

## Featured Articles II

# Development of Elevators for the Chinese Market

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*OVERVIEW: International elevator manufacturers are not the only market players who are entering China, the world's largest market for elevators, domestic manufacturers are also growing rapidly and competing to introduce products. Hitachi stepped up to the challenge by developing competitive elevators that are manufactured in China and launched them in 2010. These elevators have become Hitachi's flagship products, with a full lineup of elevators extending from high-speed to machine-room-less models, which make up approximately half of all orders by volume. Their development in China is helping to provide high-speed and greater-capacity elevators in ever-larger buildings. The elevators feature a compact design to satisfy customers who want to shrink the amount of space occupied by the elevators, and also to reduce power consumption by utilizing regenerative converters and LED lighting to satisfy requirements for energy efficiency.*

## INTRODUCTION

ALONG with rapid economic development in recent years, China has experienced ongoing urbanization that extends beyond the major cities to its small- and medium-sized cities. The continued construction of large shopping complexes and housing in these cities is driving a rapid expansion in the country's elevator market (see Fig. 1). In 2011, China led the world both in the number of elevators produced and in the number in use.

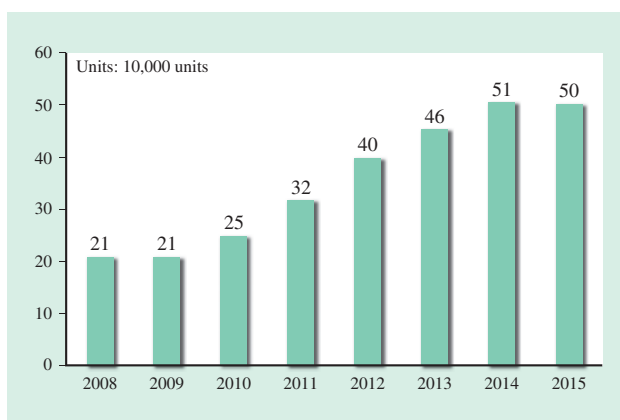


Fig. 1—Elevator Sales in the Chinese Market. The graph shows the total number of elevators sold by major manufacturers between 2008 and 2015 (based on research by Hitachi).

The market has become a focus of attention for international elevator manufacturers, with competition for market share growing fiercer every year.

## CHANGING REQUIREMENTS FOR ELEVATORS

Vendors are continuing to launch new products in response to the requirements for elevators as they change along with changes in the wider world.

### High Speed and Capacity

Amid ongoing urbanization, high-rise construction projects are getting larger. As this is driving continued growth in the market for the high-speed elevators required for these buildings, elevator development strategy is prioritizing higher speeds and capacities.

### Spread of Machine-room-less Elevators

In response to builders wanting to make more efficient use of space, there has been rapid growth in demand over the last few years for elevators that do not require machine rooms. Demand grew at an annual rate of approximately 20% between 2007 and 2015, increasing from 19,300 units/year to 83,500 units/year. The use of machine-room-less elevators is expected to continue to spread to the extent that they will become the mainstay of the market over the next decade.

### More Intelligent Elevators

The rise in public concern about elevators over recent years also extends beyond safety to include things like the visual and tactile qualities of displays and buttons, ride comfort, waiting times, and accessibility for the disabled. As a result, along with placing top priority on safety and reliability, intelligent features and designs that proactively anticipate unconscious human behavior are among the objectives of Hitachi's product development. Hitachi is also working on offering solutions that take account of how to transport people most efficiently by making elevators better at transporting users during busy times to ensure that the elevators provide a quick and comfortable way to move around the building.

### More Efficient Installation and Maintenance

China is experiencing rising wages as well as demand for shorter construction schedules (the time from breaking ground to completing a building). As elevator installation and commissioning takes place within this period, making these tasks more efficient has become one of the challenges for new product development.

Poor maintenance is believed to be the main cause of elevator accidents in China, with numerous maintenance companies involved in the elevator maintenance business and wide variations in service quality. To improve this situation, Hitachi is drawing on the benefits of having the manufacturer handle maintenance and is utilizing network technologies and information-based techniques to provide more efficient maintenance and safe elevator operation as well as seeking to bring more intelligence to management practices.

### Improvements in Energy Efficiency

Buildings make up more than 28% of China's total energy use, with the number of buildings continuing to grow year after year. Accordingly, the Chinese government set targets for reducing energy consumption between 2006 and 2010 in its 11th five-year plan and requested that the relevant parties take steps to save energy. Given that elevators are part of a building's facilities, there are growing demands for making them more energy efficient.

## ELEVATORS FOR THE CHINESE MARKET

### Development Background

Hitachi has served the rapidly growing Chinese market by selling two different ranges of elevators, namely

high-end models exported from Japan and standard models made in China. However, in response to the arrival on the market of high-end Chinese-made elevators from competing manufacturers beginning around 2007, Hitachi set out to develop a high-end version of its own Chinese-made elevators.

The main control systems in these elevators made greater use of Japanese-developed systems and adopted a traction machine made by a Hitachi company (Hitachi Elevator Motor (Guangzhou) Co., Ltd.). The new models conformed to Hitachi's global standards\* in terms of basic control performance and safety design and featured improved ride comfort and reliability. The design of the elevators was also upgraded and optional features were made available. These new Chinese-made elevators went on sale in 2010.

### New Product Range of Models Manufactured in China

The first model to go on sale was an elevator that requires a machine room, and was targeted at the volume end of the market. Energy efficiency features include LED lighting in the elevator car and a regenerative converter, and it also uses new group control systems for more efficient transportation.

This was followed by the launch of high-speed and ultra-high-speed models designed for faster speed and higher capacity.

Following the development of a traction machine with higher capacity than before, these elevators now have a maximum carrying capacity of 2,250 kg, a maximum speed of 480 m/min, and a maximum travel distance of 330 m. These features satisfy the requirements of a market characterized by larger and taller buildings.

For the rapidly growing market for elevators that do not require a machine room, as described above, Hitachi also launched a machine-room-less elevator that features a maximum carrying capacity of 2,000 kg, and a maximum speed of 150 m/min. In response to market demand, this model makes efficient use of space thanks to enhancements that include the development of a new thin-profile traction machine and smaller safety equipment.

Alongside this expansion of the product range, Hitachi has also been making improvements to operational quality and maintenance efficiency, including the incorporation of a destination floor reservation system, and remote monitoring of the

\* Previously the corporate standards of Hitachi Elevator (China) Co., Ltd. and the Chinese national standards [Guobiao (GB) Standards].

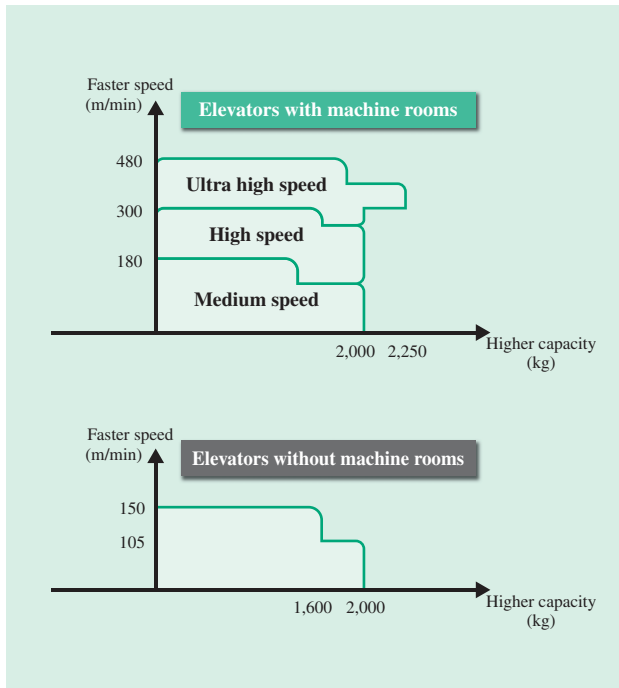


Fig. 2—New Product Range of Models Manufactured in China. The new product range offers models with faster speeds and higher capacity to satisfy market requirements.

elevator using equipment specifically designed for this purpose.

Through these measures, Hitachi has established a product range that covers almost all market requirements (see Fig. 2).

### Product Features

#### High-capacity Traction Machine and Drive System

The traction machine in the new product range was upgraded to provide faster speed and higher capacity. It was also made smaller than the previous model to satisfy constraints on the floor area and height of the elevator machine room (space for installing traction machines and control panels) and on securing access for maintenance. Fig. 3 shows a photograph of the highest capacity traction machine in the current models manufactured in China.

Development of the traction machine included making it smaller to fit inside the machine room and making maintenance easier. This smaller size was achieved by adopting a support structure that combines both an inner rotor and shaft and by changing from drum to disk brakes. The diameter of the sheave was also reduced. Along with these changes, the size of the traction machine was also reduced by using welded steel plate for the machine base and making it thinner, and by making the machine beam bearer thinner. This

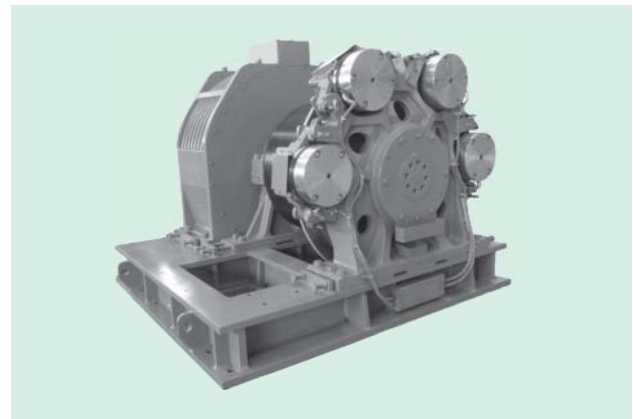


Fig. 3—91-kW Traction Machine.

The compact design has reduced the volume of the traction machine, providing greater flexibility for elevator machine room layout.

resulted in the traction machine being 465 mm shorter than the previous model, and reduced the required machine room height by 900 mm.

Higher-capacity power modules were adopted for the drive system, and the inverter capacity was increased by developing techniques for operating insulated-gate bipolar transistor (IGBT) modules in parallel, current equalization, and protection. Small heat pipes with high thermal conductivity were adopted to deal with the problem of heat generated by the power modules due to the increased capacity, thereby more than doubling the life of the power modules (relative to the previous model). To prevent interference with external power supplies, a reduced-size inductor-capacitor-inductor (LCL) filter circuit was also included to keep maximum harmonic currents below 25% of the level permitted by the Chinese national standards.

High-speed elevators are also called on to make efficient use of space, with a requirement to shrink the dimensions of the hoistway. To achieve this, Hitachi adopted an emergency terminal speed limiting (ETSL) system. This system satisfies Safety Integrity Level (SIL) 3 in the EN61508:2010 standard for functional safety and works by comparing the actual elevator car speed against the maximum speed from which it can brake to a halt in the space available to determine when an emergency stop is needed. This guarantees that the speed at which the elevator car impacts the buffer at the bottom of the hoistway will be kept below a certain level, even if an emergency occurs. The system allows the buffer to be smaller so that it takes up approximately 30% less space compared with when this system is not used.

### Machine-room-less Elevators

Hitachi developed its latest machine-room-less elevators amid rapidly growing demand for space-efficient elevators that do not require machine rooms.

Operated by a thin-profile traction machine at the top of the hoistway, this elevator was designed for greater safety and reliability and more efficient use of space for the same elevator specifications, while also satisfying market demands for comfort and high speed.

The structure of the traction machine was optimized to make it thinner, and the elevator reduces the load on the building by having the traction machine attached to the top of the rails and relocating the components in the hoistway to save a considerable amount of space (see Fig. 4).

The influence of traction machine vibration has been reduced by using high-performance vibration-isolating materials to improve ride comfort. The safety and reliability of the elevator have been improved further by adopting seismic design practices and making various improvements, including to the traction machine braking torque and to the level of protection and insulation.

### More Intelligent Elevators

#### (1) Multi-beam door sensor

Hitachi uses a multi-beam door sensor that it developed by itself. The redundancy of the door system has been increased by sending more information between the elevator controller and multi-beam door sensor to provide the controller with sensor status information, and using this sensor data as a basis for sending control commands to the door controller. The life of the sensor has also been extended by

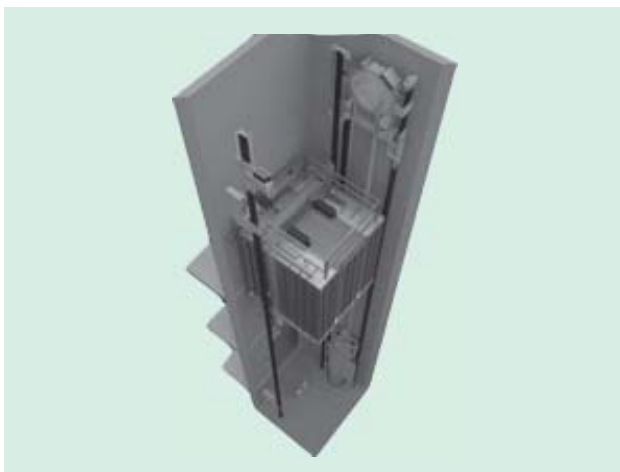


Fig. 4—Machine-room-less Elevator.  
The traction machine is installed at the top of the hoistway to make more efficient use of space.

automatically turning off its power supply when the elevator is in standby with its door closed.

#### (2) Destination floor reservation system

The addition of a destination floor reservation function to the elevator group control system means that users can specify their floor using a device provided for this purpose in the lobby and the control system will use this information to select the best choice of elevator. Directing users to particular elevators in this way provides more efficient operation and increases capacity by distributing users across the available elevators in a way that reduces the number of floor stops. The destination floor reservation system can also be used in conjunction with a flapper gate to control the flow of users, and it is particularly useful in buildings where different floors have different purposes, such as large buildings that attract a comparatively large number of people (see Fig. 5).

### More Efficient Installation and Maintenance

#### (1) Improvements to Installation Practices

One development objective for the models manufactured in China was to make installation work more efficient. The on-site installation work improvements made to achieve this included using thin-profile display units to reduce workloads, using moldings for machine room cable ducts to reduce on-site work, using bolts rather than welds for attaching the machine beams to reduce the need for on-site welding, and using rail brackets that can have their size adjusted on-site.

#### (2) Better maintenance techniques

By developing an elevator service support system and portable maintenance terminals, Hitachi ensures safe elevator operation with improved maintenance efficiency by providing functions that are specific to its own maintenance work.

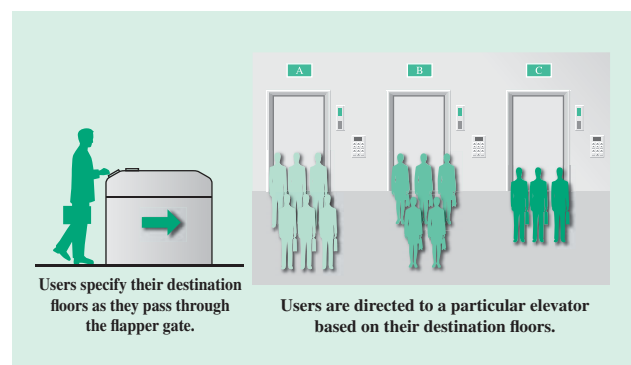


Fig. 5—Destination Floor Reservation System.  
Along with controlling the flow of people, the system provides efficient operation by enabling elevators to stop at fewer floors.

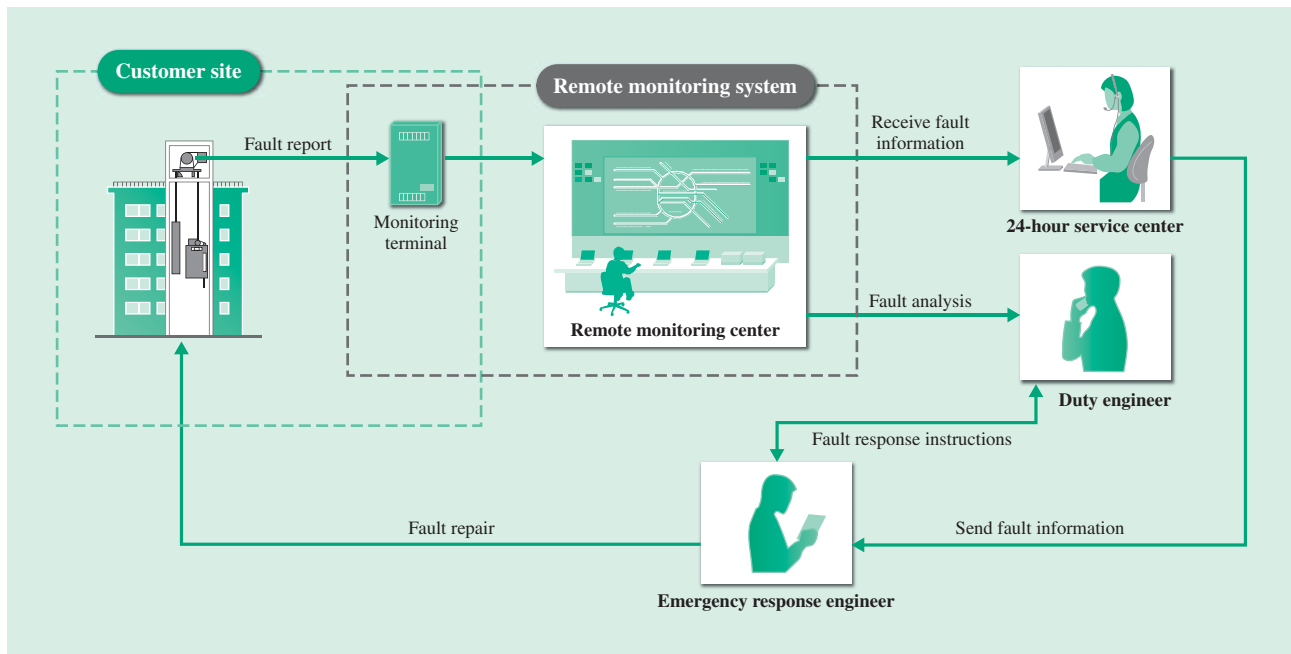


Fig. 6—Elevator Service Support System.

The system uses information technology to provide remote support to maintenance staff.

The elevator service support system includes the use of elevator communications and network technology to collect elevator data via serial communications and to transmit it wirelessly to a remote monitoring center via mobile communications. Using this data, the remote monitoring center helps improve maintenance efficiency and maintain safe elevator operation by monitoring fault information and other elevator condition data to assist maintenance staff with fault analysis and on-site response (see Fig. 6).

The portable maintenance terminals enable better site work management and more efficient administrative communications, overcoming the problem of complex site data management by using mobile communications for things like uploading work data and sending and receiving information on maintenance, installation setup, and other work. The terminal also has functions for adjusting elevators and modifying the program, and can be used by specialist staff to read and write data to the elevator controller using specific communication protocols.

The use of portable maintenance terminals to support maintenance work improves maintenance quality because it enables the consolidation and better management of maintenance tools.

### Better Energy Efficiency

The following technologies have been incorporated into the models manufactured in China to improve their energy efficiency. They have acquired Class A

energy efficiency certification under the VDI 4707 and ISO 25745 standards, and also help qualify buildings for Leadership in Energy and Environmental Design (LEED) certification, a voluntary certification system administered by the U. S. Green Building Council.

#### (1) Energy regeneration

The control system includes a regenerative converter that uses regenerative energy conversion to return energy to external power supplies for use by other facilities. At less than 10% and 1% respectively, current and voltage harmonic distortion are below the 37% and 5% limits stipulated in Chinese national standards.

#### (2) LED lighting in elevator cars

The models manufactured in China use LED lighting in the elevator cars. LED lighting reduces energy consumption by 30% compared to fluorescent lighting and has three times the operating life. Along with saving energy, the LED lighting panels also place less of a load on the environment because they do not include mercury or other toxic heavy metals.

#### (3) Car chassis

To reduce the amount of welding required, to make the elevators easier to work on, and to achieve steadier production quality, some of the welds used in the chassis have been replaced by bolts. Hitachi has also reduced the environmental impact while maintaining the machining precision and quality of components by using precision laser machining techniques and automatic assembly.



## CONCLUSIONS

Along with the passenger elevators described above, viewing elevators, hospital elevators, and firefighting elevators are also being added to the models manufactured in China. Featuring greater use of advanced technology and concern for protecting the environment, these Chinese-made elevators are safe and comfortable to ride in and are competitive in the Chinese market. They have won awards from the Chinese government and China Elevator Association as well as a science and technology encouragement prize from the Guangdong Mechanical Engineering Society (awarded to the high-speed elevator in 2015).

The elevators have performed well in the Chinese market with sales growing annually since the initial

product launch in 2010, and the models manufactured in China have become Hitachi's flagship elevator models in China accounting for more than 50% of orders by volume in 2015.

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