Thank you, Ed – I am Steven Mok, global segment leader for thermal management systems. This segment includes heat exchanger components such as charged air coolers, EGR coolers, control valves as well as the engine cooling components that come in contact with fluids.

I’ve been leading the global application development team for the past 4 years, and I spent 7 years in R&D with polymer science, helping to invent and develop materials and products that work in these hot, aggressive environments.

I am going to spend a few minutes talking about material solutions for these aggressive environments, then share with you some integration opportunities that have generated cost and weight savings, as well performance improvements.

(slide 2)
As Mike Day mentioned earlier, the current trend of downsizing engines has brought in new demand on material performance in turbo charging systems. The voice of customers has told us the following:

- Temperature is going up! Materials need to withstand temperatures above 170C for longer times and sometimes temperatures can reach 230C at peak.
- The pressure of the loop is also going up and could reach beyond 3 bars. Resistance to creep for the material is important to avoid pressure leakage.
- The acidity of the EGR gases that are being re-circulated is migrating upwards, and the pH could reach 3 or lower. Good retention of properties to the corrosive gas is important.
- Survival despite exposure to aggressive long-life coolants is important. Components such as charged air cooler, or turbocharger could be integrated with the water circuit and therefore it would need a material that offers good resistance to the coolants.
- In regard to the polymer composites, our customers also indicated that the standard heat stabilized nylon 66 material would need improvement to withstand these higher temperature conditions.
In respond to the voice of customers, our DuPont Polymer scientists accepted the challenge and subsequently came up with the new Zytel® PLUS nylon and just introduced Zytel® HTN92 Series PPA resins. These resins are based on our SHIELD technology, only from DuPont. The primary targeted improvement is to deliver a step change in thermal oxidation resistance, or long-term heat aging performance.

We have included 2 photos here to illustrate how Shield technology applied to these polymers improves the resistance to hot air aging. These photos showed the cross-sections of a 4 mm thick bar after aging for 1,000 hours at 210 C. The left-side photo showed a bar made with the standard heat stabilized nylon 66. Under severe oxidation, the material has lost some of its thickness, and thus its strength.

However, the bar shown in the right-side photo, is made with the Zytel® PLUS polyamide. The outer layer of the bar has slowed down most of the hot-air aging process. It maintained its shape and thus most of its mechanical properties and performance.

We have the pleasure and excitement to share with you that DuPont last week launched a new impact-modified Zytel® Plus and two grades of Zytel® HTN92 Series PPA resins at the K-show in Germany. These resins would be good material choice for your turbo system components because they deliver performance and durability.

In the next few charts, we are going to show you some performance data for these resins.

Data shown here include 3 new polymers based on SHIELD Technology, a standard polyamide 66 and other material like PPS used in the industry. Zytel® PLUS and Zytel® HTN92 Series PPA - shown in the solid bars - maintain good strength after exposed to the heat for 3,000 hours.

These three products also retained their strength between 75 to 100 percent better than nylon 66, shown on the right, and about 40 to 70 percent higher than that of PPS.

This improved heat aging performance would improve durability of the components, or we could use these new composites to replace metal components in higher temperature loops for cost and weight savings.

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(slide 5)
During engine shut down, the temperature of the turbo system components will climb. It is important that materials withstand the higher soaked temperatures as well. In this chart, you can see how the new resins retained their strength at the higher soaked temperatures. The bars tested had been aged at 230°C for 1,000 hours. The Zytel® HTN92 Series PPA, Zytel® PLUS nylon and the specialty PPS resins, still maintain good strength after the heat soaked. On the other hand, the standard heat-stabilized nylon 66, on the right hand side, has been degraded to the extent that we could not measure its strength.

(slide 6)
Polymer composites tend to be less creep resistant than metal. To ensure durability and performance, components made with polymers should be designed with the long-term creep upfront. In this chart, we present accelerated creep data for the new resins. They were tested under load for 1,000 hours at 200°C. The highly aromatic PPA and the higher glass reinforced Zytel® PLUS 95 grade, tend to creep less than the 40% glass-filled PPS and the conventional 35% glass-filled polyamide 66 respectively. The lower creep characteristics would help prevent pressure leakage.

(slide 7)
Another key requirement in a turbo system is property retention in a highly corrosive environment. In this chart, we present the tensile strength retention data, immersed in a simulated EGR solution. The test method was supplied by our customer - let’s say OEM “X”. It required immersion of the test specimens in a simulated EGR solution with a pH of 3.3, at 90°C for 2,000 hours. The Zytel® HTN92 Series PPA and new Zytel® PLUS nylon maintain more than 50% of its original properties at the end of the 2,000-hour aging test. We are planning to conduct further testing of these composites in more acidic environment – pH lower than 3.

(slide 8)
In this slide, we would like to summarize the material choices for both the composite body and the sealing materials. Depending on the temperature requirements in the turbo system, some composites are most cost effective than others.

Zytel® PLUS and Zytel® HTN92 Series PPA products, are labeled in italics with asterisks. For coolers and components operating at about 170°C and below, standard heat stabilized Zytel® nylon 66 remains a cost-effective solution. However, when operating temperatures get hotter at 200°C to 220°C, the higher performance polymers - such as the Zytel HTN92 Series PPA and Zytel® PLUS nylon resins, would be the more suitable choice for metal replacement, where cost and weight savings could be achieved.

In regard to the gaskets and sealing applications for the coolers, the Vamac® AEM and the Viton® FKM compounds, are good potential solutions. These elastomers provide
good performance in holding up to the temperature and the fluid resistance requirements, as Ed Mcbride pointed out earlier with the hoses.

Let me re-emphasize, material choice often depends on a combination of many factors and requirements, including costs. It would be prudent, for you and I work together upfront to select the appropriate composite solution.

(slide 9)
When turbo components are equipped with liquid circuits to enhance heat transfer, they would need to withstand aggressive coolants. In this chart, we present the tensile strength retention data in hot coolants. These test specimens, were fully immersed for 2000 hours at 130 C in two different OEM coolants, labeled “OEM A” and “OEM B”. At 130C, Zytel® HTN PPA retains properties better, than nylon 66. However, nylon 66 remains a cost effective solution when used in lower temperature circuits.

As Mike Day pointed out at the beginning, our customers are looking for performance, costs and lighter weight, with no compromise. The use of polymers in the thermal management side of your turbo system offer good potential to help you and your customers achieve your goals.

This ends the discussion on the various polymer materials that could be used in the hot and corrosive chemical cocktail environment encountered in the turbo charging system. Let’s now talk about integration and cost savings opportunities in the system.

(slide 10)
In this chart, we use 3 opportunities to illustrate the benefits in using plastics to achieve cost savings and quality improvements. In charge-air coolers, cost savings could be achieved through the use of plastic end tanks. The more costly blazing method is used in coolers with metal end tanks. However, tanks made of plastic, could be crimped to the metal core at a lower cost. This cost-savings benefit could be extended also to the cold side of the low-pressure EGR coolers.

Other future integration potential is to join the gasket with the end tanks, though a 2 component molding technique, prior to its assembly with the core. The turbo-charger resonator, made with Zytel® HTN PPA - shown here - is used in some small diesel engines. It allows complex shape design and integration, which translates into both cost and weight savings.

The cover and some components in the EGR valve actuator, are made with Zytel® HTN PPA. This allows the integration of multiple electrical components to the cover through design, over molding and welding. Again, cost and weight savings were achieved.
In this slide, we continue to illustrate how the cost savings and performance benefits that were achieved in liquid cooling parts made with composites. In the MAPP controlled thermostat housing, savings were achieved through two ways: First, two parts made with Zytel® HTN PPA were vibration welded together. Second, the compatibility between Zytel® HTN PPA and Zytel® PA 66, allowed the lower cost nylon 66 component to be over molded with higher performance PPA.

In the electrical coolant pump, the use of Zytel® HTN PPA, allowed the design to incorporate 11 discrete components into one integrated assembly. It cuts weight by one-third, while streamlines packaging significantly. In the electrical coolant valve, the use of Zytel® HTN PPA enabled a new integrated design. It reduces from four components into one assembly. This integration translated into significant cost savings. It also improves the quality due to less discrete parts used. The part was 40% lighter too.

OK – so this was a lot of information in a short amount of time ….but I wanted to share with you that we really understand the challenges and the issues you and the industry are facing. As you can see, DuPont has been working diligently to invent new materials to help take out weight and cost – permanently – while helping ensure there are no compromises in performance. In short, please remember:

- Our scientists have invented new high-heat resistant light weight materials – and importantly – a family of them to help ensure you make the best selection
- We offer deep, global technical support in elastomers, resins, and high-performance parts … we are dealing in integrated systems, sometimes in a component by component way. We continue to challenge our materials and application development teams to integrate elastomers and resins in new ways to really take advantage of integration opportunities.
- And finally, we work throughout the value chain both locally and globally. So, if you are starting a new project, we can help connect teams around the world with you, to possibly help shorten the time from ‘art to part.’

I would now like to turn it over to Dave Ritchey who will show how DuPont science can help achieve a 60-70% wear reduction in critical components … while meeting the demanding high temperature requirements of turbocharger and emission control systems.

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