The Age of Group II

By Steve Haffner

When *Lubes'n'Greases* was in its infancy, the American Petroleum Institute's base oil groups were just a couple of years old, and API Group I was the base stock of choice for most lubricants. In the mid-1990s, new refining technology was being scaled up that could deliver better base stock performance and more efficient production. These advancements would eventually turn Group II oils into the workhorse that they are today, making up 40 percent of the world's base oil production capacity.

In 1993, the American Petroleum Institute classified base stocks into five groups, with Group I, II and III paraffinic mineral oils categorized by saturates, sulfur and viscosity index. Polyalphaolefins got their own category, Group IV, and Group V encompasses all other base stocks, including naphthenics.

Group II was defined as having saturates greater than 90 percent, sulfur less than 0.03 percent and a viscosity index between 80 and 120. API Group III base stocks have a viscosity index greater than 120.

Chevron's 25,000-barrels-per-day API Group II base oil plant in Pascagoula, Mississippi (Photo: Chevron)

Industry veteran Terry Hoffman, formerly of Sunoco, remarked that the first Group II-type oils appeared in 1971 when the first hydrocrackers were installed in Japan and at the company's Yabucoa, Puerto Rico, refinery. "These initial base oils were introduced using Gulf Oil technology. The early process to make Group II at Yabucoa used furfural solvent extraction to reduce aromatics, then hydrocracking to further reduce aromatics and increase V.I.," he explained.

"Another furfural extraction step [achieved] color stabilization, and finally vacuum distillation was used to cut the material into 40, 50, 70, 100, 170 and 300 [Saybolt Universal Seconds] viscosity base oils." Hoffman noted the early 100 solvent neutral cut only had a viscosity index of 90, which was much lower than the 100 to 110 V.I.—and even higher for oils marketed as Group II+—that formulators see today.

Plants with the new technology could also make base stocks from crude that could not be used by solvent processing refineries.

The next Group II plant started up around 1978 at what is now Petro-Canada's refinery in Mississauga, Ontario, followed by Chevron's Richmond plant in 1984. These early facilities struggled to raise viscosity index in light neutral cuts (SN 100, 150 and 220) without significant reductions in the volumes that the plants could produce.

Viscosity index and pour point are two competing property targets for base oils. Normal paraffins, or waxes, have the highest V.I., but their pour points are prohibitive for base oil applications. To meet the pour point target, solvent dewaxing removes wax from the base oil fractions.

Catalytic dewaxing was also developed in the 1970s to remove wax from oil. It provided an alternative to solvent dewaxing because it separated normal paraffins and waxy side chains from other molecules by catalytically cracking them into light hydrocarbons. In the mid-1980s, Chevron began to develop a selective wax isomerization process. Instead of removing wax molecules as in solvent dewaxing or cracking them into light hydrocarbons as in catalytic dewaxing, the Isodewaxing-branded catalyst and technology isomerizes the wax molecules—rearranging the atoms to form new molecules—into low pour point lubricating base oil.

Launched in 1993 at Chevron's Richmond plant, this new process represented a breakthrough improvement in hydroprocessing technology. "The Isodewaxing catalyst significantly increases lubricant base oil yield over competitive technologies [solvent dewaxing, catalytic dewaxing]," said Bharat Srinivasan, Chevron's managing director of technology marketing. "It also can significantly improve the product's V.I. due to the isomerization of wax, which is the highest V.I. component, into the base oil fraction."

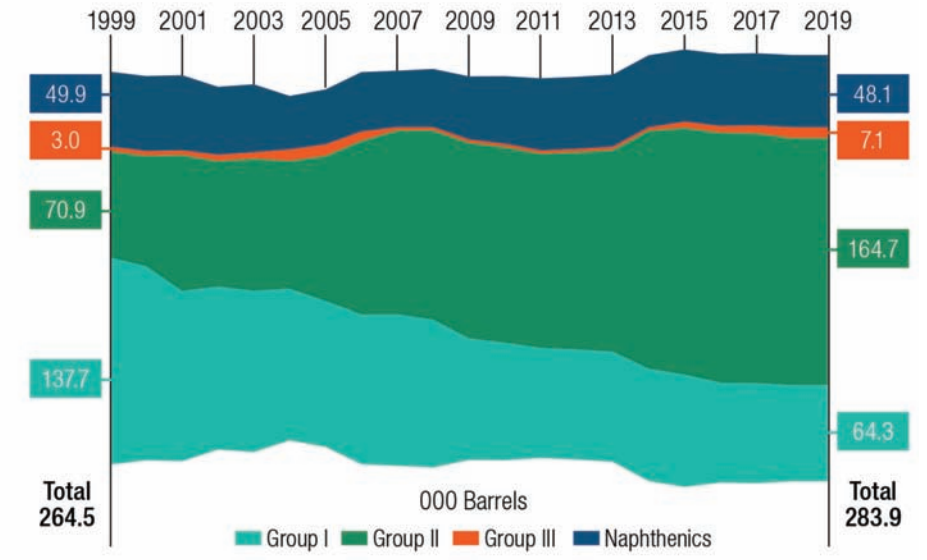
The technology "made it possible for refiners to produce large volumes of higher quality base oil economically," he boasted, which "has led to the steady increase of premium base oil production worldwide."

Brent Lok was a green engineer in the mid-1980s when he began working on the new technology. After it made its debut, "I participated in an internal study team that recommended Chevron license the technology rather than keep it proprietary to advance the overall use of Group II technology in the marketplace," Lok recalled. "It has been quite gratifying to see the phenomenal market growth of Group II and III base oils to where it is today."

Jirong Xiao, Chevron Oronite's vice president of sales and marketing, was also a young engineer on the Isodewaxing project. "No one spoke in terms of Group I or II, as API had not officially classified base stocks back then, but just how we could transform to higher quality base stocks that could extend oil drains and allow for higher quality lubricants," he noted.

Xiao pointed out that lubricant additive companies were also able to take advantage of Group II base stocks. Everyone understood the oils' improved oxidative properties and their ability to yield products at lower viscosity, lower volatility and higher V.I., which enabled better fuel efficiency. But soon the industry found other benefits, such as lower additive treat rates to meet sludge and deposit

North American Base Oil Capacity Shifts



Source: Lubes'n'Greases research. Includes U.S., Canada, Mexico.

requirements as well as the ability to handle soot in diesel engines.

Mike McMillan, former manager of the Lubricant Chemistry and Systems Group in the Chemical & Environmental Systems Laboratory at General Motors R&D, was one of the first on the automotive side of the lubricants business to notice the opportunities brought by Group II base stocks. "GM first took advantage in their factory-fill applications when we had Sunoco and Petro-Canada as key suppliers," he said.

"SAE 5W-30 [engine oil] was rolling out to the marketplace, and Group II base stocks not only facilitated improved fuel economy for that viscosity grade, they also provided a lubricant that had superior oxidation properties and eventually allowed for a step-change in oil volatility from 22 percent to 15 percent Noack when ILSAC GF-3 performance requirements were [proposed] around 1996," McMillan continued.

He also noted that further advances with Group III and Group III+ base stocks later enabled General Motors to move to SAE 0W-20 lubricants with even more stringent oxidation and volatility requirements.

ExxonMobil first began producing Group II base oil in 1997 at its Jurong refinery in Singapore. Those oils made their debut in North America at the Baytown refinery in 1999. Ted Walko, base stocks & specialties marketing manager, told *Lubes'n'Greases* that "the decision to invest in Jurong was driven by ExxonMobil's desire to serve the growing demand for Group II base stocks in Asia-Pacific."

"At the time, most lubricants were formulated with Group I base stocks; however, as the advantages of Group II—particularly its improved oxidation stability—became more well-known in the industry, ExxonMobil anticipated that more and more formulators in Asia-Pacific would consider a switch," he explained. The producer was able to utilize Jurong's existing structure, which came at a lower initial cost and provided a technology base that could be readily expanded to meet increasing demand.

The Group II upgrade at Baytown was completed in 1999 in anticipation of the rollout of ILSAC GF-3 and its lower volatility requirements. According to Walko, "this led to ExxonMobil's investment in raffinate hydroconversion technology that leveraged the existing solvent refining processes at Baytown to produce the light neutral base stock required for GF-3."

Rick Dougherty, ExxonMobil's basestocks & specialties technology chief, added, "ExxonMobil produces base stocks through several of its proprietary selective catalytic dewaxing processes that offer higher yields, contaminant tolerance and higher activity, leading to longer life of the catalyst."

The company first commercialized its Mobil Lube DeWaxing process for Group I base stocks in 1981 at its Adelaide, Australia, refinery. Based on the ZSM-5 aluminosilicate zeolite catalyst, MLDW technology was designed for dewaxing raffinate, but was later licensed to several Group II base stock producers, Dougherty said.

"ExxonMobil began development of its own isomerization dewaxing technology, Mobil Selective DeWaxing, which was first commercialized at its Jurong refinery. In 2000, ExxonMobil commercialized the second generation of its MSDW technology at Jurong with industry-leading selectivity for both light and heavy stocks," he continued. Over the years, ExxonMobil has continued to innovate with new and improved catalysts as well as advances in hydrocracking technology, most recently deployed at its API Group II plant in Rotterdam in early 2019.

Gerry Jackson, vice president of business development with Renkert Oil, recalled that selling Group II base oil was challenging in the beginning. He had worked on the 1995 startup of the Excel Paralubes plant in Westlake, Louisiana. "Early times were challenging, as the value of Group II was not reflected when ILSAC GF-2 was introduced," he said.

Motiva in Port Arthur, Texas, converted one of its Group I trains to Group II in 1998, then converted the other in 2001. Jackson was working for the producer when it streamed its new base oil hydrocracker in 2005. "Moving 41,000 barrels per day was initially challenging, but with ILSAC GF-3 the industry began taking advantage of the newer base stocks and the quality advantages they offered. Then we started seeing Group II postings in industry publications, and the [price] separation between Group I and Group II began."

"The last 25 years have seen remarkable change for base stock manufacturing, including the validation of Group II oils, the rise of Group III because of the available new technology, as well as the first world-scale gas-to-liquids plant," Jackson concluded.

Over the next 25 years, the drive toward even lower viscosity oils is expected to spur advances in API Group III and non-conventional base stocks to meet fuel savings targets without negatively impacting volatility or low-temperature performance.

API Group II is poised to be the dominant base stock for the next decade, and with their increasingly higher viscosity index, these oils will combine with Group III to meet much of the world's lubricant demand.

Refiners around the world also are rethinking their distillate slates in response to the International Maritime Organization's new curbs on burning high-sulfur fuel at sea. "IMO 2020 may also have an impact on some Group I refineries that, in turn, could accelerate the growth of Group II in lubricants applications," ExxonMobil's Walko predicted.

"In the future, quality and technical performance of base stocks will also become more prevalent, and … the industry must adapt to the changes in the base stock business. We believe that production capacity should adjust over time in line with demand trends—although it is always difficult to predict the pace." ▮

