



PETRO-CANADA AND THE PATENTED HT PURITY PROCESS

2

BASE OIL MANUFACTURE

Lubricant base oils are produced in a series of steps which are designed to enhance certain desirable properties. For paraffinic oils, these include viscosity index, oxidation resistance, thermal stability and low temperature fluidity.

Starting from petroleum crude oil, the typical process for making a lubricant base oil is as follows:

- Separation of lighter boiling materials, such as gasoline, diesel, etc.
- Distillation to give desired base oil viscosity grades
- Selective removal of impurities, such as aromatics and polar compounds
- Dewaxing to improve low temperature fluidity
- Finishing to improve oxidation resistance and heat stability

Generally both Solvent Refined and Hydrocracked base oils are manufactured this way, but differ in the processes used.

BASE OIL CLASSIFICATION

Before reviewing how base oil is manufactured, we should explain the American Petroleum Institute's (API) Base Oil Classification system. For engine oils, the API system classifies base oils into five major groups, as shown below. While these groups were originally intended to be used for engine oils, their usage has expanded beyond this area.

API Group	Base Oil Characteristics			Manufacturing Method
	Sulphur Wt, %	Saturates Wt, %	Viscosity Index VI	
I	> 0.03	< 90	80-119	Solvent Refined
II	< 0.03	> 90	80-119	Hydroprocessed
III	< 0.03	> 90	120 +	Severely Hydroprocessed
IV		Polyalpha Olefins (PAOs)		Oligomerization
V		Other Base Oils		Various

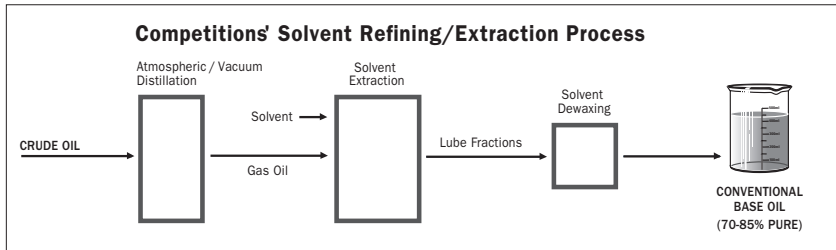
Group I, or conventional base oils manufactured by Solvent Refining, make up most of the base oil produced in the world today. Containing more than 0.03 wt % Sulphur and less than 90 wt % Saturates, they are less pure than Hydroprocessed or Synthetic base oils.

Group II and III base oils are manufactured by what the API calls Hydro - processing or Severe Hydroprocessing. These are just other names for Petro-Canada's Patented HT Purity Process. With Sulphur content of less than 0.03 wt % and Saturates content of more than 90 wt %, they are more pure than Group I base oils.



SOLVENT REFINING PROCESS

Initially, light oils such as gasoline, diesel, etc., are separated from crude petroleum by atmospheric distillation. The resulting material is charged to a vacuum distillation tower, where lubricant fractions of specific viscosity ranges are taken off. These fractions are then treated individually in a *solvent extraction* tower. A solvent such as furfural is mixed with them and extracts about 70-85% of the aromatic material present. The solvent extracted lube fraction is then dewaxed by chilling to a low temperature, which removes much of the wax. This improves the low temperature fluidity of the product. Finally, the dewaxed lube fractions are sometimes finished to improve their colour and stability, depending on the application requirements. One common method of finishing is mild hydrofinishing. This step should not be confused with Petro-Canada's Patented HT Purity Process, as conditions of temperature and pressure in hydrofinishing are mild and less effective. The API classifies the products of Solvent Refining as Group I base oils.





PETRO-CANADA'S HT SEVERE HYDROCRACKING PROCESS

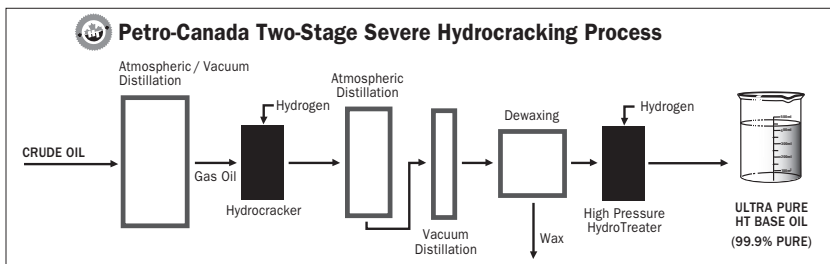
In Petro-Canada's HT Severe Hydrocracking process, the elimination of aromatics and polar compounds is achieved by *reacting the feedstock with hydrogen*, in the presence of a catalyst at high temperatures and pressures.

Several different reactions occur in this process, the principal ones being:

- Removal of polar compounds, containing sulphur, nitrogen and oxygen
- Conversion of aromatic hydrocarbons to saturated cyclic hydrocarbons
- Breaking up of heavy polycyclo-paraffins to lighter saturated hydrocarbons

These reactions take place at temperatures as high as 400°C , pressures around 3000 psi and in the presence of a catalyst. The hydrocarbon molecules that are formed are very stable and this makes them ideal for use as lubricant base oils. They are classified by the API as Group II base oils.

There are two stages in the Petro-Canada Severe Hydrocracking process. The first one removes unwanted polar compounds and converts the aromatic components to saturated hydrocarbons. After separation into desired viscosity grades by vacuum distillation, batches of waxy lube base oil are chilled and dewaxed. These are then passed through a second high pressure hydro-treater for additional saturation. This final step maximizes base oil stability, by removing the last traces of aromatic and polar molecules.





HT SEVERE HYDROCRACKING/ HYDROISOMERIZATION

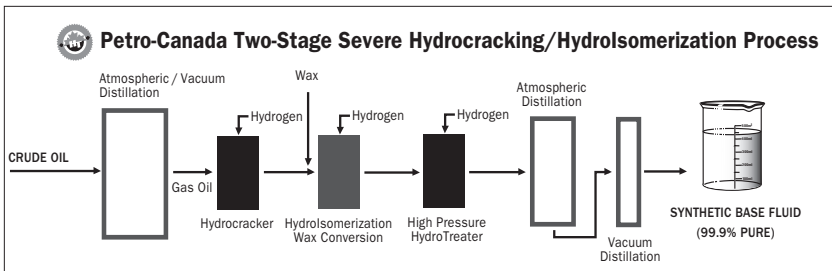
In 1996, Petro-Canada completed a new base oil manufacturing unit to run in parallel with its existing base oil plant. This new unit utilizes the HT Severe Hydrocracking process, but replaces the conventional dewaxing step *Hydrolsomerization*.

The Hydrolsomerization process employs a special catalyst to selectively isomerize wax (n-paraffin mixture) to high VI, low pour point, iso-paraffinic lube oil. The process yields base oils with higher VIs and improved yields, compared to previous conventional dewaxing techniques. The process is capable of giving 130 VI base fluids, in a single pass. More usually, it is set up to produce high viscosity index (Group II) base oils with VIs ranging from 95 to 105 or unconventional (Group II+ and III) base fluids with VIs ranging from 115 to 130. A further process feature is the flexibility it offers to produce base oils with ultra low pour points lower than - 25°C.

Petro-Canada employs Hydrolsomerization Catalytic Dewaxing in conjunction with HT Severe Hydrocracking and as a result its base oils have the following attractive features:

- Very High Viscosity Index (100 to 130)
- Low Volatility
- Excellent Oxidation Resistance
- High Thermal Stability
- Excellent Low Temperature Fluidity
- Low Toxicity

These features give performance characteristics very similar to lubricants based on poly-alpha-olefin (PAO), a type of synthetic.





COMPARISON OF THE PRODUCTS OF PATENTED HT PURITY PROCESS AND SOLVENT REFINING

• BASE OILS

There are significant differences in certain characteristics between HT Severely Hydrocracked and Solvent Refined base oils. The main reason for the difference lies in the virtual elimination of aromatic molecules (less than 0.5%) in our HT Purity Process. HT Severely Hydrocracked base oils are termed "99.5+% Pure". In comparison, the aromatics content of Solvent Refined oils is somewhere between 10-30% so Solvent Refined base oils are considerably less pure.

Characteristic	Significant Difference
COLOUR	HT Severely Hydrocracked base oils are clear and colourless
VISCOSITY INDEX	HT Severely Hydrocracked base oils have high VIs so they 'thin-out' less at high temperatures.
OXIDATION RESISTANCE	HT Severely Hydrocracked base oils respond very well to anti-oxidants and so have excellent resistance to oxidation and long lubricant life in finished products.
THERMAL STABILITY	HT Severely Hydrocracked base oils have very good resistance to heat.
CARBON RESIDUE	HT Severely Hydrocracked base oils produce low residues.
DEMULSIBILITY	HT Severely Hydrocracked oils separate readily from water.
LOW TOXICITY	HT Severely Hydrocracked base oils have low toxicity, due to a virtual absence of impurities. Petro-Canada White Oils are pure enough to be used in cosmetics and pharmaceuticals.
BIODEGRADABILITY	HT Severely Hydrocracked base oils have biodegradability characteristics.



• FINISHED LUBRICANTS

Finished lubricants blended from Petro-Canada HT Severely Hydrocracked base oils can be superior to lubricants blended from Solvent Refined base oils in several areas. These include:

- Viscosity Stability
- Oxidation Resistance
- Thermal Stability
- Reduced Environmental Impact

• VISCOSITY STABILITY

In service, Petro-Canada HT Severely Hydrocracked lubricants do not ‘thicken-up’, i.e. increase in viscosity, or thin-out as much as many Solvent Refined lubricants. This is especially valuable for *automatic transmission fluids*, where consistent shift characteristics depend on viscosity stability. This feature also contributes to greater fuel efficiency in *motor oils* and reduced power consumption from *industrial lubricants*.

• OXIDATION RESISTANCE

Finished lubricants based on Petro-Canada HT Severely Hydrotreated base stocks have shown the ability for superior resistance to oxidation compared to Solvent Refined lubricants. This allows them to be used at higher temperatures or for longer time periods than Solvent Refined lubricants. Petro-Canada’s unique line of products, such as *COMPRO™ XL-S Compressor Fluid*, *TURBOFLO™ Fluid*, etc. are based upon this valuable property.

• THERMAL STABILITY

Petro-Canada HT Severely Hydrocracked lubricants demonstrate excellent thermal stability. This leads to reduced deposits and cleaner equipment internals, compared to many Solvent Refined lubricants. Petro-Canada product lines that exploit this feature include *CALFLO™ Heat Transfer Fluid*, *COMPRO™ XL-S Compressor Fluid*, *Automatic Transmission Fluid*, etc.

• REDUCED ENVIRONMENTAL IMPACT

Petro-Canada HT Severely Hydrocracked base oils have very low toxicity and can biodegrade faster than many Solvent Refined lubricants of comparable viscosity, due to a virtual absence of impurities. When carefully formulated with selected additives, these features are preserved in finished lubricants. Applications where these features may be found include:- *Petro-Canada PURITY™ FG Food Grade Lubricants*, *ENVIRON™ MV Hydraulic Oil*, *PARAFLEX™ HT Fluids*, *SEPRO™ XL*, etc.



QUALITY ASSURANCE – SECOND TO NONE IN THE WORLD

ISO 9001 REGISTRATION

ISO 9001 is the global standard for documenting quality control throughout an entire manufacturing and business process. It is administered by the International Organization for Standardization (ISO), a Swiss based organization that sets rigid standards for a very wide range of products and services.

ISO 9001 is an international standard that adopts a process approach to quality management and business. It promotes a focus on customer quality requirements, enhancing customer satisfaction, and achieving continual improvement through the use of setting measurable objectives and targets.

Petro-Canada Lubricants earned the distinction of being the first lubricants manufacturer in North America to be ISO 9001 registered. To be registered, the ISO 9001 process requires a thorough inspection of a company's production and control systems by an independent registrar. Stringent audits are conducted to ensure detailed procedures are rigidly adhered to and all products are manufactured consistently in accordance with established standards. Following registration, twice yearly audits are conducted by the registrar to ensure ongoing compliance and improvement.

ISO/TS 16949 REGISTRATION

In March 1997, Petro-Canada became the first Canadian lubricant manufacturer to receive QS9000 certification. Developed by Chrysler, Ford, General Motors, and the North American truck manufacturers, the goal of QS9000 was the creation of fundamental quality systems to provide continuous improvement with an emphasis on defect prevention and the reduction of variation and waste in the supply chain.

In October 2002, Petro-Canada Lubricants opened the door to the global market by being the first lubricants manufacturer in the world to be registered to ISO/TS 16949. This new global standard, which replaces QS9000, is designed for third party suppliers to the automotive companies. This strongly demonstrates Petro-Canada's ability to continuously improve our quality system. ISO/TS 16949 was jointly developed by ISO and the IATF (International Automobile Task Force) and contains all requirements of ISO 9001 and additional automotive requirements.

ISO 14001

ISO 14001 is an internationally recognized approach to Environmental Management. It is a disciplined approach to identification, prioritization, and management of environmental impacts resulting from business operations, and as member of the ISO family of International Standards, provides a consistent set of operating guidelines.

ISO 14001 differs fundamentally from ISO/TS 16949 and ISO 9001. While these programs provide guidelines to address customer needs and expectations in terms of quality of product/service, ISO 14001 focuses on the protection of the natural environment and protecting people from environmental impacts. It is more rigorous than the environmental elements prescribed in Petro-Canada's Total Loss Management (TLM) Standard.

Petro-Canada Lubricants has chosen ISO 14001 as the foundation for its Environmental Management System due to its wide recognition and global acceptance. ISO 14001 principles are in line with Petro-Canada's internal TLM philosophy.