Qenos

QENOS CHEMISTRY RESOURCE KIT 2015

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Qenos
Altona Chemical Complex
Botany Industrial Park
Olefins Manufacturing Sites
Production of Ethylene
Polyethylene Manufacturing Sites
Polyethylene Products
Laboratory Tests and Quality Control

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INTRODUCTION TO QENOS

Qenos is a leader in the production of olefins and polymers in Australia. Qenos has major production facilities at Altona, Victoria and Botany, NSW which produce plastics and petrochemicals.

Using Bass Strait and Cooper Basin ethane and liquified petroleum gas as feedstock, Qenos adds value to an Australian natural resource.

Qenos supplies a broad range of products to the extensive plastics manufacturing sector throughout Australia and is a vital link in the Australian manufacturing chain.

Qenos employs around 700 people at its Melbourne and Sydney plants and supplies industries that employ hundreds of thousands of Australians.

Qenos is proud to be the leading supplier of polymer products to Australia's manufacturing sector. We have long term, secure supplies of feedstocks delivered through well-established infrastructure. We support local employment, expertise and skills through investment in research and development and our business contributes more than $1 billion each year to the Australian economy.

QENOS AND CUSTOMERS

From high volume plastics produced locally, to a broad range of imported polymers, Qenos' product range is extensive.

The product range falls into several areas:

OLEFINS

Qenos produces ethylene and hydrocarbon byproducts to meet its plastics needs and supplies other manufacturers that use these raw materials.

POLYETHYLENE

Polyethylene resins are manufactured at Qenos plants in Altona and Botany. There are several types of polyethylene which have different properties; Qenos makes High Density (HDPE), Low Density (LDPE) and Linear Low Density (LLDPE) polyethylene.

Qenos is the only Australian manufacturer of polyethylene and supplies manufacturers in diverse sectors such as packaging, mining, construction and telecommunications.

Qenos has a state of the art Technical Centre located in Altona where an extensive range of product and application tests can be conducted.

OTHER POLYMERS

In addition to its range of locally manufactured products, Qenos also provides a range of imported polymers, serving customers in a broad range of industries including packaging, construction and automotive.

QENOS AND EDUCATION

Qenos has produced the Chemistry Resource Kit in response to requests for data to support students in their Chemistry studies.

The Qenos Chemistry Resource Kit provides support material and information for teachers and students in their chemistry studies, particularly at years 11 and 12. The Qenos business has particular relevance to areas of study involving:

- Investigation of chemicals in everyday use
- Polymers, their properties, bonding and polymerization
- The selection of a polymer for a specific purpose
- Production of ethylene and polyethylene
- Management of wastes, environmental monitoring and reporting
- Recycling of polyethylene

QENOS AND ITS COMMUNITIES

Qenos is proud of its place in the Altona, Botany and wider communities.

Through the company's focus on employees' involvement in setting directions for the future, its responsible attitude to the environment and involvement in local industry, schools and other community groups, Qenos maintains a high level of local commitment.

Qenos' Altona site is one of the largest employers in Melbourne's western suburbs. Qenos has established open lines of communication with the community. Employees who live nearby are encouraged to become involved in local activities. Qenos maintains a high level of awareness on issues affecting the environment and community. This approach is also taken with the Qenos Botany site which is part of the Botany Industrial Park.

It's an essential part of the Qenos approach and part of the way the company meets its goal of creating prosperity for the community and being a responsible citizen today and tomorrow.

ENVIRONMENTAL FACTS

Qenos is very committed to actively protecting the environment and safety of our employees and the public. There are a variety of ways in which Qenos goes about doing this and they are outlined below.

Qenos is a member of the Altona Complex Neighbourhood Consultative Group (ACNCG) and The Botany Industrial Park Pty Ltd (BIP) Community Consultation Committee. Each group meets regularly and provides a forum for open dialogue between the community and the member companies. The focus is on health, safety and environmental issues.

There are 24 hour toll-free hotlines for both Altona and Botany communities that provide prompt notice enabling Qenos to carry out immediate investigations into any possible sources of concern and provide feedback to the caller. If there is an issue with Qenos operations that is causing the concern, it is generally able to be addressed at the time before causing further issues. Longer term issues arising from complaints are managed by the Qenos Environmental Improvement Process.

Qenos continues to improve efficiency and decrease pressure on resources and is an industry leader in water savings. Qenos' facilities use substantial quantities of water in the manufacturing process. The two main uses are for cooling water (approximately 50% of water use) and steam generation (~40% of water use). Since 2005, Qenos has reduced fresh water consumption significantly. This has been achieved through efficiency projects, water re-use, plant shutdowns and alternative water supplies.

At the Qenos Botany facilities, treated ground water from the Orica groundwater treatment plant is being used as a substitute supply, displacing mains water.

At Altona, onsite treatment and reuse has been facilitated by a project co-funded by the Victorian Government. Also, a City West Water project to provide recycled water from the Altona sewerage treatment plant to Qenos, local parks and golf courses was completed and commissioned in 2011. This project was also co-funded by the Victorian Government.

Through these water efficiency and water recycling initiatives, Qenos has also reduced trade waste generation. Sources of the trade waste include boilers, cooling towers, demineralization plant purges and contaminated water from the process plants.

Qenos continually monitors and measures wastes and emissions and has significantly reduced the amount of industrial waste to landfill. A highlight of this reduction was turning waste into a valuable commercial product stream. Qenos developed a new wax product from the waste polyethylene wax produced at the Altona facilities. This not only generated sales revenue, but also reduced very high waste disposal costs. Qenos sells approximately 700 tones/annum of this wax product as a feedstock to third parties. This outcome was possible through the Rewards Grant program delivered through the partnership between Plastics And Chemicals Industries Association (PACIA) and EPA Victoria.

A key project to reduce greenhouse gas emissions has been the Altona Cogeneration facility, a $45M project commissioned in 2013. The Cogeneration facility burns natural gas to produce steam and virtually all of the Qenos Altona electricity needs. This is a more efficient method of producing electricity than the regular coal fired generators in the Latrobe Valley because the heat from the process is also put to good use.

Further details regarding Qenos' mains water use, trade waste generation, energy efficiency and emissions can be found in the Qenos Sustainability Report, accessible via the Qenos website.

SAFE HANDLING OF CHEMICALS

Safe procedures for the storage, handling and transport of industrial chemicals are determined by Federal and State legislation, Australian Standards, Industry Standards and Qenos' safe operating procedures.

Worksafe Australia has produced a number of publications relating to chemicals at work. In Victoria and NSW the Dangerous Goods Acts and the Dangerous Goods (Storage and Handling) regulations dictate the way in which chemicals are used, stored and placarded in the workplace.

These regulations and standards were developed to cater for a vast range of chemicals in everyday use. Qenos recognises that there will always be the potential for chemicals to do harm which is why we take all precautions to ensure that accidents are kept to a minimum by displaying Hazardous Chemical signs and training staff to handle all chemicals in a correct and safe manner.

Specific information is required to be located on the label of every package of dangerous goods. The regulations also specify how storage areas are to be designed, constructed and located in order to minimise the risk of accidents. Other requirements include the separation and segregation of goods which may react dangerously together.

Qenos provides protection for its workers by supplying them with sealed systems, personal protective clothing and Qenos has a medical centre which provides regular health checks and education on health issues as well as conducting the initial treatment of injuries. In all cases where chemicals are handled in the workplace, a range of personal protective equipment is available to the worker, the type and range of which varies from chemical to chemical.

Classifications are given to chemicals by various bodies including Worksafe Australia. Qenos strictly adheres to these regulations and pertinent information about each chemical is contained in its Material Safety Data Sheet which details:

- Trade and chemical names and other identification
- Short and long term health effects
- First aid information and advice to doctors
- Occupational exposure standard
- Fire and firefighting information
- Storage and reactivity data
- Spill leak procedures
- Personal protective equipment requirements

Qenos continues to search for alternatives or substitutes for some chemicals currently used in production, which will maintain high quality in the end product and improve handling and storage safety.

WHAT IS A TOXIC WASTE OR POLLUTANT?

The toxicity of a substance, raw material, finished product or waste depends on:

- the substance having a chemical reaction capable of causing harm; and
- exposure to that substance–including a certain exposure time and exposure quantity.

All chemicals will exhibit toxic behaviour under some condition of exposure – it is the condition of exposure and the type of biological system being exposed, that determines the extent of the toxic effect. Some chemicals will have an acute toxic affect, i.e. after a single, short exposure.

Other substances may have a sub-chronic or chronic toxic effect, i.e. after repeated or continuous exposures.

As with toxic effects on a biological system (such as the human body), a chemical can have a polluting effect on an exposed environment, if there is a harmful chemical action combined with a certain exposure. Pollution however, is not limited to chemical actions and toxic effects. Noise, offensive odours, heat and visual impairment can all be considered forms of pollution even if they are harmless from a toxicological point of view.

An everyday chemical such as salt (sodium chloride) will have a toxic or polluting effect ifreleased into a fresh water stream. The salt may affect the vegetation or aquatic life that relies on fresh water for survival. If some organic pigments used in the chemical industry were introduced into that same stream, it is possible that flora and fauna would not experience any toxic effect because the pigment is virtually insoluble. However, the stream could be considered polluted as the aesthetic enjoyment of the water would be impaired by discoloration.

It is important to note that the control of exposure conditions can prevent any chemical substance from having a toxic or polluting effect.

ALTONA CHEMICAL COMPLEX

Qenos forms a large part of the Altona Chemical Complex. This complex is the largest production centre for petrochemicals and plastics in Australia.

There are five manufacturing plants in the Complex. These are:

- Qenos Olefins manufacturing
- Qenos Plastics manufacturing
- Qenos Resins manufacturing
- BASF Australia Limited
- Dow Chemical (Australia) Limited

Whilst Qenos, BASF and Dow each operate independently, they gain from sharing raw materials and services.

Building a major chemical complex is expensive. It would cost nearly $2 billion to build a new complex.

The economic advantages of the complex for the Western Suburbs and the Victorian economy are considerable and it is one of the state's biggest industrial operations.

RAW MATERIALS

Qenos Olefins manufacturing and the rest of the Complex depend on the ready availability of Bass Strait petroleum products and natural gas for their operations.

BASS STRAIT

There are currently 23 offshore production platforms operating in Bass Strait, which, over the past 45 years, have produced almost 4 billion barrels of crude oil, 7 trillion cubic feet of gas, 700 million barrels of LPG and 15 million barrels of ethane (one barrel is equivalent to approximately 160 litres).

Bass Strait reached peak oil production in 1985, when a record average of 500,000 barrels per day was produced. Oil production from Bass Strait is in decline and fell to an average of 83,000 barrels per day in 2005-2006.

A 600 km network of undersea pipelines, valves and pumps link the platforms and carry the various hydrocarbons from the offshore platforms to the onshore processing facilities at Longford near Sale (217 km east of Melbourne). The gas processing and crude oil stabilisation plant is capable of processing more than 500,000 barrels per day of LPG and more than 26 million cubic metres of gas per day in its three plants. The gas plants remove heavy hydrocarbons from natural gas, leaving sales quality gas for distribution to consumers.

The crude oil stabilisation facilities remove the light hydrocarbons in crude oil which would evaporate when stored at atmospheric pressure and temperature.

Liquids processed at Longford are delivered via two 220 km pipelines to the Long Island Point fractionation plant and crude oil tank farm, located 72 km from Melbourne on Western Port Bay (refer to figure 1). Here the crude oil is stored and distributed while the LPG (liquified petroleum gas) is further refined and distributed. The lighter components are fractionated as butane, propane and ethane. Long Island Point has an oil storage capacity of approximately 300 ML, which is enough for 2.5 days use. From Long Island Point crude oil is loaded into tankers at the Long Island Point pier and transported 11 km via pipeline to the Crib Point Jetty for loading into tankers. Refineries at Altona and Geelong are served by the 135 km Western Port/ Altona/Geelong (WAG) pipeline.

Source: Australian Institute of Petroleum Ltd. Melbourne.

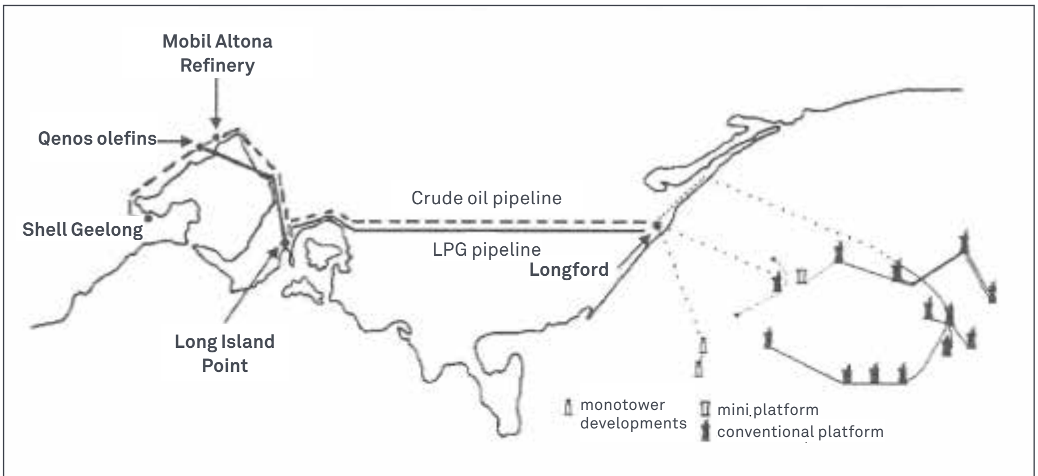


Figure 1 Ethane pipeline under the bay. Supply of raw materials to Qenos Olefins

QENOS ALTONA – A BRIEF HISTORY

The history of Qenos Olefins can be traced back to 1958, the year Standard Vacuum Oil Company executives met in Melbourne, to discuss the possibility of establishing a petrochemical complex at Altona.

Their brief also meant finding potential participants for the complex.

The aim was to form an industrial complex whereby a group of companies would supply and purchase products between them.

Such a venture was, for the time, unique in Australia.

The Standard Vacuum Oil Company or the USA, Stanvac as it was then known, was owned equally by Mobil and Standard Oil New Jersey— which became Exxon. (This entity was reunited in 2000 with the formation of ExxonMobil.)

The location of the complex was determined by its proximity to the Stanvac oil refinery. The company wanted to build an olefin manufacturing plant and to sell its products to other chemical companies, which would in turn make the final products needed by the Australian community. This company was called the Altona Petrochemical Company or APC. Consequently a number of international companies agreed to be involved in the complex e.g. Goodyear, Union Carbide, Dow etc.

In August 1961, two years after work started on the site, Qenos Olefins (then APC) began production.

Since 1961, the Altona Complex has continued to grow and respond to customer and community needs.

Some of the significant developments have been:

1961
Commissioning of the Union Carbide LDPE plastics plant.

1962
Standard Vacuum was split between two separate US based oil companies, Mobil (with a 75% stake) and Exxon (with 25%).

1966
Hoechst HDPE plant commissioned.

1967
The Polybutadiene Rubber – Elastomers plant was commissioned.

1970
Ethane Cracker (SCAL 2) construction and startup following the discovery of Bass Strait gas fields and the availability of ethane feedstock.

1983
The Union Carbide polyethylene plants were purchased by Commercial Polymers late in 1983.

1992
On December 1, 1992, three affiliated Exxon and Mobil joint ventures (Australian Petrochemical, Australian Synthetic Rubber and Compol) joined forces to form Kemcor.

1997
Kemcor acquires Hoechst's polyethylene and polypropylene manufacturing plants.

1999
On July 1, 1999, Kemcor was merged with the olefins and polythene businesses of Orica (formerly ICI). This united the businesses in Altona and Botany into Australia's only polyethylene producer. In October 1999, the merged business was named Qenos.

2000
SBR and LDPE plants closed.

2006
SCAL 1 conversion from Gas Oil feed to ethane/LPG feed.

Closure of the Elastomers and Polypropylene business since conversion project resulted in the elimination of butadiene and reduction of propylene as byproducts.

Qenos bought by China National Chemical Corp. (ChemChina).

2008
Qenos becomes a subsidiary of China National Bluestar (Group) Co. Ltd.

2011
Qenos Altona celebrates 50 years in Altona.

2012
Work commences on a major expansion to increase Altona HDPE production by 20%.

2013
The $45M Altona Cogeneration facility is commissioned.

BOTANY INDUSTRIAL PARK

The BIP, previously owned in its entirety by Orica (the former ICI Australia), was subdivided in 1998.

The following three companies now share the majority of the site and make up the BIP, which occupies over 100 hectares and is the third largest complex of its type in Australia.

- Orica Australia Pty Ltd now operates the ChlorAlkali Plant, Groundwater Treatment Plant and manages site legacy issues, including the HCB (hexachlorobenzene) Waste Repackaging Plant.
- Huntsman Corporation Australia Pty Ltd operates the Surfactants Plant. Huntsman is entirely independent of Orica, and operates other facilities across Australia.
- Qenos Pty Ltd operates the Site Utilities, Olefines, Alkathene and Alkatuff Plants. Formerly operated as a joint venture plastics manufacturing company between Exxon-Mobil and Orica, Qenos is now a wholly-owned subsidiary of China National Bluestar Group.

RAW MATERIALS

The Qenos Olefines manufacturing plant uses ethane from the Cooper Basin as its raw material. The ethane travels in a 1375 km pipeline from the Santos processing facilities at Moomba in outback South Australia to the Botany site.

QENOS OLEFINES – A BRIEF HISTORY

The Botany Petrochemical Complex developed in contrast to the Altona Petrochemical Complex. It grew out of a general chemicals plant by progressive introduction of PVC and Polyethylene plastic plants that could be converted to a petrochemical basis and to which other petrochemical based plants could be added, such as ethylene oxide, chlorinated solvents and polypropylene. In 1957 ICI Australia brought the first polyethylene plant on line. Initially there was no adequate petrochemical source of ethylene available in Australia, so they used ethanol dehydration. Later ethylene became available from the Shell refinery due to the additional ethylene demand at the site for the manufacture of vinyl chloride/PVC and ethylene oxide. A conventional petrochemical plant was constructed in Clyde by Shell and the ethylene was transported by pipeline to Botany. In 1967, ICI Australia launched the first oxychlorination plant in the ICI family and led this development world-wide. This then made it possible to develop a group of processes around a world scale naphtha plant. Subsequently ICI Australia erected a naphtha cracker and thereby established a petrochemical and plastics complex under a single management.

References

1. Technology in Australia 1788–1988: A Condensed History of Australian Technological Innovation and Adaption During the First Two Hundred Years.', Australian Academy of Technological Sciences and Engineering, Melbourne 1988 p 710.
2. (Ibid)

QENOS FEEDSTOCK, PRODUCTS AND CUSTOMERS (ALTONA)

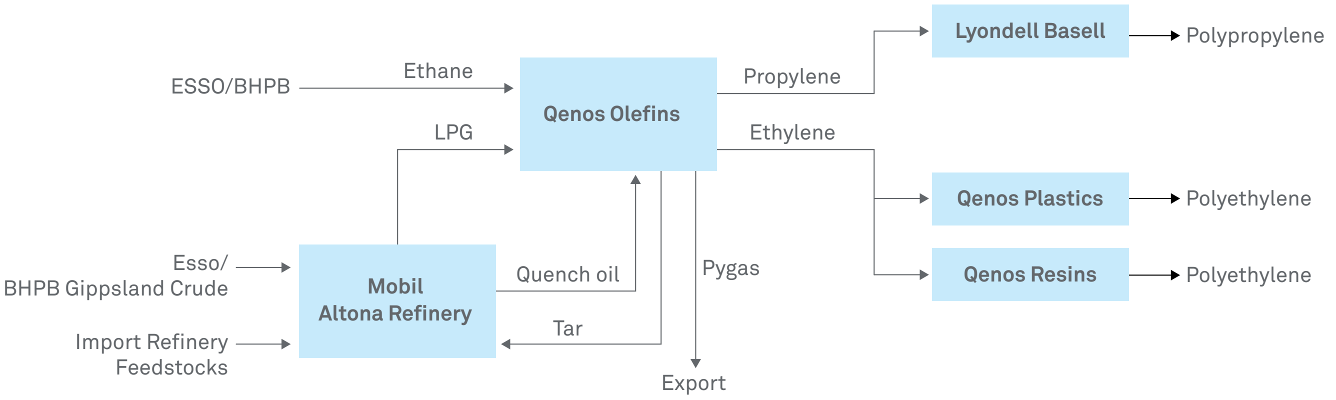


Figure 2 Qenos Feedstock, Products and Customers (Altona)

Figure 3 The Altona Chemical Complex from the air

Figure 4 The Botany Industrial Park

INTRODUCTION TO QENOS OLEFINS (ALTONA) AND OLEFINES (BOTANY) MANUFACTURING SITES

Qenos, supplies essential raw materials to the Australian plastics and general chemical industries from its olefins manufacturing plants.

The olefins produced are ethylene and propylene. These are used to manufacture a wide range of plastics and general chemicals in Australia. Also produced, as by-products, are pygas and quench oil/tar.

Qenos Olefins in Altona obtains feedstocks from two locations. Ethane is piped from the Esso-BHPB fractionation plant at Long Island Point on Westernport Bay and LPG (propane/butane) comes by pipeline from the Mobil Altona Refinery.

The production of ethylene and propylene at the Qenos Olefins plant continues 24 hours a day, seven days a week. All stages of the operation are continuous and automatically controlled, with extensive use being made of computer based technology to assist the operators to run the plant.

A BRIEF LOOK AT THE PRODUCTION PROCESS

As stated, Qenos Olefins uses two feedstocks, ethane and LPG. Petrochemicals are made from these. The process of separating the molecular chain of these feedstocks is called 'cracking'.

The section 'Production of Ethylene' outlines this process in detail.

There are two cracking units on the Olefins site – SCAL1 and SCAL2 (SCAL refers to Steam Cracking ALtona).

The two units employ very similar processes; the difference being that SCAL 1 takes an ethane/LPG feed, whereas SCAL 2's feed is predominantly ethane.

The main hydrocarbon product from the Qenos Olefins cracking process is ethylene. The ethylene molecule contains two carbon atoms so this product is often referred to as the C2 stream. Other key products are the C3 stream known as propylene and the C4 stream known as butene.

The heavier streams C5+ (pygas) and C10+ (tar) are also useful by-products.

The furnaces are at the heart of the process. The feedstock (LPG or ethane) is passed through tubes in the furnace. Steam is added to the furnace at controlled rates in order to increase yield and minimise coke formation (carbon matter) in the furnace tubes.

Coke deposits act as an insulator inhibiting the ability to 'crack' at optimum conditions.

The remainder of the plant separates and purifies the hydrocarbons into their final product forms.

The separation of these streams takes place in distillation towers, in which the lighter and lower boiling point materials rise to the top of the tower, and the heavier and higher boiling point materials are taken out at the bottom.

In 1961, the capacity of the plant was 45,000 tonnes of ethylene per year and 21,000 tonnes of butadiene per year.

Today, Qenos Olefins produces more than 200,000 tonnes of ethylene per year.

Also produced are approximately 10,000 tonnes each of propylene, butene, pygas and quench/oil tar.

The propylene is provided to LyondellBasell in Geelong for use as feedstock in their polypropylene plant.

The butene is transported to Botany Olefines where it it used as an additional feedstock to make more ethylene.

The pygas is exported and the quench oil/tar is returned to the Mobil Altona Refinery for blending.

The Qenos Olefines site at Botany is a similar process using a similar mix of feedstocks.

PRODUCTION OF ETHYLENE

This section focuses on the production of ethylene (C_2H_4, also known as ethene) using ethane feedstockat theQenos Olefins site in Altona. The plant can also produce petrochemicals using LPG feed from the Mobil refinery. Qenos Resins and Qenos Plastics are the customers for the ethylene from Qenos Olefins.

Qenos also makes ethylene from ethane at our Olefines plant in Botany. It provides ethylene to our Alkatuff® LLDPE and Alkathene® LDPE units.

Figure 5 Ethane cracker at the Qenos Olefins manufacturing plant

ETHYLENE

Ethylene is one of the most versatile and widely used petrochemicals in the world today. Its main use is for the manufacture of polyethylene.

SOME FACTS

- Ethylene is a colourless gas
- Ethylene is a hydrocarbon molecule (made up of carbon and hydrogen)
- It burns readily in the presence of oxygen
- Ethylene is written chemically as C^2H_4 i.e. an ethylene molecule consists of 2 Carbon atoms and 4 Hydrogen atoms. (Refer to figure 6.)

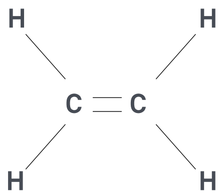


Figure 6 The chemical structure of ethylene

THE PROCESS IN DETAIL

The production of ethylene from ethane can be described as a sequence of six different processing steps. These are shown in detail in figure 7 overleaf.

Step 1 Steam Cracker/Furnace

Step 2 Quenching

Step 3 Gas Compressor

Step 4 Treating

Step 5 The Chilling Train

Step 6 Fractionation

ETHYLENE PRODUCTION

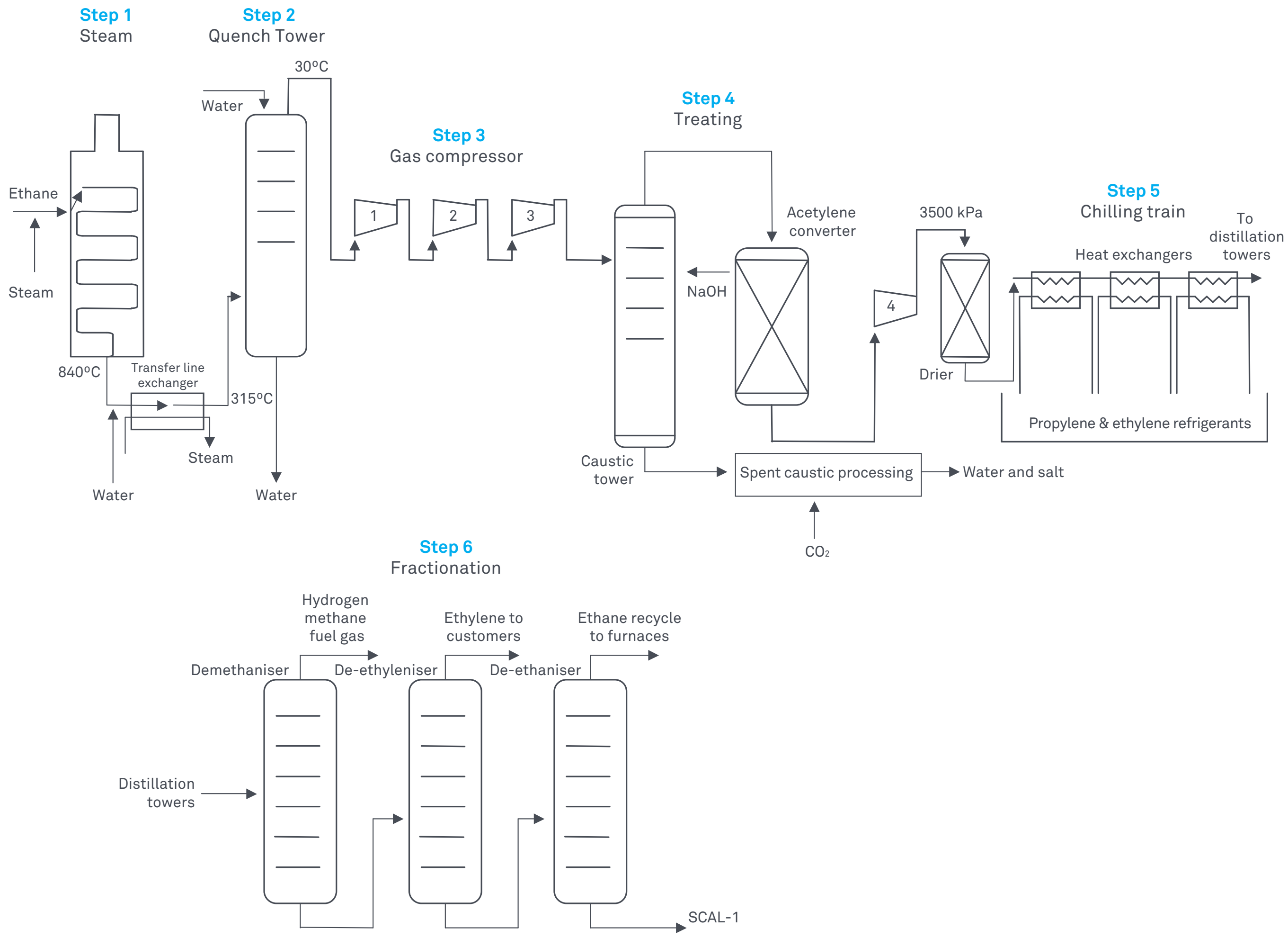


Figure 6 Simplified process diagram

STEP 1 – STEAM CRACKER/FURNACE

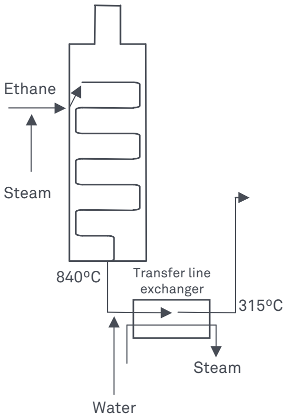


Figure 7 Cracking step

The ethane, piped from Bass Strait via Long Island Point, is fed into five gas-fired furnaces.

Steam is injected into the ethane feed immediately prior to entering each furnace. Steam is added at controlled rates in order to increase the petrochemical yield and to minimise carbon deposits (coke) forming in the furnace tubes. Coke deposits prevent the feedstock from heating to the right temperature thereby reducing the effectiveness of the cracking reaction.

The ethane is subjected to a one second surge of extreme heat, between 750°C-900°C, causing the splitting of the molecule into other hydrocarbons. Steam cracking refers therefore to the process whereby a hydrocarbon feedstock, in this case ethane, in the presence of steam and heat, changes to other hydrocarbons. The reaction is:

$C_2H_6(g)\ C_2H_4(g)+ H_2(g)$

Over 60% of the ethane is reacted in the furnaces. The composition of the furnace effluent (the gases coming from the furnace) is approximately 50% of ethylene, 35% of ethane (by weight) with the remainder being hydrogen, methane, acetylene, propane, propylene and some other hydrocarbons. The uncracked ethane is fed back into the furnaces later in the process.

Steam crackers are designed to operate at conditions that make full use of the basic chemical and physical conditions favouring the formation of ethylene.

The important conditions for successful operation of steam crackers include:

- High temperatures
- Short residence time
- The ethane is pumped through at a rapid rate as there is an optimum time for the cracking reaction to transpire. There has to be enough time for a high yield of ethylene to be produced but not too long so that the ethylene itself is cracked to form lower value by-products. Typical residence times for the molecules in the furnace tubes are less than one second.
- Low hydrocarbon concentration
- Rapid quenching or cooling to minimise secondary reactions.

This brings us to our next main processing step: Quenching.

STEP 2 – QUENCHING

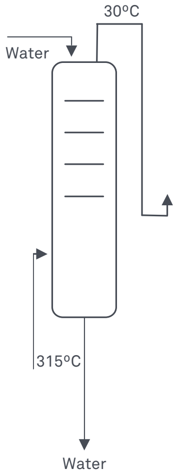


Figure 8 Quenching step

The effluent (the gases coming from the furnace) are immediately quenched or cooled by water. This drops the temperature of the effluent from 840°C to 700°C. This is necessary to stop the cracking reaction from continuing and forming coke. The furnace effluents are combined and sent to the quench tower. Here cooling of the cracked gas to 30°C is accomplished by direct contact with water. This quench water is then recovered and re-used.

Ethylene has been produced by the cracking reaction. However it is mixed in with many different hydrocarbons. It needs to be separated out so that it can be sold as a product that is over 99% pure by weight.

The remainder of the process steps are to enable the ethylene to be separated so that it can be sold to our customers.

STEP 3 – GAS COMPRESSOR

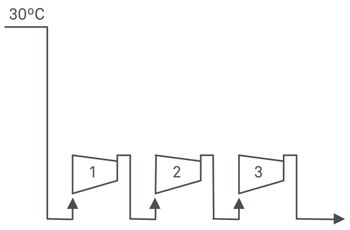


Figure 9 Gas compressors

The conventional method of separating hydrocarbons is in distillation columns. This requires the furnace effluent to be liquefied. The way to liquefy a gas is to increase the pressure of the gas and then cool it down until a liquid is formed. Gas compression increases the pressure of the gas.

The cracked gas stream from the quench tower is compressed using a centrifugal compressor. The gas compression in this section of the plant occurs in four stages. Heat exchangers are used to cool the gas between each stage of compression.

This is necessary because when a gas is compressed it heats up. It is therefore necessary to break up the compression steps to stop the gas becoming too hot.

The gas is compressed to a pressure of approx. 3500 kPa.

STEP 4 – TREATING

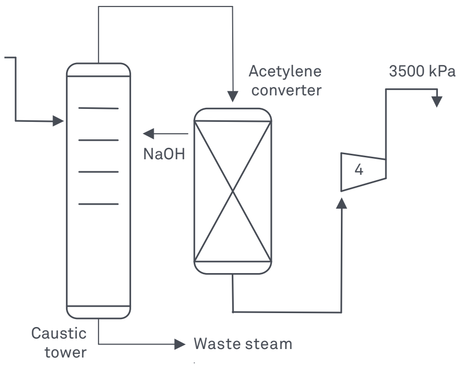


Figure 10 Treatment to remove impurities

The cracked gas stream contains impurities that need to be removed before the ethylene can be sold. These impurities include carbon dioxide, hydrogen sulphide and acetylene. Treatment of the cracked gas to remove impurities occurs between the third and fourth stages of the compressor.

The hydrogen sulphide and carbon dioxide are removed in the caustic tower.

The caustic's tower's purpose is to remove these unwanted chemicals from the ethylene. In this tower, the gas stream is contacted with dilute sodium hydroxide ("caustic"). The following reactions occur in the caustic tower:

$$2NaOH(aq)+H_2S(g) \longrightarrow Na_2S(aq)+ 2H_2O(aq)$$

$$2NaOH(aq)+CO_2(g) \longrightarrow Na_2CO_3(aq)+ H_2O(aq)$$

The waste sodium hydroxide stream is removed from the caustic tower. It is treated on site in the Spent Caustic Carbonation Unit which uses waste flue gas from a boiler to convert the stream into a benign baking soda solution prior to disposal. The carbonation unit is unique 'world first' technology that does not require any acids or oxidisers to treat the sodium hydroxide waste stream.

The acetylene is removed in a vessel called the acetylene converter. This is a large oval-shaped vessel filled with a nickel-iron catalyst. As the gas stream passes the catalyst the following reaction occurs:

$$C_2H_2(g)+ H_2(g) \longrightarrow C_2H_4(g)$$

(There are other different catalysts that can also be used). This catalyst is used to selectively promote only the hydrogenation of acetylene. Some of the other undesirable reactions include:

$$C_2H_4(g)+ H_2(g) \longrightarrow C_2H_6(g)$$

This reaction is undesirable because it is a loss of valuable ethylene.

The gas stream now needs to be 'dried'. As the gas stream is going to be cooled to temperatures as low as -100°C, any remaining water would form ice compounds thereby blocking pipes etc.

The drying is achieved by passing the gas stream through an apparatus (the molecular sieve desiccant) that is designed to absorb water. It is now necessary to cool the gas stream.

STEP 5 – THE CHILLING TRAIN

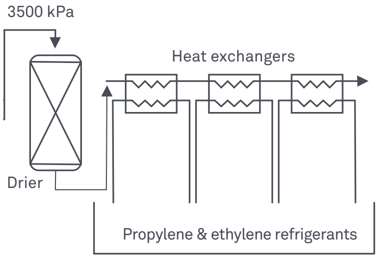


Figure 11 Chilling train process

The chilling train is a series of three heat exchangers. On one side of the heat exchanger is the gas that needs to be cooled.

On the other side of the heat exchanger is the refrigerant, liquid ethylene or propylene, which cools the gas. Neither stream comes into direct contact with the other.

The gas is cooled and then it condenses or liquefies.

The liquid stream can now go to the distillation columns to separate out the different chemical compounds.

STEP 6 – FRACTIONATION

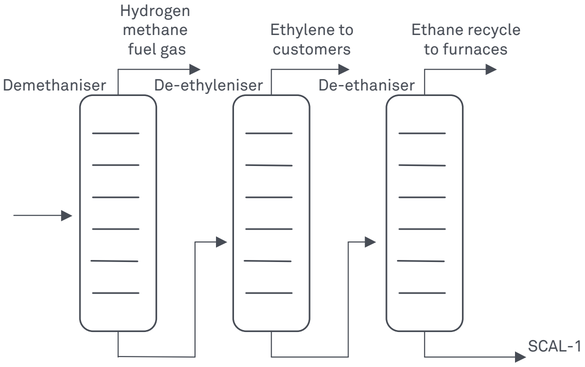


Figure 12 Fractionation process

There are three distillation columns. The way in which one of these columns works is shown in figure 14.

The first column is the de-methaniser. This separates out hydrogen and methane from the remaining components. The hydrogen and methane are used as fuel gas, ie. as a substitute for natural gas.

The remaining heavy gas exits from the bottom of the de-methaniser (e.g. ethylene and ethane), and is then fed into the second distillation column.

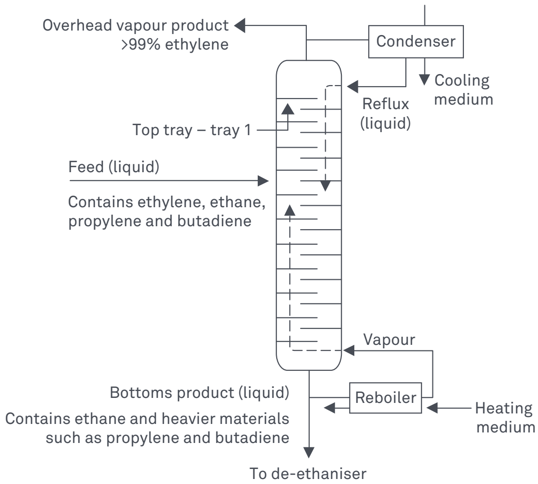
This is called the de-ethyleniser. This column separates ethylene from the heavier components of the de-methaniser bottom.

It operates at a pressure of 1950 kPa, (nine times the pressure in your car tyre) and produces ethylene product at purity greater than 99.85 %wt.

The ethylene product is heated to 20°C and sent, via a pipeline, to Qenos Resins and the Qenos Plastics manufacturing plants.

The third column, the de-ethaniser, separates ethane from the propylene and heavier components in the de-ethyleniser bottoms.

The overhead ethane stream is recycled back to the furnaces for cracking. The bottoms stream is sent to the SCAL1 plant for further separation.



ETHYLENE MANUFACTURE – SUMMARY

The production of ethylene occurs via a number of processing steps known as “unit operations”:

- Steam cracking in the furnaces
- Heat exchange
- Compression
- Distillation
- Catalytic reaction
- Steam generation
- Molecular-sieve drying

WHAT ENGINEERS DO?

- Plant monitoring/trouble shooting
- Design for plant modifications
- Design for new projects
- Process control hardware/software
- Design/selection/installation
- Plant supervision

ETHYLENE MANUFACTURE FROM LIQUID PETROLEUM GAS

Qenos Olefins also produces ethylene using a flexible feed mix of LPG and ethane in a completely separate plant to the ethane cracking plant. The process of ethylene manufacture from LPG is very similar to the ethane cracking process.

INTRODUCTION TO THE QENOS POLYETHYLENE MANUFACTURING SITES

Qenos is the only Australian manufacturer of the full range of polyethylene resin products -High Density Polyethylene Resin (HDPE), Low Density Polyethylene (LDPE) and Linear Low Density Polyethylene (LLDPE).

As the name suggests, polyethylene is formed when ethylene molecules come together. Different temperature and pressure conditions and the use of catalysts dictate the polyethylene structure and its eventual end-use application.

HIGH DENSITY POLYETHYLENE (HDPE)

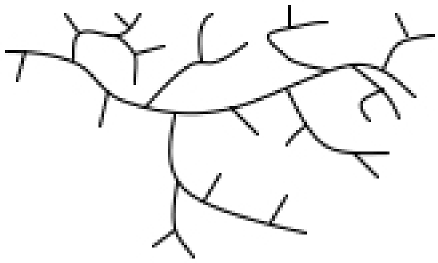
Manufacturing Conditions:

- Low Pressure
- Low Temperature
- Catalyst
- Ethylene

PE Type:

- Long Backbone
- Short Branches

LOW DENSITY POLYETHYLENE (LDPE)



Manufacturing Conditions:

- High Pressure
- High Temperature
- Catalyst
- Ethylene

PE Type:

- Long Branches relative to the Backbone
- Short chain branches also produced

LINEAR LOW DENSITY POLYETHYLENE (LLDPE)

Manufacturing Conditions:

- Low Pressure
- Low Temperature
- Catalyst
- Ethylene
- Comonomer eg. Butene

PE Type:

- Short regular branches along Backbone

These different forms of polyethylene are made by different industrial polymerisation processes which all transform ethylene into polyethylene.

POLYETHYLENE PRODUCTS

Qenos produces a wide variety of polyethylene resins that have an enormous range of uses.

Many items that are used in the home, such as cling wrap and film, milk bottles, micro irrigation pipes, moulded plastics and telecommunication cable conduit are made from resin produced at Qenos.

With its high emphasis on research, quality and productivity, Qenos has been able to achieve such results as polyethylene pipe replacing steel pipae and plastic milk and drink bottles replacing both glass and cardboard.

A BRIEF HISTORY OF POLYETHYLENE

1931–1935

Polyethylene was first made as a result of research into the effects of very high pressures on chemical reactions. Initially, only a very small amount could be made in the laboratory.

1935–1939

By 1935, eight grams of polyethylene could be produced in a small-scale apparatus. From this basis, ICI developed a manufacturing process as well as designing and inventing uses which were uniquely suited to the product.

1939–1945

The Second World War provided the opportunity for the intense development of a range of polyethylene products. In particular, materials were specifically produced for the high frequency application in radar cables. Its use in radar insulation played a major role for the allies in their victory.

1945 to present

Polyethylene gains acceptance as a material in its own right. It has found large tonnage application in mouldings, films, cable coverings and a wide variety of domestic and industrial uses.

The most significant impact of polyethylene perhaps comes from developments in its manufacture as a film which has enabled the production of a huge variety of materials and range of uses that has transformed our everyday life. Early plastic film was produced from resin manufactured by high pressure polymerisation. Now it can also be produced by low pressure polymerisation.

AUSTRALIAN POLYOLEFINS PRODUCTION FACILITIES

Qenos – Altona

- HDPE using a low pressure slurry process with a capacity of 115,000 tonnes per annum at Qenos Resins
- HDPE using a low pressure Unipol gas phase process with a capacity of 90,000 tonnes per annum at Qenos Plastics

Qenos – Botany

- LDPE using a high pressure process with a capacity of 85,000tonnes per annum at Qenos Alkathene
- LLDPE using a low pressure Unipol gas phase process with capacity of 130,000 tonnes at Qenos Alkatuff

Lyondell Basell – Geelong Victoria

- PP homopolymer using a liquid phase plant, capacity 130,000 tonnes per annum

LOW PRESSURE POLYMERISATION – UNIPOL™ GAS PHASE PROCESS

QENOS PLASTICS

The Qenos Plastics site uses low pressure polymerisation to make High Density Polyethylene Resin (HDPE). The ethylene is obtained from the Qenos Olefins manufacturing plant.

The first polyethylene made on this site was low density polyethylene which was first manufactured in a high pressure plant in 1961, when it was owned by Union Carbide. This plant stopped production in 2000.

The first industrial uses of low pressure polymerisation were in the 1950s. In 1968, Union Carbide developed the “Low Pressure Fluidised Bed” process. The Qenos Plastics plant in Altona was the third in the world to adopt this process.

The low pressure polymerisation process, which can make either High Density Polyethylene (HDPE) or Linear Low Density Polyethylene (LLDPE), was developed as a means to reduce the large energy requirements of the high pressure technology. It became possible through the use of sophisticated transition metal catalysts. (Zeigler-Natta catalysts named after Karl Zeigler and Giulio Natta).

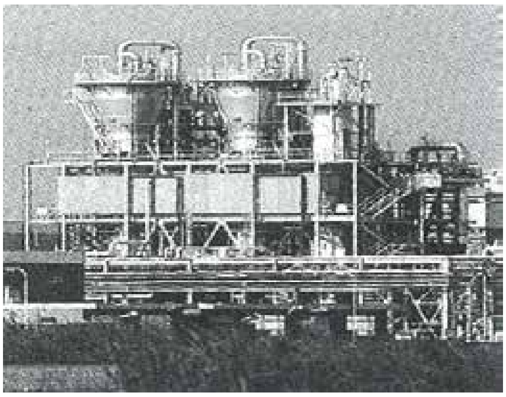


Figure 13 **Low pressure polymerisation reactors**

These highly reactive catalysts are central to the initiation of the polymerisation process and enable the reaction to occur at the relatively low pressure of 20 atmospheres (2000 kPa), which is only 5-10 times more than the pressure of normal tap water. The temperature inside the reactor is about 100°C.

The polymer molecule grows by insertion of ethylene at the interface between the polymer and the transition metal catalyst. Hydrogen is used for chain termination to control the molecular weight. No long chain branching reactions occur and short chain branches are achieved by copolymerising the ethylene with the alpha-olefin monomers such as butene-1, hexene-1 and octene.

The purity of the ethylene feedstock is crucial in low pressure polymerisation as the catalyst is attracted to reactions with polar compounds, such as water or oxygen. If contaminated feedstreams (C_2H_4, C_4H_8, C_6H_{12}, H_2, N_2) enter the process, then the catalyst is rendered inactive for polymerisation.

The reactor is a very simply designed vessel. A 'bed' of polyethylene powder is supported on a perforated plate and the recycled ethylene gas enters the bottom of the reactor, passes through the perforated distributor plate, lifts the bed and holds it in a fluidized state similar to boiling water or quicksand.

From the top of the reactor, the gas returns through the compressor and cooler back to the bottom of the reactor. As the catalyst converts the ethylene to polyethylene, the bed level increases, so the product is discharged to keep the level constant.

The fluidised polyethylene is cooled and forms a fine powder called 'fluff'. Batches of 250 to 500 kg of 'fluff' are conveyed to the fluff storage bins every few minutes. The manufacturing process is presented schematically in figure 4.

Compounding is the next processing stage and consists of a mixing stage and an extrusion stage.

During the mixing stage, additives are mixed with the base resin to form a molten material.

Additives are used to protect the plastic against degradation and to make it easier for Qenos' customers to process at their plants.

After the mixing stage, the molten material is passed through an extruder that cuts, cools, and forms the material into small pellets. The polyethylene product is then packaged into bulk containers. Offsite packaging facilities then repack into bags or semi-bulk containers as requested by customers.

This raw material is able to be transformed into a wide variety of end products, such as milk bottles, pipes and children's toys.

QENOS ALKATUFF

The Qenos Alkatuff site at Botany in NSW also uses the Unipol Gas Phase process.

Alkatuff produces mostly LLDPE plus a small amount of HDPE.

Alkatuff LLDPE can be transformed into a multitude of products including rainwater tanks, canoes and other large rotomoulded items.

SLURRY POLYMERISATION PROCESS

The slurry process is another form of low pressure polymerisation.

Qenos Resins makes polymers in a slurry process, meaning that the polymerisation reaction takes place in a saturated hydrocarbon solvent filled reactor.

Following the polymerisation the solvent is removed and recovered for reuse; the polyethylene powder then goes through a number of drying stages.

The polymer powder is stored in silos before being processed through compounding, where raw polyethylene powder is processed together with processing stabilisers and if necessary light stabilisers through an extruder and pelletizer.

The product from this process (polyolefin granules) is sold to end users in 25 kg bags, one tonne bulker bags or road tankers. See Figure 2.

HIGH PRESSURE AUTOCLAVE PROCESS

Qenos' Alkathene® LDPE is manufactured using the high pressure autoclave process developed by ICI at its Botany (NSW) plant. See Figure 3.

Low Density Polyethylene (LDPE) is produced by the high pressure free-radical polymerisation of ethylene. Pressures between 120 – 170 MPa and temperatures between 170 – 300°C are used in the process. The polymerisation is carried out in a stirred autoclave reactor.

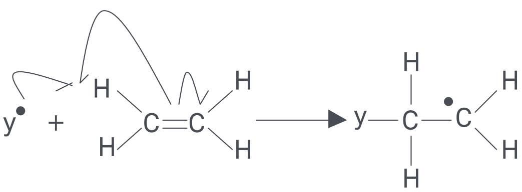
The polymerisation reaction involves free-radical initiation, polymer chain propagation and radical combination and chain transfer. The polymerisation is initiated by one or several of a range of free-radical producing compounds such as peroxides.

Initiation

$$R_1{-}O{-}O{-}R_2 \longrightarrow R_1{-}O^{\bullet} + R_2{-}O^{\bullet}$$

The molecular weight is determined by chain transfer using alkanes as the chain transfer agent. Short chain branching, mainly ethyl and butyl groups is produced by intramolecular chain transfer via a "backbiting" mechanism. Long chain branches are produced by intermolecular transfer between a completed polymer molecule and a growing polymer radical.

Propagation



$$y(CH_2CH_2)^{\bullet}_{n} + CH_2{=}CH_2 \longrightarrow y(CH_2CH_2)^{\bullet}_{n+1}$$

Chain Transfer

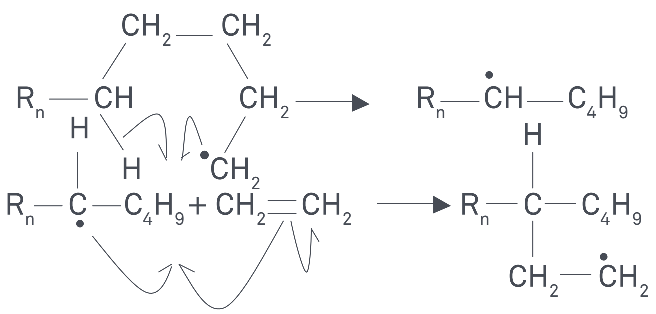
$R_nCH_2CH_2^{\bullet} + xy \longrightarrow R_nCH_2CH_{2x} + y^{\bullet}$

Termination

$R_nCH_2CH_2^{\bullet} + R_mCH_2CH_2^{\bullet} \longrightarrow R_nCH_2CH_2CH_2CH_2R_m$

$R_nCH_2CH_2^{\bullet} + y^{\bullet} \longrightarrow R_nCH_2CH_2y$

Backbiting Mechanism
The cause of short chain branching in LDPE



The process starts with a two stage compression of purified ethylene to between 120-170 MPa. The high pressure ethylene with initiator and chain transfer agent are fed into the reactor where polymerisation occurs. Because of the highly exothermic reaction, heat must be removed through reactor walls to avoid decomposition. Following polymerisation where conversion can be 15-20%, unreacted ethylene is separated from the polymer for recirculation and the molten polymer (polyethylene) goes to a pelletisation stage.

In the stirred autoclave process, residence times may be between thirty seconds and two minutes. The reaction is carried out in a zoned reactor to modify the molecular structure of the polymer.

THE MANUFACTURE OF POLYETHYLENE: SLURRY PROCESS

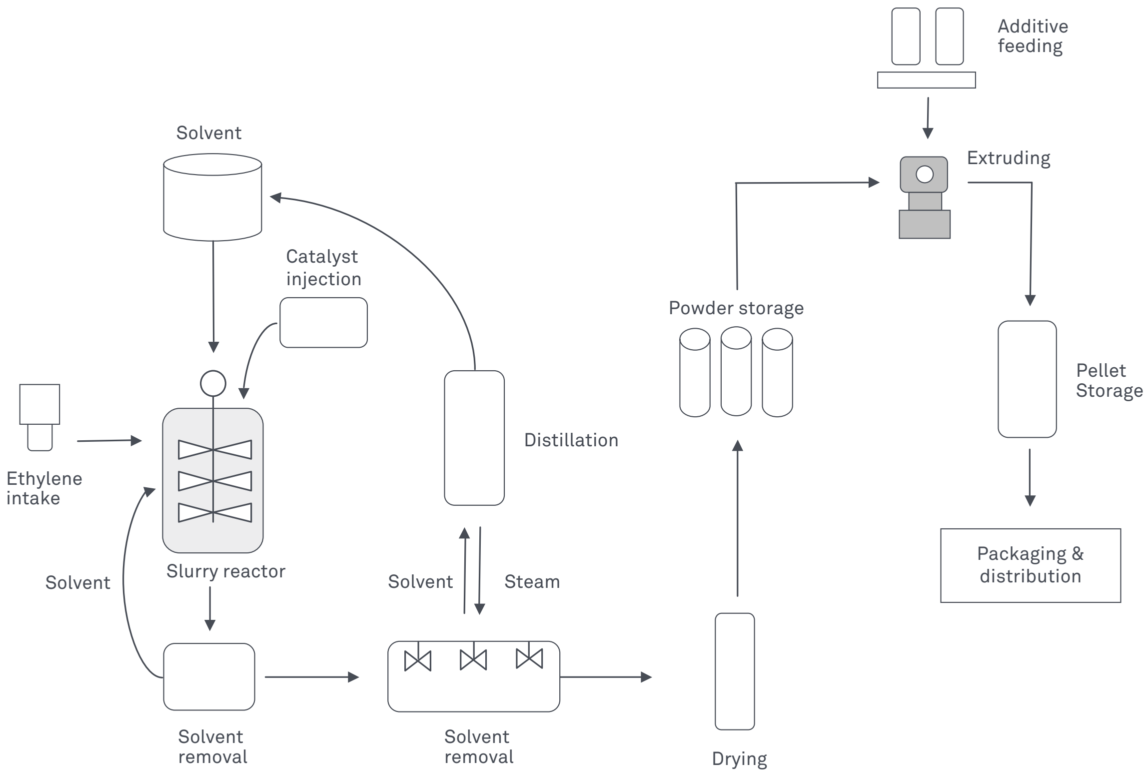


Figure 14 **Slurry manufacturing process for polyethylene**

THE MANUFACTURE OF POLYETHYLENE: HIGH PRESSURE AUTOCLAVE PROCESS

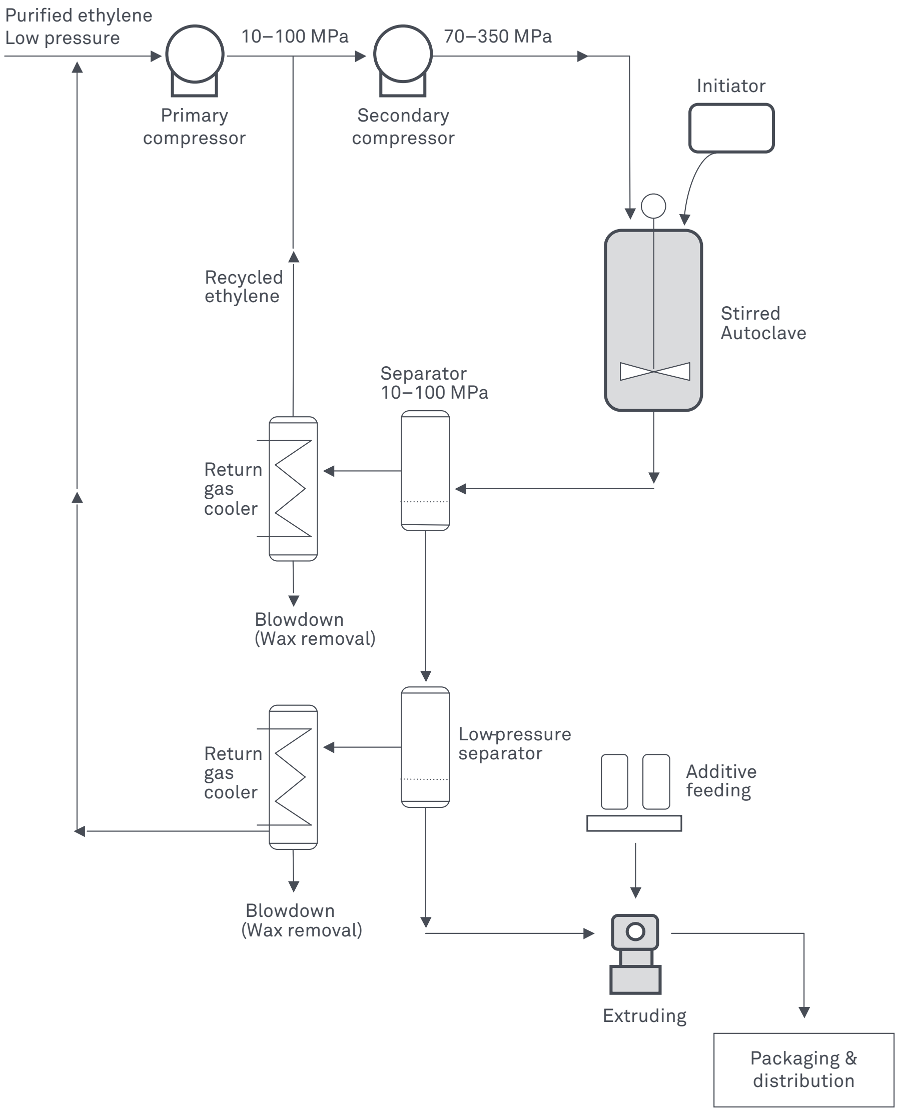


Figure 15 **High pressure polymerization manufacturing process for polyethylene**

THE MANUFACTURE OF POLYETHYLENE: UNIPOL FLUIDISED-BED PROCESS

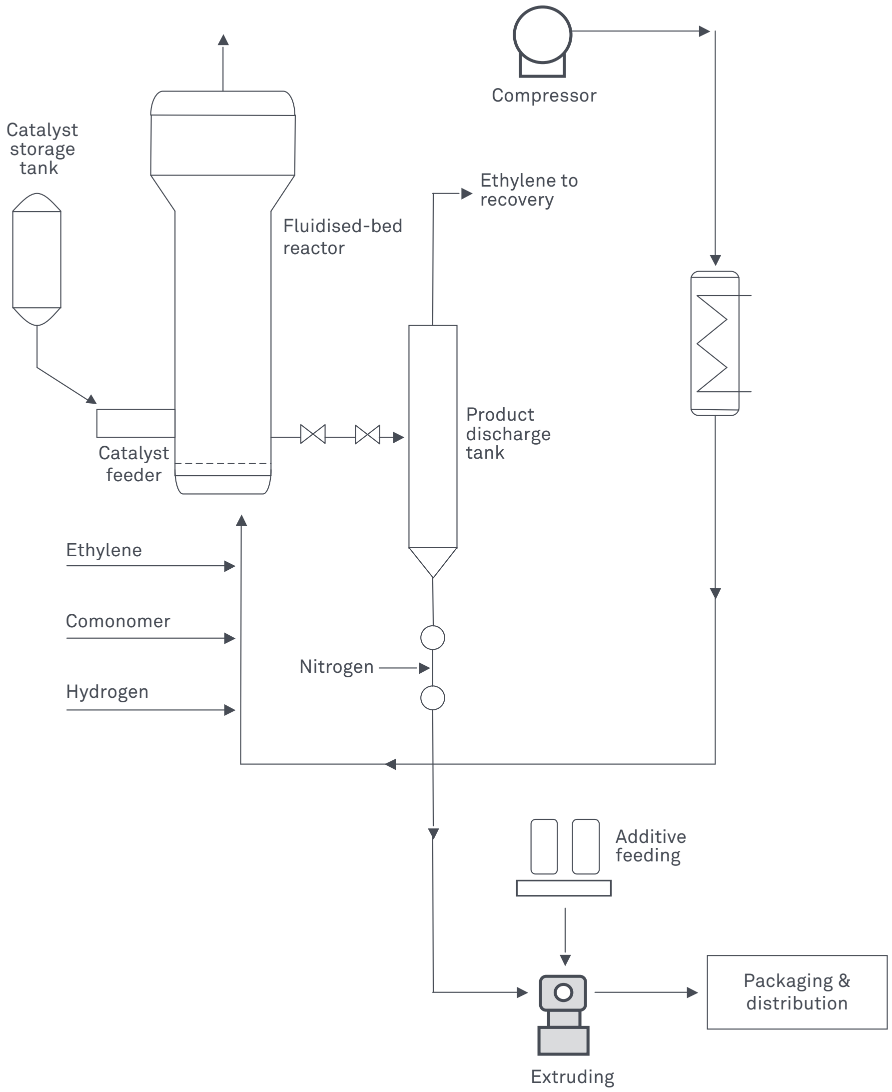


Figure 16 Unipol fluidised-bed process

MANUFACTURE OF POLYETHYLENE PRODUCTS

Qenos customers use the polyethylene raw material made by Qenos to manufacture a wide variety of goods. Different grades of polyethylene and different processes are used depending on their end use requirements.

Easy flowing grades of short chain length find use in injection moulded articles, such as caps etc. Blow moulding on the other hand, requires the polymer to have a high melt strength, and is obtained using material of high molecular weight as in the case for bottles.

A simple machine which is used to measure the flow of a polymer, is the melt flow indexer. The amount of polymer which flows out of a die in a ten minute period at certain temperatures is known as the polymer melt flow index.

Polyolefins can be processed on all common plastics forming machines; this includes, injection moulding, blow moulding and extrusion.

MANUFACTURE OF POLYETHYLENE PRODUCTS

There are five different methods which are commonly used to manufacture plastic end-products:

- extrusion – film
- blow moulding
- injection moulding
- rotational moulding
- extrusion – pipe, wire and cable coating

The polyethylene resins produced by Qenos are used in all of these processes.

EXTRUSION – FILM

Extruded film applications use up the largest portion of Qenos polyethylene resin. Familiar items such as cling wrap, garbage bags and dry cleaning bags are the major market areas for the finished product.

The most common film process is known as 'blown film extrusion'. The extruder is equipped with a thin circular opening on the die through which molten plastic is extruded to form a tube with very soft walls. The tube is blown up by compressed air via a hole in the centre of the die. The air increases the bubble diameter, and makes the film thinner. This tube is then cooled by air, flattened through nip rolls and wound onto rolls.

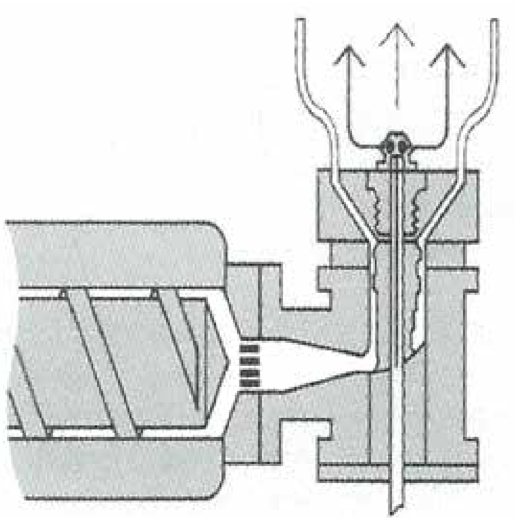


Figure 17 Blown film extrusion

BLOW MOULDING

Milk bottles, and plastic bottles for detergent, shampoo and some motor oils are made by blow moulding.

Blow moulding can use either continuous or discontinuous extrusion techniques to melt and feed the plastic to the die. To blow mould, the molten plastic is extruded downwards through a circular die in the shape of a tube. The tube is clamped in a mould and blown by air against the inner walls of the circular die. The mould is then opened and the hollow product is removed.

Temperature of the plastic, thickness of the tube, air injection pressures and cycle times all affect the quality of the finished product.

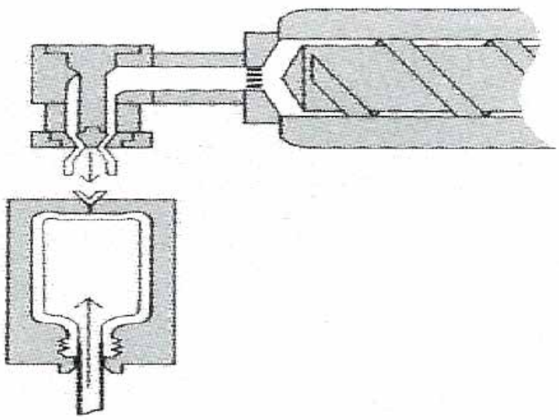


Figure 18 Blow moulding

Qenos Plastics lead the field in Australia with resin used in the plastic milk bottle—a most significant market for Qenos.

INJECTION MOULDING

Lids, caps, laundry baskets, toys, mixing bowls, thin walled containers and large garbage bins are all examples of injection moulded articles that use polyethylene resin products. Injection moulding provides the best method for producing complicated shapes and narrow tolerances.

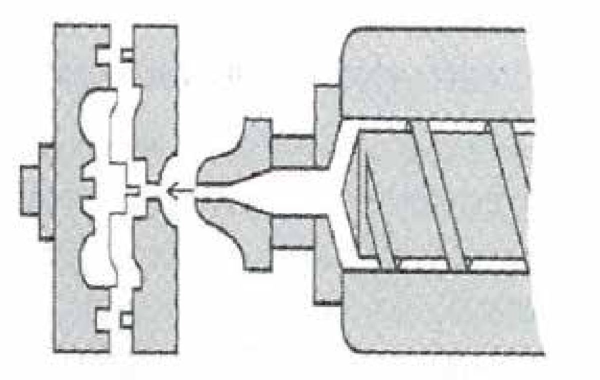


Figure 19 Injection moulding

Injection moulding machines discontinuously produce formed articles. Molten plastic is injected at high pressure through a die in the mould. The material is then cooled and solidified in the mould, which is then opened and the readymade part is ejected.

The temperature of the plastic, the injection speeds and pressures, the rate of cooling and the cooling time all affect the quality of the finished product.

ROTATIONAL MOULDING

Qenos polyethylene resin is commonly used in the manufacture of rotationally moulded products such as boats, canoes, spheres, buoys, playground equipment and large tanks and water tanks of up to 45000 litres capacity.

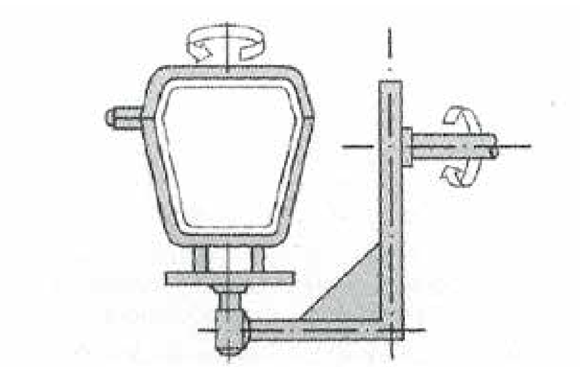


Figure 20 Rotational moulding

Rotational moulding is a discontinuous process for the production of moulded parts which does not require an extruder to melt the plastic.

A measured quantity of plastic powder is placed inside a closed hollow mould which is then rotated about two axes which are perpendicular to each other.

These rotational motions force the plastic to cover the inner walls of the mould. Heat from an outside source converts it to a continuous solid phase. By cooling the mould, the hollow part is solidified, whereby it can be removed.

EXTRUSION – PIPE, WIRE AND CABLE COATING

Pipes ranging in diameter from 12 mm to 1.5m are produced by the extrusion method. Pipe applications use up the second largest portion of Qenos polyethylene resin, behind the film segment. The major end products include domestic and commercial irrigation pipes, sewerage pipes, large pipes for the mining industry, and wire insulation and cable sheathing.

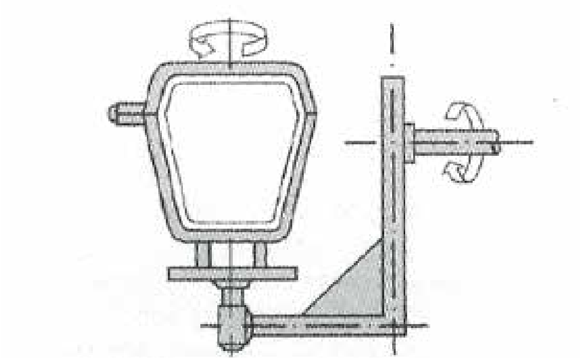


Figure 21 Extrusion of pipe, wire and cable

Pipe extrusion is a continuous process for the manufacture of uniform hollow products of various wall thicknesses and diameters. To extrude pipe, the molten plastic is passed through a sizing unit to ensure the correct dimensions, and a cooling medium that solidifies the product.

Wire and cable extrusion coating is a continuous process involving two independently moving components. When insulating or sheathing a cable, the conductor is passed through the die of the extruder, simultaneously gaining a coating of plastic. It is then passed through a cooling medium, checked for proper coating and wound onto a cable drum.

POLYETHYLENE: TYPICAL APPLICATIONS

Process	HDPE	LDPE	LLDPE
Film Extrusion	Carry bags Cereal box liners Carton liners for produce	Cling Wrap Bubble Wrap Shrink Film	Stretch Film Heavy Duty Sacks Freezer Films
Injection Moulding	Crates and bins Industrial pails Sealant cartridges	Houseware Caps and Closures Toys	Housewares Lids
Blow Moulding	Milk and juice Bottles Detergent Bottles Tanks and drums	Cosmetic bottles Squeezable bottles	
Pipe & Cable Extrusion	Irrigation pipe Shade cloth High pressure pipes	Flexible Irrigation pipe Cable Jacketing	Cable sheathing, pipe, profiles
Rotomoulding			Water tanks, Outdoor and children's toy furniture, kayaks

LABORATORY TESTS AND QUALITY

CONTROL

Quality assurance and quality control are two terms which are often used interchangeably.

However, this is incorrect as they describe two different functions.

Quality assurance includes all activities undertaken to ensure a product satisfies a customer's needs. These activities include product design, planning, selection of equipment, selection of the production process, choice of raw materials, distribution of the product and compliance with the relevant regulatory authorities.

Quality control is a measurement process. It includes monitoring of production equipment, testing of raw materials, intermediates and finished products. Quality control describes the measurements which are undertaken to ensure a product meets a specification.

Qenos uses both quality assurance and quality control to assist in the manufacture of its products. For new products, technical staff assess the customer's needs and translate these requirements into a technical product specification. This includes how the product is to be made, what properties or product characteristics are to be tested and how frequently these tests are to be performed. For our standard range of products, production processes, test methods and frequencies are continually reviewed to ensure our products continue to satisfy the needs of our customers.

Quality control at Qenos occurs both in the laboratory and in the production plant. In the laboratory, technical staff perform various tests to ensure a product complies with its specification. Tests can be visual comparisons or may need the use of sophisticated, analytical equipment. In the production plants, equipment is carefully monitored for correct operation. These quality control procedures form part of the overall quality assurance program.

THE QENOS TECHNICAL CENTRE

INTRODUCTION

- The Qenos Technical Centre is the premier polyethylene laboratory organisation in Australia. Completed in 1999 to accommodate the relocated Kemcor, Hoechst and Orica laboratories, it is located at the Qenos Resins Site at Altona, Victoria.
- The establishment of the Qenos Technical Centre represents the amalgamation of corporate Research and Development testing capabilities with Product Quality Assurance and Quality Systems Management at Altona. It has the capability and equipment to provide technical support to Qenos' customers, product development activities and manufacturing operations.

THE ROLES OF THE QENOS TECHNICAL CENTRE

(1) **Quality Assurance Testing –** undertaking sophisticated and specialised testing for specific product groups, for example, pressure performance testing on pipes produced from Qenos pipe grade polyethylenes. Such testing needs to be undertaken before products may be released into the marketplace or performed on a periodic basis to confirm product attributes.

(2) **Product Development –** Technical Centre personnel work closely with the Product Development and Manufacturing Technology groups to design, develop, manufacture, process and evaluate products with an optimum balance of properties.

(3) **Technical Service –** Technical Service testing services are provided to assist Qenos customers to optimise and enhance the performance of Qenos materials in their processes and products.

(4) **Plant and Process Support –** Technical Centre facilities and resources provide analytical, troubleshooting and process development support to plants. Plant laboratories systems and protocols are defined, supported and stewarded by Technical Centre personnel.

(5) **Quality Systems Management –** Technical Centre personnel are responsible for stewardship and development of company quality systems

QUALITY AT THE QENOS TECHNICAL CENTRE

The Qenos Technical Centre has several certified Quality Systems which ensures the integrity and quality of the testing conducted. These are:

- AS/NZS ISO 9001 accreditation
- NATA accreditation for Chemical & Mechanical Testing
- AS ISO/IEC 17025 Compliance – Testing & Calibration Laboratory Requirements
- Type Test Licence for Black Pipe Grades to AS/NZS 4131
- Type Test License for Roto Mould Grades to AS/NZS 4766

Quality systems, guided by the requirements of ISO17025, have been developed specifically for the Technical Centre to ensure a high standard of reliable and accurate service to our customers. Key tools for quality management at the Technical Centre include:

- Qenos Laboratory Manual, covering Management, Technical & Business Requirements
- LIMS systems for laboratory data management and distribution
- Calibration, Maintenance & Training management systems, purpose designed and developed for the laboratory environment
- Quality Incident Reporting and Root Cause Analysis systems

The quality of the services provided by the Technical Centre is a point of focus for all Technical Centre personnel because it is a measure of how well they meet their commitments to their customers. An ongoing Technical Centre goal is to continually improve activities to provide Qenos with a more efficient, productive and customer focused outcomes.

TECHNICAL CENTRE FACILITIES

The various evaluation and testing resources available are located in the Process, Physical Testing and Analytical laboratories within the Technical Centre. An overview of these 3 laboratories follows:

PROCESS LABORATORY

There are 14 plastics processing lines located in this laboratory, most of commercial or semi-commercial size which cover a wide variety of processes. These lines include:

- injection moulding machines
- blow moulding machine
- rotational moulding machine
- twin screw & single screw compounding extruders
- tape line
- pipe extrusion line
- single layer blown film lines
- compression moulding press

There are also a range of blenders and feeders, Brabender plasticorders and an Accelerated Weatherometer unit.

The Process Laboratory is also home to one of the largest Hydrostatic Pipe Testing facilities in Australia consisting of 14 baths with up to 27 stations per bath.

Using the processing equipment available, the Qenos Technical Centre can evaluate products under conditions similar to those at our customers.

PHYSICAL TESTING LABORATORY

The Physical Testing laboratory has extensive capabilities for various testing of polymer samples. The main tests performed include:

- Flow properties by Melt Indexer or Capillary Rheometer
- Mechanical properties – Tensile, Yield, Elongation, Modulus, Crush etc.
- Long term creep
- Impact testing – Izod, Charpy, Instrumented, ARM, Drop Dart
- Abrasion resistance – DIN, Taber
- Optical properties
- Environmental Resistance & Weathering
- Pressure Resistance
- Surface Properties

The Physical Testing laboratory also has a temperature and humidity controlled facility for testing to standards requiring these conditions.

ANALYTICAL TESTING LABORATORY

The Analytical Testing laboratory performs a wide range of analytical procedures. These include:

- Polymer Identification –
  - DSC – Differential Scanning Calorimetry measures temperature and heat flow associated with phase transitions in materials. DSC is used widely for examining polymers to check their composition.
  - FTIR – Fourier Transform Infra-Red is ideal for identification and quantification of organic and inorganic species, even at trace levels. FTIR identifies chemical bonds in a molecule by producing an infrared absorption spectrum. The spectra produce a profile of the sample, a distinctive molecular fingerprint that can be used to easily screen and scan samples for many different components.
  - NIR – Near Infra-Red is a type of spectroscopy to measure the composition of unknown samples.
  - FTIR microscope – allows the analysis of extremely small samples using infrared spectroscopy. It can provide a simple spectra of a very small contaminant in a larger matrix or detailed information about the chemical constituents.
- Microscopy & Product Defect Analysis
- Quantification of Polymer Additives –
  - GC – Gas Chromotography is used for separating and analysing compounds that can be vapourised without decomposition.
  - HPLC – High Performance Liquid Chromotography is a technique that can separate a mixture of compounds and is used to identify, quantify and purify the individual components in a mixture.
  - TGA –Thermogravimetric Analysis continuously monitors the weight of a sample during dynamic temperature scans. It is used to determine thermal stability, compositional analysis, filler content, comparative analysis, specification testing and competitor product analysis.
  - UV – Ultra Violet Spectrophotometry is used for performing rapid quantitative concentration measurements of organic species in solution. These chemical species absorb light in the ultra violet region of the electromagnetic spectrum.
- Thermal Properties

All three laboratories are used to perform Technical Service, Product Development & Plant Manufacture/Quality Assurance evaluations. New methods are continually being developed to improve Qenos' ability to provide reliable information to its customers as well as produce quality products that meet required specifications.

GLOSSARY OF TERMS

Anti-oxidant

A chemical, such as ascorbic acid, which is added to hinder the chemical reaction known as oxidation (oxygen attack).

Catalyst

Substance that alters the speed of a chemical reaction and may be recovered essentially unaltered (in form and amount) at the end of the reaction.

Coagulation

Change from fluid to more or less solid stage; may result from prolonged heating, addition of an electrolyte, or from a condensation reaction between solute and solvent; an example is the setting of a gel.

Cracking

A process that is used to create a number of smaller molecules from large molecules by breaking the molecular bonds using various thermal, catalytic, or hydrocracking methods.

Distillation

A process of purification which involves producing a gas or vapour from a liquid by heating the liquid in a vessel and collecting and condensing the vapours into liquids.

Emulsion

A stable dispersion of one liquid in another (such as oil dispersed in water) that will not mix with each other.

Ethane

A colourless, odourless gas belonging to the alkane series of hydrocarbon (freezing point of -183.3 degrees Celsius and a boiling point of -88.6 degrees Celsius); used as fuel and refrigerant and for organic synthesis. Formula: C_2H_6

Ethylene

A colourless, flammable gas (boiling at -102.7 degrees Celsius); used for the manufacture of organic chemicals and polyethylene and as an agricultural chemical and in medicine. Also known as ethene; olefiant gas. Formula: C_2H_4

Exothermic

A reaction that produces heat.

Feedstock

The starting material for a machine or process, for example, ethane is a feedstock material for the production of ethylene and propylene.

Fractionation

Separation of a mixture in successive stages, each stage removing from the mixture some proportion of one of the substances, for example, by differential boiling points in hydrocarbon mixtures.

Hydrocarbon

One of a very large group of chemical compounds composed only of carbon and hydrogen; the largest source of hydrocarbons is from petroleum crude oil.

Initiator

The substance or molecule (other than reactant) that starts a chain reaction, as in polymerization.

Monomer

Simple molecules such as ethylene and propylene.

Olefin

A family of chemically active hydrocarbons with one carbon-carbon double bond; includes ethylene and propylene.

Oxidation

A chemical reaction that increases the oxygen content of a compound.

Petrochemical

Chemical made from feedstocks derived from petroleum or natural gas; examples are ethylene, butadiene, and most large-scale plastics and resins.

Plastic

A material (usually organic) that is made of polymers and can be shaped by flow. At some stage in its manufacture, every plastic is capable of flowing, under heat and pressure, if necessary, into the desired final shape.

Polyethylene

A thermoplastic material composed of polymers of ethylene; the resin is synthesised by polymerisation of ethylene at elevated temperatures and pressure in the presence of catalysts. Also known as ethylene resin. Formula: $C_nH2_{(n+2)}$

Polyethylene, low density, (LDPE)

Long chains with branches every 2 to 4 carbon atoms. Low crystallinity and melts at 110°C.

Polyethylene, linear low density (LLDPE)

Short chain branches every 10 to 20 atoms and melts at 120°C.

Polyethylene, high density, (HDPE)

Long chains with very few branches. High crystallinity and melts at 130°C.

Polymer

Substance made of giant molecules formed by the joining of simple molecules (monomers), for example, polymerisation of ethylene forms a polyethylene chain.

Polymerisation

The bonding of two or more monomers to produce a polymer. Often involves the production of long-chained molecules.

Polypropylene, (PP)

A thermoplastic material composed of polymers of propylene.

Propylene

Colourless unsaturated hydrocarbon gas (boiling point of -47 degrees Celsius); used to manufacture plastics and as a chemical intermediate. Also known as methyl ethylene; propene. Formula: C_3H_6

Resin

Any class of solid or semi-solid organic products of natural or synthetic origin with no definite melting point, generally of high molecular weight; most resins are polymers.

Semi-Crystalline

Polyolefins have two phases or type of solid: a crystalline phase (which is highly ordered and has a regular structure) and an amorphous or random phase. The amount of crystalline and amorphous phases present, determine the properties of the plastic.

Thermoplastic resin

A material that will repeatedly soften when heated and harden when cooled; for example, styrene, acrylic, polyethylene, vinyls, nylons and fluorocarbons.

ACKNOWLEDGMENTS

A number of people from both Qenos and the Education Department made generous contributions in terms of technical expertise, curriculum knowledge and time in order to produce this resource kit. The teachers who gave much of their own time were: Rosemary Bissett, Rob King, Rob Sanders and Gayle Smith.

The production of this kit was coordinated by Jen McKinley (1991), Mark Landy (1992), and Terry Kingston (1993) under the Teacher Release to Industry Project (T.R.I.P.).

1996 Up-date coordinated by Ruth Geldard (T.R.I.P.). Thanks to Kevin Quinn and Rob Sanders, teachers of years 11 and 12 chemistry, for their assistance and time. Thanks also to Qenos employees for their input in up-dating subject matter.

The 1997 update was completed by Rob Sanders and co-ordinated by David Moss (T.R.I.P.).

The update in 2001, when the kit changed from being the Kemcor Resource kit to become the Qenos Resource kit, was completed by Fiona Wilkes of Qenos. This update principally reflected the changes in the business in becoming Qenos.

The 2012 update was completed by Tania Hooper, Qenos and reflected the changing Qenos business environment. Thanks also to Kate McKie, Paul Taranto and Andre Olszewski for their reviews.

This 2015 update was completed by Kate McKie, Qenos.

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