

TRENDS 2018

Base Stocks

Performance you can rely on.



In base stocks, we explore the trends related to the largest component in engine oils.



Recent base stock market trends continue

0.2%

Low
finished
lube
demand
growth



Demand
for low
viscosity
lubricants

>200K
b/d

Grp II/III
capacity
additions
in past
5 years



Global
supply
demand
imbalance
continues

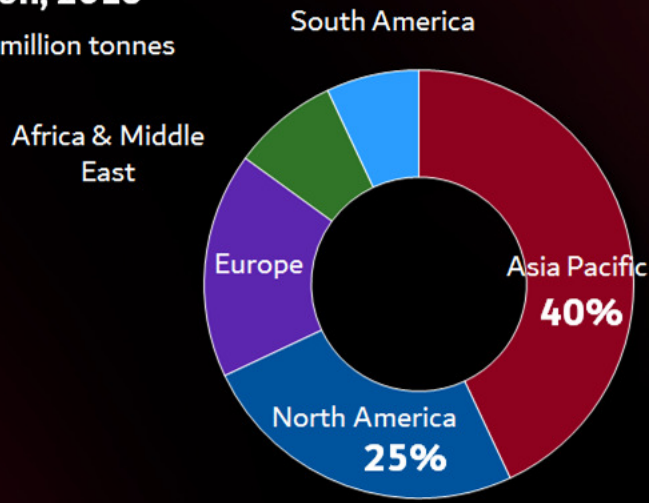
The base stock market continues to follow the evolutionary path we have seen in recent years. The finished lubricants market is growing slowly globally, with some regions experiencing a more robust growth, and the requirements are continuing to shift toward lower viscosities and higher performance to meet the demands of newer engines and fuel economy. Capital investment is occurring to meet the evolving quality requirements and the changing regional demands, and this is causing a global imbalance in supply and demand for both grades and quality levels. The expectation is that this dynamic will continue as we look into the future.

Global Finished Lubricant Demand



By Region, 2016

Total 39.6 million tonnes



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Base stock demand ~260 million bbl

Chart Source: Kline & Company

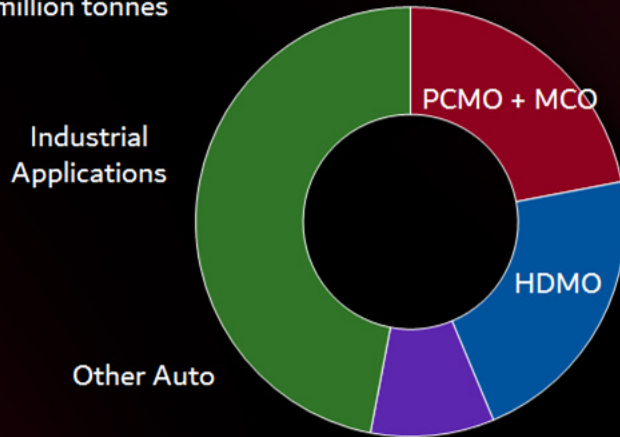
In 2016 global demand for finished lubes was reported to be nearly 40 million tons. At more than 40%, Asia represents the largest demand while North America accounted for 25%.

Global Finished Lubricant Demand



By Product, 2016

Total 39.6 million tonnes



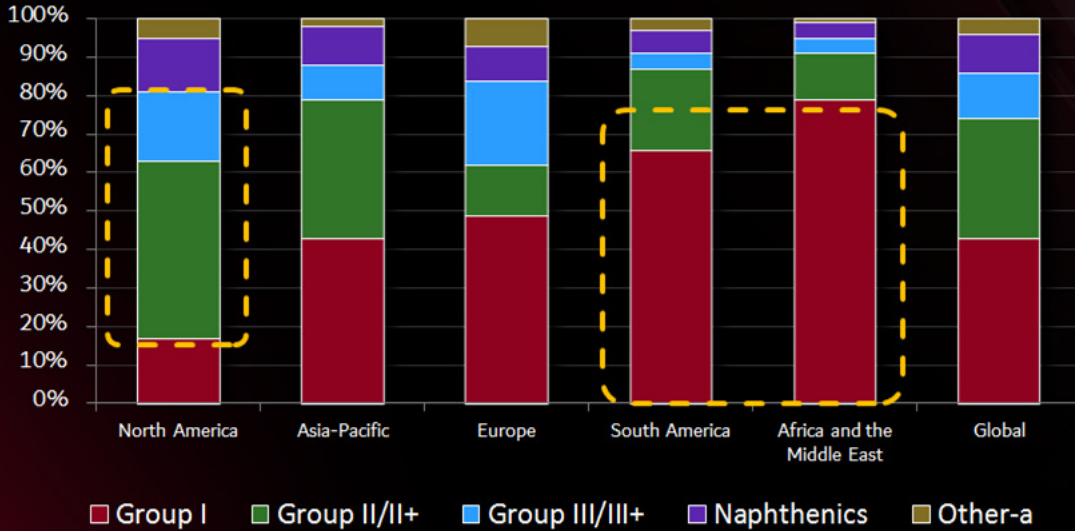
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Base stock demand ~260 million bbl

Chart Source: Kline & Company

Considering the end application breakdown, the Automotive sector consumes about half of the total volume with the rest used in Industrial applications. This translates into a base stock demand of around 260 million barrels.

Share of API Groups in the Overall Demand by Region, 2016

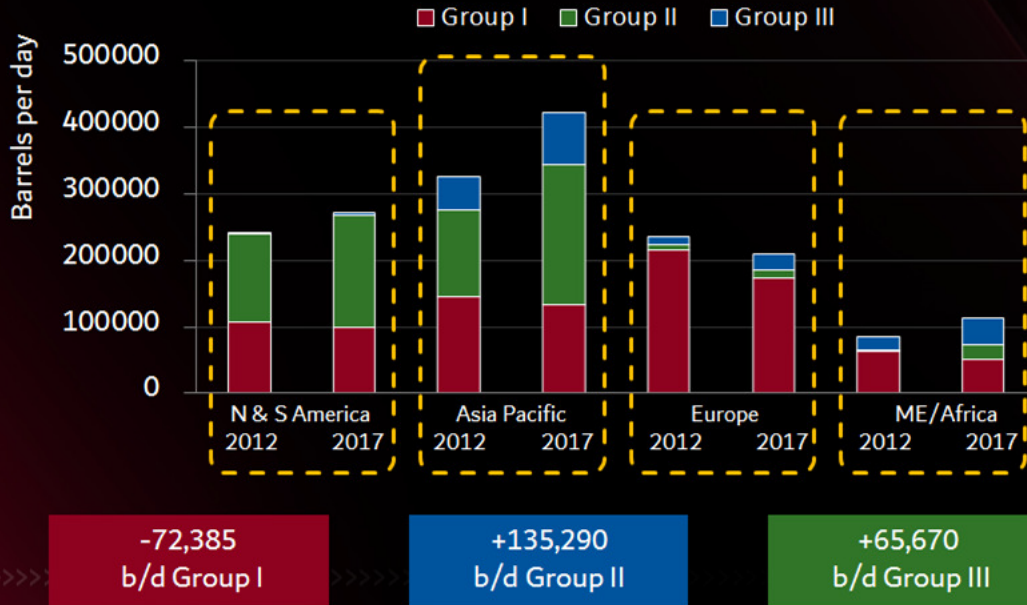


■ Group I
 ■ Group II/II+
 ■ Group III/III+
 ■ Naphthenics
 ■ Other-a

a- Includes Group IV and Group V base stocks, but excludes naphthenics | Source: Kline & Company

Base stock quality level demand varies significantly by region, and even by country within some regions. Group I base stock is the majority of the demand in South America, Africa and the Middle East while... North America is predominantly Group II and Group III. However, worldwide, emissions reductions, have been driving down use of Group I in automotive formulations and increasing the demand for higher quality base stocks.

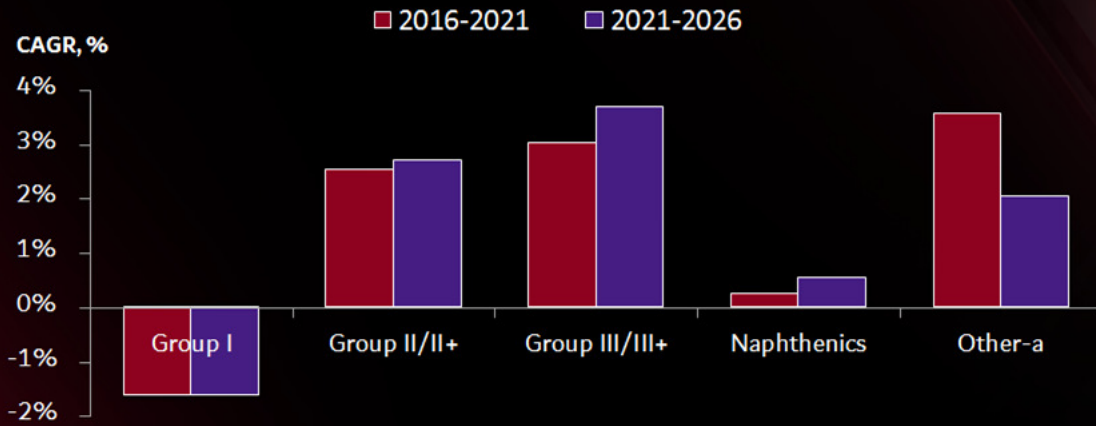
Changing Global Base Stock Nameplate Capacity



Data Source: Lubes'n'Greases 2012, 2017 Global Guide to Base Oil Refining

To meet demand, regionally there have been both rationalizations and investments in the past 5 years. In North America, Chevron has made a major investment in additional Group II capacity. Europe saw the removal of over 40,000 b/d of Group I and the addition of Group III capacity in Russia and Spain. Asia experienced the greatest growth, in Group II and III, primarily in China and South Korea. In the Middle East, significant Group III additions have come on stream in Qatar and the UAE. You can see that the greatest growth in capacity worldwide has been in Grp II.

Global Lubricant Base Stock Demand Growth Rates by API Group, 2016 to 2026



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Strongest demand growth in Group III/III+
decline in Group I demand continues

a-Includes Group IV and Group V base stocks, but excludes naphthenics | Source: Kline & Company

In the future, we expect the recent base stock demand trends to continue, as lubricant requirements trend toward even lower viscosities and improved oxidative and deposit control performance.

Recent Trends Expected To Continue

Tony Jin | Vice President, Global Base Oil Marketing, SK Lubricants

Tony Jin of SK Lubricants shares his observations in base stock trends.

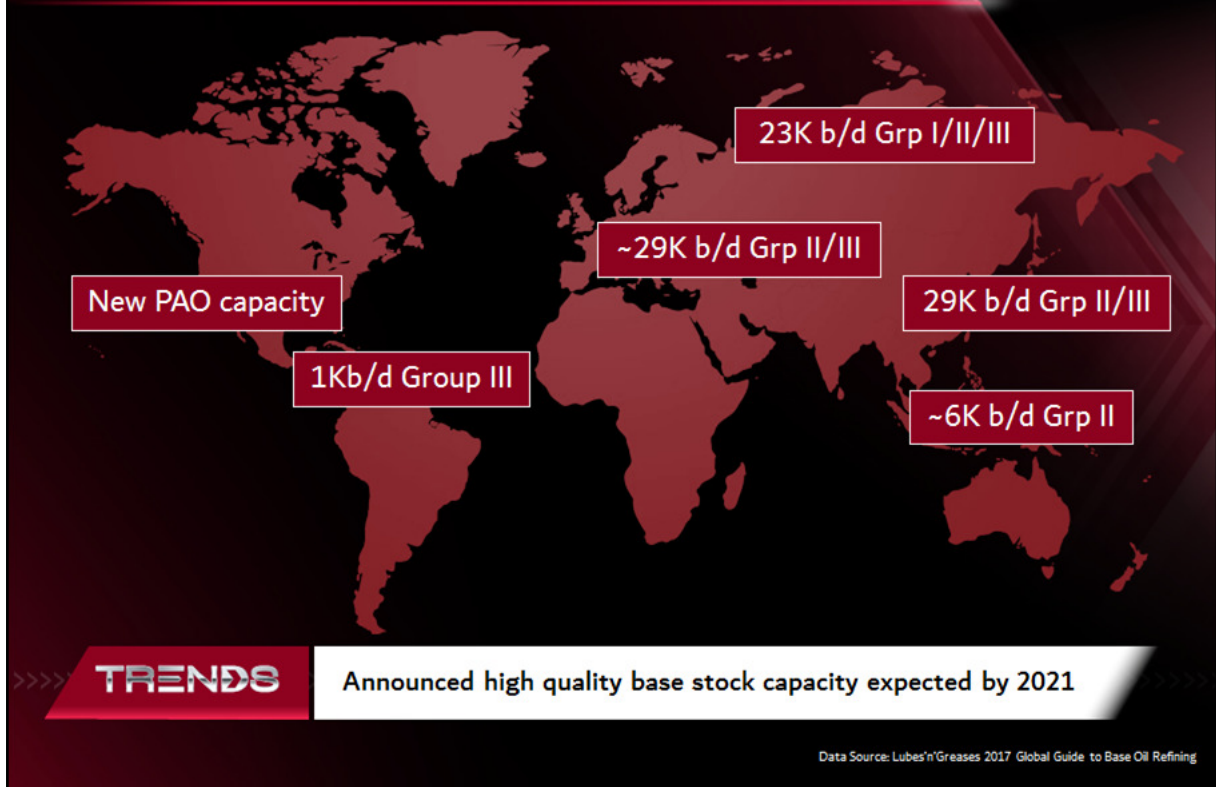
Tony Jin: "I think the trend of transitioning to Group III will also continue in the future. The transition to API Group II/III base stocks has been going on for decades with the rapid replacement of Group I base oils. I think this can only continue due to the market trend toward lower viscosity lubricants. Also, we expect more Group III base stocks will find their place in HDDO applications as demand for lower viscosity HDDO increases. I believe these changes will accelerate the transition of Group I/II to Group III base oils.

Evolving Directions for Group II with Lower Viscosity Grades

Richard Dougherty | Distinguished Research Associate, ExxonMobil Research and Engineering

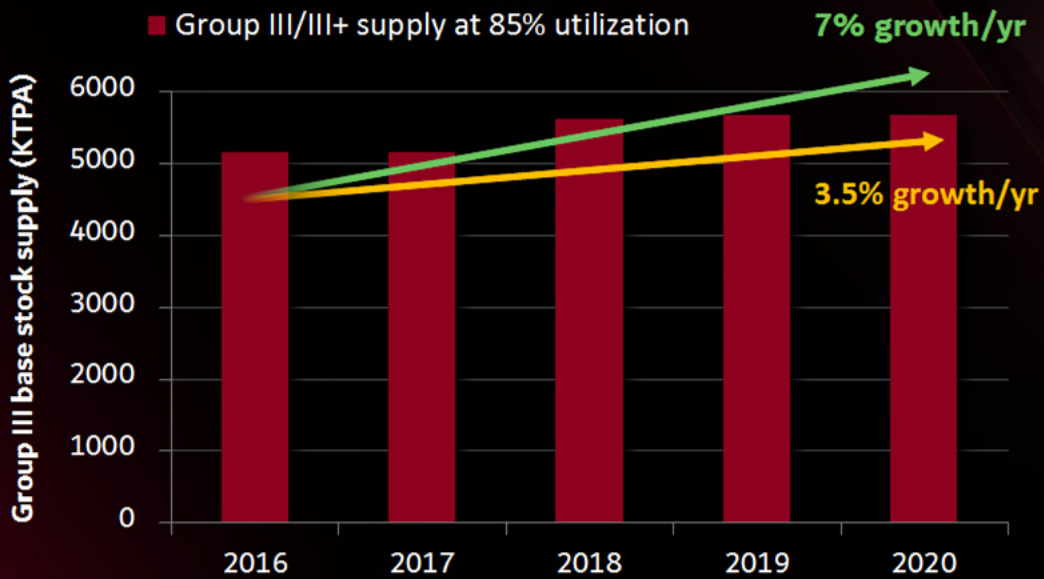
Richard Dougherty: “Chemical limits and more stringent oxidation and deposit tests have driven modern engine oils to be formulated with hydroprocessed or chemically synthesized base stocks. We believe Group II stocks will continue to be the industry “workhorse” capable of mainline and premium crankcase products which constitute most of the global demand. Very low viscosity grade engine oils have traditionally been the purview of Group III and Group IV base stocks. However, with improvements in dispersant technology, and the shift to lower high temperature, high shear oils, which require less viscosity modifier, we are seeing increased opportunity to formulate high-tier low viscosity oils with a significant fraction of high quality Group II base stock. For example, high quality Group II slates permit the formulation of 10W-30 heavy duty engine oils without Group III, and can be used as a cost reduction co-base in 0W-20 North American and 5W European PCMOs.”

Major Capacity Additions 2018-2021



And, to meet this anticipated demand, further capacity additions have been announced through upgrades, expansions and new projects. Major investments include: Group II capacity additions by ExxonMobil in Rotterdam and Singapore and by Rosneft and Gazprom in Russia. China is also seeing new projects and expansions. For PAO, INEOS is expected to start up a new plant in the US in late 2019 and Chevron is completing a 20% capacity expansion in the US.

Group III Supply/Demand



Source: Norman Sheppard, Bahrain

Group III demand has been growing in several regions and a number of new investments are coming on stream. North America has seen several new Group III suppliers enter the market in the past 12-18 months, but is this a short term or longer? According to one forecast shared at the ICIS base oil conference in NA, the nature of the supply demand balance hinges on assumptions on global demand growth rate, resulting in either long or short supply situations of Group III.

Group III Supply/Demand Will Remain Tight

Tony Jin | Vice President, Global Base Oil Marketing, SK Lubricants

Again, Tony Jin of SK comments on Group III Supply.

Tony Jin: "SK Lubricants' internal analysis shows that Group III global supply and demand is currently still tight. The Group III market has become much larger than expected and is forecast to grow at a fast pace in the future as well. Therefore, I expect these market conditions to continue for the time being. SK believes it is the right time to consider investing in new facilities to meet the rapidly increasing Group III demand."

Re-Refined Base Stocks

Re-refined base stocks fill niche applications

- Cost effective base stock option
- Municipal and military bids

Re-refined base stocks have lower carbon footprint

- Less emissions in production
- Reduction in disposal



With the global focus on sustainability and reducing our impact on the environment, the base stock market is no exception. Re-refined base stocks have had a significant presence in the North America for quite some time. They have been seen as a cost effective base stock option for many lubricant marketers and have been a requirement of participation in certain municipal and military bids. Work carried out by the US Department of Energy has reported that one gallon of lubricating oil can be produced from either 1.6 gallons of recycled oil or 67 gallons of crude oil. As sustainability becomes an increasingly important factor, our expectation is that re-refined oils will make their way into more NA applications and will become an increasing presence in the other regions as well.

What is the Future of Re-refined Base Stock?

Josh Frederick | OEM Technical Manager, Valvoline Inc.

Selda Gonsel | Vice President, Global Commercial Technology, Shell

Josh Frederick of Valvoline and Selda Gonsel of Shell shares their views on the future of re-refined base stock.

Josh Frederick: "We don't view re-refined base stocks any differently from any other source of paraffinic base oil. We believe that a base oil ought to be evaluated based upon its properties. In fact, we're less concerned about the source of the base oil than we are about the broad categories that API currently has for base oils."

Selda Gonsel: "Today we use limited amounts of re-refined base oils in our finished lubricants in certain parts of the world. This is limited due to the availability, consistency, and supply quality of the re-refined base oils. Sustainability is a very big agenda item for us. We have very ambitious targets around reducing our carbon footprint, both for our businesses, operations, and also our products. So we are exploring all options that include expanded use of re-refined base oils."

Passenger car increasingly Group III:

- Lower viscosities
- Increasing penetration of low viscosity oils

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Choice of base stock solution is increasingly complex

We saw in an earlier slide that North America is predominantly a Grp II and Grp III market for automotive applications and as the passenger car OEMs continue to move to lower viscosities, the market will drive further toward Group III and even Group III plus. As the need for Group III becomes more prevalent, and with the number of Group III suppliers in the market increasing, the industry will need to decide if there is a need for Group III BOI guidelines.

Development of Group III BOI Will Be Challenging

Selda Gonsel | Vice President, Global Commercial Technology, Shell

Tony Jin | Vice President, Global Base Oil Marketing, SK Lubricants

Selda Gonsel and Tony Jin offer their thoughts on the development of Group III BOI:

Selda Gonsel: “So the industry-wide move towards lower viscosity engine oils in order to support fuel economy mandates will require the use of Group III base oils. I think this will drive the need for developing base oil interchange guidelines for Group III base oils. And this is a challenging and an important subject that requires the collaboration of the industry to move us forward.”

Tony Jin: “A full evaluation of the Group III BOI guidelines should involve replacing and using each of the different base oils. This is what must be done to demonstrate with data that the individual OEM and industry specifications can be met. However, as you know, it is very difficult to reach agreement on who will lead and who will bear the cost of these investments. Therefore, I think a lot of time will be needed before discussions are begun in earnest.”

**Passenger car increasingly
Group III:**

- Lower viscosities
- Increasing penetration of low viscosity oils

**Increasing base stock
portfolio complexity**

- Base stock economics
- Claims availability
- Plant operations complexity

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Choice of base stock solution is increasingly complex

Lubricant marketers will be faced with a difficult balancing act. The lack of base oil interchange and the significant spread of base stock characteristics within the group will force the marketers to balance a number of elements: base stock economics, claims availability, supply reliability, and plant operations complexity. This is certainly achievable, but challenging.

Large Number of Group III Suppliers Increases Complexity

Kent Morris | President, Pinnacle Oil Holdings, LLC

Richard Dougherty | Distinguished Research Associate, ExxonMobil Research and Engineering

We close Base stocks with Kent Morris of Pinnacle Oil and Richard Dougherty of ExxonMobil providing his perspective.

Kent Morris: “For Pinnacle Oil and our customer base, the expansion of Group III base oil providers, while providing some supply chain benefits, has really created more organizational and operational complexity for us. We have a number of customers who have existing commercial Group III relationships, or have formulations that require specific Group III base stocks; as a result, at any given time Pinnacle will have more than five different Group III base oil providers within our facility.”

Richard Dougherty: “Unfortunately, the industry is able to generate interchange reads only on the basis of those base stock slates submitted to the industry for testing. It is a valid question as to whether these reads should encompass all base stocks within a certain API group – particularly those produced by non-traditional processes. We have begun to debate this within the API Base Stock Manufacturers interest group and it’s my hope that for tests subsequent to GF-6, we’ve found a way to assess a broader range of base stocks in the development of interchange guidelines.”

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