reconfiguration of both steam system and pyrolysis furnace heat recovery system**

Two cases:

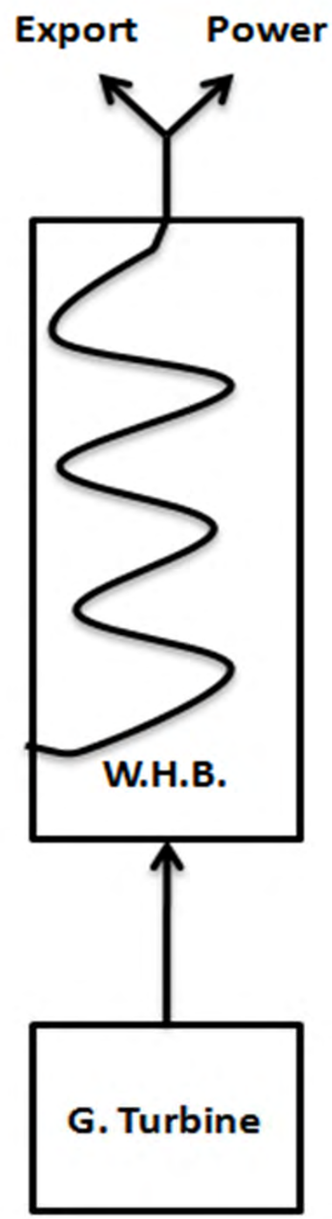
- Gas turbine exhausts into a boiler, while pyrolysis furnace use combustion air preheated with flue gas.
- Gas turbine exhaust into the pyrolysis furnaces and supplementary combustion air for the furnace is preheated with steam.


Aux. Boiler is required
No W.H.B
Exch. Gas
G. Turbine
Direct Furnace Integration
Aux. Boiler is required
Additional Power
Export
Steam
W.H.B
Exch. Gas
Excess Gases
G. Turbine



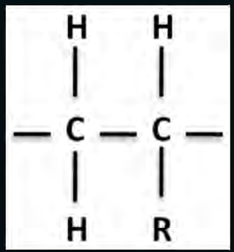
Steam System Integration

Standalone Combined Cycle/ Cogeneration



Polyethylene Production

Polyethylene Production

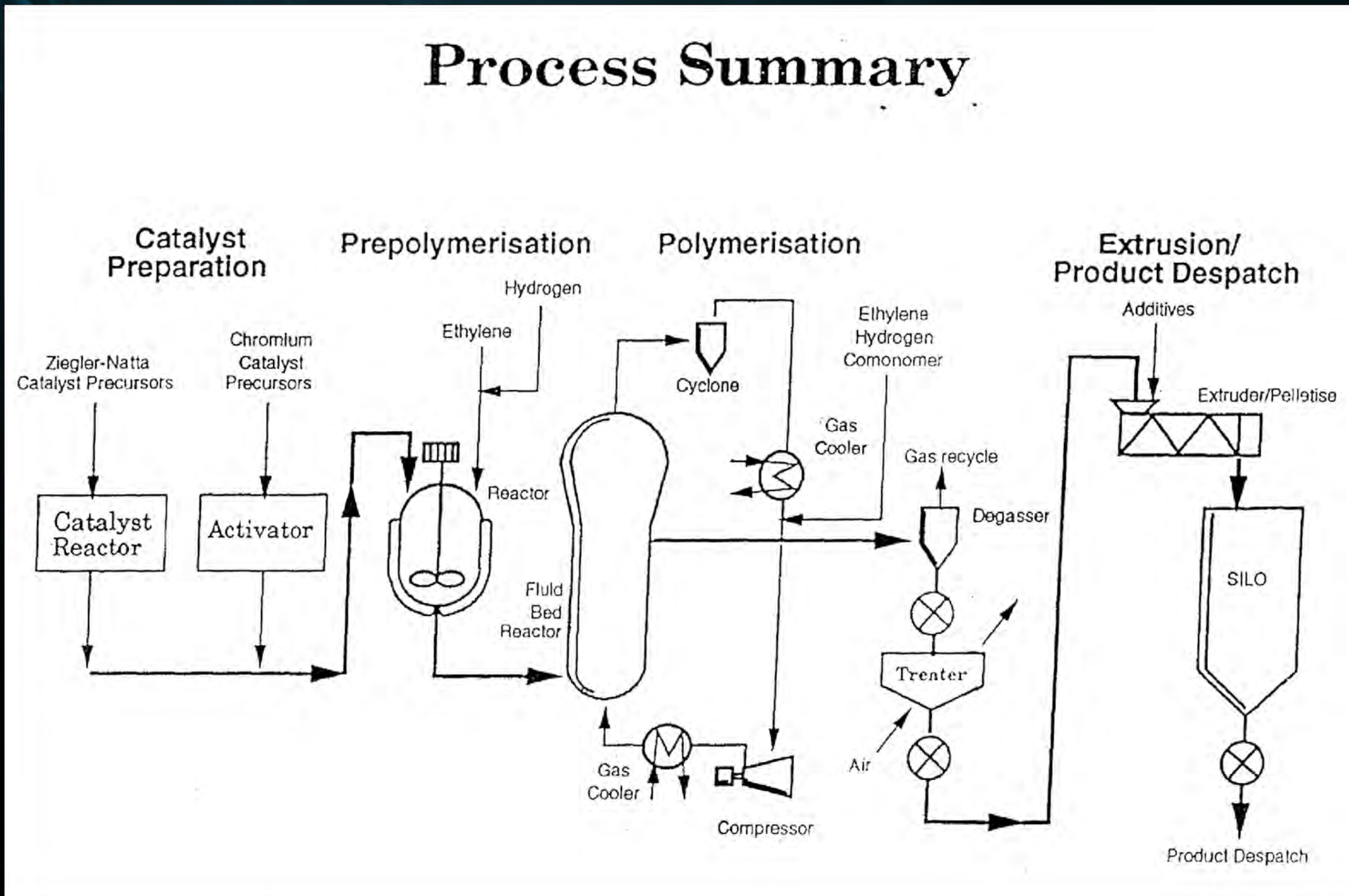


Polyethylene:

Partially Crystalline

Uses: Tubing, Film, Bottle, Cups, Electrical Insulation and Packing.

Fluid Bed Process



Polyethylene Production

Basic ethylene polymerization mechanism using Ziegler Catalyst:

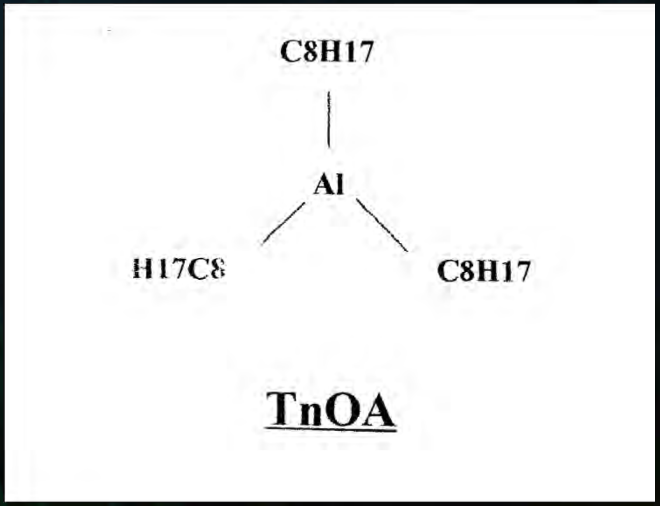
- In a Ziegler catalyst, TI (III) must be activated by an organo aluminum compound called Co-Catalyst.
- The active site is built through the alkylation of titanium by organo aluminum compound.
- In the reaction propagation process, insertion of ethylene into Ti-C bond, hetrogen. polymerization.

Polyethylene Production (Cont.)

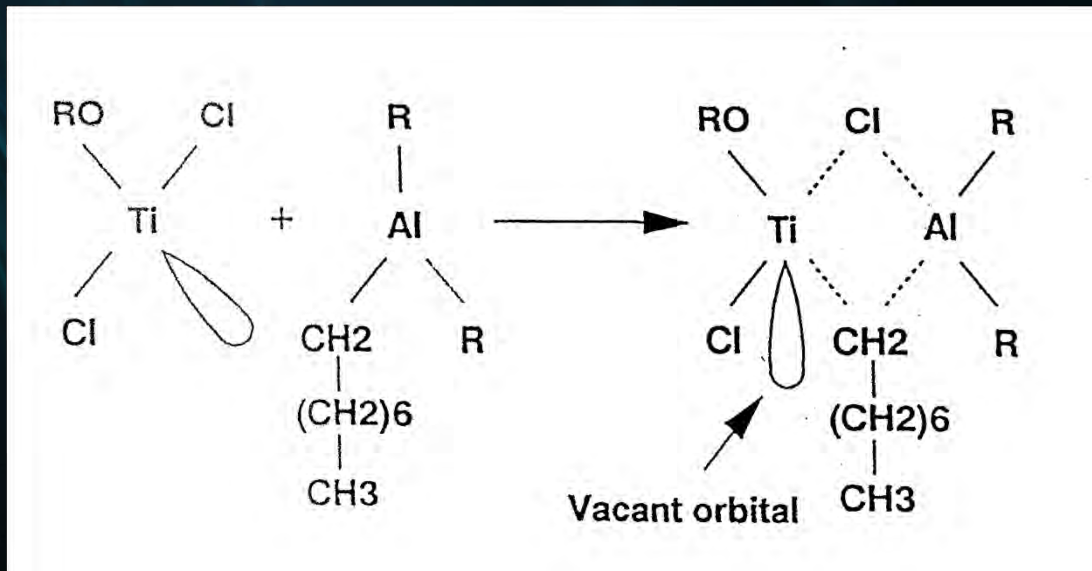
- Termination step performed to control the final M.Wt. of the polymer by:
- Self termination
- Chain transfer to monomer
- hydrogen chain transfer, H-Ti.

Basic Ethylene Polymerization Mechanisms

- In a Ziegler-Natta catalyst, Titanium (III) is potentially active.
- However, it must be activated by an organo aluminum compound. i.e. the co-catalyst.

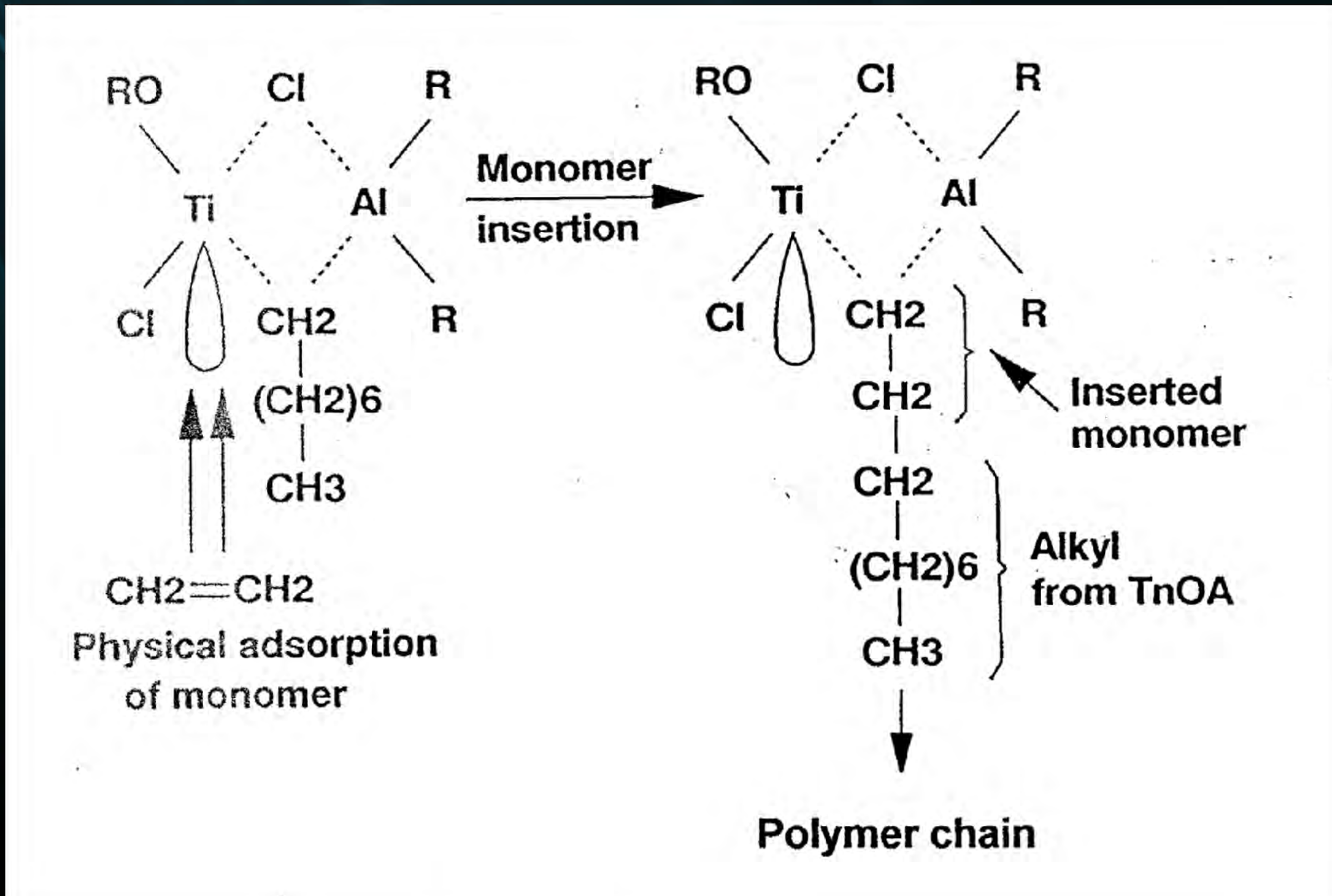


Constitution of the Active Site



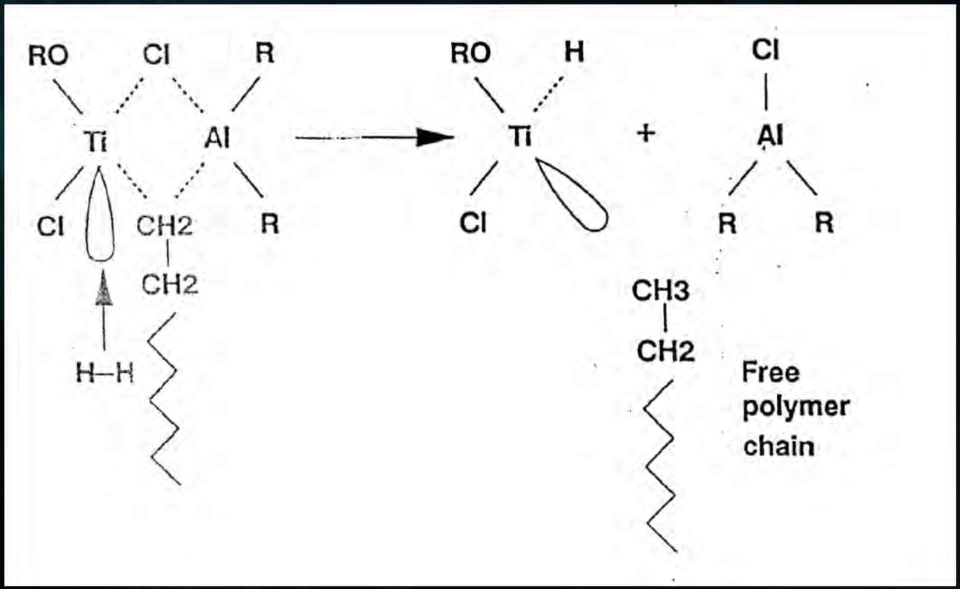
- The active site is built through the alkylation of titanium by the organo aluminum compound (TnOA).

Propagation

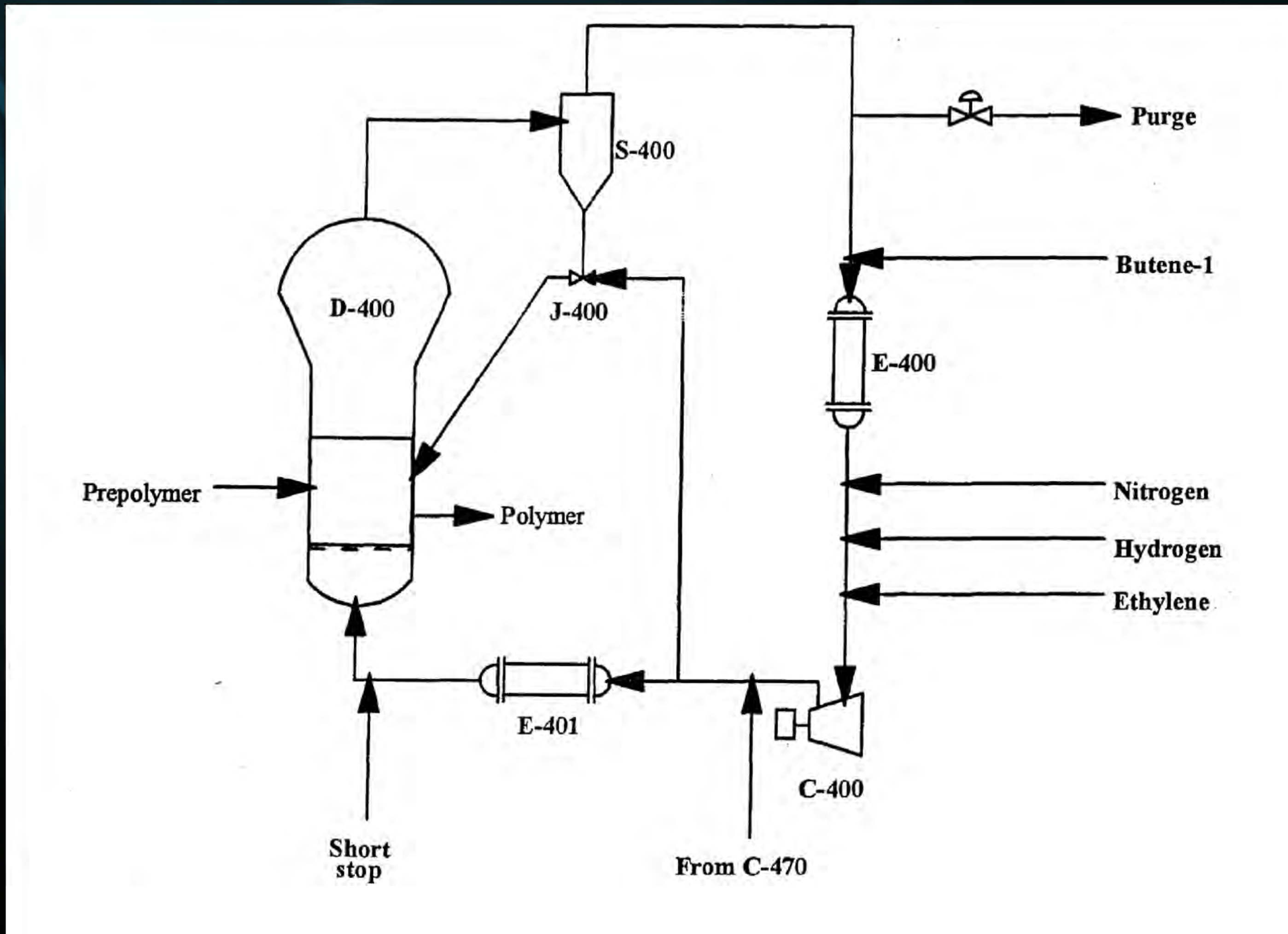


Termination

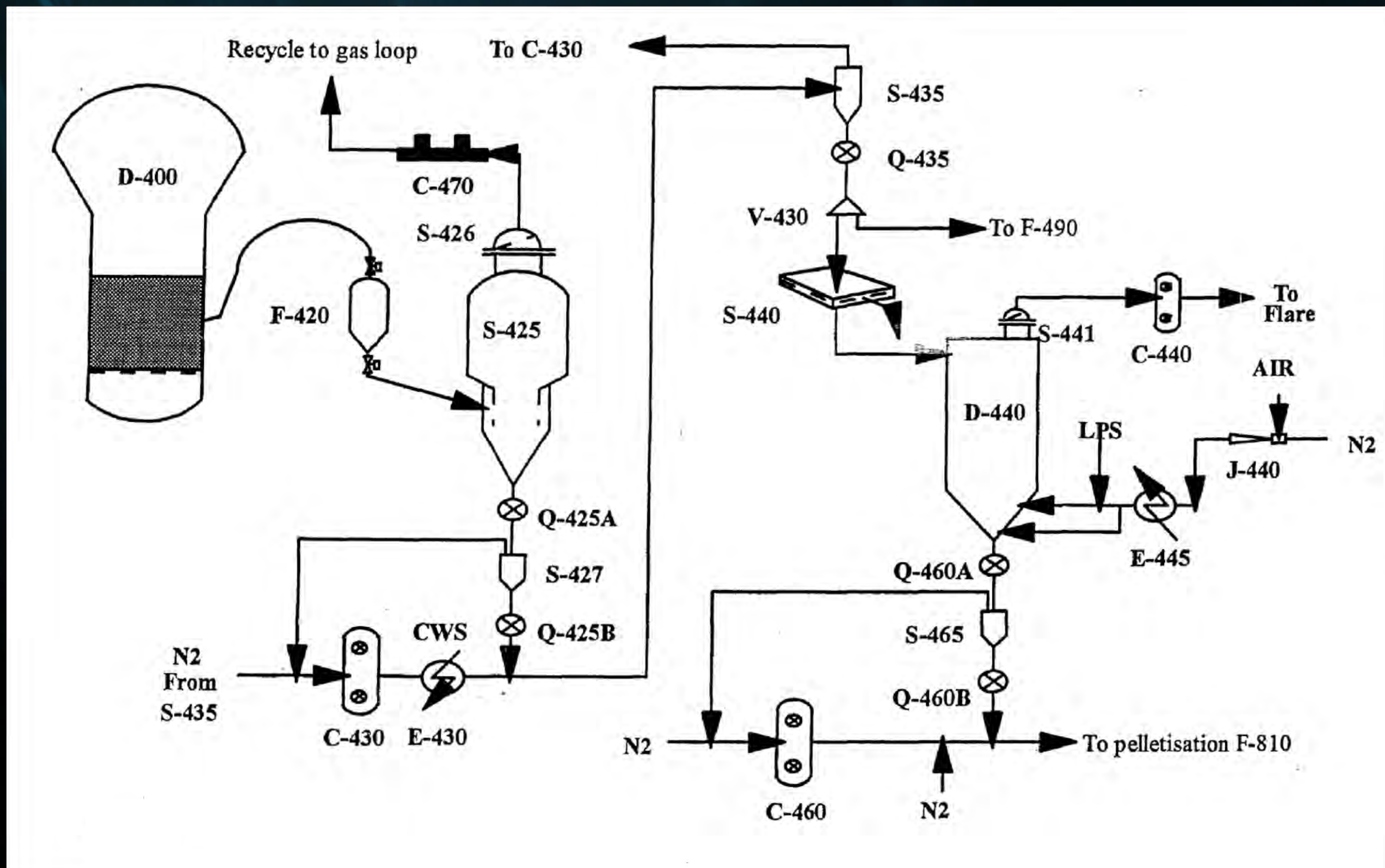
- The polymer growth is terminated by means of hydrogen chain transfer.
- This is done to control the final molecular weight of the polymer.



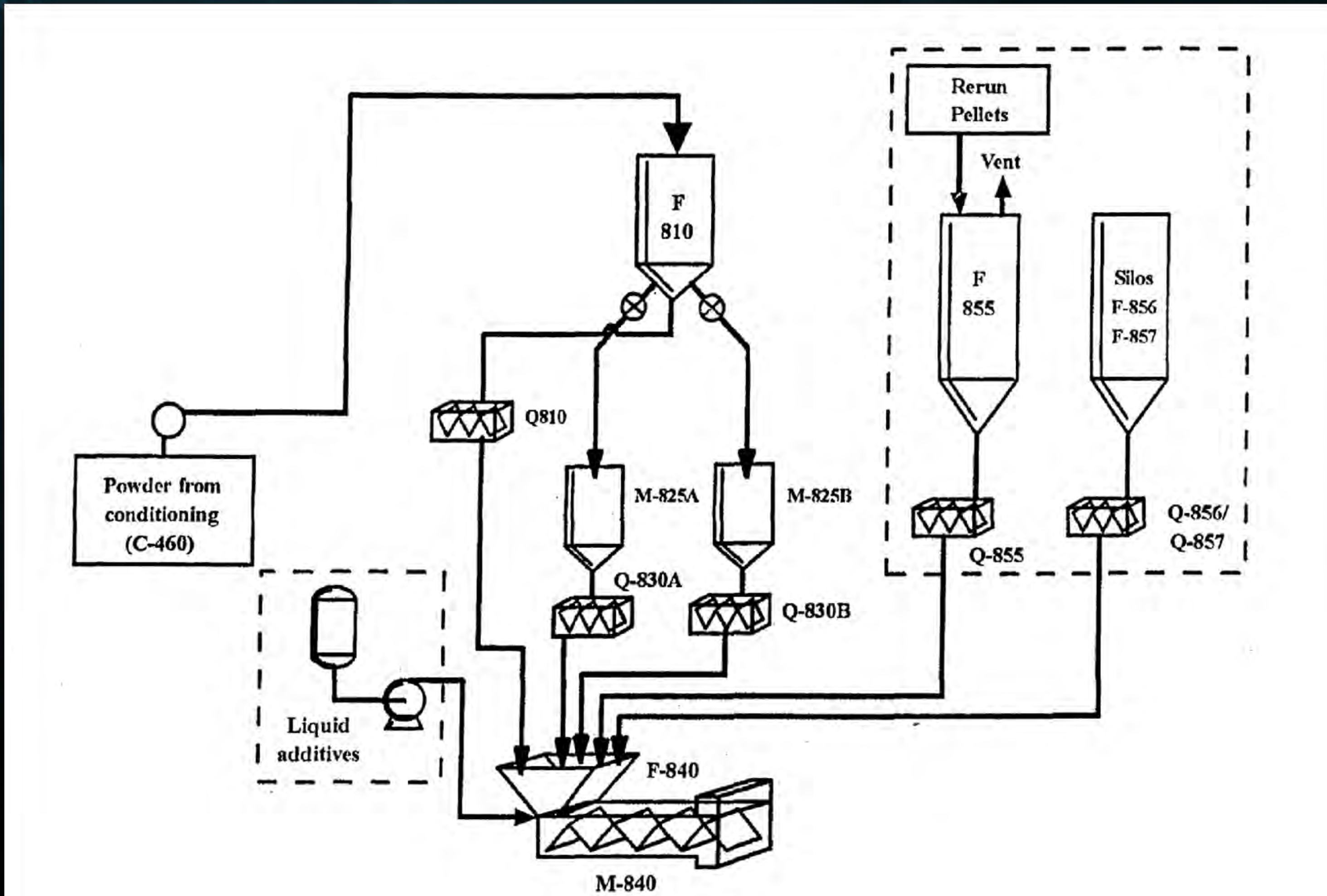
Reaction Loop



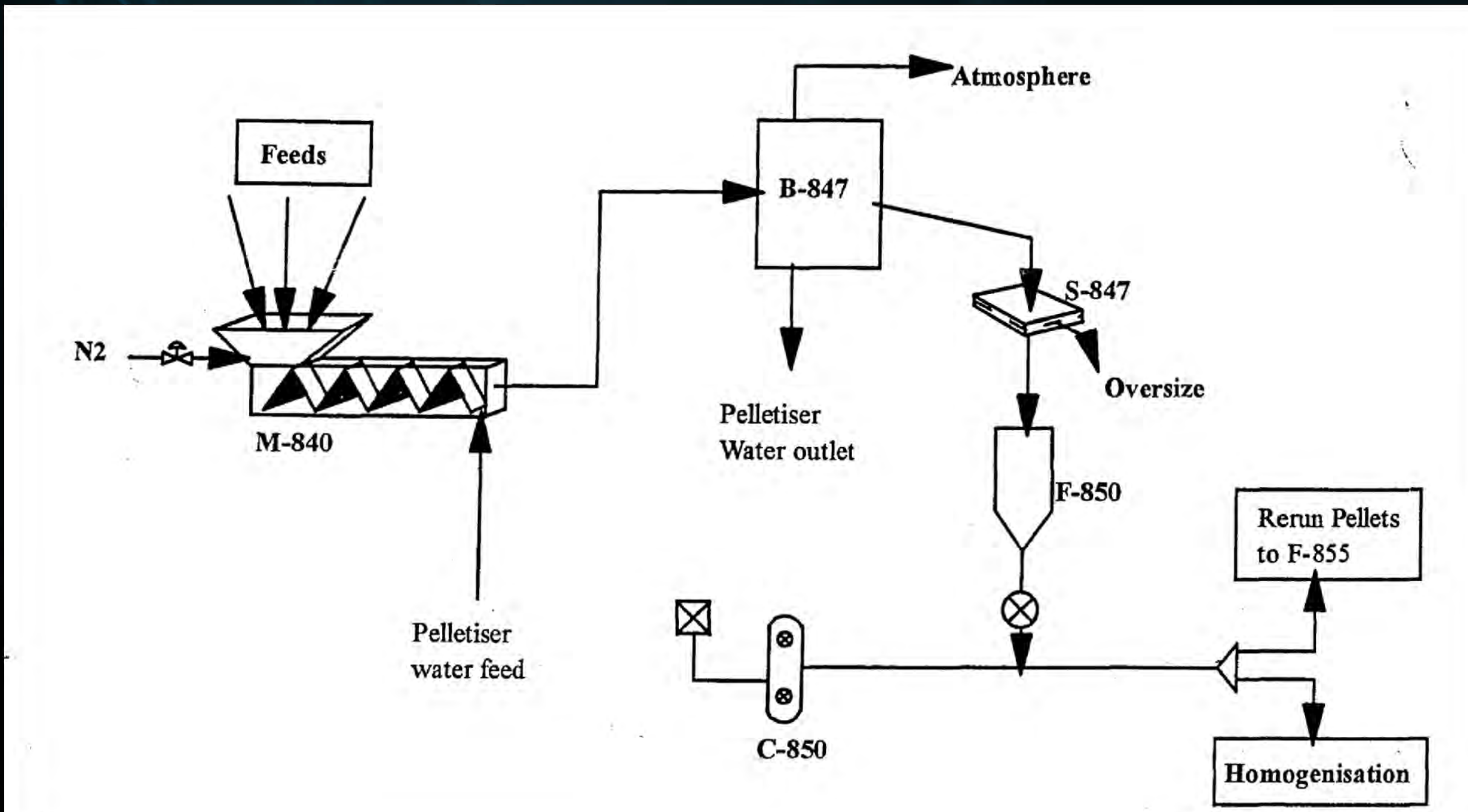
Polymer Withdrawal and Conditioning



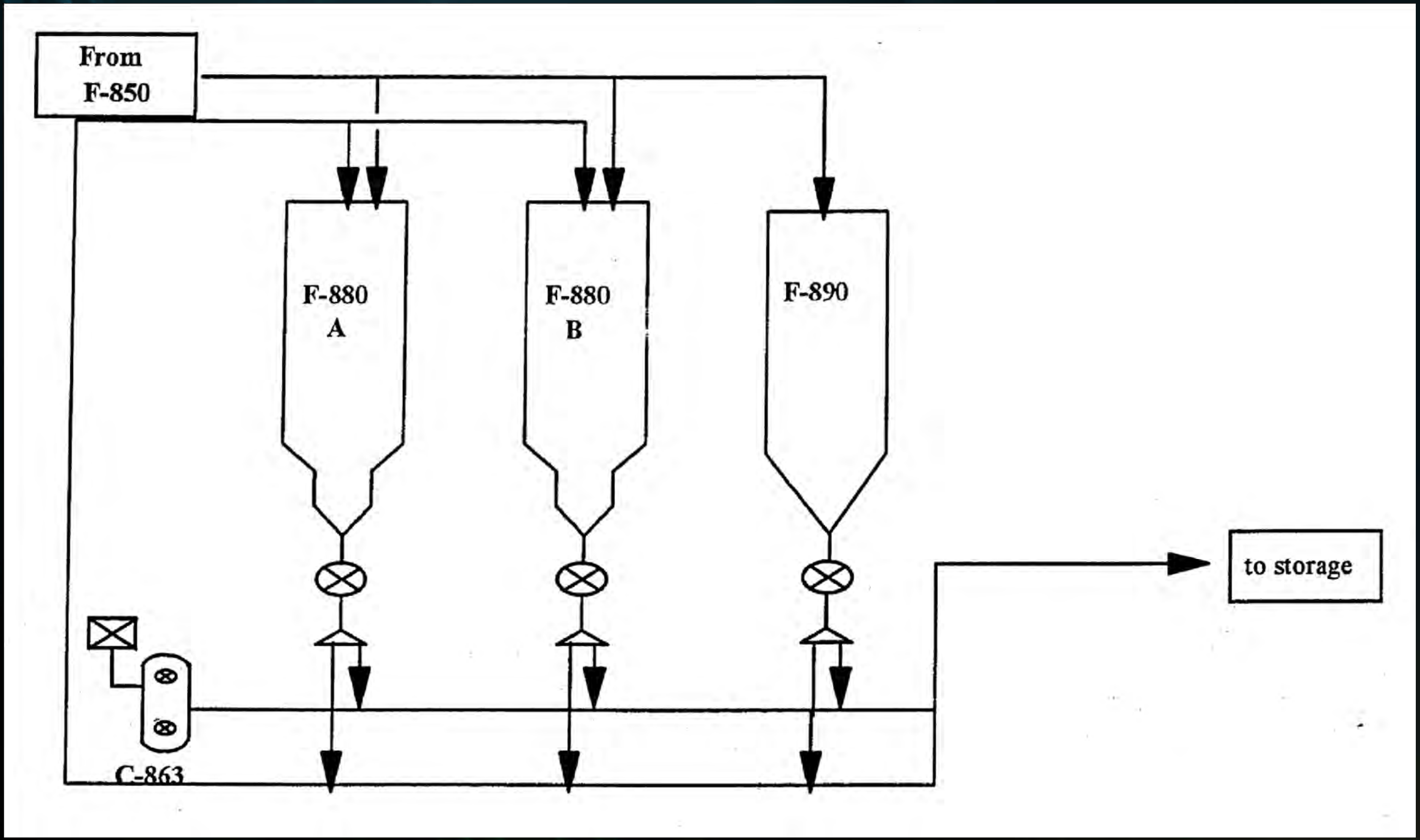
Extruder Feeds



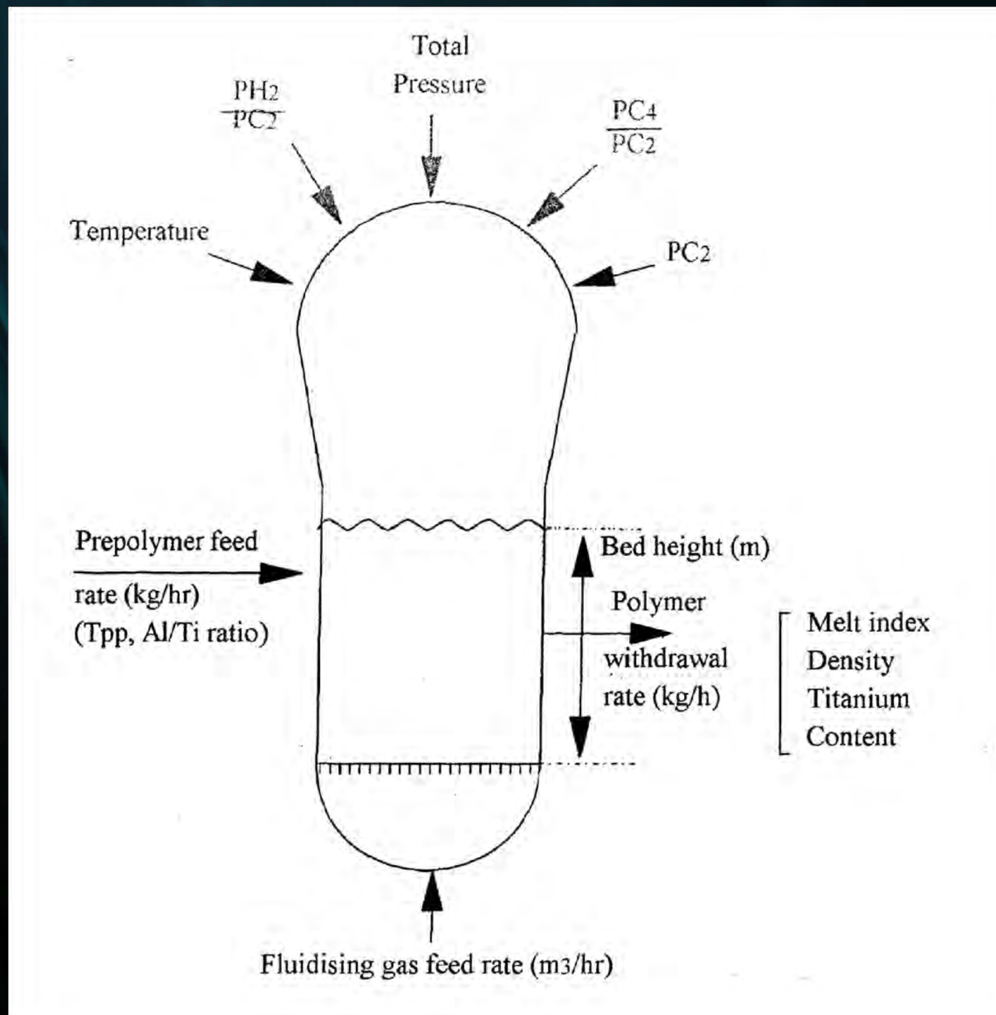
Pelletisation



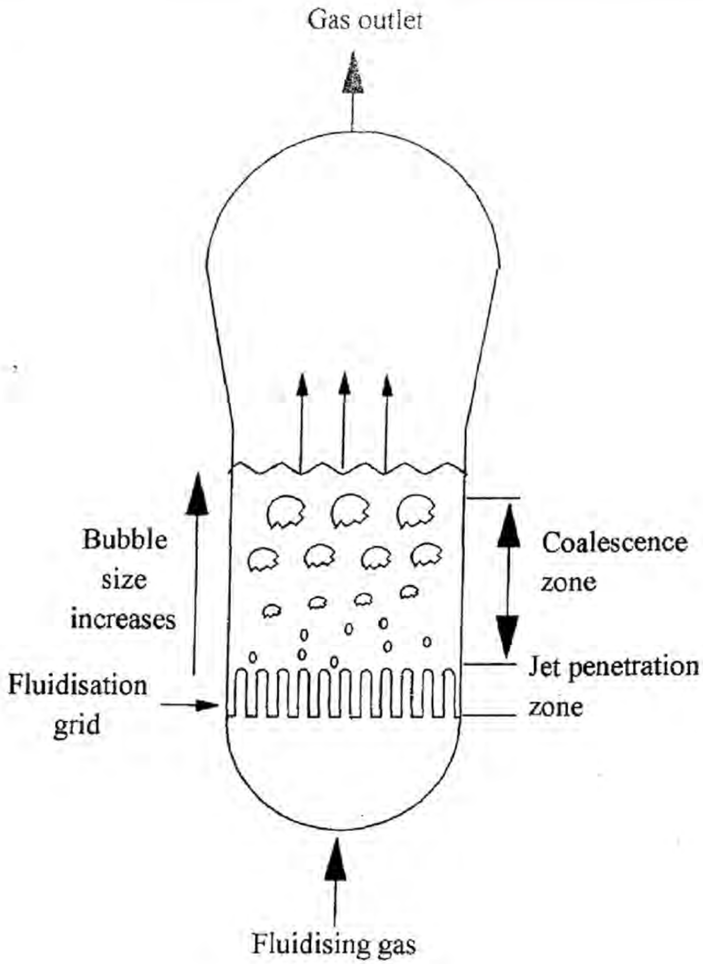
Silos / Despatch

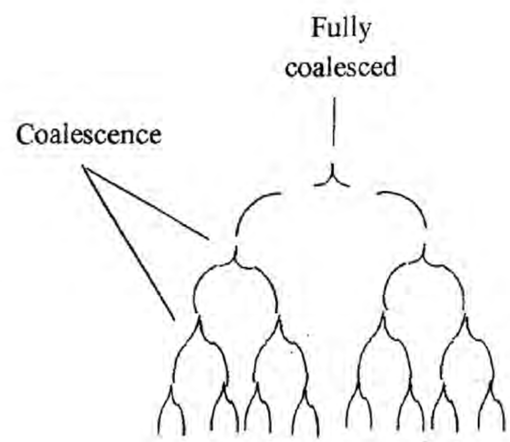


Reaction Control Parameters

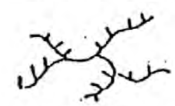
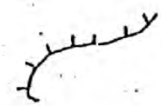


Gas Flow in the Fluidised Bed





Main Properties of Polyethylene

	HDPE	LDPE	LLDPE
MELT INDEX G/10 MIN	0.01-80	0.2-70	0.2-50
DENSITY G/CM^3	0.960	< 0.920	< 0.920
MOLECULAR STRUCTURE			
SHORT CHAIN BRANCHES/1000C	0-5	15-25	15-25
LENGTH	C_2 OR C_4	C_1, C_2, C_3, C_4	C_2 OR C_4 OR C_6
LONG CHAIN BRANCHES/MOL	~ 0	~ 30	~ 0
MORPHOLOGY			
- CRYSTALLINE MP°C	130	108	123
- SPHERULITE SIZE	LARGE	SMALL	LARGE
TENSILE STRENGTH (PSI)	3,500-4,500	1,000-2,000	3,000-4,500
ELONGATION (%)	100-1,000	300-600	600-700
SHORE D HARDNESS	60-70	41-45	44-48
MAXIMUM SERVICE TEMPERATURE (°C)	110-130	80-95	90-105

Process Improvements

- 1) Spheriline Gas Phase Technology, Basell Technology, high performance and bimodal grades based onapplied Molecular Model

  VLDPE-HDPE Density: (0.900-0.96)

  MI: (0.1-100gr/10)
- Prepolymerization step, slurry phase
- 2 Gas Phase Reactor

Process Improvements, (Cont.)

- 2. Borstar Polyethylene Process, Borialis,
- Bimodal and Unimodal products
- Density: 0.917-0.970
- MI :0.1-100
- MWD: narrow – Broad
- Prepolymerization
- Loop reactor
- Gas phase reactor

PE Processing

LLDPE:

- Tm is higher 15 C for LLDPE of same density as LDPE.
- T.S. at break is higher. T.S. at yield is about the same of the same density. (down gauging that is justified on T.S. at break basis, lead to products that stretch unacceptably under load).
- Stiffer for the same thickness of LDPE film.

HDPE:

- _Mechanical properties of HDPE grade applications are affected by M.Wt, MI and sp. gr.

Main Additives

1) Anti Oxidants:

- Degrading Agents: Oxygen and Sunlight.

  Most polymer processing is above 180 C

  Auto-oxidative free radical reaction

  Thiols & Phenols.

2) Heat Stabilizers:

Epoxy base or Ca-Zn , Sb, ….

Additives, (Cont.)

3) Light Stabilizers:

Solar Radiation

- Photo-oxidation depends on:

  Stabilizer Type

  Degradation Mechanism

Classes :

a) UV Screeners and /or Absorbers

b) Free Radical Scavengers

Additives, (Cont.)

4) Fillers:

Crystalline or Amorphous, e.g. CaCo3, TiO2,Glass beads.

Objectives: Plastic properties & Cost Reduction

Impact on polymers:

High Young's Modulus

Better Thermal Stability

Reduction of fracture strain under tensile load

Non-uniformity in some applications

Film Product Range

MFR	Density	Butene Copolymers	Hexene (4MP-1) Copolymers
Blown Film			
0.6	920	LL0205	LL7206
0.9	920	LL0209	LL7209
0.9	924		LL7409
0.8	926	LL0410	
0.6	928		LL7606
0.9	936		LL7909
HLMI 14.0	939	HD 3802-2	
HLMI 9.0	950	HD 5001-2	
Cast Film			
2.4	920	LL0220	LL6130
2.0	924		LL7420
4.0	930	LL0640	

Mainly for:
Lean blends with LDPE
general purpose
lamination
cast stretchwrap

Mainly for:
Rich blends or pure
Heavy duty packaging
Higher Strength/Stiffness
Higher temperature resistance

A range of additive formulations is available to meet final application requirements (slip, antiblock, processing aid, cling agent,...)

Key Applications for Film Grades

Application	Property Requirements	Recommended Grades
Sacks	Impact strength Tensile strength Puncture resistance	LL0209AA (medium duty) LL7206AF (heavy duty) HD3802EA (blends)
Stretchwrap	Puncture resistance TD tear strength Low gel level	LL0220AA, LL6130AA (cast) LL7209AA, LL0209AA (blown)
Carrier bags	Tensile strength Puncture resistance	LL0410KJ, HD5001FA LL7606LJ
Lamination film	Hot tack Good opticals properties Low gel level Low odour	LL1209AA/KJ, LL0209LL LL7409AA/KJ LL7909AA/KJ
Produce bags	Good optical properties Puncture resistance	LL0209KJ LL7409KJ

Market Leader

Moulding Product Range

	MFR	Density
Injection		
HD5120EA	1.9	950
HD5050EA	4.5	950
HD5740EA	4	957
HD6070EA	7.5	960
HD6070UA	7.5	960
HD5211EA	11	952
[illegible]	[illegible]	[illegible]
BD24250AA	25	926
BD30500AA	50	930

Heavy Duty applications

General packaging crates, boxes

[illegible]

Flexible lids and containers

Key Applications for Moulding Grades

Application	Property Requirements	Recommended Grades
Crates, heavy duty cases	High stiffness Impact strength ESCR and UV resistance	HD6070 UA
Large bins, waste bins	Very high strength ESCR and UV resistance	**HD5740 UA**
Screw stoppers	High ESCR Tightness Low taint	HD5050 EA HD5120 EA **HD6070EA** (mineral water)
Thin wall containers	Fast injection Surface appearance	HD5226 EA HD5150EA BD24250 AA BD30500 AA
Rotomoulded tanks, silos, drums	Toughness UV Resistance Easy mould release	**HD3840 UA** HD2840 UA (stress)
Blow moulded detergent bottles	Good processability High ESCR	HD5402-5EA **HD5403-4EA**
Bulk containers	Impact strength ESCR	HD5301-2EA

Market Leader

HD/LLDPE Product Range for Extrusion Applications

Blow Moulding	HD 5402-5EA	0.2	955	Containers 0-5l - sheets
	HD 5403-4EA	0.35	955	Containers 0-5l (high flow)
	HD 5702-4EA	0.2	958	Containers 0-5l (high stiffness)
	HD 5301-2EA	HLMI 10	953	Containers up to 2000l
Film	HD 5001-2EA	HLMI 9	950	Thin film
	HD 3802-2EA	HLMI 14	939	Medium duty packaging
Wire & Cable	LL 2406-1AA[(1)]	0.6	924	Jacketing (low density)
	HD 4002 EX [(1)]	0.25	933	Jacketing (medium density)
Pipe	HD 5402-1EA	0.2	955	Ducting pipe
	LL 2406-1AA [(1)]	0.6	924	Small diameter water pipe
	HD 4401-1EX[(1)]	HLMI 11	945	Water/gas pipe (high density)
	HD 3902-1EX[(1)]	HLMI 19	938	Water/gas pipe (medium density)

(1) Base resin for compound

Extrusion Applications
Product Range

Wire & Cable	LL 2406-1AA[1] HD 4002 EX [1]	0.6 0.25	924 933	Jacketing (low density) Jacketing (medium density)[2]
Pipe	HD 5402-1EA LL 2406-1AA [1] HD 4401-1EX[1] HD 3902-1EX[1]	0.2 0.6 HLMI 11 HLMI 19	955 924 945 938	Ducting pipe Small diameter water pipe [2] Water/gas pipe (high density)[2] Water/gas pipe (medium density)[2]

(1) Base resin for compound

(2) Not commercialised in Europe

Injection and Rotational Moulding Product Range

	MFR	Density	Applications
Injection			
HD5120EA	1.9	950	Screw stoppers
HD5050EA	4	950	Closures, technical parts
HD5740EA	4	957	Boxes, dustbins (UV)
HD6070EA	7.5	960	General purpose
HD6070UA	7.5	960	Crates, toys (UV)
HD5211EA	11	952	Houseware, toys
HD5813EA	13	956	Houseware
HD5218EA	18	952	Food containers, houseware
HD5226EA	26	952	Thin-walled products
HD5150EA	55	948	Disposable cups
BD24250AA	25	926	Lids, closure
BD30500AA	50	930	Ice cream boxes, margarine tubs
Rotational			
HD3840UA	4	938	Tanks, hoppers, silos
HD2840UA	4	930	Tanks, hoppers, silos, drums
HD3560UA	6	933	Toys

PE Local Market Survey

HDPE 350,000 – 400,000 T/Y

APPLICATION	% OF TOTAL	DENSITY RANGE	MFI RANGE
– FILM			
* MMW	10	0.930 – 0.965	0.2 – 1.6
* HMW	10	0.930 – 0.965	0.1 – 0.15
– INJECTION M.	32	0.935 – 0.965	2 – 55
– BLOW M.	39	0.940 – 0.965	0.1 – 0.7
– PIPE			
* GAS PIPES	1.5	0.933 – 0.960	0.2 – 0.8
* DRAINAGE PIPE	1.5	0.933 – 0.960	0.2 – 0.8
– WIRE & CABLES			
* JAKETING & INS.	1	0.933 – 0.950	0.2 – 0.8
* CROSSLINKALE	5	0.933 – 0.945	1.2 – 5

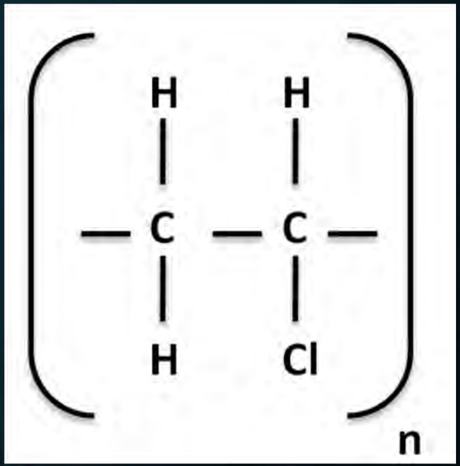
PE Local Market Survey (Cont.)

L.LDPE 80,000 – 90,000 T/Y

APPLICATION	% OF TOTAL	DENSITY RANGE	MFI RANGE
- FILM			
* L.DUTY FILM	40	0.920 - 0.930	1.5 - 2.2
* H.DUTY FILM	60	0.918 - 0.930	0.3 - 1.5

Polyvinyl Chloride Production

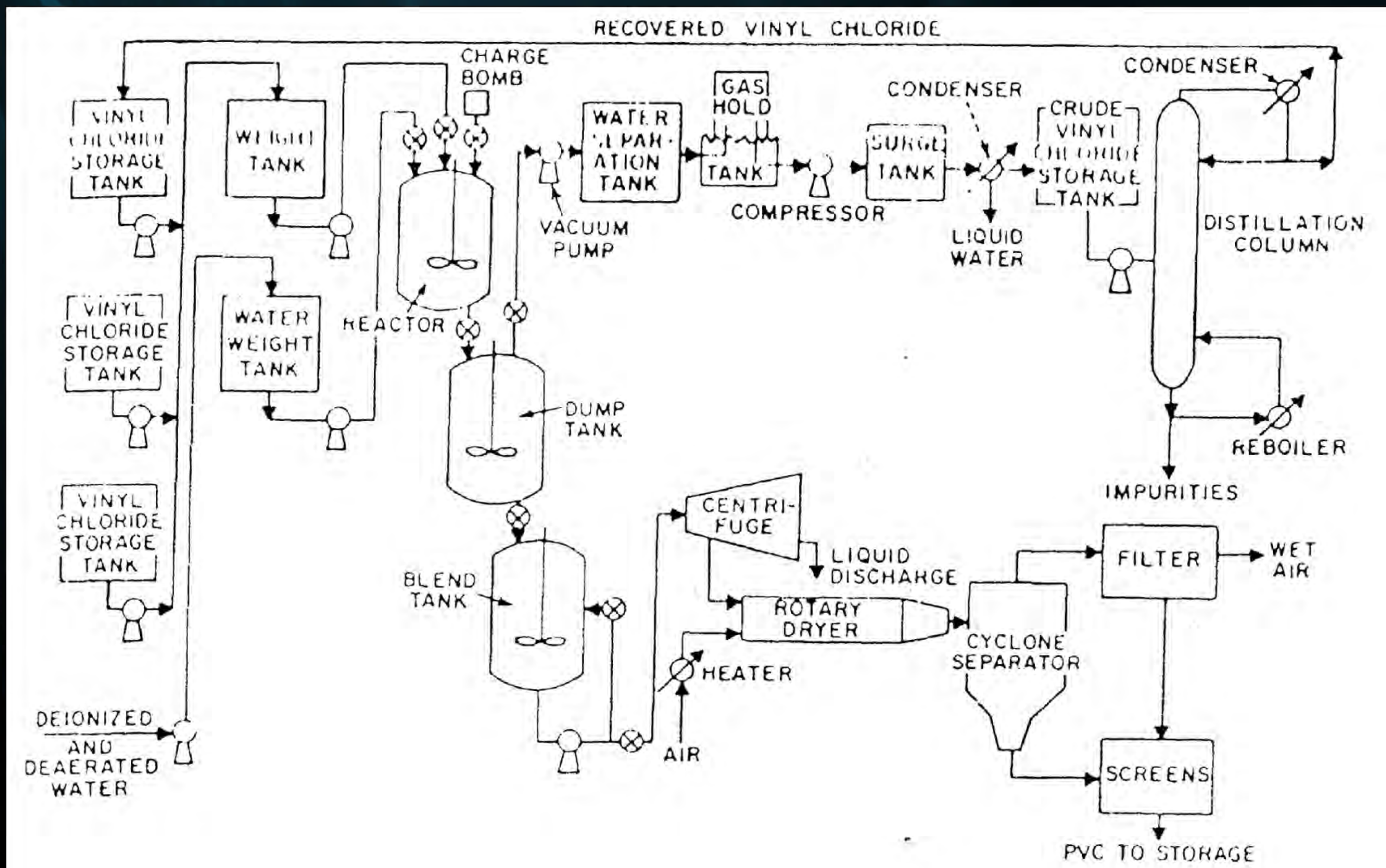
Polyvinyl Chloride Production



Amorphous

Uses: architectural uses (windows, frames, etc…), plasticized to make artificial leather, hoses and clothing.

Polyvinyl Chloride Production (Cont.)



Polyvinyl Chloride Production (Cont.)

I. Raw Material Storage

A. Hot & Cold De-mineralized Water

B. Fresh & Recovered Vinyl Chloride Monomer (VCM)

C. buffer

D. Emulsifier(s)

E. Catalyst(s)

F. Shortstop Solution

G. Coating

Polyvinyl Chloride Production (Cont.)

II. Charging & Polymerization

A. Poly Charge Procedure

B. Water and VCM Charging

C. Additive (or pigment) charging

D. Poly & Polymerization Control

Polyvinyl Chloride Production (Cont.)

III. Slurry Transfer

A. Blow Down Tanks

IV. Slurry Stripping

A. Flash Column Feed Tanks

B. Slurry Stripping Column

C. Blend tanks

Polyvinyl Chloride Production (Cont.)

V. drying

A. Centrifuge

B. Rotary Dryer

C. Dust Collection

D. Screening

Polyvinyl Chloride Production (Cont.)

VI. VCM Recovery

A. Batch Recovery

B. Continuous Recovery

C. Vent Gas Recovery

VII. Waste Water Stripping

Polyvinyl Chloride Production (Cont.)

VIII. Process Quality Control

A. Specifications

B. Control Charting

C. Process Changes for quality Control

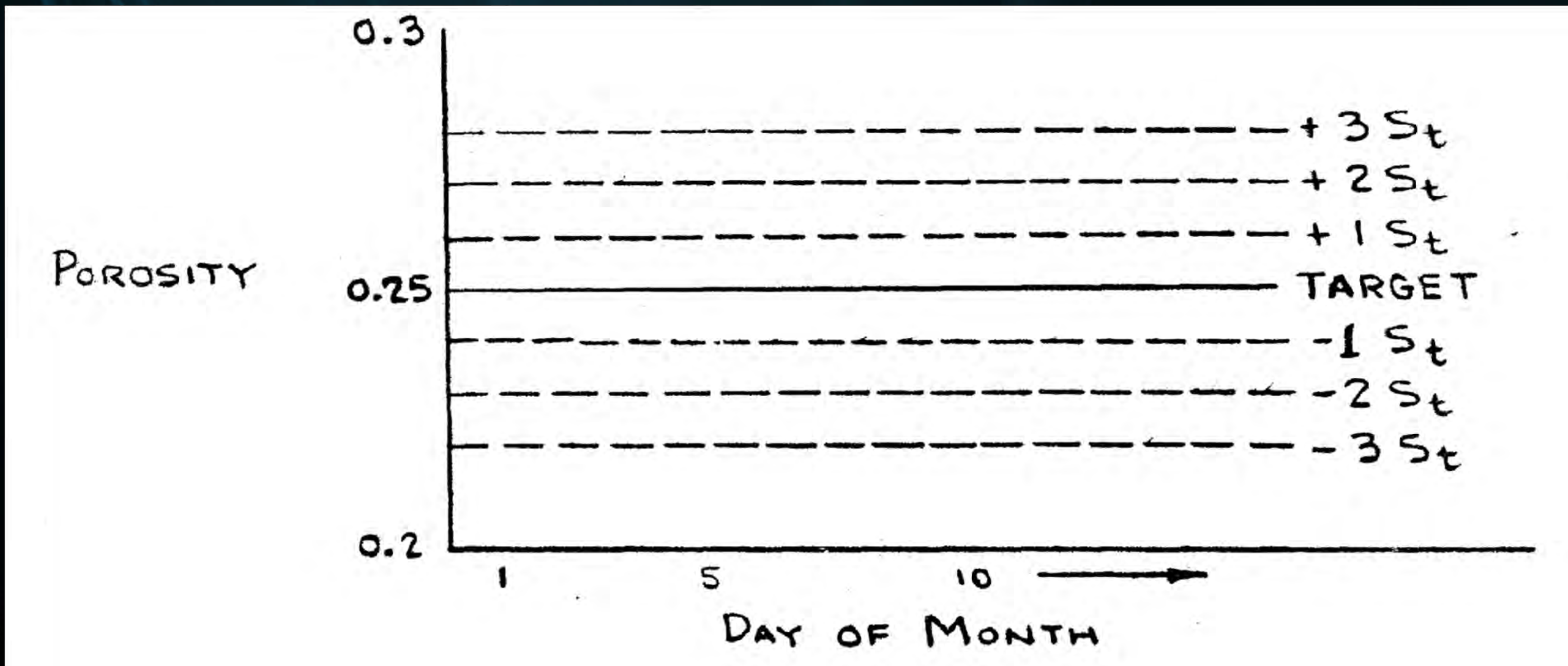
Control Charting

Technique to monitor specification properties and determine when process changes should be made to maintain specification.

Process change is made when:

- Data point exceeds 3 S_t.
- 2 of 3 successive data points exceed 2 S_t.
- 4 of 5 successive date points exceed 1 S_t.

Control Charting (Cont.)



E.P.C. Product Specification

	K-70	K-67	K-61	K-57
INHERENT VISCOSITY (I.V)	0.98 - 1.05	0.90 - 0.94	0.75 - 0.78	0.66 - 0.70
HEAT LOSS (H.L)	0.3	0.3	0.3	0.3
POROSITY (D.O.P) ml/gm	0.27-0.37	0.20 - 0.32	0.17 - 0.27	0.17 - 0.27
DENSITY gm/ml	0.47-0.53	0.50 - 0.56	0.50 - 0.56	0.50 - 0.56
FlOW TIME sec.	15-25	15 - 25	15 - 25	15 - 25
SONIC SIFTER Mesh				
R 40 % MAX.	1	1	0.5	0.5
R 60 % MAX.	5	5	5	5
T 140 % MAX.	25	25	50	50
APS ± 10	155	160	135	135
PSD	< 25	<25	<30	<30
DARK RESIN	6	6	6	6
RVCM	1	1	1	1
FISH EYES	20	20	20	20

1. PVC Compounding

i. Fabrication Equipment:

1. Mixing: batch banburys, kneaders, mixing rolls.
2. Extrusion: single or twin screw.
3. Molding: single or twin screw injection molding; and compression molding.
4. Calendaring: Z- Calendars, mill roll calendars.

1. PVC Compounding (Cont.)

ii. Additives:

Cross linking activation:

organic peroxide.

Cross linking agents:

- Diallyl phthalate
- Diallyl maleate
- Silanes
- Bivalent metal soaps

1. PVC Compounding (Cont.)

- **Plasticizers:**
- Objectives: Lower Tg, softer product
- Esters of poly-carboxylic acid with aliphatic branching
- Two classes:
- **Low M.Wt**.; DOP,DEHP, DBP, DIBP
- **High M.Wt**.; DINP, DIDP
- Selection is based on :

  Lower toxicity, compatibility, non-volatility, and costs.
- New trend; Biobased plasticizers, Proviron.

1. PVC Compounding (Cont.)

Stabilizers:

1. Lead base (tri basic lead sulfate, lead stearate).
2. Metal soaps (cd-zn soap, cd-Ba system).
3. Organotin compounds (octyltin, Ca-Zn, lubricant).
4. non-metal stabilizer, secondary stabilizers (organic phosphities, epoxy compounds).

1. PVC Compounding (Cont.)

Flame retardants:

- Phosphate esters or chlorinated hydrocarbons are used to overcome the flammability problems of plasticizers.

Processing acids:

- To reduce the melt viscosity of PVC compound and make it easier to process/ (PE, epoxy compounds and ABS).

1. PVC Compounding (Cont.)

Antistatic agents:

- PVC is poor electrical conductor and may readily accumulate static charges.
- Friction is the most common source of charge generation. Static charges are responsible for handling difficulties in film processing operations.
- Internal or external application of antistatic agents are similar to lubricants. (amides, amines, PE glycol derivatives and quaternary ammonium compounds).

1. PVC Compounding (Cont.)

Impact Modifiers:

- Vital for rigid applications.
- Can be incorporated into PVC by dry blend or melting compounding.
- Can also be incorporated during polymerization by adding rubber emulsion.

2. Compounding Processes

1. **Extrusion**
   a) **Rigid PVC**
      i. Pipes: high thermal stability, IV 0.88 – 0.95
      ii. Profiles: high thermal stability, IV 0.88 – 1.12
      iii. Plates: high thermal stability, clarity, IV 0.74 – 0.95
      iv. Film: high thermal stability, IV 0.74 – 0.82

2. Compounding Processes (Cont.)

b) **Flexible PVC**

i. Cables: high plasticizer absorption, good electrical properties, IV 1.00 – 1.12 .

ii. Profiles: high plasticizer absorption, IV 0.9 – 1.12

iii. Plates: high clarity, IV 0.9 – 0.98

2. Compounding Processes (Cont.)

2. **Blow Molding**
   i. Bottles: high thermal stability and color, V.I. 0.6 – 0.82.
3. **Injection Molding**
   i. Rigid application: high thermal stability, IV 0.6 – 0.82.
   ii. Flexible applications: high plasticizer absorption, IV 0.9 – 1.04.
4. **Calendaring flexible applications:**
   i. high plasticizer absorption and color, IV 0.72 – 1.04.

Rigid PVC Compound Specifications

TYPE	GRADE	Colour	Relative Density	Tensile Strength	Elongation at Break	Heat Stability Oven 180°C	Heat Stability Brabender 180°C	Izod Impact	Flexural Strength
			max.	Kg/Cm² min.	% min.	mins	mins	J/m min.	Kg/Cm² min.
Pipes	Corrugated	Yellow	1.47	455	140		> 12	55	700
	Pressure	Grey	1.40	465	145		> 12	65	750
	Drainage	Grey	1.48	450	148		> 12	57	650
Fitting	Pipe Fitting	*	1.40	500		> 135		45	
Profiles	Folding Door	*	1.48	390			> 12	60	700
Film	Cellophane	Transparent	1.37	480				65	800

PVC Compound Flexible Specifications

PVC COMPOUND FLEXIBLE SPECIFICATIONS

[redacted]

TYPE	GRADE	Colour	Shore "A" Hardness	Relative Density max.	Tensile Stength Kg/Cm^2 min	Elongation Break mm	Cold Flex C min	Volume Resistivity Ohm.Cm
CABLES	I.C	Natural	75 - 85	1.40	160	250	14	10^{13}
	SHEATH	Natural	70 - 80	1.50	140	330	12	10^{13}
	FILLING	Natural	75 - 85	1.50	140	250	- 17	10^{14}
	A4	Natural	75 - 85	1.35	175	200	- 17	10^{15}
	A5	Natural	90 - 95	1.40	225	250	- 20	10^{14}
SHOES	SH-55	Transparent	55 - 60	1.16	128	350		
	SH-60	Natural	60 - 65	1.24	110	300		
	SH-70	Natural	65 - 70	1.30	150	390		
	SH-75	Natural	70 - 75	1.45	190	290		
	SH-80	Transparent	75 - 80	1.30	220	320		

Thank You