

Equistar TECHNOLOGY

Equistar is one of the largest producers of ethylene, propylene and polyethylene in the world today. Equistar's proven technologies for the production of LDPE and HDPE have been in continuous improvement during of the many years. Equistar operates over ten different process technologies using more than thirty different catalysts. Equistar licenses the same technology that gives company the competitive advantage:

- **Bimodal HDPE Slurry Technology**

The Equistar-Maruzen bimodal HDPE process is a low-pressure, two-reactor slurry technology for the manufacture of HDPE utilizing highly active supported catalysts. Initially developed by Nissan Chemicals, the technology has been enhanced and improved by both Equistar and Maruzen Polymer Company Ltd. and is available for license by the joint efforts of these two companies. The two-reactor system in this technology allows the manufacture of resins that offer exceptional processability and strength. At the heart of the process is the specialized catalyst system ideally suited for bimodal resin production with an optimal balance of molecular weight and molecular weight distribution for both the high and low molecular weight reactors. The process design includes state-of-the-art control instrumentation as well as environmental and safety systems. An additional benefit of this technology is the ability to target the comonomer incorporation where it has the maximum benefit. This results in excellent consumption factors, and allows one to produce lower cost, butene-based copolymers with physical properties that far exceed those of a more expensive, single-reactor, hexene-based resin.

- **High pressure LDPE Technology**

Equistar's high-pressure production processes offer proven technology for the manufacture of LDPE and EVA resins. The unique design of Equistar's reactors have led to the development of LDPE and EVA resins that satisfy the requirements of many different applications: Film; Extrusion Coating and Laminating; Injection Molding; Blow Molding; Wire and Cable Jacketing and Insulation; Sheet and Profile Extrusion. With Equistar's technology, a licensee can choose between producing resins for high-margin specialty markets or for high-volume commodity markets. As markets change, licensees benefit from Equistar's experience in molecular weight distribution control. Through training in the modification of reactor conditions, licensees can modify their manufacturing conditions to meet new product requirements as they develop.

- **Simplified Tubular LDPE Process**

In the Equistar tubular process, LDPE and/or EVA copolymers (up to 30 wt % and up to 9 wt % without significant additional equipment) are produced by the polymerization of ethylene and various comonomers in a high-pressure tubular reactor. Reactor conditions, comonomers and additives are used to tailor resin properties for specific applications. A cost effective catalyst system using an organic peroxide initiator, with or without air, is introduced at various points in the reactor to control temperature and the molecular weight distribution of the polymer. Unlike other processes, the reactor does not require periodic solvent washing. The reactor effluent is let down to low pressure where the unreacted ethylene is separated from the polymer. The ethylene is compressed and efficiently recirculated back to the reactor. The polymer melt is fed to a mixer/pelletizer where additives are incorporated to enhance the physical properties of the final polyethylene pellet. Product uniformity is excellent largely due to advanced process control (APC) and advanced model-based process control techniques

- **Autoclave LDPE and EVA Technology**

In the Equistar autoclave process, LDPE and/or EVA copolymers up to 40 wt % are produced by the polymerization of ethylene and various comonomers in a high-pressure stirred autoclave reactor. Reactor conditions comonomers and additives are used to tailor resin properties to produce the broadest line of LDPE resins. Optimized reactor design includes conversions rates of 25 percent, multiple reaction zones, a new agitation system design, a redesigned catalyst feed system, and lower operating pressures. The polymer melt is fed to a mixer/pelletizer where additives are incorporated to enhance the physical properties of the final polyethylene pellet. Product uniformity is excellent largely due to APC and advanced model-based process control techniques. Included in the APC are an automated and integrated safety shutdown system, automatic temperature control, and model based MI and density control. Equistar also provides transition control systems that allow the unit to quickly transition between products with minimal operator intervention.

- **Polypropylene Technology**

Novolen Technology Holdings C.V. (NTH), an 80/20 joint venture of ABB Lummus Global and Equistar affiliated companies, licenses the Novolen gas phase polypropylene (PP) technology for the production of the full range of polypropylene resins. This reliable, versatile and environmentally clean process makes products meeting the requirements of even the most demanding applications. The Novolen polypropylene process utilizes one or two vertical, stirred bed, gas-phase reactors. Homopolymers and random copolymers can be manufactured either in a single reactor or in a reactor cascade with two reactors, depending on the required capacity and product range. Impact copolymers require two reactors connected in series: in the first reactor, propylene homopolymer or random copolymer is polymerized; in the second reactor, rubber is added by polymerizing an ethylene/propylene mixture.