

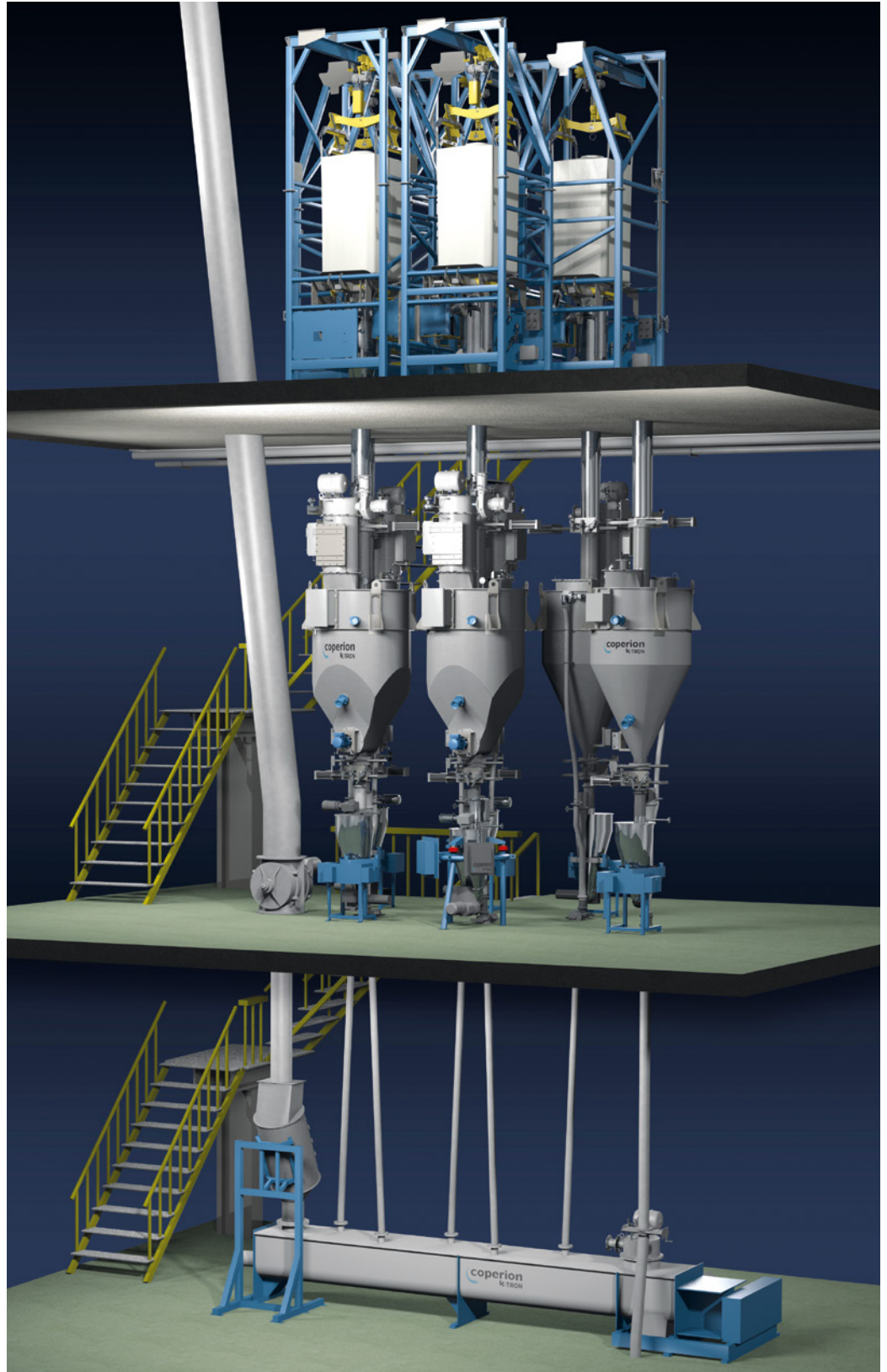
## Introduction

Polyolefins are produced by the polymerization of olefins or alkenes (molecules with the general formula  $C_nH_{2n}$ ) such as ethylene, propylene, butene, isoprene, pentene, etc. The name "olefin" means "oil-like" and refers to the oily character of the materials. The most important commercial polyolefins are polyethylene (PE), polypropylene (PP) and ethyl vinyl acetate (EVA). Polyethylene is classified according to its density as Very Low Density Polyethylene (VLDPE), Low Density Polyethylene (LDPE), Linear Low Density Polyethylene (LLDPE), Medium Density Polyethylene (MDPE), and High Density Polyethylene (HDPE).

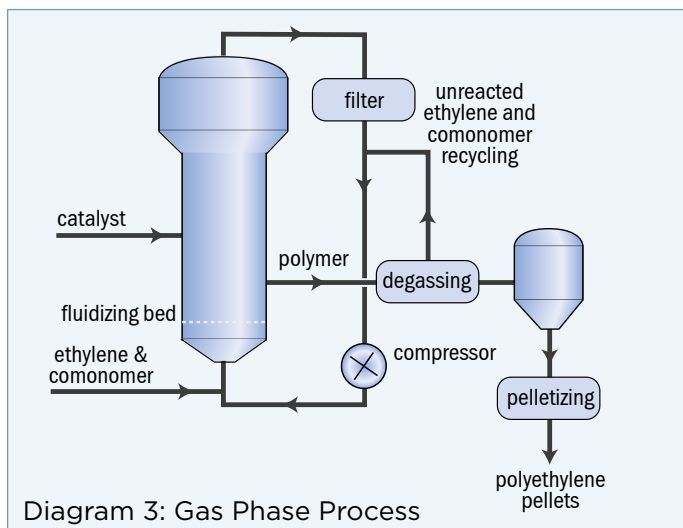
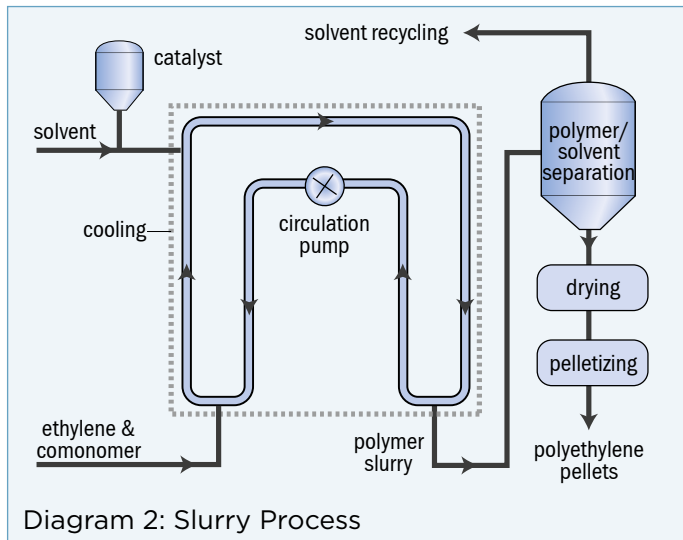
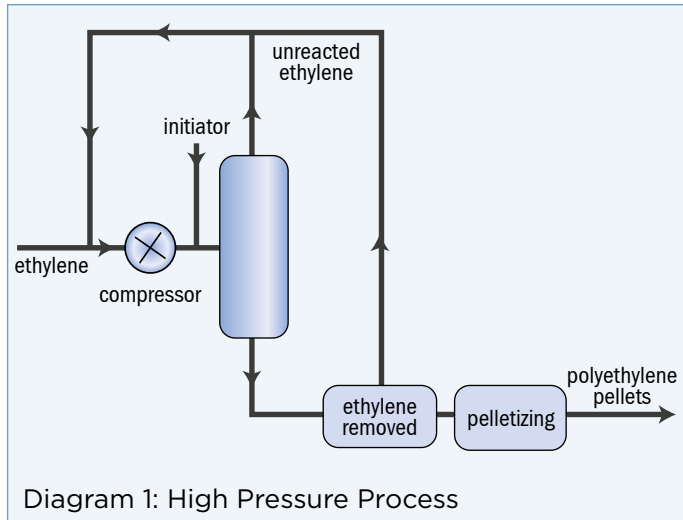
Polyethylene and polypropylene are two of the top polymer resins used in the world today. These resins can be tailored to achieve a wide range of mechanical and chemical properties, making it possible to use them in a myriad of applications such as garments, tapes, stretch films, agricultural films, retail bags, bottles, containers, pipes, etc.

The selection of a polyolefin for a particular application depends on the resin's type and grade, which are determined by the manufacturing technology or process, the catalyst, and the raw feedstock used in production. In turn, the polyolefin grade is determined by key properties such as molecular weight, molecular weight distribution (MWD), crystallinity, branching and density that affect how and where each resin is used.

Two distinctive process sections can be identified in polyolefin production, a wet-end and a dry-end process.



# Wet End Polyolefin Process



## Wet-End Process

The wet-end process for the manufacturing of polyolefins can be high pressure (autoclave and tubular) or low pressure (slurry, solution or gas phase) such as those shown in Diagrams 1, 2 and 3; it includes feed preparation, catalyst handling, polymerization reaction, diluent recovery and polymer separation, where the polymer is cleaned and dried.

## High Pressure Technology

- Produces low density polyethylene (LDPE) resin
- Uses continuous-flow, mechanically stirred autoclave and tubular reactors
- Operating temperatures of 140 to 300°C (280 to 570°F)
- Operating pressures of 1000 to 3000 bar (14,500 to 43,500 psi)
- Yields homopolymers containing both high and low degrees of short chain branching (SCB) and long chain branching (LCB)

## Low Pressure Technology

Low pressure processes can be classified as slurry, solution or gas phase.

## Slurry Phase Process

In the slurry phase process monomers and catalyst are added to a liquid (i.e. isobutane) in which the polyethylene product is not soluble, forming a slurry of solid particles suspended in the liquid.

- Produces HDPE and MDPE as a secondary product
- Polymerization is carried out in controlled stirred tank reactors or loop type reactors
- Operating temperatures of 70 to 110°C (160 to 230°F)
- Operating pressures of 5 to 40 bar (73 to 584 psi)

## Solution Phase Process

In the solution phase process polymerization takes place in a hydrocarbon solvent (i.e. cyclohexane) above the melting temperature of polyethylene, thus dissolving the polymer in the solvent.

- Produces LLDPE and VLDPE
- Polymerization is carried out in controlled stirred tank reactors
- Operating temperatures of 160 to 300°C (320 to 570°F)
- Operating pressures of 25 to 100 bar (365 to 1,450 psi)

## Gas Phase Process




In a gas phase reactor the polymerization takes place in a fluidized bed of polymer particles. Inert gas or gas mixture is used for fluidization.

- Produces LLDPE and can produce HDPE and MDPE in swing units
- Operating temperatures of 75 to 110°C (167 to 230°F)
- Operating pressures of 20 to 25 bar (292 to 365 psi)

## Wet End Product

Regardless of the process used, the polymerization reaction produces a powder (sometimes called fluff or flake) that is transferred to a bin that serves as a buffer between the Wet End and Dry End processes.

## Density and Applications of Polyolefin Products

Name	Abbr.	SPI Resin ID Code	Density g/cm <sup>3</sup>	End Use Examples
High Density Polyethylene	HDPE		>0.941	Plastic lumber, fuel tanks, furniture, storage sheds, chemical & heat resistant piping & containers
Medium Density Polyethylene	MDPE	n/a	0.926 to 0.940	Containers with good shock and drop resistance, gas pipes, shrink film, packaging films
Linear Low Density Polyethylene	LLDPE	n/a	0.915 to 0.925	Industrial containers, trash cans, automotive parts, packaging materials under FDA regulations
Low Density Polyethylene	LDPE		0.910 to 0.940	Trays & general purpose containers, weldable & machinable parts, computer parts, plastic bags, playground equipment
Very Low Density polyethylene	VLDPE	n/a	0.880 to 0.915	Blown films, molded parts, industrial & general rubber, stretch wrap
Polypropylene	PP		0.855 to 0.946	Packaging, textile fibers, carpets, ropes, thermal clothing, automotive components, reusable containers
Ethyl Vinyl Acetate	EVA	n/a	0.93	Biomedical applications for time release medications, foam padding for sport equipment, flotation devices, sandals, hot melt adhesives

## Raw Materials

### Feedstock

Alpha-olefin monomers derived from crude oil or natural gas.

### Catalysts

Catalysts influence the physical properties and characteristics of the polyolefin produced as well as the economics of the process. Typical catalysts are chromium oxide (Phillips type), titanium halides & organoaluminum compounds (Ziegler-Natta), and metallocene.

### Additives

Additives are incorporated in the process to achieve specific properties and overcome inherent weaknesses. Depending on the end-product desired, the number of additives and their concentration vary significantly from one resin grade to another. The most common additives are:

- Stabilization agents to prevent thermal degradation and discoloration
- Antioxidants to prevent oxidation during and after processing
- Calcium & zinc stearates to neutralize catalyst residues and impart lubricity
- Slip additives to reduce friction in flexible packaging films
- Antiblock agents such as silica, talc and kaolin to create air gaps between two film surfaces so they can be pulled apart
- Processing aids to help improve the surface appearance of the end product produced
- UV stabilizers to help protect the polymer during long term outdoor exposure
- Pigments such as titanium dioxide and carbon black

## Principle Licensors of Polyethylene Technology

Company	Technology Name	Type	Resin Grade Produced
Borealis Polymers	Borstar	Slurry Loop & Gas Phase Fluidized Bed	PEX / HDPE / MDPE / LDPE / LLDPE
Chevron Phillips		Slurry Loop Reactor	HDPE / LLDPE / LDPE / MDPE
ExxonMobil		High Pressure (Tubular / Autoclave)	LDPE (Homopolymer)
Ineos	Innovene G	Gas Phase	LLDPE / HDPE
Ineos	Innovene S	Slurry	HDPE / MDPE Bimodal
LyondellBasell	Spherilene	Gas Phase	HDPE / MDPE / LDPE/LLDPE
LyondellBasell	Hostalen	Slurry Cascade Technology	PE Bimodal
LyondellBasell	Lupotech T	High Pressure Tubular	LDPE
LyondellBasell	Lupotech G	Gas Phase	HDPE / MDPE
Mitsui Chemicals	CX Process	Slurry Phase Two Reactor System	HDPE / MDPE
NovaChemicals	Sclairtech	Solution	LLDPE / HDPE
Polimeri Europa		High Pressure Slurry / Solution	HDPE / LLDPE / LDPE
Sabir	Sabtec	Tubular	LDPE
Univation	Unipol	Gas Phase	HDPE / HDPE Bimodal / MDPE / LLDPE

## Principle Licensors of Polypropylene Technology

Company	Technology Name	Type	Resin Grade Produced
Borealis Polymers	Borstar	Loop & Gas Phase (Bulk)	PP Homopolymers / Random & Heterophasic Copolymers
Chevron Phillips		Slurry Loop	PP
Dow Chemical	Unipol	Gas Phase Fluidized Bed	PP
Ineos	Innovene	Horiz. Stirred Gas Phase	PP Homopolymer / Random & Impact Copolymer
Japan Polypropylene Corporation	Horizone	Gas Phase	PP Homopolymer / Random & Impact Copolymer
LyondellBasell	Spheripol	Slurry Loop Reactor (Bulk)	PP Homopolymers / Copolymers
LyondellBasell	Spherizone	Multizone Circulating & Gas Phase Fluidized Bed	PP Homopolymers / Copolymers
LyondellBasell	Metocene	Gas Phase	PP
Lumms Novolen Technology	Novolen	Vert. Stirred Gas Phase	PP Homopolymers / Random & Heterophasic Copolymers
Mitsui Chemicals		Loop & Mitsui Gas Phase	PP
Mitsui Chemicals	Hypol II	Bulk Process (2 Liquid & 2 Gas Reactors)	PP



Primary Resin  
from Wet-End Process

Additives Supplied  
in Big Bags

Big Bag  
Emptying Stations

Automatic  
Bin Vent Filter

Slide Gate Valves

EDK Rotary Feeder  
and Delumper

Buffer Hoppers

Refill Valves

Loss-in-Weight  
Additive Feeders

K-SFM  
Smart Flow Meter

Screw Conveyor /  
Homogenizer

Degassing Filter

to Extruder

# Dry End Polyolefin Process

## Dry-End Process

The polymerized powder (also called “fluff” or “flake”) needs to be cleansed of residual monomers, catalysts and solvents. This can be done using a decanter centrifuge, purge bin, degassing vessel, low-pressure and high-pressure separators, or deodorizing silos, depending on the individual process.

The dry section of a polyolefin manufacturing process begins once the clean, dry powder has been stripped of these impurities and is pneumatically transferred with nitrogen (to prevent oxidation) to an intermediate storage or powder surge hopper situated several levels above a melt extruder. In some technologies, the polymer is transferred in a molten state directly from the reaction area into the melt extruder.

## Delumping

The properties of the polyolefin powder are affected by a large number of variables and changes in processing conditions such as temperature, pressure, type of diluent, catalyst purity, flow conditions inside the reactor, monomer and comonomer concentrations, residence time, etc. A non-uniform distribution of reactor contents or reactor temperature may lead to the



Polypropylene Lump

creation of “hot spots” within the reactor that contribute to the formation of polyolefin lumps, sticky agglomerates of polyolefin resin.

Freshly formed resin particles may adhere to these sticky surfaces, causing the lumps to grow over time. Eventually, the large polymer lumps find their way into the dry-end section of the polyolefin processing plant. Lumps that are able to reach the melt extruder may cause the polyolefin resin to be off-spec. Depending on their size, lumps may also block or jam the lines connecting the powder bin with the melt extruder creating a stall condition in the polymer process that requires a shut down and a thorough cleaning of the line before the entire system can be restarted.

The Jeffrey Rader EDK is a rotary feeder that also acts as a delumper, thanks to its double knife arrangement and double helix blades. The unit consists of three main components: a basic rotary feeder assembly, a hydraulic power unit and a control panel. The rotor assembly has a specific number of pocket dividers that limit the size of the polyolefin lumps that can pass through the feeder. The low-speed motor operates in the 3 to 30 rpm range and is capable of 11,763 Nm (8675 ft-lb force) of torque while operating at a maximum of 246.14 bar (3570 psi). The control panel regulates the speed of the feeder and, in turn, the flow of material going through it.

The largest EDK can handle over 350 m<sup>3</sup>/hr (12,360 ft<sup>3</sup>/hr).

If a lump of polyolefin reaches the inlet of the EDK feeder, the unit cuts through the lump or if the lump is too dense and stalls the feeder, the controller reverses the rotation of the valve and cuts through the lump in the opposite direction. This reversing action is repeated until the lump is sheared and the remaining particle is small enough to pass through the feeder. If the feeder is unable to shear the lump, an alarm is triggered to alert the operator.

## Primary Resin Feeding

There are three types of gravimetric feeders used to measure and control the rate of the primary resin being delivered to the process. They are: 1) smart flow meters with rotary valve pre-feeders, 2) large loss-in-weight feeders and 3) large weigh belt feeders. Selection of the right feeder depends on the licensed technology used to produce the polyolefin and plant preference.

## Mass Flow Meters

A Coperion K-Tron Smart Flow Meter (K-SFM) located below the rotary feeder or the EDK delumper monitors and controls the flow of the polyolefin resin. Installations also include an additional manually operated slide gate shutoff valve installed upstream of the rotary valve or EDK to facilitate maintenance. The K-SFM has two Coperion K-Tron Smart Force Transducer (K-SFT) weighing units mounted in a cylindrical body with no moving parts. The polyolefin resin flows by gravity over the first measuring sensor where the force acting perpendicularly on the chute is measured as mass. The second measuring sensor is mounted to a vertical channel, where the resin’s velocity or speed is determined from the force of impact.

The K-Tron Control Module (KCM) receives the signals from the two sensors, computes the actual mass flow rate, com-



Coperion K-Tron Smart Flow Meter without cover, showing upper chute

pares the actual mass flow rate against the desired setpoint and makes appropriate adjustments to the rotary pre-feeder speed to maintain the desired flow rate. The system can also function as a mass flow meter, where the rotary pre-feeder runs at a constant speed and the KCM computes the actual mass flow of the polyolefin. The throughput as controlled or simply measured by the Smart Flow Meter provides the master rate signal for the rest of the additive feeders in the line. Each additive is then proportioned into the process at the respective desired % flow rate.

## Large Loss-in-Weight Feeders

For some polyolefin grades, using a large loss-in-weight (LIW) feeder is preferred over the K-SFM with rotary valve or EDK pre-feeder. When using this approach, a large hopper – capacities of up to 7,000 dm<sup>3</sup> or 250 ft<sup>3</sup> are common – is supported on three or more KSFT digital load cells. Polyolefin produced

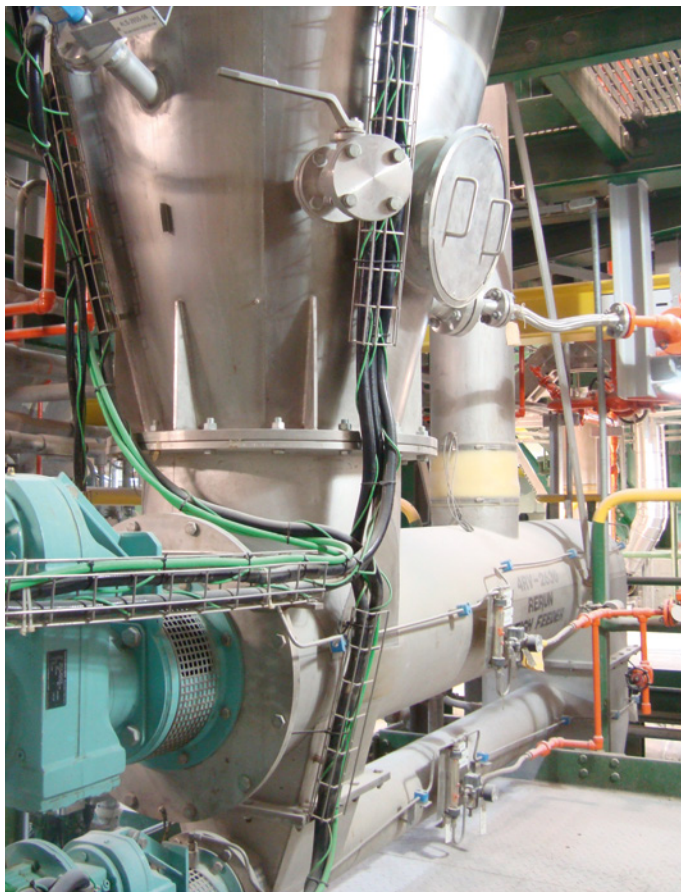


EDK Rotary Feeder / Delumper



in the Wet End process must be screened and transported to a receiving surge hopper directly upstream of the LIW Feeder. The hopper must be of sufficient capacity to store enough material required for one refill of the LIW feeder and be able to receive the production rate of the Wet End process. A fast acting slide gate valve mounted at the discharge of the surge hopper is opened and closed by the LIW Feeder controller for the refill cycle.

Installations also include an additional manually operated slide gate shutoff valve installed upstream of the automatically operated refill slide gate valve to facilitate maintenance. The LIW feeder is equipped with a large feed screw. If significant turn-down in feed rates is required, a secondary smaller diameter feed screw is mounted parallel to the primary screw. The KCM controller automatically selects one or both screws to be running and their appropriate speed in order to maintain the desired flow rate of polyolefin resin into the downstream process. The feeder is also equipped with a pressure compensation system to equalize the nitrogen purge pressure between the inlet and discharge side of the feeder during the refill and feeding process. As with the Smart Flow Meter, the LIW feeder KCM control provides a master polyolefin resin flow rate signal for the additive feeders.



Large LIW Feeder for Feed Rates of up to 172,000 dm<sup>3</sup>/hr (6072 ft<sup>3</sup>/hr)

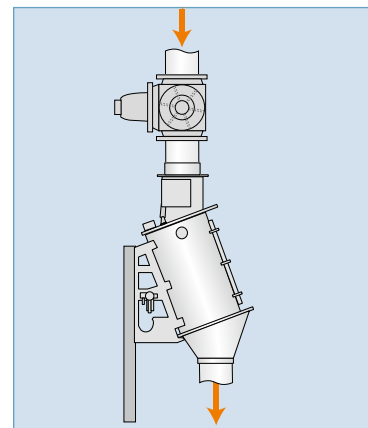
### Large Belt Feeders

In applications where there is not sufficient headroom to support a LIW Feeder with its associated refill surge hopper, a second alternative feeder, the Smart Weigh Belt Feeder can be used. This gravimetric

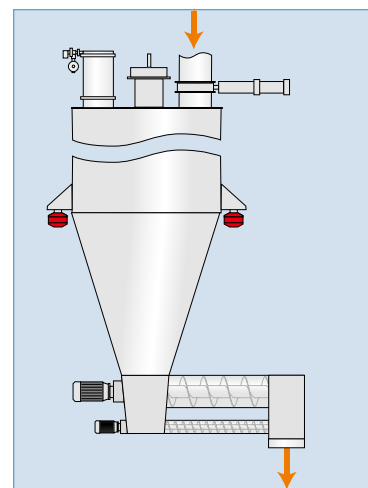
feeder is typically interfaced to an upstream rotary valve or EDK pre-feeder. Installations also include an additional manually operated slide gate shutoff valve installed upstream of the rotary valve or EDK to facilitate maintenance. As with the Smart Flow Meter, the pre-feeder speed can be controlled by the Smart Weigh Belt Feeder's KCM controller in order to maintain a desired flow-rate of polyolefin or the Smart Weigh Belt can function as a weigh-meter and simply monitor the rate of polyolefin being produced and fed into the downstream process. The unit includes a totally enclosed stainless steel frame and conveyor assembly. The weight of the polyolefin resin on the belt is measured using a digital K-SFT weighing system. The KCM controller



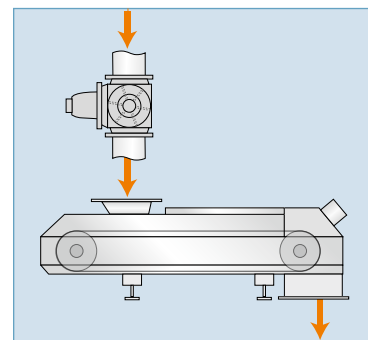
Large Weigh Belt Feeder with Belt Exposed



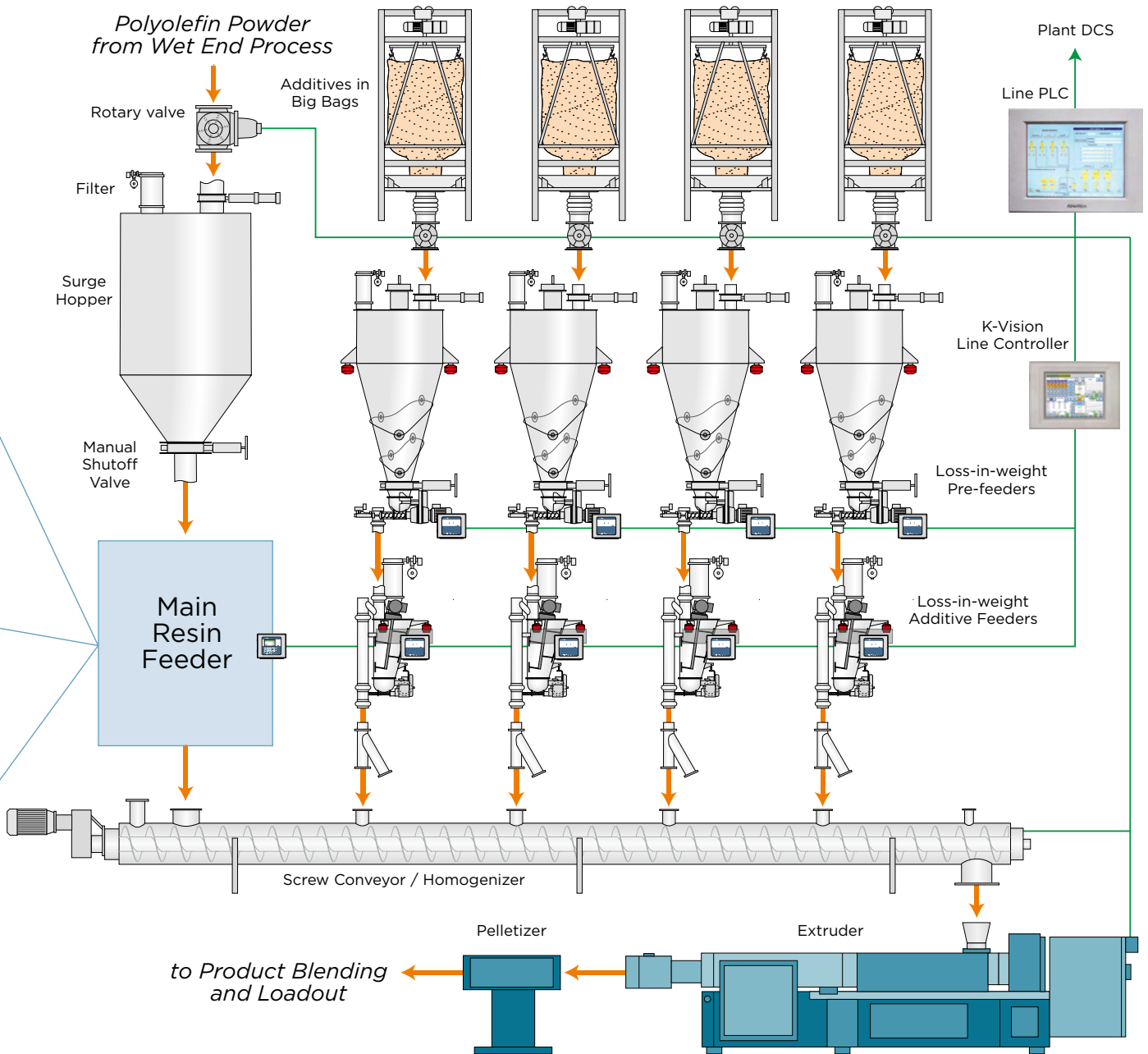
Smart Flow Meter



Large Loss-in-Weight Feeder



Large Weigh Belt Feeder



### Polyolefin Production Plant - Dry End Process

Choices for the main resin feeder include a large LIW feeder, a large weigh belt feeder or a Smart Flow Meter.

varies the speed of the belt and pre-feeder in order to control the flow of polyolefin into the downstream process or simply measures the flow of polyolefin. In either control concept, the KCM controller provides a master flow rate of polyolefin for all additive feeders.

### Additives Supply

Depending on the polyolefin grade, the recipe may call for one or more additives. The handling of additives requires the use of specialized equipment to ensure accurate flow and a safe environment.

Additives arrive at the production facility in different sized bulk bags and are loaded into bag-unloader stations fitted with paddles or rams that help break agglomerates and stimulate material flow. Bulk-bag unloaders have a variety of discharge systems to interface with the bag's spout and provide a dust-free environment with the aid of automatic venting systems. A combination of bulk bag unloading station and small bag (25kg or 50lb) dump station is a clever design that

allows for quick additions of smaller additive quantities.

### Bin Vents & Vent Filters

The discharge of additives into surge hoppers and storage tanks creates dust that must be contained as the confined air leaves the vessel. Airborne dust particles are trapped by bin vents mounted on top of the surge hopper. The choice of an automatic, modular or static bin vent depends on the size of the tank, the volume of additives processed per unit of time and the particle's characteristics and containment requirements.

In automatic bin vents, sequentially timed bursts of compressed air (or nitrogen) pulse the filter bags and dislodge dust particles. The additive material remains in the storage tank and clean air exhausts through the vent into the atmosphere or the nitrogen blanket is returned to the recovery system. For applications where self-cleaning bin vents are not required, static bag bin vents can provide the same filtration efficiency but require periodic manual bag cleaning. Increased filtration

capacity is achieved with multiple bag vents.

### Discharge Gates and Valves

As material is transferred from bulk bag unloading stations to surge or storage hoppers and from these to LIW feeders, the various pieces of equipment must alternate between recharge and discharge modes. This alternating cycle ensures that additives are available without interruption.

Level sensors mounted in surge and storage hoppers provide signals to automatic controls for the timely opening and closing of slide gates. LIW feeder controls open and close refill valves based on 'refill request' and 'refill complete' weight setpoints.

In most cases, additives are gravity-fed from bulk bags to surge hoppers to LIW feeders. Butterfly and slide gate valves are used to control gravity flow discharge from storage bins and hoppers. A slide gate is an excellent choice for controlling a gravity fed material stream where the shutoff is made against a flow of material. The gate blade is designed to shear through the material, and provide a positive material shut-off. Maintenance gates are also used to control gravity flow discharge and are fitted with hand crank actuators.

### Additive Feeding

Due to the wide range of material characteristics and often difficult flow properties of additives used in polyolefin production as well as the wide range of feed rates required, LIW feeders are usually implemented for each ingredient.

LIW feeders provide maximum flexibility, total containment of materials and dust, and optimal feed-rate performance to guarantee overall end product quality. LIW feeders are available in a variety of configurations, where the type of feed device, hopper



Automatic bin vent

size, weight scale capacity and material flow aid device can be tailored to the specific material to be fed.

The feed device can be a single screw feeder for granular or free flowing materials or twin screw feeder for cohesive, sticky or floodable materials. Other feed device options include vibratory trays for fibrous materials, small belt feeders for compressible or friable materials or Bulk Solids Pumps (BSP) for pelletized or granular dry bulk materials.

For liquid additives various pumps are available depending on the specific gravity, temperature and viscosity of the liquid and the discharge pressures that are required. Hoppers range in size and capacity as well as configuration; cylindrical, asymmetrical and symmetrical shapes are available. Hoppers can also include mechanical vertical agitation or ActiFlow™, non-product-contact smart bulk solid activator.

The weighing system can range from small capacity platform scales to large three point suspension scale systems.



Bulk bag unloading stations combined with bag emptying stations for a PE Plant





Specialized additive feeders

All weighing systems employ state-of-the-art digital K-SFT weighing technology with 1:8,000,000 in 20 ms weighing resolution and vibration and temperature drift immunity. For those applications where a variety of polyolefin grades are being produced and a variety of additives have to be fed, LIW feeders provide the maximum flexibility since screw configurations (type, diameter, profile, etc.) can be changed between production runs to be able to handle a variety of material flow properties. When specific additive change-over is required and ease of cleaning or quick re-configuration is needed, LIW feeders are available in quick-change designs that minimize downtime and eliminate cross contamination of additives.

Most importantly, when extrusion lines are running at very high capacities, a fast responding LIW feeder provides second to second accuracy for additive feed so end product quality is uniform and maintained within specification.

### Dispersive and Distributive Mixing

The addition of minor amounts of additives into large amounts of polyolefin resin may result in non-uniformity of the compounded product because additives can agglomerate and/or not spread throughout the resin. In compounding polyolefins with minor additives two processes occur: distributive and dispersive mixing.

Dispersive mixing relates to the

reduction in size of cohesive minor components such as clusters of solid particles (e.g. carbon black) or liquid droplets. Distributive mixing relates to the process of spreading these components throughout the resin in order to obtain a good spatial distribution. Both mixing processes are essential to achieve good polymer homogenization.

Distributive and dispersive mixing are achieved by the use of screw conveyors upstream of the melt extruder. A conveyor screw is used to mix a given amount of minor additives with a large amount of polyolefin resin before the mixture enters the melt extruder. The screw conveyor is sealed and under slight nitrogen pressure to prevent the oxidation of the polyolefin.

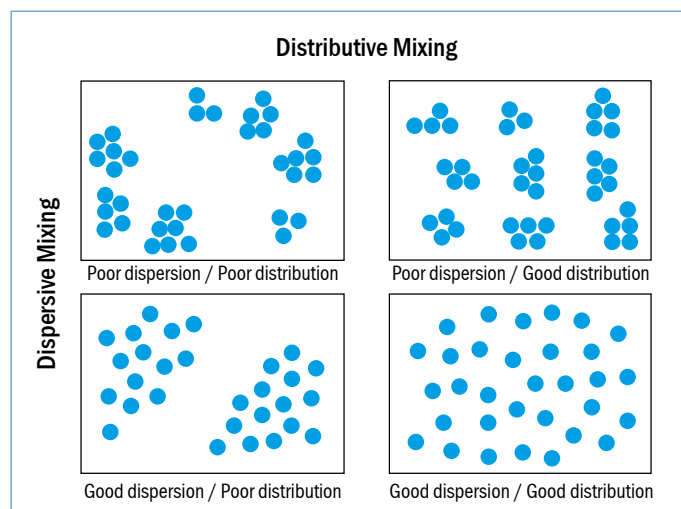
The screw uses the principle of Archimedes to move powder and granules while separating low cohesive materials as they are conveyed from one end of the screw to the other. Additives are proportioned throughout the length of the screw conveyor; those with stronger cohesive forces are fed closer to the polyolefin inlet so their residence time inside the screw conveyor is maximized.

Polyolefin resin flows through the main resin feeder between 80 and 120°C (176 to

248F). The screw conveyor operates very close to these temperatures once steady-state conditions are achieved in the operation. Nitrogen gas expansion, feeding of additives in powder form and the mixing operation of the screw itself promote the creation of many airborne particles inside the screw conveyor, which could be dangerous if allowed to escape to the atmosphere. The screw conveyor has a degassing filter at the discharge end to allow warm nitrogen to escape the screw conveyor system while trapping and re-depositing any airborne particles. Coperion K-Tron degassing filters are made of stainless steel and fitted with reverse jet filters for self-cleaning purposes. The degassing filters operate with polyester filter cartridges with anti-static PTFE coating that can be easily changed without breaking the nitrogen atmosphere.

### Compounding

The polyolefin produced in the polymerization reactor needs to be modified chemically and physically by the incorporation of various additives so it can be processed into useful products. The final application along with process economics determine the type and grade of polyolefin used, which in turn specifies these additives.





Screw Conveyor with multiple Inlets

Compounding is the overall process of intimately mixing these additives in ratios according to a specific recipe, melting them within the extruder and creating a modified and tailored polyolefin pellet for further application. The type of compounding extrusion equipment employed depends on the operation's size and the desired end-product properties.

### In-Plant Transfer and Polymer Blending

The extruder melts, mixes, and extrudes the mixture of polymer and additives, which is then pelletized. After this operation, polymer pellets must be transferred to product storage and, if needed, blending.

The compounded polyolefin pellet is typically transported from the pelletizing area to the storage and or blending silos using a pressure conveying system. Homogenization is achieved by circulating the pellets from the bottom to the top part of a silo with a pneumatic conveying system.

Homogenization also prevents the hot pellets from settling and avoids clumps. The Coperion K-Tron ProBlend™ Zone Blender can be used for blending and homogenizing any free flowing bulk material within a hopper or silo. With its special geometry, the ProBlend Zone Blender provides ten different flow zones such that the material passes through the silo at different velocities and residence times. As a result, the discharged material contains a blend of material from throughout the silo or hopper. The Zone Blender uses a combination of mass flow "first in, first out" (FIFO) with funnel flow "last in, first out" (LIFO) to provide a homogenous blend and eliminate the effects of segregation, even with dissimilar materials.

### Pneumatic Conveying

From the blending silo area, pellets are pneumatically transferred via a vacuum/pressure convey system to load out area silos.

Dust (a.k.a. fines) and floss

(a.k.a. angelhair, fluff, snake-skins, streamers, threads, ribbons) are produced when the pellet breaks during the pneumatic transport, especially when conveying LDPE. One of the major causes for the creation of dust and floss is the combination of friction and heat that results when pellets rub against the walls of the convey line.

Blower assemblies are used to create positive pressure (push air). Air coolers are installed in pressure conveying lines to reduce heat and the formation of dust and floss. In addition, pellets are conveyed via cyclones or elutriators that use a countercurrent air flow to separate these small particles from the pellets.

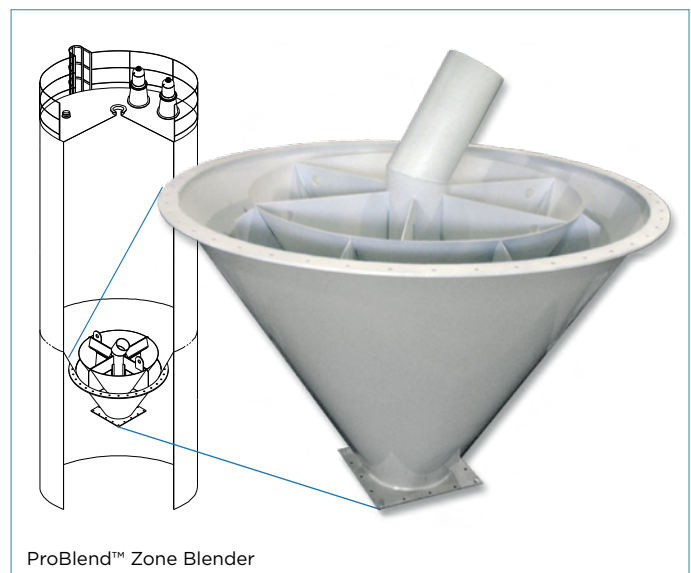
Pellets from load out area silos are gravity fed into bulk transport containers such as rail hopper cars and bulk hopper trucks. A Coperion K-Tron Smart Flow Meter is used to meter the material into the rail car or hopper truck. Once a predetermined weight has been delivered, a shutoff valve is closed and a new car or truck is positioned to receive the next weigh-out. Polyolefins may alternatively be packaged in gaylord boxes, supersacks or bags.

## Process Controls

Within a polyolefin production facility a plant wide central Distributed Control System (DCS) is used to monitor and control a variety of operations and functions within the entire process. Each sub-section of the process has its own or multiple sub-control modules that interface and take direction from the central DCS system.

Within the "Dry End" section of the process, the controls for the main polymer feed system, the additive supply systems and the screw conveyors/homogenizers interface with the upstream "Wet End Process" as well as the down-stream extruder through a Programmable Logic Controller (PLC).

Each ingredient feeder is supplied with a dedicated Coperion K-Tron Control Module (KCM) that guarantees the bulk material is delivered into the process as precisely as possible and within specified tolerance levels. A process line operator interface called K-Vision allows the operator to monitor and interface with up to 16 ingredient controls from a single point. All ingredient setpoints and actual mass flow rates are displayed.



ProBlend™ Zone Blender



Cyclone and Aerolock

Alarm conditions are displayed and recorded. The K-Vision also acts as a consolidator of line information that in turn can be communicated to the central PLC or DCS system for monitoring and recording. It receives line and ingredient setpoints from the central DCS system and makes that information available for reading by the operator on the line floor.

For multiple extrusion lines with multiple feeders in each line, a K-Tron Smart Commander (KSC) can be used as the operator interface. The KSC can interface with up to 30 feeders or devices in 1 to 8 extrusion lines. The PLC in the "Dry End" process is used to control start/stop

functions for all devices, monitor and control additive feed supply systems, control various slide gate functions, control the mixing screw conveyor and interface with upstream and downstream interlocks.

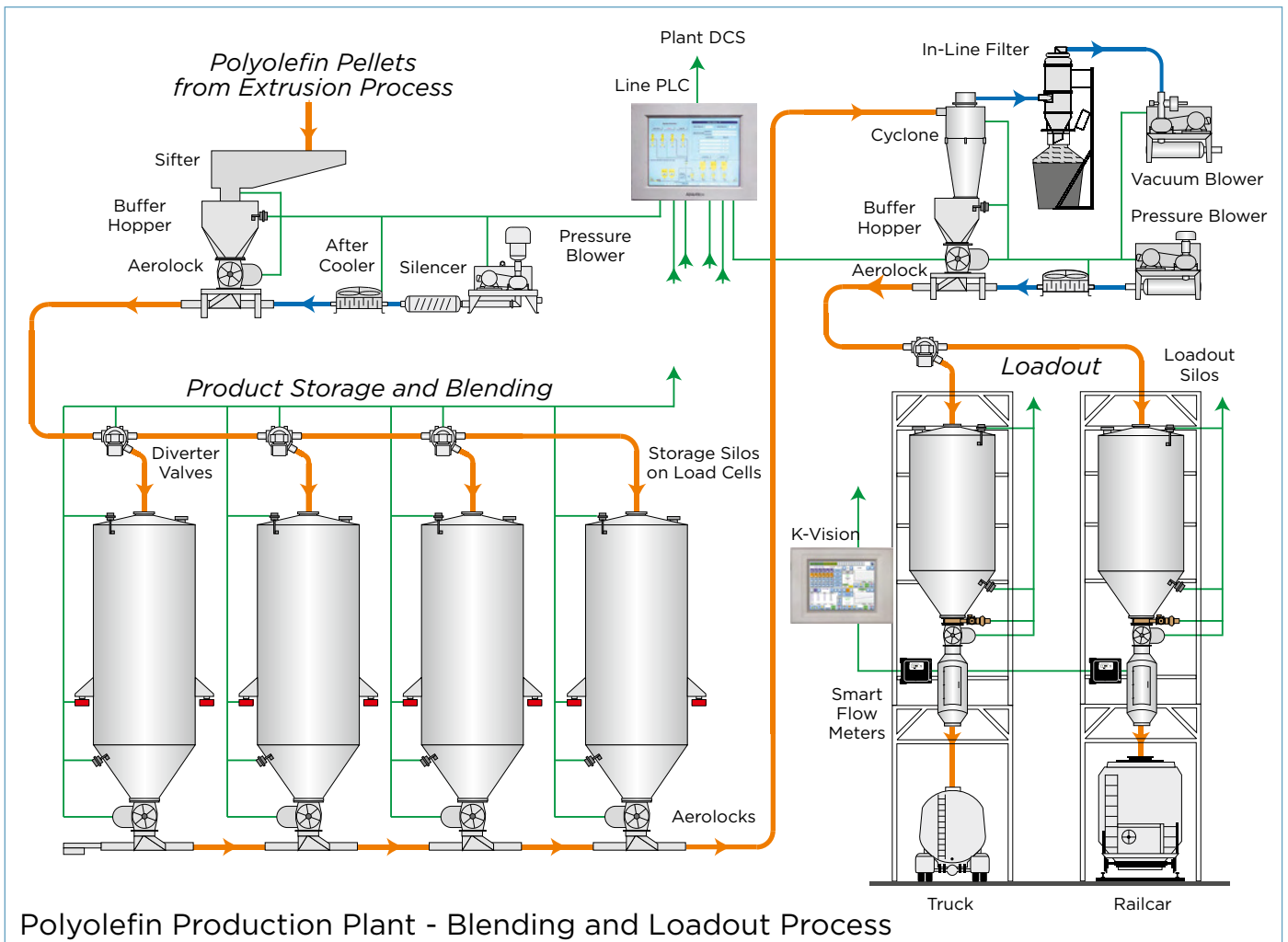
## Systems Engineering

Projects for the design and construction of a polyolefin manufacturing plant range from simple plant expansions or line modifications, to complex inquiries for the construction of a new facility.

From the initial concept to the plant going into operation, there are a large number of vari-

ables that must be considered and handled correctly for the entire project to be successful. These variables can be categorized as materials, equipment and people.

Polyolefin manufacturers use a myriad of additives and sophisticated chemistry to formulate new and existing products. The challenges posed by abrasive, friable, sticky, moisture and temperature sensitive, hazardous, hard-to-filter, prone to oxidation, and poorly flowing materials may be overwhelming. While the chemical properties of each component are, no doubt, at the core of the product's success, a bulk material handling system is at the





# Feeding & Conveying in Polyolefin Production

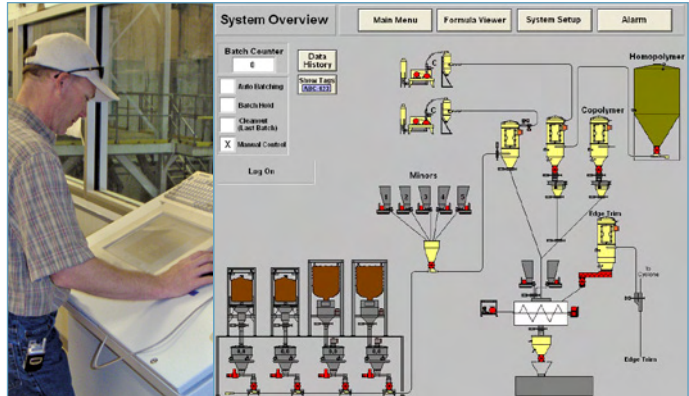
center of the operation's profitability as it allows for increased production and plant efficiency while decreasing labor, material and energy costs.

The engineering of such a complex system calls for know-how and experience not only in materials science, but also in pneumatic conveying systems (pressure and/or vacuum), bulk unloading and storage systems, weighing and feeding systems, mixing and homogenization systems and integration of all controls with central DCS systems.

In the end, it is all about people. At Coperion K-Tron, a dedicated project manager / systems engineer provides an interdisciplinary approach to polyolefin manufacturing projects, centering all activities, first and foremost, on the customer's business and technical needs. The project manager is responsible for meeting with the client, reviewing the project specification, gathering information, developing the concept and design, preparing and presenting the proposal, overseeing the design and manufacture, commissioning and starting up the project, and training the customer's personnel on the proper operation of the equipment. From beginning to end, the project is managed by one individual; a single point of contact approach to systems engineering that is highly valued by our customers. That project manager is supported by numerous factory systems engineers, design draftsmen, mechanical and electrical engineers and after sales support personnel around the world.

## The Coperion K-Tron Advantage

- › Pre-engineering team capable of interpreting complicated engineering specifications and quoting accordingly
- › Proven project management skills
- › Established international partners as sub-vendors around the globe, e.g. Saudi Arabia, India, China and many more
- › Experience and know-how handling challenging powder additives
- › Experience in design and implementation of nitrogen closed-loop systems
- › Experience in the control of resin velocity and temperature to reduce product damage
- › Experience in design and supply of specialized equipment to provide unmatched product homogeneity
- › Comprehensive product line with all necessary accessory products such as filters, level indicators, diverter valves, rotary valves, coolers, piping and blowers
- › Experience loading into packages such as sea/land shipping containers, trucks, railcars, boxes, and bags.
- › Experienced Global After Sales Service network with factory trained and certified engineers
- › Service engineers familiar with working in harsh environments



Custom controls provide a user-friendly graphical interface for the operator



Main Offices:

**Coperion K-Tron Salina, Inc.**  
606 North Front St.  
Salina, KS 67401, USA  
Tel +1 785 825 1611  
Fax +1 785 825 8759

**Coperion K-Tron Salina, Inc.  
Sewell Office**  
590 Woodbury-Glassboro Rd  
Sewell, NJ 08080, USA  
Tel +1 856 589 0500  
Fax +1 856 589 8113

**Coperion K-Tron (Switzerland) LLC**  
Lenzhardweg 43/45  
CH-5702 Niederlenz  
Tel +41 62 885 71 71  
Fax +41 62 885 71 80