TEK Series Electric-Driven Transport Refrigeration Units Achieve High-quality Constant-temperature Transportation Even for Last-mile Delivery

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Trucks equipped with refrigeration units are widely used in the food distribution and logistics industries to transport goods needing to be kept under controlled-temperature conditions, such as food and pharmaceutical products. These refrigerated trucks play an important role in ensuring food safety, the reliability of pharmaceutical products, etc.

Especially after the COVID-19 pandemic, there is a growing worldwide awareness of safety and well-being, increasing the need for the delivery of high-quality foods and medicines. Refrigerated trucks are in growing demand especially as small and medium-size trucks for constant-temperature last-mile transportation. Trucks are also undergoing fuel efficiency improvement and electrification because of environmental considerations and soaring crude oil prices. Under such circumstances, it is required to develop transport refrigeration units with high versatility and the capability to keep the temperature constant during transportation.

This report presents the TEK series, electric-driven transport refrigeration units for small and medium-size trucks in Europe and Australia, developed by Mitsubishi Heavy Industries Thermal Systems, Ltd.

1. Overview of TEK series electric-driven transport refrigeration units

The TEK series presented herein adopts the plug-in hybrid system, which has already been highly acclaimed in the previous models of TE20/30 series, as highlighted by receiving awards such as the "Agency for Natural Resources and Energy Commissioner's Award (Transportation Field)" in 2019 and the "Technology Award" from the Japan Society of Refrigerating and Air Conditioning Engineers in 2021. The combined use of a commercial plug-in power source and a generator/battery dedicated to the refrigerator enables the refrigerator's energy source to be automatically changed depending on the status of vehicle operation (**Figure 1**). Therefore, no refrigerator control is needed to maintain high-quality control of cargo container temperature, allowing the driver to focus on driving and delivery.

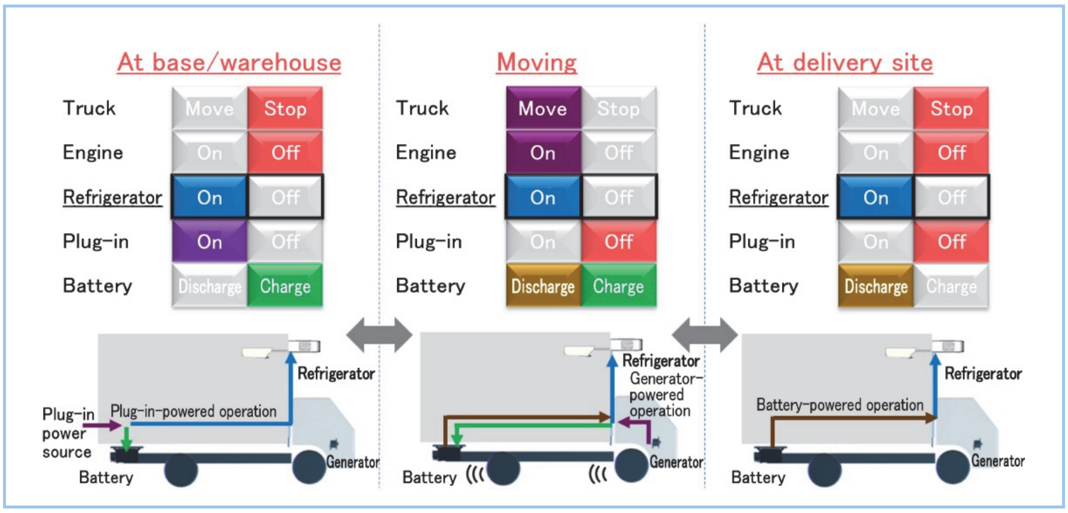

Figure 1 Plug-in hybrid system operation, while truck is moving or has stopped

While having the same features as the TE20/30 series, the TEK series is also characterized by improvements such as being smaller in size, and having higher cooling/heating capacity and greater versatility. By expanding the range of installable vehicle types and enabling even more sophisticated temperature control/management, the TEK series helps customers to achieve safe transportation and environmental impact reduction, in addition to economic improvement.

2. Features

2.1 Technology of our electric-driven transport refrigeration units

While trucks are on the move, our electric-driven transport refrigeration units operate on electricity produced by the alternator in the case of engine vehicles, or use part of the electricity from the main (traction) battery in the case of electric vehicles. Therefore, the power consumption of the refrigerator directly affects the truck's fuel efficiency and cruising range. The transport refrigeration units are also required to exhibit sufficient performance of high-quality temperature control for safe cargo transportation.

In response to these challenges, our electric-driven transport refrigeration units have adopted the air conditioner inverter control technology using a power semiconductor, thereby making it possible to quickly reach a target temperature with the capacity maximized soon after the start of operation and, once the desired temperature is achieved, operate with high efficiency. Thus, as the compressor speed can vary depending on the thermal load conditions, the limited resources of electricity and fuel during last-mile transportation are utilized effectively (**Figure 2**).

Moreover, the use of the aforementioned plug-in hybrid system enables the refrigerator to keep in operation without running the engine while the vehicle is not moving.

Our electric-driven transport refrigeration units, therefore, attain the following two features: safe cargo transportation with the capability of keeping the refrigerator in operation when the vehicle engine is stopped, and environmental impact reduction by appropriate usage of electricity according to the cargo container temperature conditions.

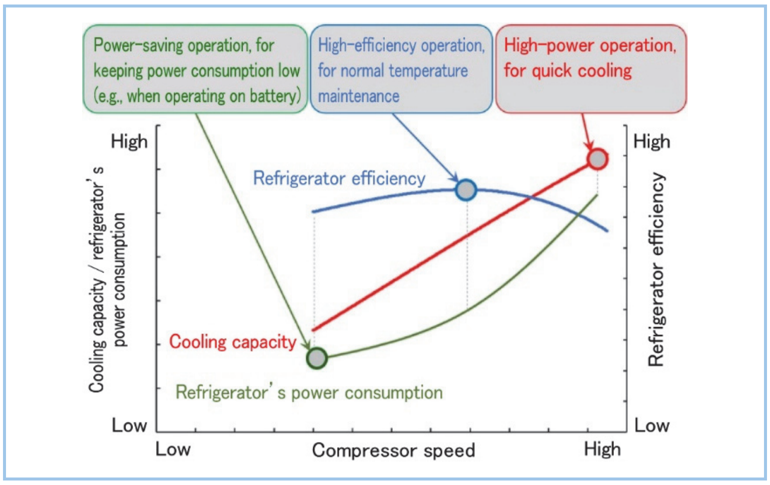

Figure 2 Conceptual diagram of compressor revolution control

2.2 Reduction in unit size and enhanced cooling capacity

For a refrigerated vehicle, customers select individually the vehicle type, refrigeration container, and transport refrigeration unit according to the intended application. Depending on their combination, therefore, the space for refrigerator installation can be limited. Especially in Europe and Australia, the height of refrigeration containers tends to be lower than in Japan, because of compliance with the regional fuel efficiency standards. If the product shape remains the same as the previous TE20/30 series, the installable vehicles and refrigeration containers will be greatly narrowed down because of the limited allowance for refrigerator height (**Figure 3**).

In the TEK series, a new type of space-saving fan is used in both outdoor and indoor units, while the compressor in the outdoor unit is laid horizontally to reduce the product height. For the indoor unit, the structure of the air outlet has been optimized to achieve better efficiency. With these improvements, the new refrigerator is smaller in size, can reach a target temperature more quickly, and exhibits higher performance in maintaining the temperature throughout the entire cargo container (**Figure 4**).

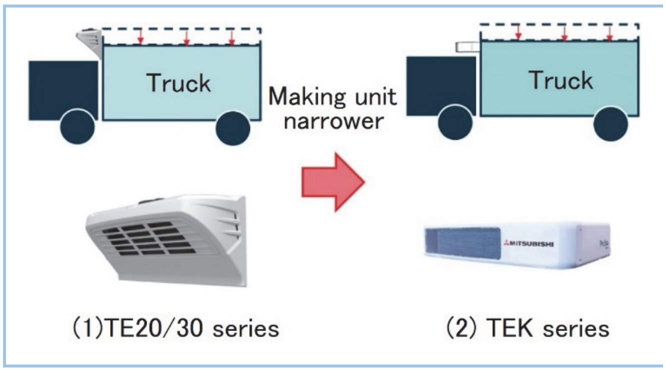

Figure 3　Limited space for condensing unit (outdoor unit) installation

Figure 4　Evaporator unit (indoor unit)

2.3　Improvement of pressure maintaining function to enhance heating capacity

The heating capacity of the TEK series in an environment of -20°C has been enhanced by a factor of more than 1.5 from that of the TE20/30 series, by making a functional improvement to keep the pressure higher during heating operation. This is expected to expand the applicability of safe cargo transportation in cold regions such as Northern Europe.

2.4　Versatility enhancement

To meet customer requests for different performances, layouts and sizes depending on the intended application, the TEK series has introduced a multi-system option. The evaporators available in three different sizes can be installed in separate partitioned compartments enabling setup of different temperatures according to cargo volume and content.

Moreover, the new shape of the outdoor unit makes stationary installation possible, in addition to the attachment to the front wall of a cargo container as in the case of the previous units. Thus, our product can not only be installed in trucks, but also can be mounted on the top of a van or cargo container (**Figure 5**).

Being made compact, the TEK series has the versatility of being mountable on vehicles for last-mile transportation in which the space for refrigerator installation is limited. Thus, the demand for refrigerators with improved flexibility can be satisfied. Since the launch of the TEK series, the application has been expanded from the conventional transportation of food and goods to a warehouse or between shops, to new fields such as supermarket home delivery, transportation of pharmaceutical products, and airport/leisure facility catering trucks.

Figure 5　Examples of attachment to vehicle

3.　Specifications

Table 1 shows the specifications of the TEK series. Our indoor-unit lineup offers a range of capacities required for cargo containers of varying sizes. The cooling capacity ranges from 2,800 W to 4,000 W.

Table 1 Specifications table of electric-driven transport refrigeration units: TE20/30 series and TEK series

	Current TE20/30 series		New TEK series			
	TE30GAE2	TE30GAEM	TEK250SA	TEK350SA	TEK450SA	TEK450MA
Cooling Capacity at 0°C (W)	3,019	2,925	2,825	3,424	4,056	4,205
Cooling Capacity at -20°C (W)	1,170	1,229	1,572	1,740	2,096	1,933
Refrigerant	R410A		R452A			
Air Flow (m^2/h)	732	*	891	1,452	1,814	*
Outdoor Unit Size (mm)	W 1,585 × D 580 × H 725		W 1,180 × D 630 × H 248			
Indoor Unit Size (mm)	W 966 × D 623 × H 151	*	W 600 × D 620 × H 190	W 850 × D 620 × H 190	W 1,100 × D 620 × H 190	*
Weight (kg)	177	197	185	190	230	245

*Depends on combination of indoor units in use, because of multi-system option
- The weight of TE30GAEM is estimated by using two identical indoor units in combination.
- The weight of TEK450MA is estimated by using indoor units of TEK450SA and TEK250A in combination.

4. Future prospects

The safe transportation of products needing to be kept under controlled-temperature conditions is an infrastructure that is critical and closely connected to our daily lives. For the continued fulfillment of such an important role, it is required to have the capability of balancing people, society and the global environment in a flexible manner.

Toward achieving a sustainable society, we will continue to develop/provide transport refrigeration units that remain harmonized with people, society and the global environment, by further improving their performance based on the feedback from customers.