Featured Articles

Improvements to Environmental Performance and Comfort of Rolling Stock

Takashi Yoshida
Yuta Kawaguchi
Naoji Ueki
Kazuki Okamura
Tokuichirou Oku
Kenji Okuma

OVERVIEW: As a rolling stock manufacturer, Hitachi develops a wide range of railway cars for use in everything from high-speed trains such as the Shinkansen to commuter trains. To provide the Shinkansen with an interior that passengers will find comfortable even during long trips, work by Hitachi includes the adoption of active suspension to prevent the transmission of vibrations through the floor and the use of fittings designed to ensure barrier-free accessibility. On commuter trains, Hitachi uses equipment that reduces power consumption, including LED headlights. Hitachi is also seeking to make further improvements in environmental performance and comfort, with development work that includes adapting the UD seats used at public and medical institutions for use on trains.

INTRODUCTION

RAILWAYS have received attention in recent years for being a form of public transportation with low energy consumption.

Hitachi supplies rolling stock aimed at reducing the load on the environment by building high-speed trains such as the Shinkansen and commuter trains developed under the brand name "A-train" from lightweight aluminum alloy.

To meet the demand in recent years for further improvements in environmental performance and comfort, Hitachi is working on developments for both high-speed and commuter rolling stock.

This article describes what Hitachi is doing to improve the environmental performance and comfort of both high-speed and commuter trains.

TECHNOLOGY DEVELOPMENT FOR HIGH-SPEED SHINKANSEN ROLLING STOCK

High-speed Shinkansen rolling stock plays an essential role in long-haul travel in Japan, and major advances have been made in the punctuality, comfort, and convenience of travel by Shinkansen. Several new technologies are used on the latest high-speed Shinkansen rolling stock, not only for the basic performance factors of running and stopping, but also for various other objectives, including minimizing internal and external noise, minimizing vibration, improving energy efficiency, reducing size and weight, and making the trains easier to maintain.

Latest High-speed Shinkansen Rolling Stock

The East Japan Railway Company was the first operator in Japan to introduce commercial Services with a top speed of 320 km/h, running the Series E5 high-speed Shinkansen rolling stock on the Tohoku

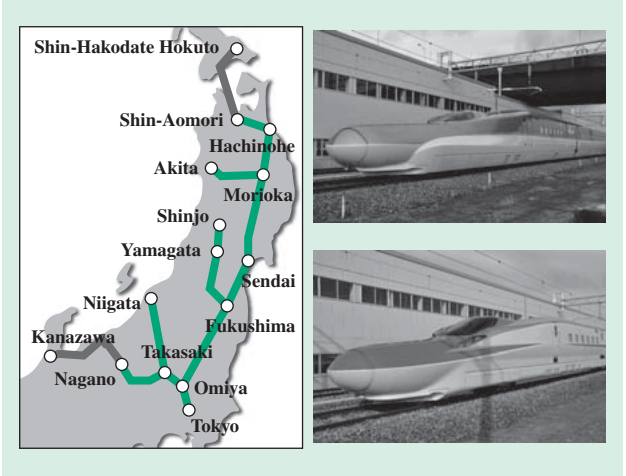

Fig. 1—Network of High-speed Shinkansen Services and E5 and E6 Rolling Stock.
The network linking the major centers in the Tohoku and Kanto-Koshin'etsu regions uses new high-speed Shinkansen rolling stock such as the Hayabusa Series E5 (top right) and Komachi Series E6 (bottom right).

Shinkansen and the Series E6 on the Akita Shinkansen (see Fig. 1).

For the commencement of Hokuriku Shinkansen services to Kanazawa in March 2015, the East Japan Railway Company and West Japan Railway Company also plan to introduce the Series E7 and W7 high-speed Shinkansen rolling stock which has a top speed in commercial operation of 260 km/h. The Hokkaido Railway Company, meanwhile, plans to introduce Series H5 high-speed Shinkansen rolling stock at the commencement of Hokkaido Shinkansen services to Shin-Hakodate Hokuto in March 2016. The Hokkaido Shinkansen has a planned top speed in commercial operation of 260 km/h, with speeds of 140 km/h expected to be used on sections of track that are shared with commuter lines, such as the Seikan Tunnel.

Latest Technology for High-speed Shinkansen Rolling Stock

The latest high-speed Shinkansen rolling stock incorporates a variety of leading-edge technologies. The Series E5 and E6 are long-nosed models to cope with their top speed in commercial operation of 320 km/h, with the Series H5 also expected to use the same nose design. The Series E7 and W7 have a top speed in commercial operation of 260 km/h.

Recognizing that the latest high-speed Shinkansen rolling stock is used for long journeys, it is fitted with active suspension to ensure ride comfort in the passenger compartment by preventing the transmission of vibrations through the floor when traveling at high speed.

The Series E5 and other high-speed Shinkansen rolling stock are designed to have superior deceleration, with improved brake performance to ensure that they can be brought to a stop more quickly than existing models in the event of an earthquake. To deal with earthquakes or similar emergencies, emergency stop performance has also been improved by fitting high-speed Shinkansen rolling stock with devices for detecting a loss of voltage on the catenary so that they can be brought to a stop more quickly when such a power outage is detected.

Because the Series E7 and W7 have to operate on track supplied by multiple power systems that use 50 Hz and 60 Hz respectively, they are fitted with electrical equipment capable of working with both frequencies (see Fig. 2). Along with increasing Shinkansen speed, Hitachi is also designing the traction electrical systems to be smaller and lighter with lower noise than existing models, while still achieving the output required for running at high speed.

Interior Fittings on High-speed Shinkansen Rolling Stock

High-speed Shinkansen rolling stock is provided with interior fittings designed to provide a comfortable passenger compartment and barrier-free accessibility (see Fig. 3).

(1) Barrier-free accessibility

The fittings in the Series E7 and W7 are designed to provide barrier-free accessibility. In addition to braille signage in the deck to indicate the passenger compartment layout, braille seat numbers are provided at the top of all seats and multi-function toilets that are designed for use with electric wheelchairs are available.

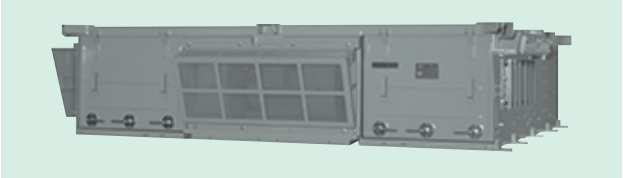

Fig. 2—Electrical Equipment on High-speed Shinkansen Rolling Stock.
This main converter (50 Hz/60 Hz) is used on the Hokuriku Shinkansen.

Fig. 3—Interior Fittings on Latest High-speed Shinkansen Rolling Stock.
The internal fittings use the latest technologies such as LED lighting and are designed for barrier-free accessibility.

(2) Light-emitting diode (LED) passenger compartment lighting

LED lighting is used for the ceiling lights in the Series E7 and W7. Not only does this reduce the amount of power consumed to provide the required level of illumination compared to older forms of lighting, the longer life of LED lighting also reduces maintenance.

(3) Electric power sockets provided for all seats

The Series E7 and W7 have electric power sockets for all seats, including in standard-class cars. For window seats these are located in the lower part of the side panel and for aisle and center seats in the lower part of the seat ahead.

(4) Toilets with warm water bidets

To improve toilet comfort, all western-style toilets on the Series E7 and W7 have a warm water bidet. The design also includes measures such as clear labeling to prevent passengers from mistaking the SOS emergency call button for the flush button.

(5) Security

The security of high-speed Shinkansen rolling stock has been improved by fitting security cameras in the deck and passenger compartments, and installing an emergency call system in the passenger compartments and toilets.

Latest Design for High-speed Shinkansen Rolling Stock

The exterior design of high-speed Shinkansen rolling stock uses regional colors. The Series E7 and W7 use a design concept based on Japan's future that signifies the link between the future and the traditional Japanese culture of the Hokuriku region. The car colors are based on ivory white, with a sky-blue color that represents traditional culture used for the top of the cars, and a copper color used for the center stripe. The color scheme of the Series H5 is based on Tokiwa green and Hiun white with a Saika purple center stripe to present an image of the lilac, lupine, and lavender flowers of Hokkaido (see Fig. 4).

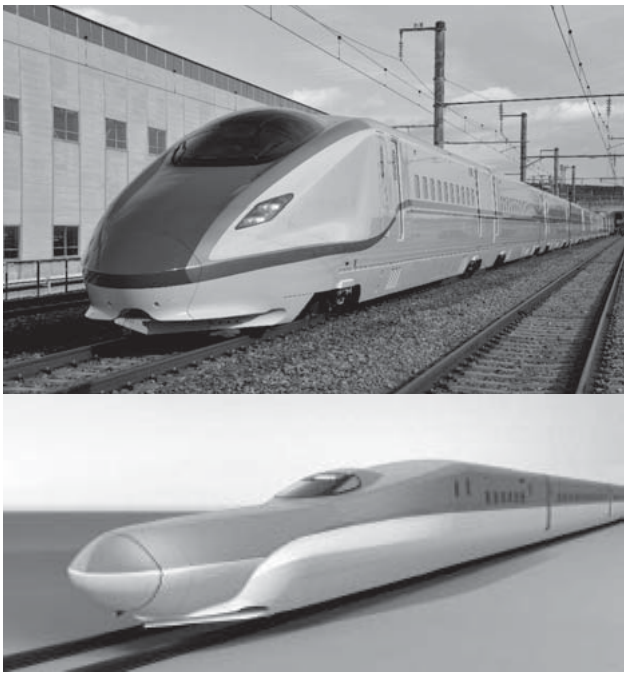

Fig. 4—Exterior Design of High-speed Shinkansen Rolling Stock.
The Series E7 and W7 (top) use a concept based on Japan's future that draws on both the nation's traditional culture and its future, while the Series H5 (bottom) design is inspired by Hokkaido's flowers.

IMPROVEMENTS TO ENVIRONMENTAL PERFORMANCE AND COMFORT OF A-TRAIN ROLLING STOCK

Evolving A-train Rolling Stock

Since 1997, Hitachi has been developing its A-train rolling stock based on the concepts of reducing the load on the environment and reducing lifecycle costs, and has supplied around 2,300 cars to a large number of users. The following sections describe the LED headlights and seating that can be used comfortably by the elderly or people with reduced mobility, and which were developed based on considerations of energy efficiency and universal design (UD) in response to demand for improvements to environmental performance and comfort in recent years.

LED Headlights

While the headlights on trains have in the past used high-luminance halogen lamps or high-intensity discharge (HID) lamps to improve forward visibility, reducing lighting power consumption has become an important issue for rolling stock in recent years as

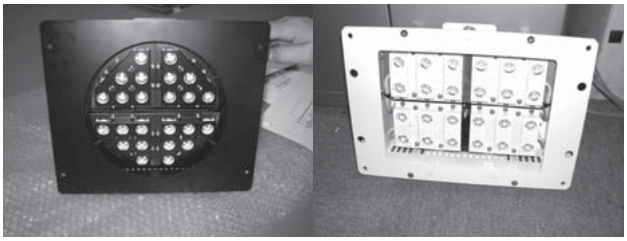

Fig. 5—New LED Headlight Units.
These round (left) and square (right) LED headlights were developed for use in different rolling stock designs.

TABLE 1. Illumination Measurements
The table lists the results of measuring the illumination provided by a variety of headlights.

	Supplier A	Supplier B
Headlight type	Sealed beam	HID
Reference axis	High-beam focused 150 m ahead	
Reference illumination level	0.75 lx or better	0.5 lx

HID: high intensity discharge

a countermeasure to global warming, with growing demand for the use of energy-efficient LEDs for headlights as well as in other applications. Hitachi has drawn on the development know-how it has derived from interior LED lights to develop and supply LED headlights with superior environmental performance that are more energy-efficient and reliable, and have a longer life (see Fig. 5).

Challenges in LED Headlight Development

Headlights are important safety equipment on trains. Accordingly, because new headlights need to provide better illumination and visibility than before, Hitachi conducted comparison trials with existing headlights. Using high-beam lights focused 150 m ahead as a reference, sealed beam lights produced 0.75 lx or more in the trials and HID lights produced 0.5 lx. Accordingly, the targets for LED headlights were set at 0.75 lx with a light intensity of 16,700 cd or better. Table 1 lists the results of illumination measurements.

Visibility Testing

Based on light distribution simulations, a light intensity of 16,700 cd was found to correspond to illumination of 0.75 lx, which is equal to or better than the sealed beam and HID lights. A visibility comparison was then performed between a prototype built based on the simulation results and sealed beam and HID headlights fitted in a train, confirming that the new headlight provided better visibility (see Fig. 6).

It was also confirmed that the LED headlight provides illumination equal to or better than sealed beam and HID lights, with illumination of 0.78 lx when on high-beam focused 50 m ahead.

Power Consumption

The LED headlights that were confirmed as providing equivalent visibility to the existing sealed beam and HID lights consumed 42 W/lamp (350 mA) of power when producing 16,700 cd. The power consumption of the existing HID lights is 250 W/lamp. That is, the power consumption per lamp had been reduced to about one-sixth the consumption of the existing headlights.

Development of Body-friendly UD Seats

Railway car interiors are designed with users in mind, including priority seating for the elderly, people with reduced mobility, and pregnant women. Typically, although these seats have used different seat fabrics, floor coverings, and interior panel coloring to differentiate them from ordinary seating, the materials and shapes have been the same as ordinary seating.

Meanwhile, sites such as medical facilities or railway stations and other public spaces have increasingly been adopting UD seats that are less physically demanding and easier to use for those who take more time to sit down or stand up, such as the elderly and people with reduced mobility.

Recognizing that the use of UD seats would be in keeping with the original purpose of priority seating, which is intended for the elderly, pregnant women, and people with reduced mobility, Hitachi conducted a survey of UD seats used at public facilities to look at whether they could be adapted for use in trains.

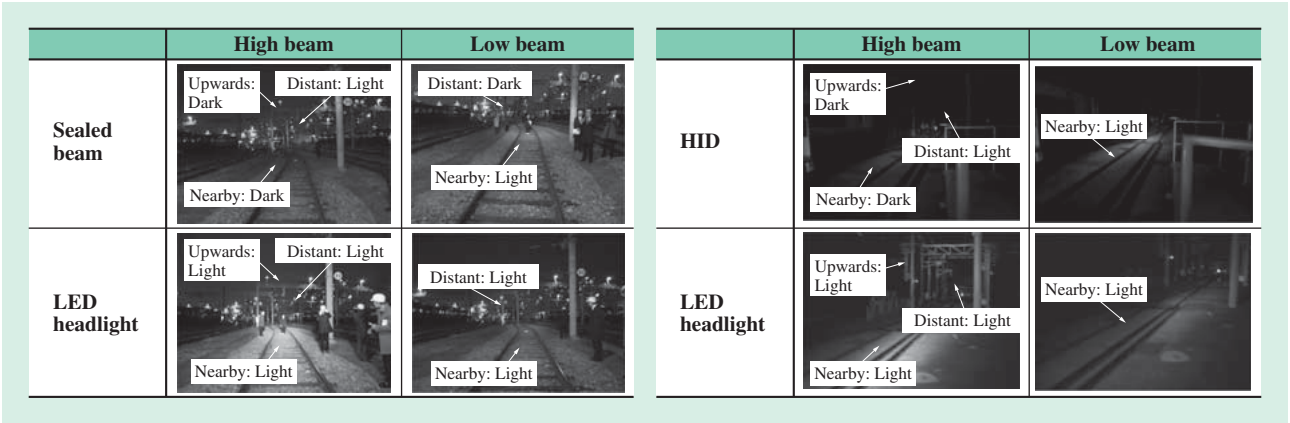

Fig. 6—Comparison of Visibility Provided by LED Headlights.
The photographs show the results of visibility testing of sealed beam, HID, and LED headlights performed using an actual train.

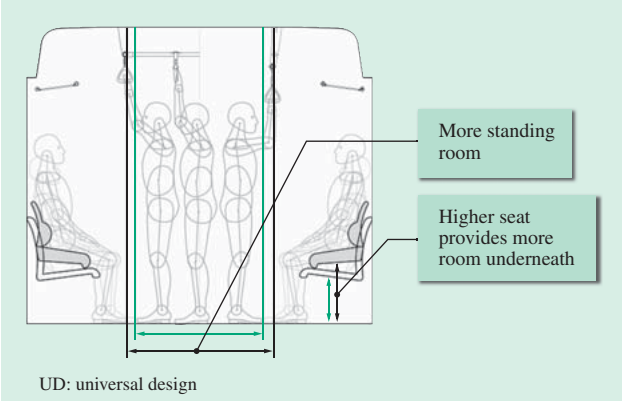

Fig. 7—UD Seating Layout.
Use of UD seats makes more effective use of space by providing more standing room and more room under the seats.

Fig. 8—UD Seat Mockups.
Two mockup seats were produced as actual-size models.

Results of UD Seat Survey

The survey found that, compared to the dimensions of existing seating, for which the seat was 42 cm off the ground and 45 cm deep (approx.), the UD seats were higher (50 to 60 cm) and not as deep (15 to 30 cm). Based on this survey, Hitachi embarked on the development of UD seats for trains in consultation with external experts, with the aim of developing a new multi-purpose seat rather than a seat intended solely for priority seating.

Aims and Benefits of UD Seat Development

Based on market surveys and other information, Hitachi set out to develop seats with the following benefits based on the primary objective of making the seats easier to get into and out of by increasing the seat height slightly and reducing the depth (see Fig. 7).

(1) Reduce the physical effort of sitting down by avoiding the need for major bending of the knee. (Making it easier for the elderly and people with reduced mobility who take more time to sit down or stand up, and also for those who find sitting down or standing up difficult such as parents carrying infants).

(2) Make a larger area of the interior available by raising the seat height and making seats less deep. (Raising the seats makes more room for items underneath. It also inhibits leg stretching and provides more standing room. This reduces the likelihood of strollers, suitcases, or other luggage blocking the aisle.)

Production and Testing of UD Seat Mockups

Following the market survey and dimensional investigation, mockup UD seats (full-size models) were used to perform an evaluation (see Fig. 8). The final dimensions were chosen based on the evaluation results using the following sample users.

- People for whom sitting down and standing up are an effort
- Pregnant women
- People of short stature

Next, in preparation for commercial production, the seats were fitted in a train to assess and verify their performance in practice.

CONCLUSIONS

This article has described the work being done by Hitachi on the latest technologies and universal design for the Shinkansen, on improvements to the environmental performance of LED headlights, and on measures for enhancing comfort for a diverse range of passengers by introducing UD seats in its A-train rolling stock.

There will continue to be strong demand for improving the environmental performance and comfort of rolling stock in the future. Hitachi intends to continue being proactive about identifying customer needs and working on further improvements to environmental performance and comfort.

ABOUT THE AUTHORS

Takashi Yoshida
Kasado Works, Rail Systems Company, Hitachi, Ltd. He is currently engaged in the system engineering of Shinkansen train systems.

Yuta Kawaguchi
Product Design Department, Design Division, Hitachi, Ltd. He is currently engaged in the design of rolling stock.

Naoji Ueki
Kasado Works, Rail Systems Company, Hitachi, Ltd. He is currently engaged in the system engineering of A-train and monorail systems.

Kazuki Okamura
Kasado Works, Rail Systems Company, Hitachi, Ltd. He is currently engaged in the system engineering of A-train and monorail systems.

Tokuichirou Oku
Rolling Stock Engineering Department, Rail Systems Company, Hitachi, Ltd. He is currently engaged in the system engineering of Shinkansen train systems.

Kenji Okuma
Rolling Stock Engineering Department, Rail Systems Company, Hitachi, Ltd. He is currently engaged in the system engineering of commuter train systems.