Kawasaki
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# Scope

Kawasaki Heavy Industries Quarterly Newsletter


Special Feature

## Taking Aircraft Safety to New Heights

Summer 2015
No. 104

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## Contents



**About the Cover**

*Autoclave awaiting start of operation (East Plant, Nagoya Works 1). See Special Feature for further details.*





The Boeing 787 was originally called the 7E7 during the development phase. E stood for efficiency, and true to its name, the aircraft dramatically improved fuel efficiency and reduced operating costs. Kawasaki and other Japanese companies accounted for 35% of the overall production effort.

# Taking Aircraft Safety to New Heights

*The Boeing 787 Dreamliner is a mid-size aircraft which is capable of accommodating from 200 to 300 passengers, with fuel efficiency representing an improvement of about 20%, and operating cost compared to the previous model in the same size category, owing to weight savings, an improvement of about 30%, advanced aerodynamics and new systems and engines.*

March 13, 2015
**New plant completed**


Forward fuselage cured in an autoclave. The steel mold inside will be removed (picture taken in North Plant).


East Plant gets ready for full operation (bottom right). Adjustment of the AFP machine, which forms composite layups (top left), and installation of the panel riveter (bottom left) are also underway. Picture at top right shows the combustion system and other parts of the autoclave extending outside the facility.

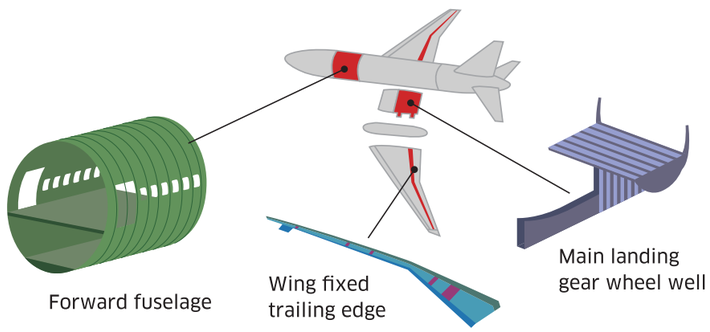
## Taking Manufacturing to a New Level

The Boeing 787 Dreamliner is a 200- to 300-seat, mid-size airliner featuring advanced aerodynamics as well as new systems and engines. Its lighter frame boosts fuel efficiency by 20% and reduces operating costs by 30% compared to existing airplanes of the same class. This improvement has also dramatically increased the flight range, making the aircraft hugely popular among airlines across the world. The 787 comprises the 787-8, the base model, and the -9 and -10 derivatives which feature an elongated fuselage for increased seating capacity. According to figures released by Boeing, orders for these three models totaled 1,105 as of the end of March 2015. To ensure the airplanes are delivered on time, Boeing is working with its global partners to boost production capacity.

As a partner in the 787 program, Kawasaki manufactures the forward fuselage, wing fixed trailing edge, and main landing gear wheel well. The recently completed East Plant of Nagoya Works 1 is the third facility fully dedicated to the 787 program, following the North and South Plants. The East Plant will produce the forward fuselage of the 787-9 and 787-10. The plant is now getting ready to start production of the 787-10 by introducing state-of-the-art equipment also used in the two other plants. Kawasaki aims to take manufacturing to a new level at the new plant by building on its experience and achievements so far.

Aircraft must be absolutely safe in order to protect passengers. Every manufacturer involved in the production of aircraft must therefore obtain international certification for its production equipment. The crucial thing is to continually produce the required functionality and quality with precision. The means to achieve this end, however, are not prescribed. There is room for each manufacturer to exercise ingenuity.

### Components in red indicate Kawasaki manufactures.




## Making One-piece Barrel Fuselage with Carbon Fiber

Akihiro Shiraishi, Deputy General Manager of Manufacturing Division of Kawasaki's Aerospace Company, sheds light on one of the main challenges faced in aircraft manufacturing. "The most difficult thing," he says, "is to continue making the exact same thing with absolute precision, every day. Technology to make this possible is an area where advancement is constantly taking place. Kawasaki has produced most of the tools and equipment it uses to maximize efficiency, while ensuring that information is shared across the organization to facilitate technological development."

The 787 is said to have revolutionized aircraft manufacturing. This is epitomized by the use of carbon fiber composites even in primary structures including the fuselage and wings. While carbon fiber composites offer such benefits as high strength-to-weight ratio, they also bring new challenges. Due to the nature of carbon fiber to change properties during processing, manufacturers are required to guarantee both material properties and geometry through process assurance. This process assurance is said to be the most difficult aspect in the production of the 787.

In particular, the forward fuselage which Kawasaki manufactures uses composites to create a one-piece barrel that is entirely seamless. This was the first time the technology was used in a commercial jetliner, and overcoming the technical challenges involved was where Kawasaki had to prove its merits.

## Pursuit of Ultimate Precision

The one-piece barrel structure of the forward fuselage of the 787 is produced in six steps. First, carbon fiber composites are laminated onto a cylindrical mold, after which the composites are cured with heat in a pressure vessel called autoclave. In the third step, holes are made for positioning of parts. After undergoing ultrasonic nondestructive testing, reinforcements are installed inside the fuselage, and in the final step, floors, ducts, and other parts are installed.

Lamination of carbon fiber composites is performed using an automated fiber placement (AFP) device. The device works much as a silkworm spews out thread, depositing a number of carbon fiber tows onto a cylindrical mold. Syoji Tada, who leads the process engineering team of the 787 Manufacturing Engineering Department, says, "Carbon fiber composites are extremely changeable and must be treated like fresh foods. The challenge was to understand their characteristics and establish a stable method to form composite layups." For instance, viscosity, which determines the adhesive strength of carbon fibers, changes with time. "We worked to deepen our understanding about the correlation between the various elements," explains Tada. "That includes everything from the structure of the composite placement head and the method of placement to the humidity of the shop floor. Through these efforts, we sought to establish the optimal method. The AFP machine we have installed at the



From left) Kanji Maekawa, General Manager, Industrial Plant Department, Kawasaki Engineering, Kazuhiko Miwa, Senior Staff Officer, and Syoji Tada, Assistant Manager, 787 Manufacturing Engineering Department, Kawasaki Heavy Industries.

East Plant incorporates all the experience and knowledge we have gained through the project so far."

The composite layups will then be cured in an autoclave. The autoclave installed at the East Plant is an enormous structure, weighing 900 tons overall, and measuring 8 meters in diameter inside the curing oven and 19 meters in length. Compared to the base model 787-8, the 787-10 will have a significantly longer forward fuselage. The autoclave at the East Plant was manufactured at Kawasaki's Harima Works by the group company Kawasaki Engineering, and it is designed to handle production of the 787-10.

Kanji Maekawa, General Manager, Industrial Plant Department of Kawasaki Engineering Co. Ltd., says that "the key point with autoclaves is achieving an ability to maintain an even temperature inside the vessel. That's the most crucial thing." In order to maintain the strength and performance of carbon fiber composites, they must be cured evenly throughout the entire construct. The ability of the autoclave to maintain an even temperature inside the vessel leads directly to meeting deadlines and even improving turnaround. Achieving this ability was more important than anything else for the autoclave at the East Plant, which has the world's largest-class diameter and will be used to cure elongated fuselages. Maekawa explains that various simulations were repeatedly performed to analyze the temperature distribution inside the vessel, using the thermal analysis technology developed mainly by Kawasaki's Corporate Technology Division and the group company Kawasaki Technology. "We managed to create an autoclave that works like a precision machine by combining Kawasaki's entire manufacturing know-how cultivated through the development of plants and boiler equipment."

Autoclave quietly awaiting start of operation.
This autoclave can also make the long fuselage of the 787-10.

## Automated Riveter, Guided with the Five Senses

Once cured, the carbon fiber composites command an imposing presence as a large one-piece barrel fuselage. The ultrasonic nondestructive testing device used for inspection is a world first developed by Kawasaki.

Once the testing is done, the fuselage moves to the next stage: installing a reinforcement frame. This will be performed using a machine called the panel riveter. It performs the full operation automatically, from drilling holes simultaneously through the fuselage and frame, then tightening bolts. Long rails extend both inside and outside the fuselage, on which the machines move. Specifically, a machine on the outside opens a hole through which it inserts a bolt, then a machine on the inside rivets it down.

Kazuhiko Miwa, Senior Officer of 787 Assembly Manufacturing Engineering Section 1, 787 Manufacturing Engineering Department, who oversees the introduction of the panel riveter, explains the difficulty inherent in this process. "Opening a hole and inserting a bolt may sound easy enough. But we're talking about a forward fuselage of an aircraft, which has considerable length. Positioning and synchronizing machines pose a huge challenge in terms of accuracy."

The forward fuselage requires numerous holes and riveting. The margin of error allowed for the positioning of each hole is 0.3 mm. Although the operation is fully automated, Miwa points out that "using our five senses is essential to improving accuracy and securing quality." To ensure the operation can be continued with consistency, the experience of a skilled operator is needed to assess the wear of a drill. Before and after each operation, a test piece is made to check the accuracy of automated work with human eyes.

Kawasaki's proprietary technology is also used in this process. During the riveting operation, the riveter remains fixed in the same position, and the fuselage is rotated to bring the next bolt into position for riveting. This allows the operator inside to maintain the same posture. "To enable accurate riveting," Miwa says, "we created a machine that makes it easier for operators to work. We constantly review the programs and equipment to make sure everything is right, including the rotating speed and angle of the fuselage.

## World's Most Efficient Factory Built on Quality and Safety

With the East Plant now ready for operation, Kawasaki's production capacity is expected to increase from 10 to 14 planes a month. For Kawasaki, mass production of large aircraft brought some new challenges. The Aerospace Company learned the method of mass production from Boeing, and also looked to its own motorcycle business, where the Kawasaki Production System (KPS) originated, for its valuable know-how.

It is based on persistent execution, and the idea that "safe operation is synonymous with quality." This policy promoted widely sharing operational improvements and emulating good practices. For instance, while an airplane is symmetrical, its parts slightly differ from one another, so improvements were made to jigs to avoid installing the wrong parts at the wrong places. In addition, the operators' movement in each process was filmed to analyze and streamline their movement, which resulted in shorter process time.

Thanks to such efforts, the site received the honor of being named the most efficient factory in the world by Boeing. Kawasaki's passion for manufacturing has done more that winning it the Supplier of the Year Award and other accolades: it is contributing to the safety of the skies.

East Plant seen from above.

News

## East Plant Revealed to the Public at Completion Ceremony



On March 13, 2015, Kawasaki held a ceremony to celebrate the completion of the East Plant, newly built at Nagoya Works 1 (Yatomi City, Aichi Prefecture). Press members were also invited to tour the inside of the plant.

Construction of the East Plant, which has a total floor space of 60,000 m$^2$, began in December 2013. Representatives from Boeing and Governor Omura of Aichi Prefecture attended the ceremony to celebrate this new step forward for the aerospace industry of the Chubu region.

## From the Project Team

### By Akihiro Shiraishi

Deputy General Manager, Manufacturing Division, Aerospace Company & Director, Nagoya Production Department.

### *Developing a Solid Production System to Work Together with Partners Around the World*

The 787 is produced with the participation of many companies across the world. Under the slogan of "Working Together," Boeing specifically called for the adoption of the Boeing Production System (BPS) on the shop floor. As a result, partners around the world collaborated much like an orchestra, in an attempt to create a smooth flow of manufacturing. This was a new approach for creating safe aircraft.

While BPS has its roots in Toyota's Kaizen activities, Kawasaki's own Kaizen activities, KPS, were also derived from Toyota. As such, BPS and KPS have close affinity. Efforts toward mutual learning and improvement are producing excellent results, including consistent quality, zero delays, and no missing parts, which are raising Kawasaki's profile.

In building the East Plant, which will produce the -9 and -10 variants of the 787 family, ensuring enough capacity to be able to accommodate future ramp-ups was a crucial challenge. Procurement of parts and the production lines have to be in synchronized, an area where special know-how unique to aircraft manufacturing is exercised.

Constant efforts are made to develop that know-how, with the help of Kawasaki's Corporate Technology Division and group companies. These efforts have already led to the development of tools for cutting composites, an analytical method using an ultrasonic nondestructive testing device, and more. In building the East Plant, simulations were performed to optimize production management by linking the activities of the three plants, including the handling of work in process and delivery schedule. The collective effort of Kawasaki is directed toward the creation of safe aircraft.

Epoch Maker

# Hydraulic Pump

**Japanese-made hydraulic excavators have played a leading role in construction sites around the world. Ever since the first home-grown hydraulic excavator was developed in Japan, Kawasaki has underpinned the construction machinery industry with its hydraulic pumps—the heart of hydraulic equipment—that boast outstanding performance.**

Hydraulic excavators are star players on the construction field, and Kawasaki's hydraulic pumps are adopted in many excavators across the world thanks to their high performance. Features such as high operability, high efficiency, low noise and high reliability found in Kawasaki's hydraulic pumps are based on its wealth of experience and advanced technology.

The first hydraulic excavator that was made entirely in Japan was actually built not so long ago, in 1965. The hydraulic pump for this excavator was developed by Kawasaki. Hydraulic pumps serve as the heart, so to speak, of hydraulic excavators, supplying hydraulic oil to motors, cylinders, and other components. Kawasaki developed the KV Series, which was adopted in the first hydraulic excavator, in 1968, after which the hydraulic pump business took off.

The evolution of hydraulic pumps can be summarized in one phrase: increasing power density. The goal is to provide a large volume of hydraulic fluid at high pressure and high speed, while making the pump itself smaller. In the KV Series, Kawasaki aimed to develop a swash plate pump that anticipated an era of ultra-high pressure operation of 50 MPa. A swash plate pump is a type of pump in which the piston slides along the surface of a swash plate in a reciprocating motion to send out hydraulic fluid. With the NV Series, which came out in 1981, the angle of the swash plate was made steeper to enable high-pressure, high speed motion. The parts were further refined down to the micron level to achieve increased output density. The latest K7V Series boasts an output density approximately 10 times greater than that of the KV Series. Today, Kawasaki has become the leading player in the hydraulics field.

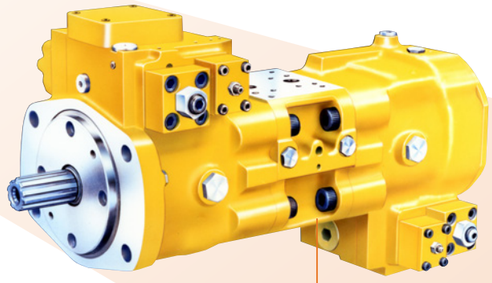
First Model

## 1968

### KV Series

#### Foundation of Hydraulic Machinery Industry

The KV Series was developed and used for Japan's first home-grown hydraulic excavator. The working pressure was 21 MPa. The chief design engineer at the time recalls: "It took one year before it was fully ready for use. We competed against U.S. competitors' products in a 500-hr non-stop operation test at the riverside. Kawasaki's pump emerged as the winner in this competition."



## 1981

### NV Series

#### Dawn of Further Innovation to Come

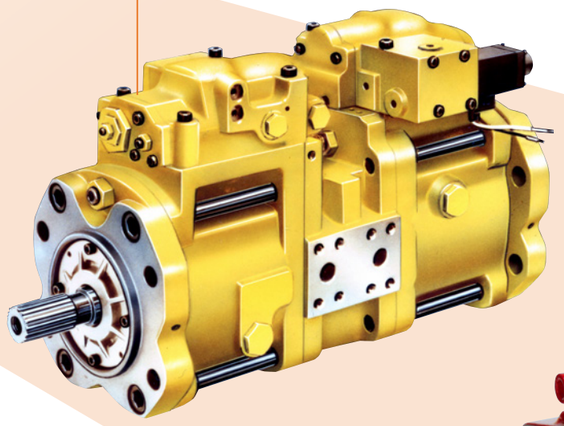
The NV Series, released in 1981, offered higher pressure and higher speed in a smaller frame. This was achieved by optimizing the piston shape, developing a new material for the sliding surface, joining two pumps in a tandem arrangement, and other improvements. In the end, the working pressure was brought up to 32 MPa, while achieving high reliability at the same time.

## 1988

### K3V Series

#### Significant Reduction in Number of Parts

The K3V Series, developed in 1988, was built on the innovation of the NV Series, further enhancing its reliability and productivity, and taking standardization a step further. It managed to reduce the number of parts by 30% as part of an effort to make it more price competitive. This helped Kawasaki to step out to the world stage. The working pressure ultimately reached as much as 38 MPa.

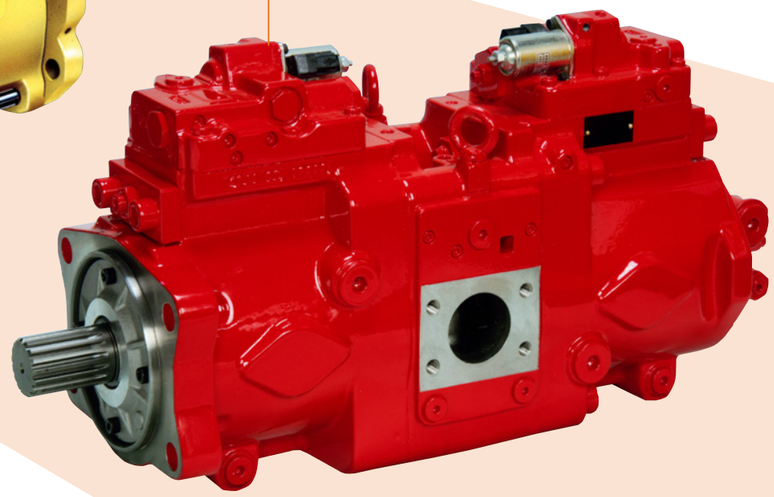


## 2014

### K7V Series

#### Optimum Environmental Performance at High Output Density

The K7V Series took the eco-friendly features passed on from the K3V to the K5V and gave them a boost. It achieved a maximum working pressure of 40 MPa, and an output level 20% greater than that of the K3V while the weight remained the same. It is also 3% more efficient than the previous model.



Techno Box 06

# Highly Efficient Gas Turbine L30A Featuring Hydrogen Combustion Technology

# L30A


Commentary

**Atsushi Okuto (Right)**
Manager, Planning Section, Gas Turbine Development Dept.

**Takeo Oda (Center)**
Senior Staff Officer, Combustor Section, Technology Dept.

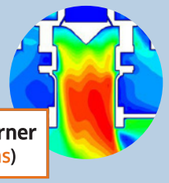
**Satoshi Nakayama (Left)**
Senior Staff Officer, Development Section 1, Gas Turbine Development Dept.

Engineering Center, Gas Turbine Division Gas Turbine & Machinery Company Kawasaki Heavy Industries, Ltd.


## Designed for the energy of the future!

Mixed combustion of up to 60%※ hydrogen

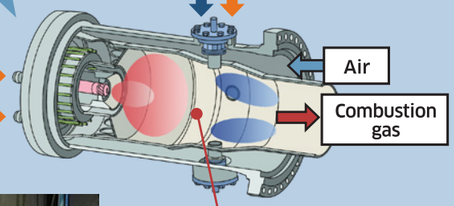
Proprietary Kawasaki technology



Supplemental firing burner (hydrogen/natural gas)

Pilot burner (natural gas)

Main burner (natural gas)

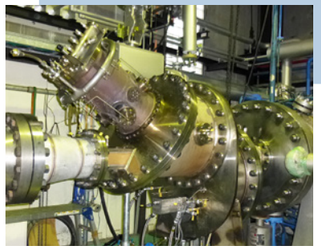



Designed to achieve uniform combustion of fuel.

### Reduces $CO_2$ by burning fuel mixed with hydrogen!

The L30A can use hydrogen, which produces no $CO_2$, as supplementary fuel. It uses a supplementary firing combustion system called the dry low emissions (DLE) system featuring four supplemental firing burners provided for each combustor. This system achieves a mixed combustion ratio of up to 60% hydrogen (in volume), and achieves combustion in a manner that is tailored to the unique properties of hydrogen, namely, its high flame speed and high flame temperature.

※ Hydrogen fuel: fuel that partially contains hydrogen, as opposed to hydrogen-only fuel.

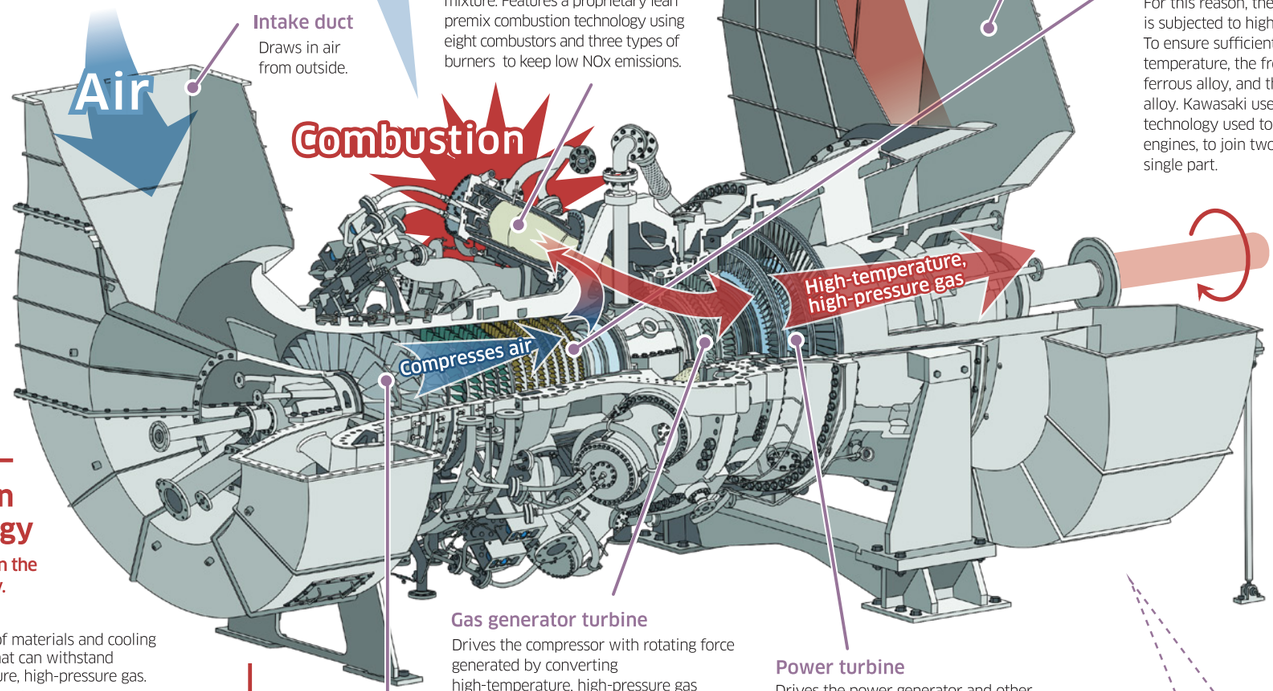


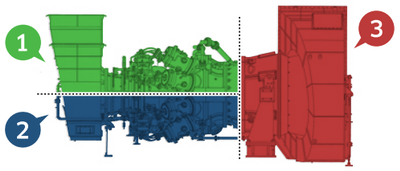
Combustion test with JAXA's high-temperature, high-pressure combustion test facility

## Kawasaki Challenge

### Electrical Efficiency of 40.1% No.1 Performance in the Popular 30 MW Class

The beginnings of Kawasaki's industrial gas turbines go back to 1972. With proprietary technology, Kawasaki went on to create hit products such as the M7, which became Japan's first cogeneration gas turbine in the 6-8 MW class to top a total production of 100 units. As Kawasaki got ready to enter the 30 MW class–the most competitive segment–with the L30A, its internal development departments and others worked together to achieve high efficiency leveraging the state-of-the-art design technology. Kawasaki's L30A also boasts high overall efficiency in cogeneration, and draws attention from around the world with its superior performance.




### Ease of maintenance

The L30A can be disassembled in front of the power turbine. The gas generator case can be split horizontally for easy maintenance.

## World's Highest Level 30 MW Class Gas Turbine

A gas turbine is a type of engine that burns natural gas or utility gas to produce motive power. First it draws in a large volume of air and compresses the air with a compressor. Inside the combustor, injected fuel is burned with the compressed air, and the resulting high-pressure, high-temperature gas drives the turbine. The rotating force of the turbine is harnessed to generate electricity, and recovered exhaust heat is utilized to produce steam.

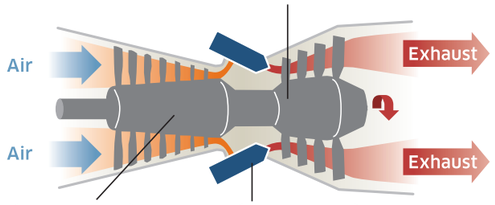
The L30A, a 30 MW class gas turbine developed by Kawasaki in 2012, has achieved a class-leading electrical efficiency exceeding 40%. When incorporated into a cogeneration system, it can achieve a total thermal efficiency over 83%. The proprietary combustor keeps nitrogen oxide (NOx) emissions at 15 ppm or less–the world's highest level–and enables mixed combustion with hydrogen fuel, a technology that is attracting wide attention these days. For reference, 30 MW of electricity meets the power needs of 15,000 households.

The three key points in boosting electrical efficiency are air compression ratio, the temperature of gas at the turbine inlet, and component efficiency. Combining Kawasaki's long-cultivated expertise in small- and medium-size industrial gas turbines and its highly sophisticated aircraft engine technology, the L30A delivers specifications that lead the world in its class.

### Key considerations in gas turbine technology

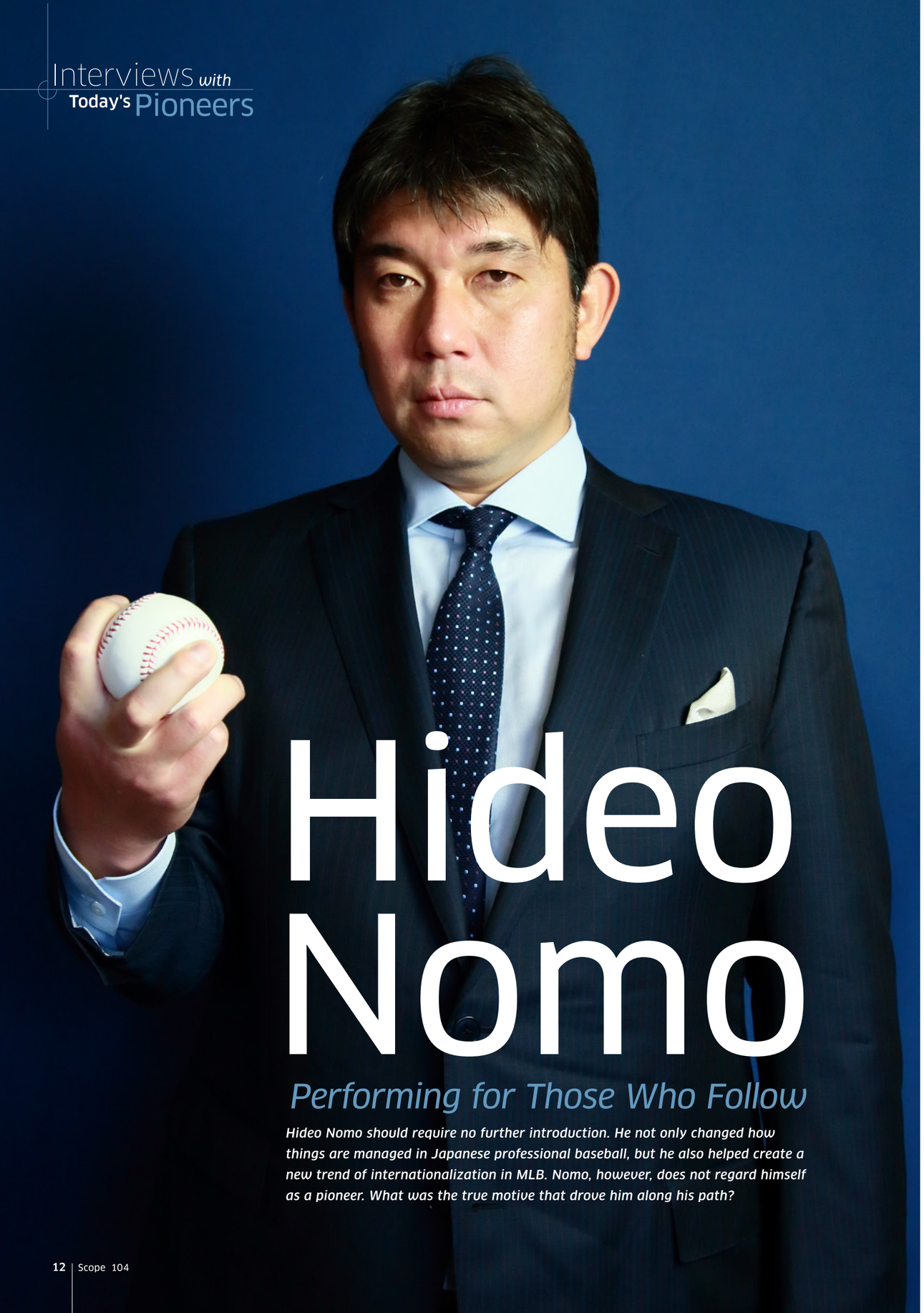
There are three things to consider in the evolution of gas turbine technology.

**Turbine** Development of materials and cooling technologies that can withstand high-temperature, high-pressure gas.




**Compressor** Designing the blade (cascade) geometry for efficiently compressing air.

**Combustor** Development of a mechanism and geometry that facilitate the mixture and uniform combustion of compressed air and fuel.



# Hideo Nomo

## *Performing for Those Who Follow*

***Hideo Nomo should require no further introduction. He not only changed how things are managed in Japanese professional baseball, but he also helped create a new trend of internationalization in MLB. Nomo, however, does not regard himself as a pioneer. What was the true motive that drove him along his path?***



### Being Committed to Your Own Decision and the Allure of MLB

To take a shot at playing in Major League Baseball was the first decision he ever made on his own in his baseball career. The decision to join an amateur baseball club and to later enter professional baseball was not his—he simply accepted what someone else had told him. But before long, he started dreaming of one day playing in the major leagues, where he would be able to pitch against the strongest hitters in the world. This dream soon became a resolve.

"Because it was my own decision," Nomo recalls, "I was prepared to start from the minor leagues if I had to. But I was also confident that if I could keep pitching in my tornado pitching style, I should be able to succeed in the major leagues as well. That is, if I did everything right—the delivery and release off the fingertips, everything executed just as I had visualized in my mind."

Around the time Nomo entered MLB, it was undergoing a period of transformation, with the MLB Players Association carrying out a major strike and so on. It was against this backdrop that "Doctor K" appeared on the big-league stage, and stunned other major leaguers with his unique pitching style. The fact that he threw two no-hitters—there were only three others who had ever done that before—proves his prowess as a pitcher. Nomo's success heralded the beginning of a new era in MLB as a place where the finest players in the world come to make a name for themselves..

Nomo says there was a culture in MLB that was totally different from the culture in Japanese professional baseball. "In Japan, people talk as if the manager's decisions are everything. In MLB, the manager makes decisions to bring the best out of each player, so people tend to focus more on the players' performance. Of course, that means if a player does poorly, he will have to deal with a lot of tough criticism. And the fans really know the game and can get really fired-up. Anyone who has ever had a chance to stand on the mound as a starting pitcher, has seen the view from up there, and felt the roar of the cheering fans would want to be up there all year long."

Being a mature show business, the players are expected to always show their best performance. For any player, and especially a pitcher, that often comes with a price in the form of injuries. Nomo also had his share of injuries—he injured his right elbow. He also experienced a fall from a top team to the lowest-ranking team. He even pitched in the Venezuelan Winter League for a certain time. On April 10, 2008, after 1,000 days of rehabilitation, he made a comeback to the major leagues as a starting pitcher. The thing that drove him to go that far to keep trying to come back to the major leagues was that he could not forget the view he saw, and cheers he heard, on the mound as a starter. "I was not at all satisfied with my performance in that game, though," he said with a smile.

### The Responsibility of a Professional

"I don't think my ability as a baseball player improved while I was in MLB," Nomo says. "But I did learn a lot of things as a baseball player." One of the things that left an impression was the amount of work players put into helping develop the next generation of youths. "MLB players do everything they can to make time out of their busy schedule traveling and playing for the team to take part in baseball workshops to coach kids. In Japan, the clubs were trying to keep the players away from fans to make them look special. I was impressed by the deeply entrenched attitude in the U.S. that it is the responsibility of professionals to hand down the field in which they were fortunate enough to play into the next generation."

Looking back, Nomo, too, was fostered in the incubator of amateur baseball, from which he entered professional baseball. Wasn't it his duty to help develop the next generation of professionals like the MLB players?

It was such thoughts that led him to found the NOMO Baseball Club, an amateur baseball club team based in Sakai City, Osaka Prefecture. In 2005, two years after the team was formed, the team managed to play in the Intercity Baseball Tournament, and won the All-Japan Club Championship, hosted by the Japan Amateur Baseball Association. The club later moved to Toyooka City, Hyogo Prefecture, where the players are pursuing their dream of one day becoming a professional baseball player while working to support their family. "First you become a professional baseball player. Then you coach kids who aspire to becoming a baseball player. It became my dream to make that cycle a common practice."

Here, too, is the image of a man who is doggedly trying to be committed to his own decision.

**Hideo Nomo**
A star pitcher who made a name for himself with his signature "Tornado" pitching style. He is known to have pioneered the path to MLB for Japanese players. Born 1968 in Osaka Prefecture. In 1988, when he was playing for an amateur baseball club, he was chosen as a member of the national team representing Japan at the Seoul Olympics, where the team won the silver medal. In 1990, he entered Nippon Professional Baseball. In 1995, he joined the Los Angeles Dodgers. He played in MLB for 12 years until he retired in 2008. His stats are 78 wins and 46 losses in Japan, and 123 wins and 109 losses in MLB. He became the fourth person to achieve two no-hitters.

## WMATA Places Orders for 220 More New Subway Cars

In July, Kawasaki received an approximately 400 million dollar order from the Washington Metropolitan Area Transit Authority (WMATA) for an additional 220 subway cars (Series 7000). All 220 of the Series 7000 subway cars will be manufactured at Kawasaki's Lincoln plant in the U.S. state of Nebraska and are scheduled for delivery between 2018 and 2019.

This order completes the final option of an original base contract for 64 cars ordered back in 2010. The exercising of this option brings the total number of Series 7000 cars ordered up to 748 and the cumulative total value of the contract to 1.47 billion dollars.

The additional 220 cars will replace existing cars in the WMATA subway fleet. Once their delivery is complete, more than half of all the WMATA's transit cars will be Kawasaki-made.

The Series 7000 cars are being introduced as part of the WMATA's efforts to enhance customer service. They will be used in an expansion project linking Dulles International Airport, replace some of the oldest rail cars in the existing fleet, and help ease congestion. The WMATA began phasing the new rail cars into service in April 2015 and so far everything has been running smoothly. The first stainless steel cars to be put into service by the WMATA, the Series 7000 increases passenger capacity over existing models by eliminating one operator compartment every two cars. The Series 7000's state-of-the-art systems, including monitors for displaying digital content, CCTV cameras, and a communications network, guarantee a safe, reliable, and comfortable ride.

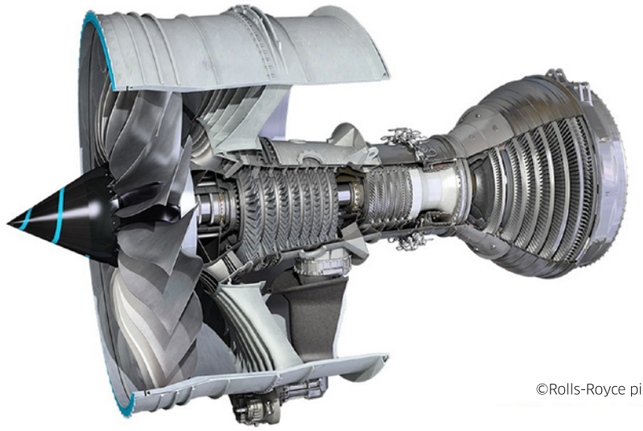

## Participation in Rolls-Royce Trent 7000 Program Announced

Kawasaki has reached an agreement with Rolls-Royce on contracts for Kawasaki's participation in the Trent 7000 engine program as a Risk and Revenue Sharing Partner, including module design, development and production activities.

The Trent 7000 is the exclusive powerplant for the Airbus A330-neo aircraft, which offers improvements on A330-200/300 and is currently under development by Airbus S.A.S.

Kawasaki will participate in the design and be responsible for the production and assembly of the intermediate pressure compressor (IPC) module for the Trent 7000. As one of the eight main modules that constitute the engine, the IPC module has a diameter of about 1.5 m, a length of about 1.5 m and is comprised of approximately 4,000 components.

Kawasaki and Rolls-Royce have previously worked together on military, marine and civil aerospace engines in a relationship dating back to an overhaul license agreement on Orpheus engines in 1959. In 1988 Kawasaki began its participation in Rolls-Royce civil engine programs with the RB211-524 and Trent 700.



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## New Management Team Announced

At the General Meeting of Shareholders held on June 25, board members were elected as shown here. Among them, Toshiyuki Kuyama, Kazuo Ota and Hideki Fukuda were newly elected to the Board of Directors, and Toshiyuki Kuyama and Kazuo Ota appointed senior vice presidents at the meeting of the Board of Directors that followed.

**Shigeru Murayama**
President

**Joji Iki**
Senior Executive Vice President

**Eiji Inoue**
Senior Vice President
*President*
*Plant & Infrastructure Company*

**Yoshinori Kanehana**
Senior Vice President
*President*
*Rolling Stock Company*

**Akio Murakami**
Senior Vice President
*President*
*Ship & Offshore Structure Company*

**Munenori Ishikawa**
Senior Vice President
*President*
*Aerospace Company*

**Kazuo Hida**
Senior Vice President
*President*
*Precision Machinery Company*

**Kenji Tomida**
Senior Vice President
*President*
*Motorcycle & Engine Company*

**Toshiyuki Kuyama**
Senior Vice President
*President*
*Gas Turbine & Machinery Company*

**Kazuo Ota**
Senior Vice President
*General Manager*
*Corporate Planning Division*

**Yoshihiko Morita**
Outside Director

**Hideki Fukuda**
Outside Director

## Motor-driven Natural Gas Compressors Ordered for FPSO

Kawasaki has recently received an order for two motor-driven natural gas compressors for a floating production, storage and offloading system (FPSO) from TH Heavy Engineering Bhd. The FPSO will be operated in Layang Field of Sarawak, Malaysia, in which JX Nippon Oil & Gas Exploration (Malaysia) Limited has 75% working interest as an operator.

An FPSO (in this case known as Layang FPSO) is a floating vessel designed to process and store crude oil or gas and liquid hydrocarbons, which are extracted from offshore oil and gas fields and will be offloaded onto a shuttle tanker and transferred ashore. This vessel can be operated at any water depth and is also easy to transfer and reuse.

The FPSO will be used for the development project at Layang Field, located 200 km off the coast of Bintulu, Sarawak, Malaysia. TH Heavy Engineering Bhd. is an engineering, procurement, construction, and installation (EPCI) contractor for the FPSO. Kawasaki's compressors will be installed on the FPSO and used to compress natural gas produced from Layang Field.

Natural gas produced from Layang Field, together with natural gas from Helang Gas Field, is planned to be supplied through subsea pipelines approximately 200 km long to the Malaysia Liquefied Natural Gas Tiga Sdn. Bhd. plant in Bintulu, Sarawak, Malaysia. The natural gas will be sold as LNG after liquefaction, while the condensate and Layang oil are planned to be shipped from the FPSO.

# Paving the way for a hydrogen-based society.


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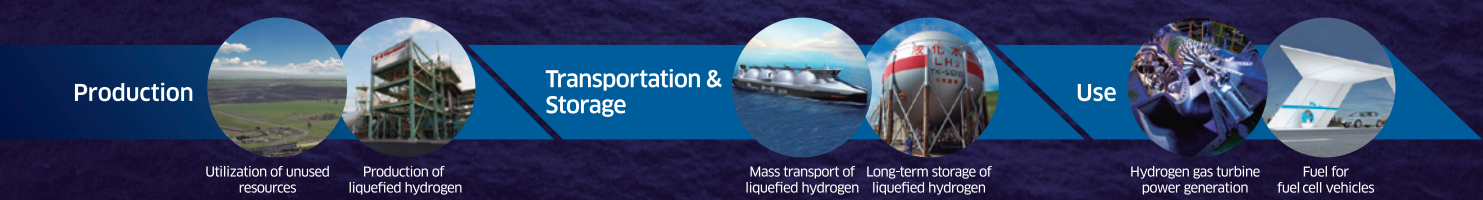
two of the most pressing environmental issues facing humanity: global warming and resource depletion.
To help spread the use of hydrogen made from untapped resources and natural energy,
Kawasaki is working to develop the technological foundation of
a hydrogen energy supply chain—production, transportation, storage, and use.
We believe that by handling hydrogen in a manner that is safe, stable, and affordable,
we will be able to achieve an abundant life.
The road to that future is what we call the Kawasaki Hydrogen Road.




## Kawasaki Hydrogen Road

Special website for the Hydrogen Project: http://global.kawasaki.com/en/stories/hydrogen/

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