video transcript

chevron oronite presents on bridging the gap from GF-5 to GF

Introduction: Beth
Our presenter is Kaustav Sinha, and he is currently the global project manager with Chevron Oronite, leading the GF-6 and dexos 1® developments within the automotive and engine oil group in the United States. During his career in the automotive lubricants and tribology industry, he has led and managed lubricant product research and development, strategy, business development, and industry activities as well.

A materials scientist by training, his work in the area of smart materials, automotive tribology and lubricants has been presented at over 40 leading conferences and published in over 20 journals, articles, proprietary technical reports and patent applications. You keep yourself very busy, I see.

Kaustav did receive his BE in instrumentation and control from the University of [Pune] in India, in 2002, and an MS PhD in metallurgy and material science and engineering from the University of Nevada Reno. So please welcome Kaustav Sinha.

Kaustav Sinha
Thank you. Good afternoon everybody. Thanks Beth.

It's always difficult to stay on track when you're in San Diego, right? Gorgeous weather. Why should you be listening to GF-5, GF-6, rather playing golf? So the next one hour, what we would try to do here is take you through a journey – where we are today and where we will be in the next couple of years, and where are we going to be in a couple of months. So that's how we call it the bridge from ILSAC GF-5 and GF-6.

But the challenge or the question that we all ask ourselves is, "What are the drivers behind this GF-5, dexos, GF-6? What is making it different this time around?" What we have done is the simple answer to this bridging, as we all have played an important role.

And unlike the past, where we could meet some of these challenges working in isolation and working together in some shape and form, the challenges and the problems are becoming much more complex as we move forward. So it is high time for us to again work together collaboratively as the demands are increasing. And our industry plays an important role, a driver to enable some of these hardware changes that the OEMs are doing.

So what we want to discuss today is a direct and an indirect role of what the lubricant does to enable some of these technologies to bring to the marketplace. So for the next 30 to 45 minutes, I will take you through the key trends and challenges we are seeing with the passenger car motor oil, provide you with the latest information of the two upcoming gasoline engine oil specifications that are incorporating the new performance needs.

How is Oronite and the industry coming together to set up and address the change with innovative solutions that are being developed and updated with the real-world feedback? And we'll wrap it up with summary, and certainly, open it up for discussions and some questions.

So over the past few decades, the focus has largely been in certain tailpipe emission reductions. Fuel economy surfaced in the 1970s and 1980s when there were geopolitical events and spikes in crude prices, which led to the now-famous Corporate Average Fuel Economy, or the CAFE standards as we know.

Today, we tend to take a much more holistic view, and overarching driving force for the passenger car and the heavy duty motor oil engine development, which boils down to one simple concept, which is the total cost of ownership. Fuel economy and extended service or drain capability or durability fits into that larger umbrella.

If we now look at the historical trends starting in 1975, we see that significant gains in power density have been made over the past 40 years. Fuel consumption per horsepower has decreased, while fuel consumption per displacement had remained fairly steady.

During the 1970s and early 1980s is when modern electronic modules and controls were introduced into the vehicles, and technology, such as port fuel injection, moved from high-end specialty vehicle applications to the mainstream. The significant increases in horsepower per displacement paves the way for downsizing to take place as fuel economy demand increases.

There was a significant drop in average engine displacement in the late 1970s through the early 1980s as we started to move away from the market dominated by large V-8 engines. This was a big step towards downsizing, but then the trend stopped for the next 35 years. Even with advances in power density since 1980, engine displacement remained largely flat through almost 2015 and actually increased some during the mid-2000s.

Gains in power per displacement were largely targeted at improving vehicle performance, not necessarily fuel economy. That's not to say OEMs were at a certain fault, but it was simply meeting the demands of the marketplace. Today, vehicle manufacturers are starting to leverage the gains in power density by downsizing engines to improve, specifically, the fuel economy.

So if you look at this chart, why sudden interest in fuel economy? First, fuel economy is directly correlated to carbon dioxide, which we all know about, and emissions – we just call it greenhouse gases. Secondly, if you look at the United States, currently lags more from other countries in fuel economy. Fuel taxes are relatively low in the U.S., which does not encourage consumers to buy more fuel-efficient vehicles.

Corporate Average Fuel Economy regulations are aimed at now forcing OEMs to produce more fuel-efficient vehicles, even though the natural market demand may not be there with relatively low prices for the current environment. So in order to meet these targets, which is 56.2 miles per gallon by 2025, the OEMs needed to make some adjustments – needed to improve on corporate average fuel economy by 4 percent per year from now through 2025.

The target gets progressively more difficult as the low-hanging fruit is captured and more sophisticated technologies and expensive equipment are adopted. However, if you look at this chart, I'm sure these numbers would be further reviewed with the current administration taking place.

So if you look at the impact of various technologies on the magnitude of potential fuel consumption reduction, various cost effectiveness, we see there are options available across the board and that low-friction lubricants are clearly an outlier. Low-friction lubricants provide a relatively small reduction in fuel consumption reduction, but are very cost effective compared to other options.

In addition to being cost effective, switching to low-friction lubricants can be accomplished with little effort. Implementation, very easy. You just make the change and put it in the fleets across the vehicles quickly, without making any major hardware or infrastructure changes that are needed to penetrate existing car park.

What's not shown in this chart is the indirect impact that low-friction lubricants, for example, would have, and we'll talk a little bit around that.

So when you look at fuel economy, there are various ways in which fuel economy requirement drive new technologies into the marketplace. One of the first considerations is which conditions should be used to measure fuel economy, and are those conditions really representative of the market?

So you have drive cycles. You have friction reduction. You have combustion optimization, downsizing, downspeeding. These are some of the examples. Changes in what I'm calling the operating environment have an

impact on the engine technology, which then has an impact on the oil formulations. Some of these relationships are not always obvious, or even predicted.

[LSPI] is an example of which we will be seeing or discussing a little bit.

If we now take a look at the penetration of many of these technologies highlighted on the previous chart, we see the OEMs are using various means to improve fuel economy. Of course, those with the highest penetration were in many cases the easiest and the most cost-effective – low-hanging fruit which we call.

Virtually all of these technologies shown have a direct or indirect impact on the engine oil. Changes in the engine oil have been required to enable many of these technologies. Let's now take a closer look at some of them. Specifically, in order to provide optimal fuel economy performance, many OEMs are offering turbocharged EDI engines coupled with six, seven, eight, even nine-speed transmissions or even [CVT].

We see a rapid growth of products incorporating these technologies in the marketplace, and in order to enable some of these technologies, the passenger car motor oil must provide protection against LSPI, which is low-speed pre-ignition oxidation deposit, soot or particulate matter, which we have never dealt before on the gasoline side.

So when you look at the combination of GDI and turbo that allows the engine to generate high levels of power at relatively slow operating speeds, a relatively new phenomenon was discovered when operating turbo GDI engines under these conditions, which is low-speed pre-ignition or LSPI. And that certainly has some catastrophic impact if not treated appropriately.

There has been a fair amount of work recently on LSPI, and there are various theories out there regarding the mechanism. In many of the studies, the engine oil composition has been having an impact on LSPI, and LSPI test is being developed as a part of the next categories -- including GF-6 dexos -- to address some of these.

In addition, many OEMs around the world are developing their own LSPI test, which is now becoming more of a global phenomenon as this technology penetrates the marketplace. Let's take a little deeper look into the technical aspects of what is LSPI. LSPI results in formation of a new flame front, due to an unknown initiator that leads to knocking, which we all know from a traditional knocking perspective, it's just not good to that engine.

Besides making an audible noise, which is detectable by vehicle operators, which will not make them pass through the [NVH] testing, LSPI can result in pressure spikes up to [130 bar]. Passenger car gasoline engines are not designed – the metallurgy is not designed – to operate at those pressures an engine. And engines will damage if we hit them with such high, big pressures.

And what you saw in the previous slide is an image or illustration of a broken piston. So as OEMs make those developments, we are evaluating these aspects of LSPI to fully understand the impact of fuels, impact of lubricants, impact of operating conditions, in trying to make sure that we can take care of this challenge or performance.

As mentioned, various studies have taken place to investigate the impact of fuel, lubricant, hardware, et cetera, on LSPI. But there are specifically certain lubricant components – as we have heard probably from multiple literature sources and work that has been done – that are known to promote LSPI, while others can neutralize or others can actually suppress LSPI.

However, many of these compounds are included in engine oil formulations and have been used to deliver the traditional performance of fuel economy, cleanliness and durability. They can't simply be removed without affecting other areas of performance.

So in order to formulate the future engine oil technologies while addressing LSPI, a rebalance of the chemistries of the compound is needed to provide the needed performance in all areas, and not just LSPI.

As I said, this is not a regional phenomenon. It started and led by the American OEMs, mainly General Motors and Ford Motor Company, but now we are seeing the penetration of this technology around the globe.

So what you see in this chart is a cross-section of various OEMs who are looking at LSPI and looking at LSPI testing from an engine oil perspective, and looking at engine oil as one of the solutions to address the needs. And specifically, to this one, you will see in the Americas region we are coming up with the dexos, and we're also coming up with the ILSAC GF-6, which will be incorporating the LSPI test.

Another relatively new phenomenon, which we are seeing with direct injection – passenger car engine oils now need to deal with soot or particulate matter, which was probably the first time we're dealing. Soot or particulate matter in the oil has historically been limited to diesel engines, which also inject fuel directly into the combustion chamber.

As a result of GDI, passenger car oils now must be able to provide [wear control] with the soot or particulate matter in the oil. As a part of the ILSAC GF-6 category, Ford is developing a timing chain [wear] test with the industry, using a 2.0 liter turbocharged GDI engine. The test uses [silent] chain material and will measure [person chain] or timing chain stretch, which is a function of wear between the link pin and the plate.

There has been a lot of work that has been done in the past five years. There has been a lot of in-house work that has been done by multiple OEMs and multiple folks in the industry. But traditionally, a chain wear test has responded to the materials and the metallurgy. But in this case, it's the first time where we are trying to bring in a chain wear test to an engine to measure oil performance.

So with this in mind, with the trends and the drivers and the hardware that is in the marketplace, how do we address it? How do we bring it to this industry? How do we develop a specification and then cater to the performance needs? So specifically, for today, we'll focus on GF-6 and dexos, because those are the two big volume and big key specifications that are hitting the marketplace pretty soon.

So, before we look into GF-6 or dexos Gen 2, let's step back, because it's always nice to sometimes step back and look at how the industry has come together to develop and cater to these new technologies over the period of time. And what you see here is a snapshot of the key developments, the key tests, all the way from the GF-2 to GF-5. And oil specifications are regularly upgraded to reflect the latest engine hardware and their needs.

Each new specification has either new tests or replacement tests. The specifications are not licensable or credible without the standardized and monitored tests. The starbursts and doughnuts that you see on the right-hand side, the bottom, are API license symbols to help consumers identify the correct oil to use in their vehicles. Those specifications cover concerns raised by OEMs, including those listed in the slide.

So there are a lot of things that happened in these couple of lines that I just said. There are a lot of industry bodies, a lot of partnership that happens, coming together to develop a spec that would take care of the OEM's needs or the hardware needs.

So going forward, can we use the same infrastructure to address the next set of challenges which is coming up with GF-6? So what to expect.

Fuel economy and oil robustness are always the key drivers, either directly or indirectly. In this case, fuel economy will be the key driver for moving to GF-6. Measured fuel economy benefit will be through the updates to the new tests, sequence 6-E and sequence 6-F, which will include fresh and used oil requirements.

GF-6 oils will certainly have an indirect impact to fuel economy by minimizing LSPI, allowing for an indirect fuel economy benefit through the introduction of the GF-6 technology. At the same time, durability, by providing some form of LSPI mitigation, will be the primary defining characteristics of GF-6. So, it's kind of the gateway to GF-6.

And after you are in there, it's basically the traditional performance that is oil robustness: the cleanliness, the hardware protection and [sludge] performance.

Another additional component that is being introduced as a part of the GF-6 is the formal introduction of GF-6B, which is going to take care of a 0-16 viscosity grade.

So what you see on the screen are two different symbols. One is for the traditional viscosity grades all the way up to 0-20, and then for GF-6B, a 0-16 symbol – which has not yet been decided, but the choices are up there – to make sure that the consumers and the manufacturers are protected and well informed while they make the choices for the right oil for the right engine.

So here is a quick snapshot of the high-level qualitative comparison of GF-5 performance to GF-6. What you see on the slide is a quick illustration of the GF-5 performance. And when I look at the GF-6, what I want to illustrate here is probably in the history of the passenger car motor oil development, the amount of work that is going on in bringing GF-6 online is tremendous.

If you look at the blue performance parameters, which is the traditional performance parameter that is getting updated by hardware – whether it's fuel economy, whether it's engine sludge protection, whether it's cam wear protection or piston cleanliness and oxidation control – every single test is getting upgraded with the new hardware, either from the same OEM or a different OEM. At the same time, there are two brand-new OEMs who are coming and contributing to this development, which is Chrysler and Toyota.

At the same time, we are also bringing in two new tests: timing chain wear protection and low-speed pre-ignition, which has never been there. So if you look and count pretty much the number of tests that the industry is bringing online with GF-6 it almost accounts to seven. I don't think in the past, to my recollection – and I haven't been there for all of these developments – I don't think any of these GF updates have gone through that kind of development.

So I just wanted to level set the amount of work that the industry is going through in bringing some of these specifications online to update the hardware needs. So, if you look at the common theme that we are continuing on from GF-5 to GF-6, it's pretty much the left-hand side bottom where we have a bunch of tests which are probably looking at some very small components.

One is turbocharger through [TIOS], the bench test; shear stability through Sequence VIII, which is probably the only test that will be carried over as it is; and volatility, which has not been updated yet from GF-5 to GF-6.

And plus, what you see here is the global nature – the global footprint with requirements not only in Americas but now there is an emerging requirement at the same time in Asia, which is adopting these GF-6 categories at the same time and implementing it at the same time as in the Americas. So, there is a lot of challenge that is in front of us and that the industry is coming together to develop that.

So where are we? What is the road to GF-6? So here we are today. Engine test development. I'm sure you have read a lot of articles, a lot of trade shows; you have been exposed to a lot of dates from an API first license date – and I always come to, even within my management they say, "When is GF-6?"

And as a matter of fact, last year we collectively as a team in AOAP, we decided not to throw out first license date because unless we complete and get some ground running on the engine test development, it doesn't make sense for us to project something because it gives a false notion of the delays. But I think what people need to understand, as I said in the previous slide, is the amount of work that is going on in bringing some of these categories online.

So engine test development is where we stand, and this is probably the simplest picture of a GF-6 development. And I'll show you the more complicated one in the next one.

But after – we are coming to an end to an engine test development. The light is probably coming. We can see the light at the end of the tunnel around that. But even after that, there is a lot more work that needs to be done.

BOI/VGRA is another big piece of it, because when you bring in seven new tests, you bring in a lot of BOI/VGRA development work. So, I know some of our folks here are pretty involved in some of this development, and this will take – we don't know how long it will take, but it will take a lot of time to bring and develop the BOI/VGRA rules before as we develop the product.

After that comes the technical demo period, which typically takes around a year or so. That's what we have traditionally taken up. Then comes a specification development based on the technical demo period, what the data said. Mandatory waiting period. And finally, the first license date. So there is quite a bit of work still left.

One thing, we have to work with the OEMs that this is not the end of GF-6 – from here to here is also a lot of work. So what I'm trying to address here is there is still more work. There is progress being made. We are making quite a bit of progress. But as soon as we are done with the engine test development and approval, I think we'll get a good sense of what this timeline would look like.

So right now, I think there are a lot of dates thrown out, but from an engine test we are looking at some time this year to complete all of these test development and also start, be able to start, the BOI/VGRA.

However, this is the way we operate. Right? So if you can read, kudos to you. I can read, and I've read that in detail, and I still am not familiar with all the acronyms.

In fact, I just texted one of my colleagues and I said, "Can you tell me the full name of this acronym?" This has worked very well, but the question is – and this is something – I was not involved in some of these developments; a lot of you folks have worked together for the last 30 years, 40 years. This has worked well.

But the question that we are all asking ourselves from all aspects of the industry – whether it's OEM, whether it's the oil marketers, whether it's the lubricant additive companies – is this the system that is going to take us forward? Is it becoming too complex to manage and be agile? Because I think what you are seeing in the future, agility is important to bring some of these specifications online to meet the market needs.

Because by the time GF-6 is developed, the hardware has gone through another bunch of changes. So there is a lag. So you are developing the oil for the future, but the hardware that you are using is of the past. So that's a dilemma, and that is part of this development process.

So, I think there is a lot of effort, there are a lot of articles, there's been a lot of keynote speeches, there's a lot of work in different industry bodies to look at this, look at the lessons learned from the GF-6 and [PC-11s] and some of these recent developments, and see if we can optimize this process. I'm not going to go into detail, but I just wanted to give you a snapshot of the simplest way and how it happens actually. [Laughter]

And then let's look at how the Americas market is breaking up. The Americas market is now breaking up into dexos. Dexos is now into Generation 2. When we were in Generation 1 and GF-5, they kind of overlapped at the same time. In case of Generation 2 and GF-6, now there is a gap. So now Generation 2 is right in front of us, but GF-6 is a couple of years from now.

But if you look at the common theme there, the theme is that the hardware is still the same. And if you look at the spider chart, I would focus on the far turbocharger/pre-ignition side, which pretty much is a cornerstone of the dexos upgrade. So, if you look at the hardware requirements, they are very similar to what the GF-6 spider chart is, but it's just a different way of developing specification.

So if you look at the simple timeline here, as I said, GF-5/dexos very similar; dexos went Gen 2, and then GF-6. And then, again, the global need. As you recall from some of the presentations that probably GM folks have made, the largest market for GM today or for the last three years is China. And it is becoming increasingly important for GM.

So, if you look at the main markets for GM today it's Americas, it's Brazil, it's South Korea, it's China. And the implementation is not lagging. The implementation is a global implementation, so their expectations to launch some of these products are at the same time, and the changes are at the same time. So with that, a quick reminder: dexos 1 first generation licenses are scheduled to expire on August 31, 2017, which is in a couple of months.

And I'm sure there's a lot of dialogue that is going on in the industry in how to address that and how the product needs to be updated. But as we do that, we also are keeping in mind that two years from now we have GF-6. So

that's a new challenge, and that adds a little bit of product complexity in how we develop and how we bring things to the marketplace. So what is the solution? We are all working towards a solution, right?

So what is the solution, or what are the steps that we are taking to develop a solution? Let's step back and look at when we look at hardware. So, we're all a bunch of engineers, chemists, scientists coming together to develop technology. One of the first things we look at is trying to break it down, break down the problem, break down and try to simplify them.

One aspect we need to always keep in mind is that regardless of what the vehicle engine hardware is, let's boil it down to a system or boil it down to technologies that we need to develop to address that system or the operation environment. And how the basic functional oil additives are impacted, because that's where we need to focus on, because we need to know what are the chemistries that we need to develop for the future.

So this is a very fundamental or very simplistic way how to help us develop the products or technologies. But eventually, I always come down to this Holy Grail of engine oil development, the classic balance of fuel economy and durability. So that's the classic balance, and that's not going away. It's just coming in different shapes and forms, but that's the classic balance that we always have to take care.

There are many ways in which an engine oil could be formulated to improve fuel economy if that's the only concern. However, as we will discover a little bit later, fuel economy is just not one piece of the puzzle. Additives have to help to find the right balance to formulating technologies, need to provide wear, reduce friction, universal oil capability without sacrificing wear protection and durability.

Simultaneously meeting some of the future challenges and be able to connect to those.

We have all done puzzles. My four-year-old gets better at solving puzzles as she grows up. But I think the biggest challenge for us is taking care of these smaller systems and then fitting it into the bigger puzzle. And that's a big piece of it.

So when I say a smaller system, right now the system that is in front of us is turbocharged EDI engine. And the performance areas that we have to address are turbo protection, low-speed pre-ignition, and chain wear, to name a few. However, when we solve this puzzle, that has to fit into the traditional puzzle, which takes care of the fuel economy, which takes care of the wear, which takes care of the sludge.

And then we also have to ready for the future, because sometimes we want that flexibility for another platform.

So how are we doing that? LSPI is the first one. What you see on this slide are two different tests, two different chemistries, but trying to understand and simulate how to handle multiple different LSPI tests.

Because as I showed in the earlier slides, there are multiple OEMs coming up either with their own tests, or developing as a part of the specification. But sometimes, from a simplistic view or reducing complexity, we want to minimize and understand the fundamentals. So what you see here is on the left-hand side a GM LSPI test. If you put a conventional GF-5 oil, you see high LSPI events, which is not acceptable.

When you look at a dexos1 Gen 2 type platform, this is the requirement. You have to meet the GM dexos1 Gen 2 limits, which requires you to have at least three zeroes in the test, and also maximum of peak pressure of two events, not more than that. However, what we are trying to illustrate here is as we move into the Ford engine, these same oils could actually behave a little bit differently.

Here is a small snapshot of a matrix of a detergent and an antioxidant just to show what are the drivers for us to formulate around. But the key part to these two tests is the definition of the counting of LSPI events, which is extremely important, because when we develop specifications after the technology, it is extremely important to know how the limits will be drawn.

And so, when you're looking at a GM test you might see all zeroes, and you might see some events here, but that doesn't mean that they are looking at the same thing. In case of GM LSPI events, the way they are counting some of these events are very different. They are looking at peak pressure. When you're looking at Ford LSPI, they are looking at peak pressure, the [mass fraction] burn, just everything.

So it is important that the absolute numbers may not match, but the performance of the oil is very similar. So those are the things that the OEMs need to understand that they cannot have – that industry cannot develop single products for every single engine or LSPI test. It has to fit in. We wrote a paper just to explain that process of how we need to understand the mechanism of counting as we go into the limit-setting process.

The next one in this equation is the turbocharger. And in case of GF-6, we don't have a turbocharger engine test; however, we do have it for the dexos test. And we do see one that is probably going to be introduced in some shape in form in the [SIA] test, which I think Toyota is promoting.

Turbocharger protection is extremely important. Engine oil needs to be designed to resist [coking] caused due to high thermal gradient that you can observe here. This is the breakdown of the oil; that's what they are looking at. During the initial evaluation phase, GM ran the test to failure, but eventually they brought it down to almost 2,000 thermocycles.

So here you see dexos1 2015 product; you see a conventional GF-5 product, which also met the dexos1 2010, but after they ran it to failure they decided to stick with 2,000 thermocycles, and ideally to understand where the oil breaks down and take off. And based on that, the limit was designed. So eventually, what this test is looking at is the antioxidancy performance, or the oxidation strength of the oil.

So we have to take care of the LSPI and make sure once you reformulate the product to address LSPI you can deliver the antioxidancy performance to take care of the turbocharger protection.

These are the limits -- less than 13 percent for the dexos1 Gen 2 approval.

And finally, in the turbocharged EDI engine equation, you have the chain wear. All of the tests have completed precision matrix. There is still some work going on, on the precision matrix, post-precision matrix, to fine-tune the test, but what you see here is the cross-section of what exactly we are measuring.

We are trying to measure the wear between the pin and the plate; however, it's extremely complex to put down a fundamental tribological system in place to measure this wear and develop a specification. So indirectly, what we are measuring is a timing chain stretch, which is a function of the wear that we see in this contact.

And what you see here are two reference oils that are being used in the industry. One is the high reference oil and another one is the low reference oil. The idea here is, again, once you formulate to achieve a certain number, which is low-reference oil for example, if I take this one as a passing or a good oil going forward in GF-6, you have to make sure whatever changes you make to this chemistry you are now able to address all of the other GF-6 tests accordingly.

And there has been a lot of work, as I said, has been done in this area. There are a lot of papers around understanding the [soot] size, the differences into the soot particles between diesel and gasoline. Traditionally, this test as I said has always responded to metallurgy differences. You put a coating here; you can drop the numbers. There hasn't been a test where it can statistically separate oils, and this probably would be the first one.

If you look at also the numbers, you're looking at very small numbers. If you're familiar with the timing chain stretch, these differences are extremely small. Resolution of some of the measurements that we are bringing online with GF-6 and dexos are extremely small numbers that we are looking at.

So to sum it up, how are we going to deliver this performance? As I said, the traditional areas are enabling fuel economy directly and indirectly through viscosity changes, through additives, friction modifiers, low-friction lubricants;

enabling hardware indirectly like LSPI; but after that, it comes down to engine protection. It comes down to delivering engine cleanliness and durability.

However, after performance we've got to make sure that we address the supply chain aspect of it. We have to make sure that the product is available globally. And I guess a lot of you folks are interested – at the end of the day, it has to be cost effective. It has to meet the market economics. So that's another piece of the puzzle that we'll have to address. Plus, as I said, products are becoming more global and that needs to be addressed.

So the complexity is not just limited to the technical development; it also is part of how to bring a product the marketplace. A technical product in the marketplace is extremely important to keep in mind as you take a holistic view of the development process.

So here are some performance profiles, just to give you a summary of the performance profiles of products that we probably need to think of as we address the turbo GDI performance.

Here we are with GF-5. I've just listed out the key performance areas. We are all familiar with it. This is what they expect with GF-6, and these are conventional products. But again, how do we jump there? We are not yet here. We are getting there. Dexos1 came in, so we are addressing LSPI capability there. Reduced LSPI.

As you have seen, GM dexos is very limited in terms of the flexibility on BOI/VGRA, so there is a limited set of products in the marketplace. There is a lot of work that is going on with GM and the industry to bring products. There is [unintelligible] viscosity profile that they are looking for, because a lot of these engines are looking at 5-30, 0-20.

There is a 5-20, and there is a little bit of 0-30; and they have also introduced 0-16, although they have explicitly said in a lot of their presentations that none of the engines right now use a 0-16. But again, I think the concept that they use is future-proofing the specification if there is a need in the future. And then, as I said, a turbo GDI.

I mean dexos is for GM, but when you look at the gamut of turbo GDI engines not just in the Americas but globally, there are a lot of engines that are coming out in the marketplace with turbo GDI technology, and there is an increasing need for a product that could be developed to meet the turbo GDI platform.

And we see that market here, and that's why we kind of provided a quick snapshot of what that product profile could look like. Finally, you always have to stay connected to the real-world feedback. Nothing is perfect unless we hear it from the field. So what we do is traditionally, like all of us in the industry, we throw product in the field.

In this case, it's a quick snapshot of some data set, or some oils that have been thrown in Vegas with turbo GDI engines. Two specific oils – one is the conventional GF-5 and another one is turbo GDI product platform – just to understand, is there any performance difference compared to the GF-5 from a [no-harm] perspective?

And what we are looking for in these type of no-harm situation is to make sure that with all of these chemistry changes that we are making, is it in line with the GF-5 technology in terms of [giving], or is it better or is it worse, just to help us feed in that information as we develop the products. So here is a quick snapshot of the viscosity TAN/TBN performance, and we are comparing the GF-5 technologies to the turbo GDI platform.

And pretty much if you look at it from a field performance standpoint, very similar. Pretty much I would say overlapping the GF-5 technology. So, it gives a lot of satisfaction for us to understand that all of the modifications that we have made address or meet the field requirements that we traditionally put in place. Looking at nitration and oxidation in metals, again, very similar performance compared to GF-5.

So protection-wise there is that same protection that we are providing just from a bare, used oil analysis. However, this is a very small snapshot. There is a lot of work the industry is doing along with ourselves in trying to understand what these engines look like, the parts look like, and trying to fine-tune the technologies as we progress into the GF-6 and the next generation of oils.

Another key part that we also do is to get some real-time feedback to help some of the industry folks, and even from an education standpoint to get a sense check of what the market is looking for, what the consumers and installers are looking at from some of these specifications. I mean frankly speaking, you go to an installer and you say 3-G or 3-F or – they don't understand. They don't care.

At the end of the day, they have to service their customers, and they want to make sure that the performance is delivered through the products for their customers. So we do a kind of pulse check on that. So there is a series of questions, just to give you a quick snapshot. In this particular case, what we are asking is which engine oil performance areas are most important to your customers today. And then feed that into our system to develop those technologies.

And if you look at it – and here is a quick data point, goes back to 2015 until recently – extended drain, wear, improved engine durability, fuel economy – nothing new. These are all the traditional performance that we talk about. So just making sure that the products that are developed are meeting some of these consumer or installer needs.

So durability, [long drain] and fuel economy are still the most important features.

Another question that we look at. How does your typical customer specify the performance grade and viscosity of oil to use in their vehicle? Again, they're asking that question and more than one answer is allowed. Most of them ask the installer.

Now the DIFM – do it for me – is becoming more prevalent than DIY, so people are more leaning towards installers to make the final judgment on what products to use. And finally, the installer is playing a critical part in this process and playing a major role in the engine oil selection for the consumer.

Next question around specifications. Which specification is most important to you and your customers? And I don't think we like to hear about the first one, "I'm not generally aware of any of the above," because we place a lot of emphasis – I know a lot of industry bodies try to educate. I think we want to reduce that bar. API SN, dexos. So you do see.

So basically a summary, a takeaway from this is recognize specifications are still important to consumers.

Finally, to wrap up this section, I hope I was able to give you a holistic view of this entire process of how we look at the future. What is important? What are the drivers? How engine oil comes into that equation.

How do we look at a technical development and bring it into a specification process, and then take that specification process, develop products that meet the market needs, and eventually deploy it? And also deploy it in a sustainable format and make it as much as possible future-proof, because the future is not that far. I have seen presentations where people have already started projecting GF-7. And I scratch my head.

I say I'm sitting here in GF-6 and people are already thinking about – I'm not even thinking beyond engine test development completion, and people are already projecting GF-7. But that's a reality. OEMs, once they are done with a test development, they are looking at the next set of hardware.

So overall, as I said, we are continuously investing in meeting the current and future technology needs as our partners, our friends, as industry is, to make sure that the consumers are updated and to get the latest product or the best products in the marketplace to meet the global [PCMO] market. With that, I thank you for your attention.

And at this point in time, I would also thank a lot of contributors who have contributed to this information deck, because this is a lot of work as I said. It's just not limited to the products and technology folks here, but a lot of our sales teams and supply chain teams who are working behind the scenes to make things happen. Again, thank you to the team at Oronite, and thank you to you all for spending time and listening to us.