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# 1 | St Towa Recycling Technology

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**Turning Waste Problems Into Energy Solutions**

## SUCCESSFULLY CONVERTING PLASTIC WASTE & END-OF-LIFE TIRES TO VALUABLE FUEL

Chain Finance Waste Solutions provides jointly with St Towa (Japan) & ERI Bio Solution (Korea) an efficient and effective way for converting potentially hazardous plastic wastes and end-of-life tires into valuable energy and commodity resources. Mainly diesel fuel & fuel oil.

By recycling non-degradable plastic wastes and tires, and by converting hard to recycle low-value plastic and tires into high-value oil and by-products, St Towa's conversion technology provides practical solutions to two of the world's greatest environmental challenges:

- It helps redirect these waste streams, preventing them from entering local landfills.
- It increases energy resources by converting them to diesel fuel &/or fuel oil.

Chain Finance Waste Solutions mission & mandate are:

★ To apply the best-of-class technology and process to recover energy and resources from waste plastic and tire streams.

★ To build and operate plants that are not only "green" but extremely profitable, and which produce easily marketable high quality commodities that have a worldwide demand.

## KEY INFO & FIGURES

Sector:
**Waste-to-Energy**
**Plastic Waste &/or End-Of-Life Tires Oil Recovery**

1 Ton Plastic Waste =
**800 L Diesel fuel + 200 kg Carbon black**

1 Ton End-Of-Life Tires =
**575 L Fuel oil + 350 kg Carbon black**
**+ 150 kg Steel scrap**

Plant Processing Capacity:
**3,000 to 11,000 tons of feedstocks yearly** depending on furnace capacity (6 or 8 tons) & on number of furnaces (1 or 2 per plant)

Turnkey Plant Investment / CAPEX:
**USD 2.8 to 5 million** depending on plant processing capacity

Yearly Sales:
**USD 1.75 to 5 million** depending on plant capacity, on feedstocks processed and on international & local fuel prices

Source of Revenue
**The sale of diesel fuel, fuel oil & other valuable commodities** recovered via pyrolysis conversion from the waste stream

IRR & ROI:
**High**

**High volume feedstock processing capacity. High conversion efficiency. Low operating cost.**

**High quality diesel fuel and fuel oil produced. No additional refining required. Low sulfur diesel and fuel.**

**Proven technology. Existing plants operating successfully for years in Japan & Korea.**

**Proven economically. Cost effective technology. A viable alternative to conventional recycling of waste plastics and tires.**

**Safe & eco-friendly process. Zero-pollution conversion technology & zero-waste philosophy.**

**Processes unwashed & unsorted waste plastics, composites and mixed materials of different kinds and sizes.**

**Multiple feedstock types. Converts plastics, tires & various kinds of solid industrial wastes.**

**Proven team. Takes overall responsibility for the project, hands over turnkey installation & sets-up operations.**

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## II- Drivers For St Towa Oil Recovery Plant

### A Breakthrough Approach To Plastic & Tires Recycling.
### A commercially viable alternative to traditional methods of recycling waste plastics and tires

Plastics and tires recycling has continued to grow worldwide over the past few decades.

Usually waste plastics are recycled to produce renewed plastic products or resins.
And scrap tires are recycled to produce / manufacture crumb rubber which is used as a feedstock in the production of finished goods. Or they are simply crushed as for supplemental fuel of boiler or cement kiln.

While reuse and recycling are the preferred methods of plastics and tires recovery, it was not always proven economically feasible - or even possible - for all plastics to be recycled, illustrating the opportunity for other economical means of recovering plastics and tires.

Because they are derived from hydrocarbons, plastics and tires have a high energy content that can be converted to crude oil and fuels.

However, conventional methods / plants related to producing oil from waste plastics and scrap tires that have been operating have proven insufficient due mainly to the poor quality of oil recovered / recycled and/or to technical problems (ignition and explosion). Moreover, most of the time, the investment for such conventional plants is quite high and the return low (requiring therefore subsidies from local governments / authorities to be profitable).

**St Towa's breakthrough technology clears all these issues of conventional recycling and oil recovering plants. Their competitive advantages are namely the quality of oil produced, its high-volume processing capacity, its conversion efficiency, the capability to use multiple kinds of solid waste as feedstock, its low operating cost and the small investment size required.**

## II- Drivers For St Towa Oil Recovery Plant

# The Global Plastic Problem
# The Scope of the Global Plastic Problem - Why to recycle plastics?

- ★ Plastics play an important role in our daily life yet proper management of plastic waste streams has not been adequately addressed.
- ★ The result has led to the world being confronted with an enormous waste plastic problem — one that continues to grow every day.
- ★ Compared to other waste streams, such as paper or metals, the rate of plastics recovered for recycling is relatively low.
- ★ We currently recover only 5% to 8% of the total plastic waste and most of that is PET (#1 - plastics bottles, textiles, etc.) and HDPE (#2 - films, plastic bags, cosmetic bottles, etc.).
- ★ What happens to the rest of it? Roughly 50% is buried in landfills, some is remade into durable goods, and much of it remains “unaccounted for”, lost in the environment (where it ultimately washes out to sea).
- ★ Unlike paper, cardboard, and other biodegradable organic materials entering the landfill, plastic does not significantly break down over time. While organic waste decomposes to produce methane and carbon dioxide gas that can occasionally be harvested and used as an energy source, plastic carries no such benefit.
- ★ Although diverting waste may reduce the amount of plastic waste in landfills and prevent a rise in the number of future landfills, the burning of waste generally results in the high emission of toxic and greenhouse gases such as methane.

**Reduce, Reuse, Recycle and Recover (the energy) of plastics are essential to make environment greener and safer.**

## The Global End-Of-Life Tires Problem. Why to recycle tires?

★ Tires are among the largest and most problematic sources of waste, due to the large volume produced, their durability, and the fact they contain a number of components that are ecologically problematic.

★ For many years end-of-life tires have been accumulating in landfills, illegal stockpiles, vacant lots, fields, abandoned buildings and roadsides. These stockpiles can pose a serious threat to public health and safety, as well as to the environment.

**Landfill disposal:**

Tires are not desired at landfills, due to their large volumes and 75% void space which quickly consumes valuable space, and to the environment problems they create. Buried tires trap air and/or methane gas, causing tires to "float" / "bubble" to the surface. Which can result in expensive damage to landfill cover and containment systems.

**Tire stockpiles & "dumps"**:

Large stockpiles have the potential for large fires that are tremendously detrimental to the environment and extremely hard to extinguish once started.
Fires may burn for months all the while creating acrid black smoke and toxic liquid runoff that is released into surrounding water and soil.
Attempts to extinguish fires by conventional means can actually increase the damage.

## End-Of-Life Tires Management Strategies (until now)

Solutions for end-of-life tires are ranked in terms of the 3R hierarchy:

**1- Reuse -** Some tires find their way "as is" into domestic second-hand markets. Others, particularly medium truck tires, are retreaded first. About 10% of scrap tires from industrialized countries are sold as second-hand tires in less developed regions.

**2- Recycle -** Most recycling efforts involve the manufacture of crumb rubber which is used as a feedstock in the production of finished goods.

**3- Recover (energy)** - More than half of recovered scrap tires are used as tire-derived fuel (TDF) burnt in cement kilns, pulp mills and other industrial plants.
Even in advanced countries like Germany and the US, 55% are simply burnt for their fuel value.
But the use of TDF is controversial because "atmospheric contamination dramatically increases when tire rubber is used as the fuel."

## III- The Pyrolysis Conversion Technology

### St Towa's pyrolysis technology converts difficult-to-recycle waste plastics and end-of-life tires into valuable diesel and fuel (and other commodities).

**What is Pyrolysis? / the conversion technology of pyrolysis, referred to here as —plastics-to-oil or —PTOll technology?**

Pyrolysis is a process of thermo-chemically decomposition of organic materials by heat in the absence of oxygen which produces various hydrocarbon gases.

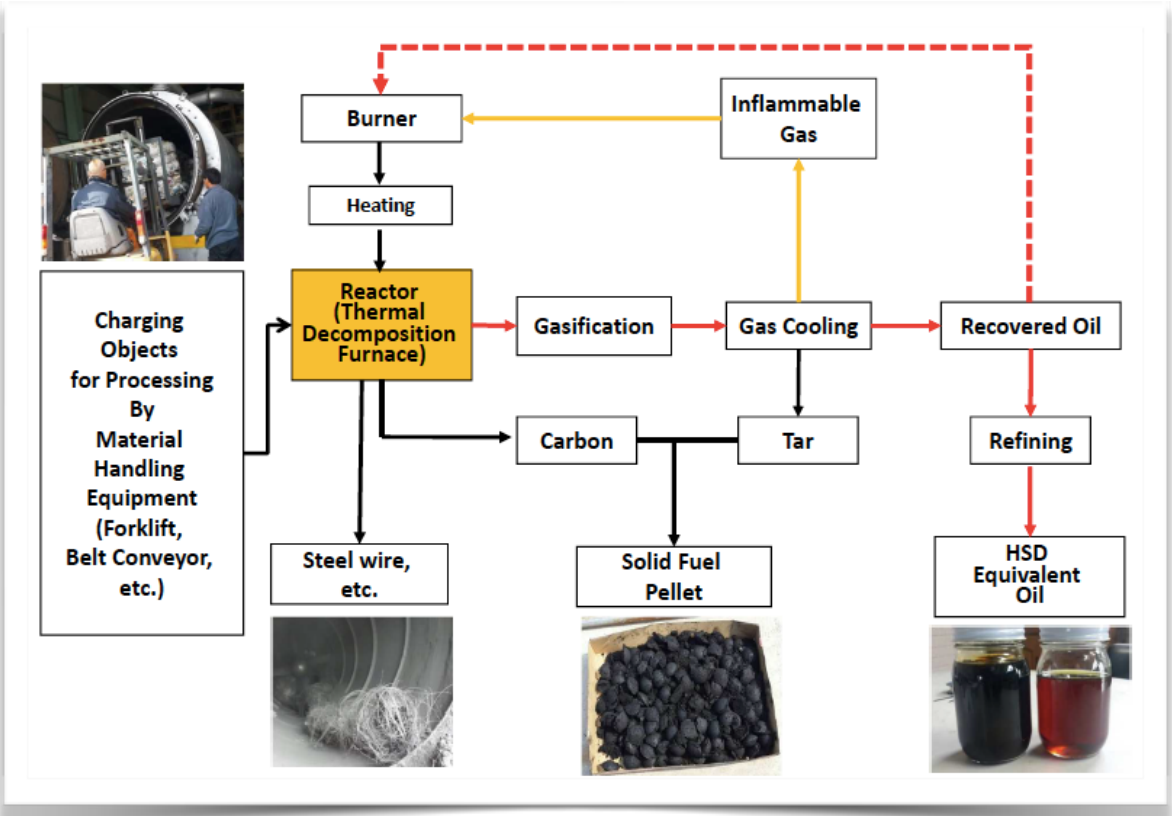
**Plastic Pyrolysis**

Non-recycled plastics (NRP) are converted to synthetic fuel oil by means of thermal treatment.
The basic steps of the process are:

- First the non-recycled plastics (NRP), which can be mixed plastics, is collected and loaded in the reactor;
- Then heat converts the plastics to a gaseous state and any non-plastic materials (char) are removed;
- Finally, the gas is distilled into a liquid (fuel) and either sold as is, or further refined into other petroleum products before entering the market.

**Tire Pyrolysis**

The pyrolysis process heats whole or shredded tires in the reactor.
The rubber is softened after which the rubber polymers break down into smaller molecules. These smaller molecules vaporize and exit from the reactor. These vapors are condensed into an oily type liquid, used as a fuel.
Some molecules are too small to condense. They remain as a gas which can be burned as fuel. The minerals that were part of the tire, about 40% by weight, are removed as scrap steel.



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## IV- What Makes Our Conversion Technology Different?

**A technology that clears all the issues of conventional recycling and oil recovering plants.**

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### 1- High conversion efficiency - High Yields

★ 1 ton **plastic waste** = **800 Liters** diesel fuel + **200 kg** carbon black

★ 1 ton **EOL tires** = **575 Liters** fuel oil + **350 kg** carbon black + **150 kg** steel scrap

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### 2- High Quality Diesel Fuel & Fuel Oil Produced

★ No additional refining required
★ Hi-Speed Diesel & Fuel oil
★ Low-sulfur and high cetane value diesel fuel; and low-sulfur fuel
★ High quality, valuable & marketable commodities that have a worldwide demand

### 3- Proven technology. Existing commercial plants operating

★ 4 plants operating in Japan and Korea
★ Japanese Technology
★ Solid background.12+ years experience

### 4-Cost effective technology. Proven Economically

★ Small investment size unlike other technologies. From USD 2.8 to 5 million
★ Limited floor area / space needed for the plant < 250 m2
★ High-volume feedstock processing capacity. Up to 16 tons per batch

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### 5- Safe & Eco-friendly process. Zero-pollution conversion technology & zero-waste philosophy

★ Waste free
★ Odor & smoke free
★ Polluted water free
★ Small footprint
★ High safety level

### 6- Low operating cost. Unique operational features that save significant operating costs and efforts

★ No pre-treatment necessary / required
★ Energy self sufficient system / technology
★ Only 5 workers needed to process 6 tons of waste per 12 hour batch

### 7- Converts various kinds of solid wastes. Multiple feedstock types capability

★ Plastics (except PVC products)
★ Rubber tires & various kinds of solid industrial wastes made of chemicals can be mixed

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## IV- What Makes Our Conversion Technology Different?

### HIGH CONVERSION EFFICIENCY - HIGH YIELDS

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**1 ton plastic waste = (yields)**

**800 L Diesel Fuel**
**+**
**200 kg Carbon Black or Solid Fuel Pallets**

**70% Hi-Speed Diesel Equivalent Oil (synthetic)**
Hi-Speed Diesel (HSD) is normally used as a fuel for high speed diesel engines operating above 750 rpm. i.e. buses, lorries, generating sets, locomotive, pumping sets etc. Gas Turbines requiring distillate fuels normally make use of HSD as fuel.

**20% Carbon black**
Remaining raw material weight is converted to carbon black or solid fuel pallets.
Calorific value of pelletized solid fuel made of carbon is around 6,000～7,000 kCal which is equivalent to standard coal for boilers.

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**1 ton used tires =**

**575 L Fuel Oil**
**+**
**350 kg Carbon Black**
**+**
**150 kg Steel Scrap**

**50% Fuel Oil**
or LDO (light diesel oil) which is used for diesel engines, generally of the stationary type operating below 750 rpm or for boiler fuel.

**15% Steel scrap**
Tires contain steel wires. Their amount (level) range of 10% to 15% of the total tire weight. All of the (tire) steel is detached after the Pyrolysis recycling process is completed since the rubber part is melted and completely gasified. Valuable steel wires are pressed and sold as steel scrap.

**35% Carbon black**
Remaining 10% can be sold as a carbon black (to the chemical industry). Carbon black is used as raw material or main ingredient in many industries. Its chemical structure strengthens, lengthens the endurance, and improves the coloring features of the materials.

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## IV- What Makes Our Conversion Technology Different?

## HIGH QUALITY PRODUCTS / COMMODITIES

### High Quality Diesel Fuel & Fuel Oil

Low sulfur and high cetane value diesel fuel & fuel oil are produced.

St Towa's Advanced Oil Recovery Technology eliminates wax, paraffin, chlorine content, impurity materials, etc. aiming at increasing quality of oil produced and plant operation efficiency.

As quality oil is produced no polluting material is generated when it is burned.

### No Additional Refining Required

The oil produced does not need any further processing nor to be refined.

### Solidification of Carbon as a Solid Fuel

St Towa's proprietary technology enables Solidification of Carbon as a Solid Fuel.

The sludge generated through the oil recovering process is reproduced as solid fuel by proprietary solid fuel pellet production machine.

The calorific value of the solid fuel pellet is around 6,000～7,000 kCal which is equivalent to coal.

## SAFE & ECO-FRIENDLY PROCESS

### ZERO-POLLUTION CONVERSION TECHNOLOGY

Our technologies and process of converting plastics and tires into fuel are not only efficient, but are also environmentally sound based on a zero-waste and zero-emission philosophy.

### Waste Free

No residue or wastes are generated after processing of waste products. All wastes are effectively used or sold to relevant market(s).

### Odor & Smoke Free

No smoke and no odor come out of the plant *because of* St. Towa's technology and philosophy of zero waste.

### Polluted Water Free

No polluted water comes out from the plant since no cleaning / washing of feedstock is needed / necessary .

## HIGH SAFETY LEVEL

Unlike other conventional oil recovering plants where risks of ignition and explosion due to a high temperature and pressure are likely to happen, St Towa has designed, developed and manufactured special furnace operated under low temperature and pressure that eliminates the danger of ignition and explosion.

More generally St Towa converts plastic waste &/or end-of-life tires into fuel and develops, designs and manufactures the equipment used in the pyrolysis conversion process. They observe the highest standards of safety, quality, reliability and environmental sustainability in all of their manufacturing and conversion operations.

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## IV- What Makes Our Conversion Technology Different?

### LOW OPERATING COST

**Unique technical and operational features that save significant operating costs and efforts:**

#### Energy Self Sufficient

Self-standing energy recycling system that eliminates the cost of fuel to heat the furnace(s). 100 % of the energy needed for the process is produced by the recycling operation from the recycled waste.

#### Limited Number Of Workers Needed

The plant requires only 5 workers to process 6 tonnes of waste plastics or tires per batch.

#### No Pre-Treatment Of Plastic Feedstocks

Unlike other recycling systems in use today, the system does not require any pre-processing of feedstock.

The waste products are processed as received. No selection needed. Accepts / processes unwashed, unsorted waste plastic, composites and commingled / mixed materials of different kinds and sizes such as rubber, plastic, metal, glass, organic materials, etc.

*Note: PVC products are to be eliminated from mixed feedstock.*

### MULTIPLE FEEDSTOCK TYPES CAPABILITY

Processes and converts plastics (including waste vinyl products), rubber tires & various kinds of solid industrial wastes made of chemicals. Except PVC products.

### COST EFFECTIVE TECHNOLOGY. PROVEN ECONOMICALLY

Unlike conventional plants / methods currently operating which require considerable investments, St Towa / ERI Bio Solution's CAPEX for a turnkey plant processing 9 to 12 ton daily feedstock is less than USD 3 million.

Notes:

- In case of bulky waste, pre-shredding is recommended.
- The raw material weight is max. 1.7 tons per batch when scrap tires are not crushed before charging into furnace.

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## IV- What Makes Our Conversion Technology Different?

### PROVEN TECHNOLOGY. EXISTING COMMERCIAL PLANTS OPERATING

#### Plants operating in Japan and Korea since 2005

**☑ 2018**
**>** Handing over the world's first 20 ton continuous waste plastics recycling plant to Korea Power Company (KEPCO), the largest electric utility company of South Korea

**☑ 2017**
**>** Commissioning of Obihiro, Hokkaido, Japan plant. Capacity of 6 tons per batch per 10 hours

**☑ 2012**
**>** Commissioning of Tondabayashi, Osaka, Japan plant. Capacity of 6 tons per batch per 10 hours

**☑ 2008**
**>** Commissioning of Jeoun Eub, Jung Eub, Jeollabuku-do, Korea plant. Capacity of 10 tons per batch per 10 hours

**☑ 2005**
**>** Commissioning of Hongcheon-eup, Hongcheon-gun, Gwanguon-do, Korea plant. Capacity of 10 tons per batch per 10 hours

#### A Japanese Technology

With a very large population (over 125 million) but very limited space, Japanese industry was forced to confront the problem of too much waste many years ago and as a result, many of the leading waste management technologies have emerged from Japan. It soon became clear that waste materials should no longer be considered worthless and sent to landfill sites, but should be viewed and treated as a valuable resource.

#### Solid Background: 12+ Years Experience

The technology applied for the conversion process of waste plastics and tires to diesel equivalent fuel has been developed based on accumulated experiences of research and development of a technology that converts raw garbage into forage in Japan.

The research and development efforts of the engineers of both St. Towa (Japan) & ERI Bio Solution (Korea) in the past 12 years resulted in the successful completion of the current Solid Hydrocarbon Waste Recycling Plant.

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## V- TURNKEY SOLUTION

### "WE BUILD & OPERATE"

Jointly with ACE Japan and our partners we provide project development, project management and project financing from a single source.
Our services can cover the entire process, from providing the technology to engineering to financing to turnkey handover to operating.

### Project Development

We put the project on a solid basis with feasibility studies, market analyses, a business plan and the search for strategic investors.

**Project Developer:**
- ★ Develops project concept
- ★ Provides market analyses
- ★ Provides preliminary works and feasibility studies
- ★ Searches for strategic investors

### Project Management / EPC

Jointly with our partners we (can) take on overall responsibility for the project, as the EPC Contractor managing the engineering, procurement and construction of the plant through to startup. This also includes setting-up operations and handing off the turnkey installation to the customer / investor.

**Project Management / EPC:**
- ★ Provides basic / detailed engineering
- ★ Provides waste recycling engineering and expertise
- ★ Provides global procurement
- ★ Plant construction
- ★ Coordination of partners
- ★ Commissioning

### Project Financing

The success or failure of projects is determined by financing. Our competencies in this area represent a clear competitive advantage because we combine financing with operational responsibility.

We focus on three different types of financing: structured financing, financing of equipment and working capital financing (payables and receivables).
We mediate bank financing with banks that are associated with us. We arrange and secure export financing from Korea Eximbank - to support the purchase of equipment.

Korea Eximbank
THE EXPORT-IMPORT BANK OF KOREA

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## VI- ST-06 | 1 Furnace Plant Technical Specs

| | |
|---|---|
| ★ Target Feedstocks: | Waste products made of hydrocarbon such as Waste Plastics, End-Of-Life Rubber Tires, Waste Electric Appliances, Waste Cable, Waste Vinyl, etc. |
| ★ Needed Floor Area required for the plant: | 18 m x 12 m = 216 m2<br><br>Note: Some open space is needed for stockpiling or storing feedstock materials nearby the plant. Its required area depends on the operation plan of the plant and on local conditions of delivery of such feedstock. |
| ★ Total Gross Weight:: | Approximately 40 tons. |
| ★ Total Gross Volume: | All components of the plant can be contained in 4 to 5 40-footer containers for transport. |
| ★ Inner Volume of Furnace: | 20 m3 |
| ★ Maximum Processing Capacity: | 6 tons per batch and per furnace. |
| ★ Processing Time: | Furnace net processing time: 8 to 10 hours per batch, depending on feedstock.<br><br>Batch overall processing time: 12 to 15 hours per batch, depending on feedstock. |
| ★ Power Consumption: | Approximately 25 kWh for plastics up to 80 kWh for tires when end-of-life tires are crushed before / prior to being loaded into furnace to maximize the processing volume per batch. |
| ★ **Extension Possibility:** | **A second furnace can be added that will double the processing capacity (tandem furnaces).** |

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## VII- Diesel Oil & Fuel Oil Specs

| Test Items | Test Method | Unit | Waste Tire | Waste Plastic (produced) | Waste Plastic (cleaned) |
|---|---|---|---|---|---|
| Pour Point | JIS K 2269 | °C | -7.5 | -2.5 | -2.5 |
| Flash Point | JIS K 2265 | °C | <2.0 | <2.0 | <2.0 |
| Kinematic Viscosity | JIS K 2283 | mm2/S | 1.563 | 1.438 | 1.326 |
| Density | JIS K 2249 | g/cm3 | 0.8652 | 0.8571 | 0.8406 |
| Distillation Character | JIS K 2254 | | | | |
| Beginning | | °C | 66.0 | 67.0 | 71.5 |
| 5% outflow temperature | | °C | 107.5 | 110.5 | 111.0 |
| 10% outflow temperature | | °C | 120.5 | 121.5 | 121.0 |
| 20% outflow temperature | | °C | 136.0 | 133.0 | 131.5 |
| 30% outflow temperature | | °C | 148.0 | 141.5 | 139.0 |
| 40 outflow temperature | | °C | 161.0 | 147.5 | 149.0 |
| 50% outflow temperature | | °C | 183.5 | 170.5 | 162.0 |
| 60% outflow temperature | | °C | 213.0 | 202.0 | 191.0 |
| 70% outflow temperature | | °C | 251.5 | 242.0 | 241.0 |
| 80% outflow temperature | | °C | 298.5 | 319.0 | 293.5 |
| 90% outflow temperature | | °C | 346.0 | 360.0 | 345.5 |
| 95% outflow temperature | | °C | 362.0 | - | 360.5 |
| Ending | | °C | 364.5 | - | 362.0 |
| Total Outflow Volume | | vol% | 98 | 96 | 97.5 |
| Residual Volume | | vol% | 1.5 | n.a. | 1 |
| Lost Volume | | vol% | 0.5 | n.a. | 1.5 |
| Plugging Point | JIS K 2288 | °C | -2 | -1 | -2 |
| 10%Residual Carbon | JIS K 2270 | mass% | 2.31 | 2.41 | 0.98 |
| Cetane Index | JIS K 2280 | - | 31.3 | 30.7 | 29.7 |
| Sulfur Content | JIS K 2541 | mass ppm | 0.49 | 0.11 | 0.16 |
| Calorific Value | JIS K 2279 | kJ/kg | 40,870 | 40,470 | 41,810 |
| Date of Analysis | | | 1/3/2014 | 5/3/2014 | 3/4/2014 |