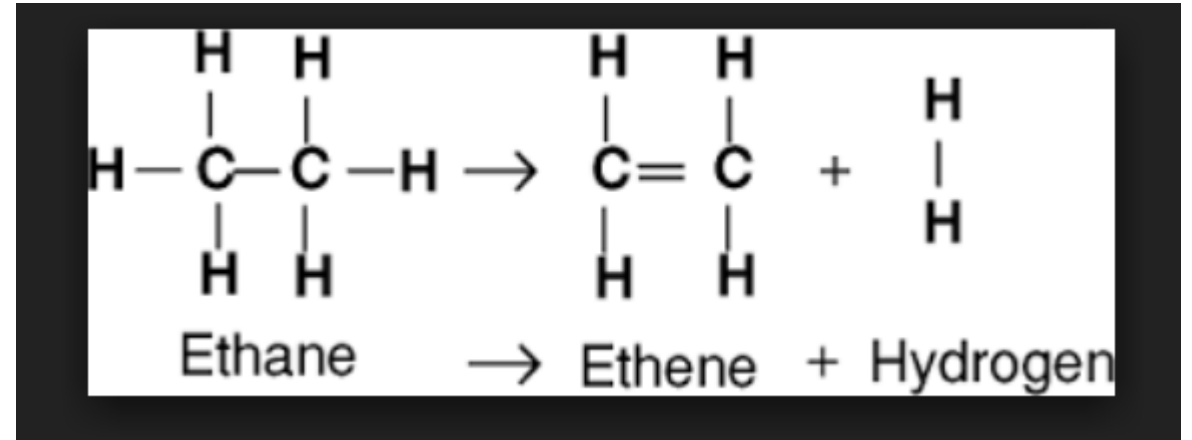
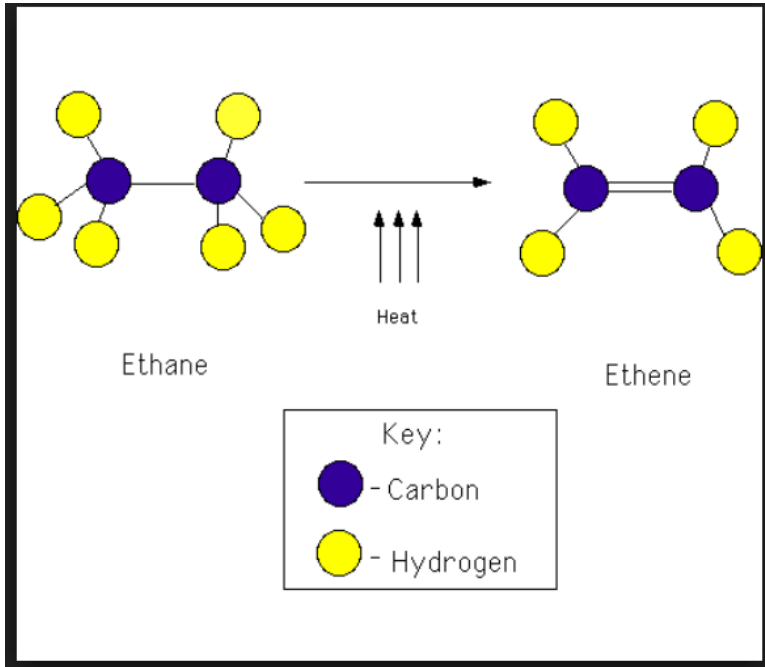




PE Manufacturing 101

Tom Styraneć
Polyethylene Technology Manager

ECU – What is the point? “Crack” ethane to ethylene



Polyethylene is defined by three attributes

- Molecular Weight – length of the polymer chain
 - Measure: Melt Index is a measure of viscosity with a fixed weight and orifice (g/10 minutes)
 - Control: reaction conditions (composition, poison, temperature) to terminate the chain growth
- Crystallinity – ability of the chains to pack together
 - Measure: Density is determined analytically or via displacement (g/cc or g/cm³)
 - Control: reaction conditions (composition) to impact chain disruption
- Uniformity – range of polymer chain lengths and composition around the average
 - Measure: Molecular Weight Distribution (broad to narrow, bi-modal) and Composition Distribution
 - Control: Catalyst type

➔ The combination of these attributes determine product performance and therefore, the application / market

Catalyst Types – Why does it matter?

- The type of catalyst chosen is the driver for the molecular weight distribution of the polymer

- **Chromium – Broad MWD (BM)**

 - Pros – Impact Strength, **Processability**

 - Cons – Clarity, shrinkage

- **Metallocene – Narrow MWD (FILM)**

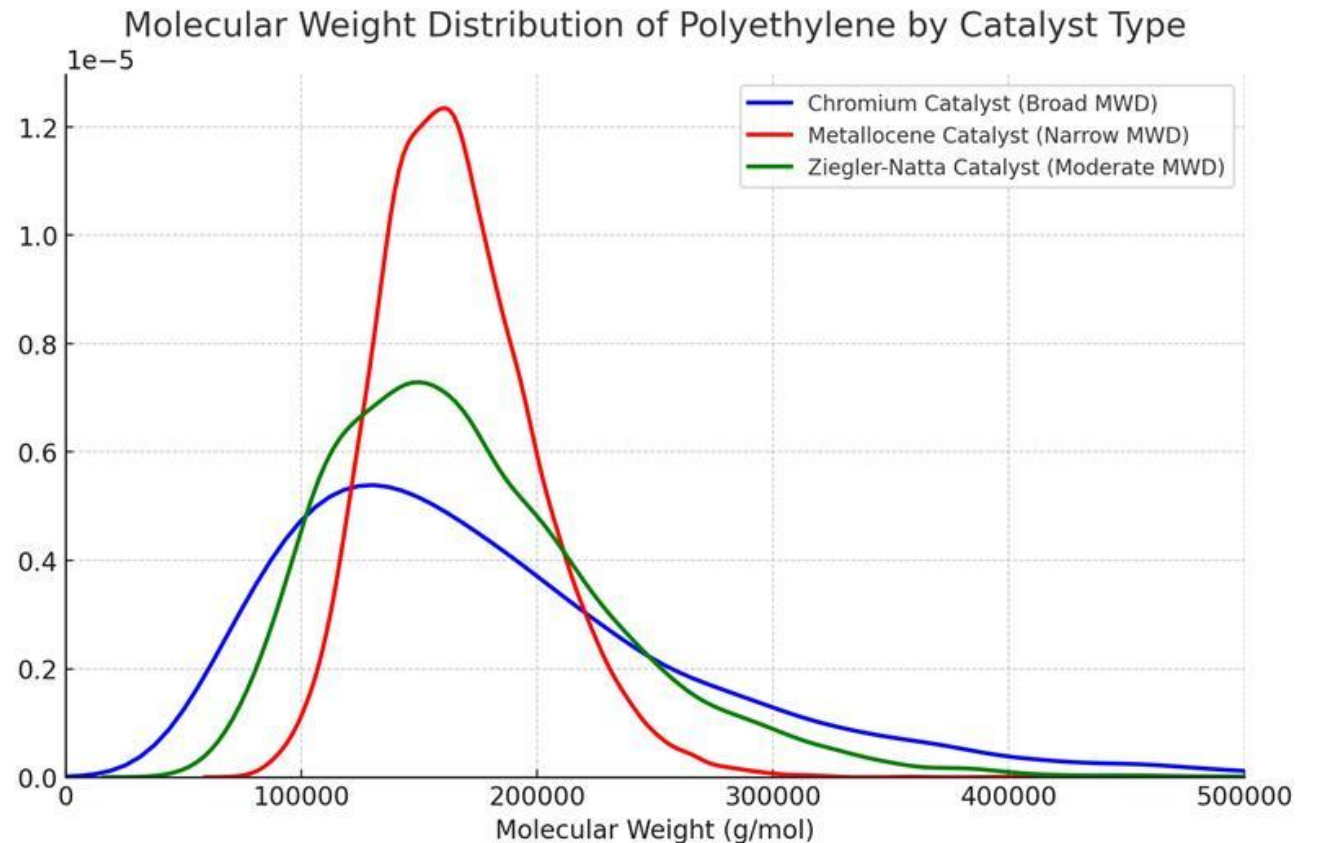
 - Pros – ESCR, Surface Finish

 - Cons – Cost, processing

- **Ziegler-Natta – Intermediate MWD (INJ)**

 - Pros: Blend of Properties

 - Cons: Blend of Properties



Co-Monomers: What do they do?

- Co-monomers disrupt the *regularity* of the polyethylene chain by inducing short chain branching
- We use co-monomers to lower the density of the resin

No Comonomer = Homopolymer!

- Butene: Better processability, cost
- Hexene: Better physical properties, dimensional stability

Types of co-monomers:

Butene – C_4H_6

Hexene – C_6H_{12}

Octene – C_8H_{16}

LLDPE

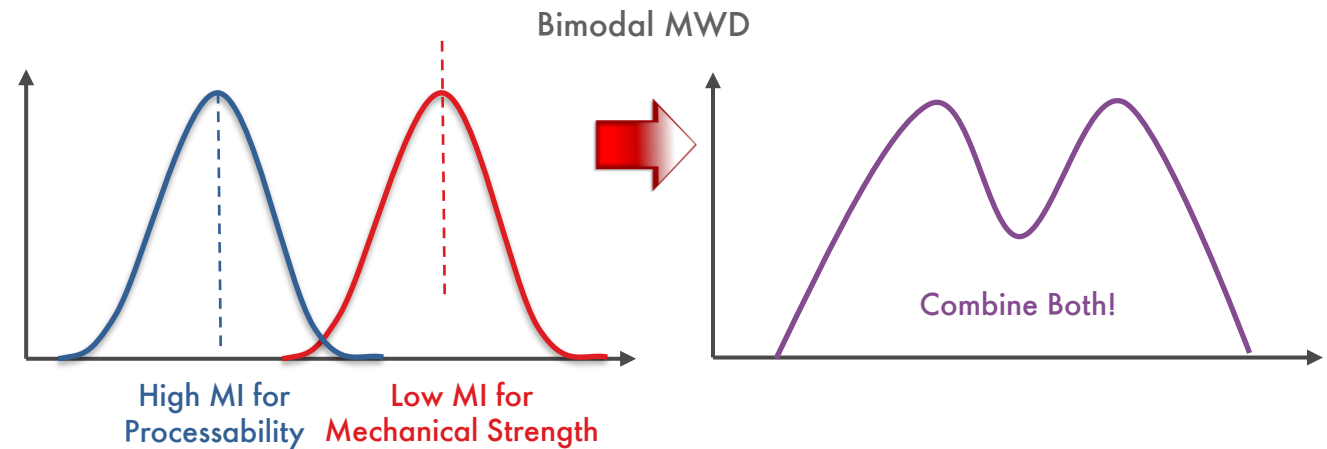
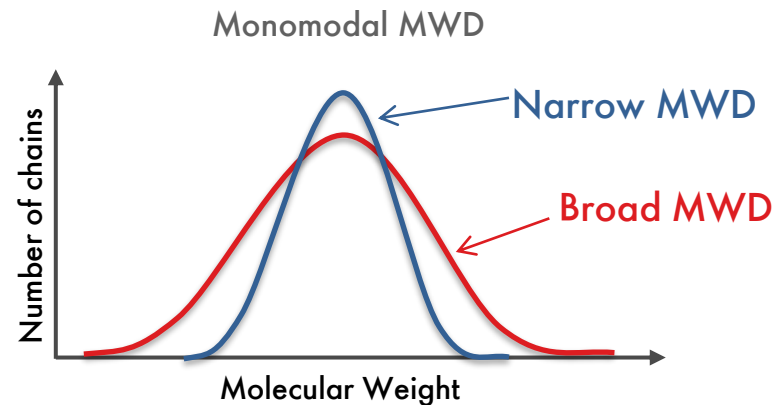


HDPE



Controlling Melt Index

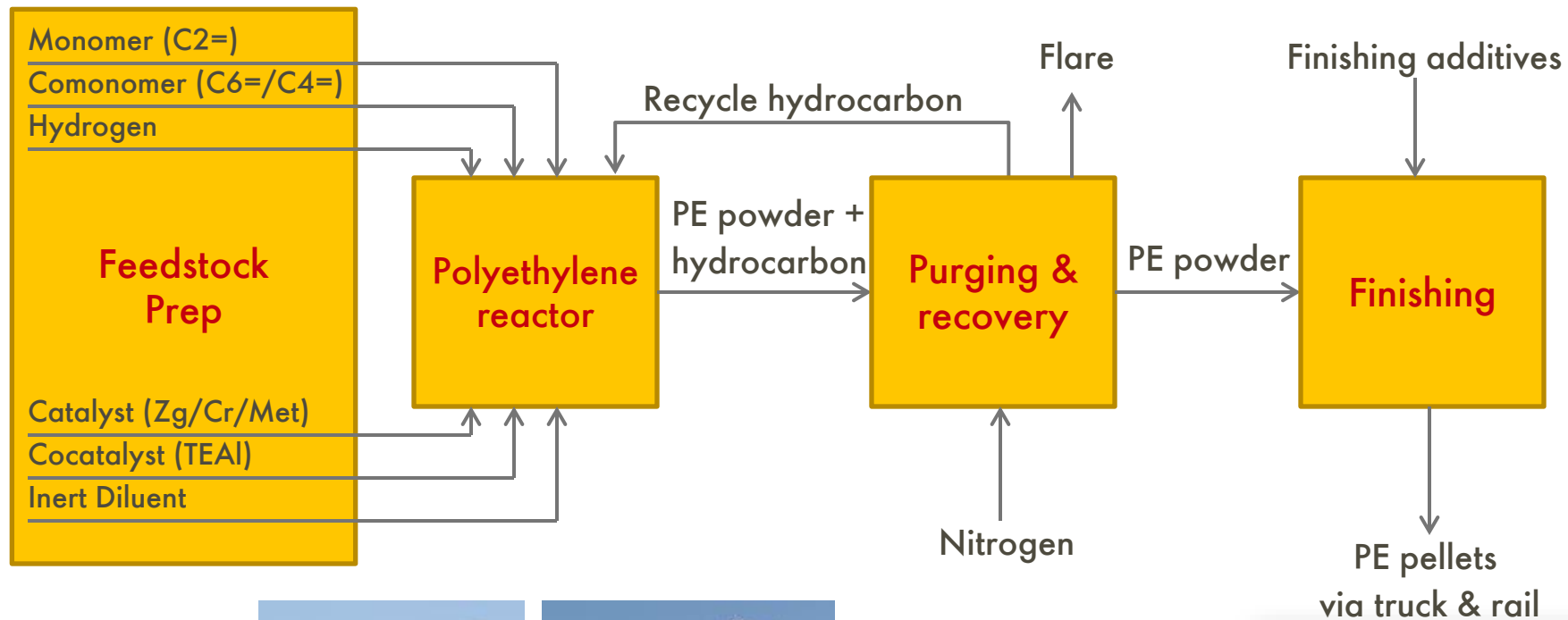
- Molecular Weight (MW): the measure of the length of the polymer chain: control MW by terminating chain growth
- Melt Index (MI): viscosity measurement related to the inverse of MW
 - Long chains = Low MI; polymer is difficult to flow
 - Short chains = High MI; easier to flow
- Molecular Weight Distribution (MWD): the average MW (MI) is a mixture of different MW's; the breadth of the different MW's define the MWD (end use product performance is determined by the MI and MWD)



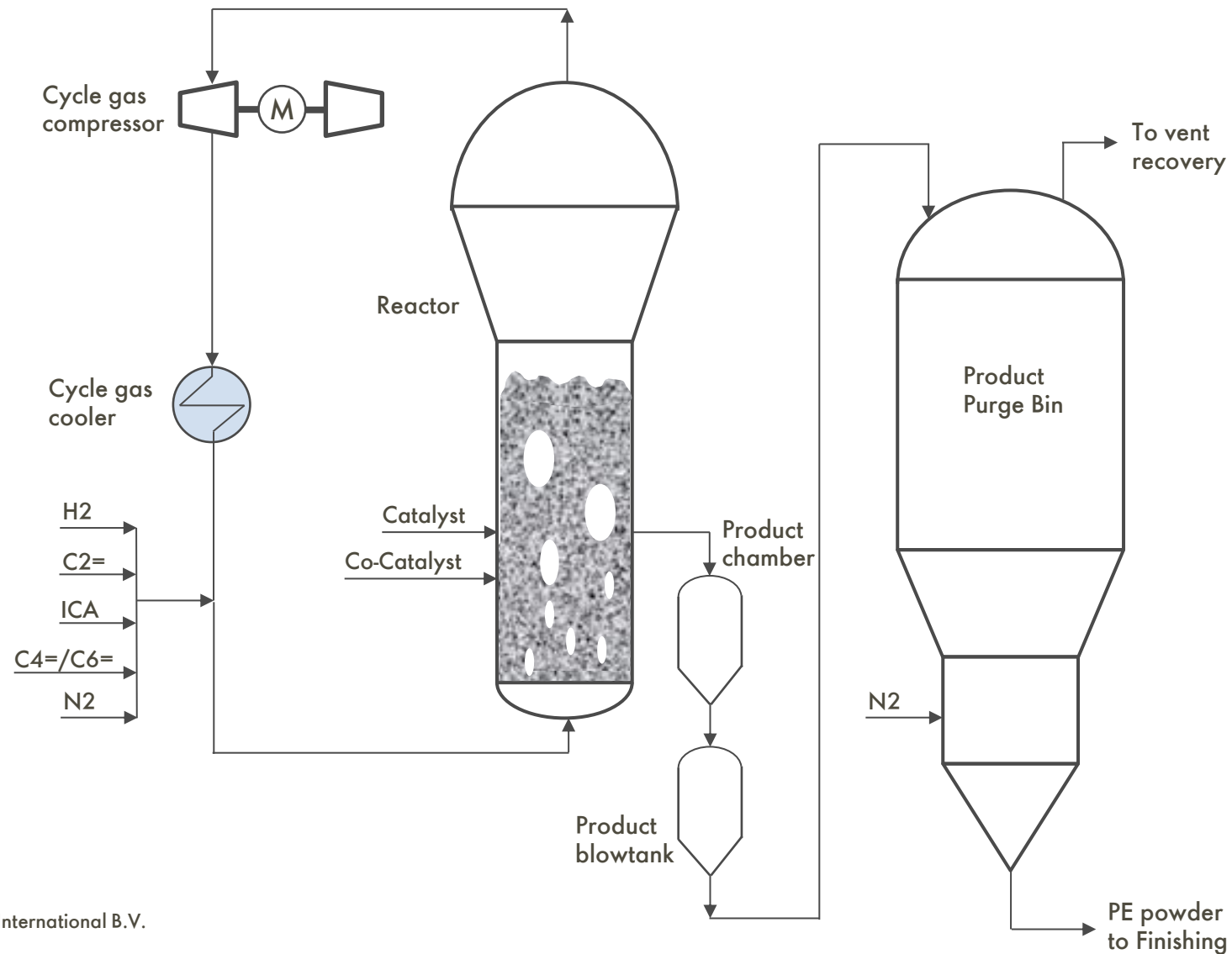
Control Melt Index by the length of the chain; Ratio of Hydrogen / Ethylene ($H_2/C_2=$), O_2 or Temperature

Control MWD by Catalyst Type

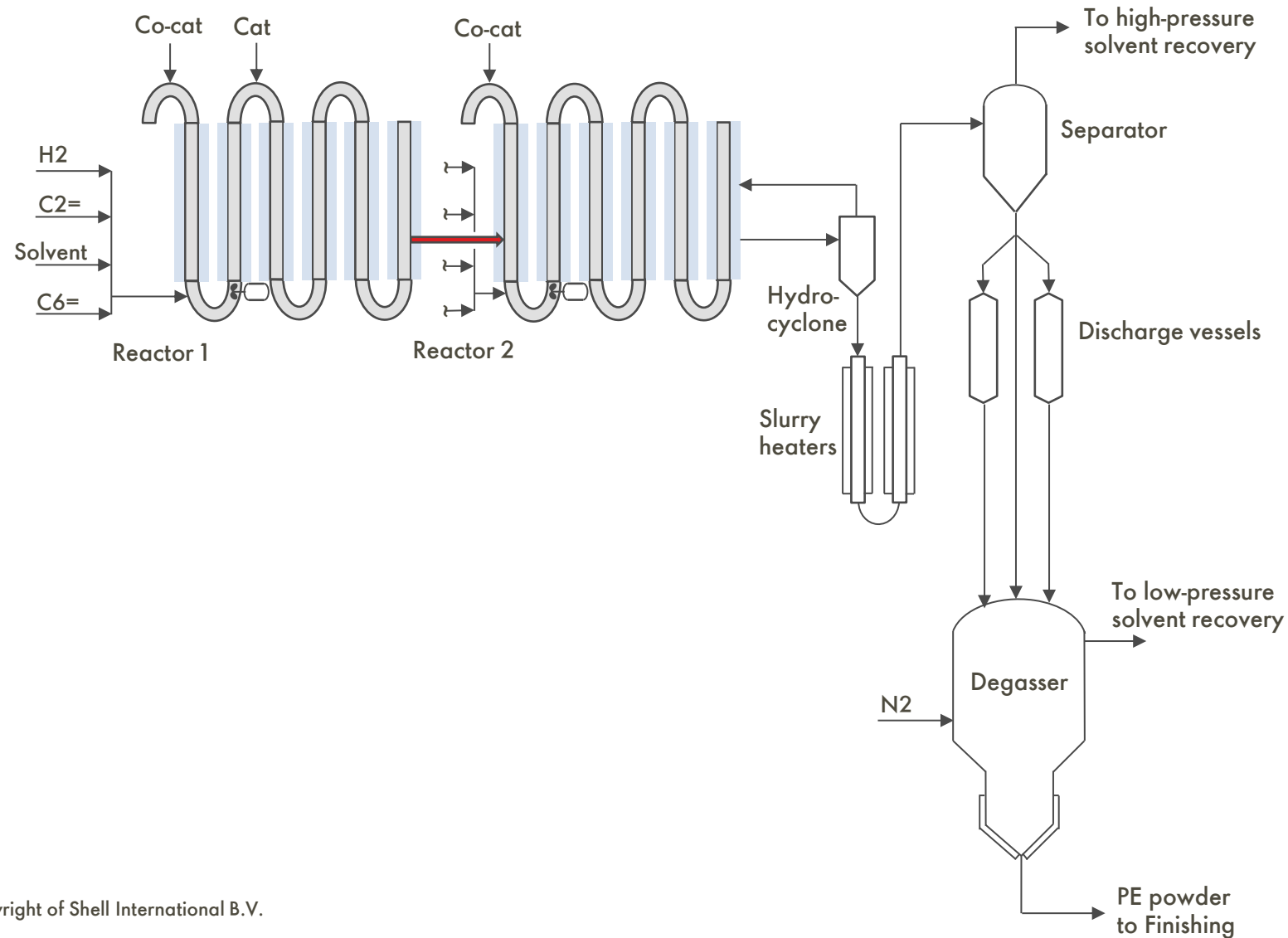
Generic PE Process Overview



Gas-phase Reaction Technology

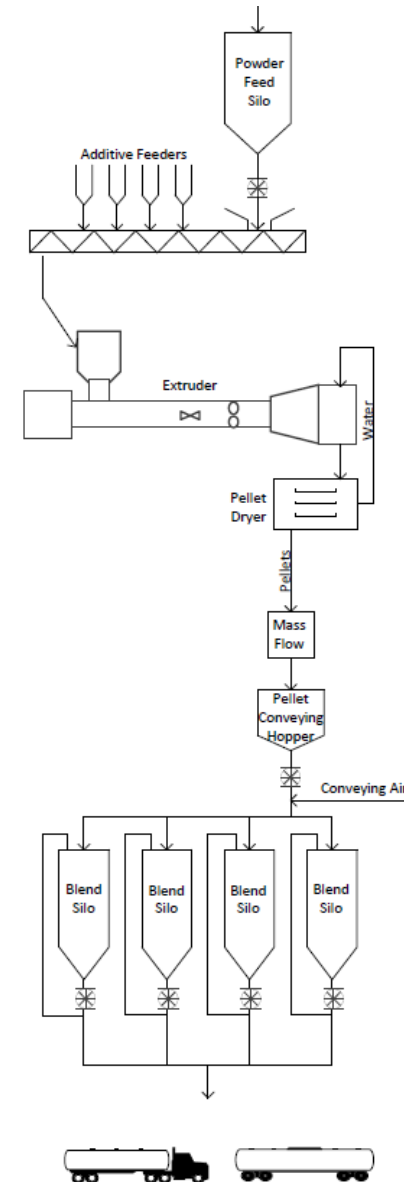


PE3 – Slurry-loop technology



Finishing

- Three objectives of finishing (in order of operation):
 - Blend-in additives that prevent degradation and impart beneficial properties
 - Convert powder into pellets
 - Batch segregation, quality control, and offloading



- Powder Feed
- Extrusion
- Pellet Conveying
- Packaging / Transportation

Questions and Answers

Q&A

