

Railway Technology Today 3 (Edited by Kanji Wako)

Railway Electric Power Feeding Systems

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Introduction

Electric power technology in the railway industry refers to the means of supplying good-quality electric power to the electric motors. It primarily consists of power conversion technology at sub-stations, feeding circuits for DC and AC feeding systems, and the structure, materials, measurement, and maintenance of the electric overhead lines.

Power collection via the overhead line and pantograph, introduced nearly 100 years ago early in the history of electric railways, remains basically unchanged in physical appearance. However, technological developments during the past century have done much to greatly increase the current capacity, speed, and safety. Today, the capacity is more than sufficient to drive modern super high-speed trains. This article discusses all aspects of electric power supply systems for railways, ranging from the history of electrification of Japanese railways to today's sophisticated power supply facilities. It also compares them with their counterparts in other countries.

World Railway Electrification Systems

Table 1 shows various feeding systems around the world and the electrification distances.

The history of electric railways dates back to 1835 when T. Davyport fabricated a model electric car powered by voltaic cells and put it on public exhibition. The first practical electric cars debuted in 1879 when a 150-V dc, 2.2-kW, bipolar motor pulled three passenger cars at a maximum speed of 12 km/h at the Trades Exhibition in Berlin. In 1881, Siemens-Halske built the world's first electric railway in Lichtenfelde marking the first passenger electric railway.

Electric operation is often preferred on

railways with many long tunnels or on underground railways because the energy efficiency is higher than steam or diesel locomotives and does not involve on-board combustion. The high tractive force also makes electric operation suitable for lines running through hilly regions. As a consequence, electric train operation made remarkable progress. It started first with direct-current feeding systems capable of driving a DC motor directly and offering high tractive force and easy-speed control.

Although a 3000-V dc feeding system is widely used in many other countries, some Japanese railways using DC rely on a 1500-V dc system.

The other alternating-current feeding system originated in Europe using a single-phase, commutator-type motor. Special low frequencies such as 25 Hz and 16.66 Hz were introduced in Austria, Germany,

and other countries to minimize rectification failures. Later advances in silicon commutator technology paved the way for AC feeding systems using commercial frequencies in France and elsewhere. The 25-kV system is used widely around the world while Japan relies on a 25-kV system for shinkansen and a 20-kV ac feeding system for 'conventional' railways. (In this article, 'conventional' means all JNR/JR narrow-gauge lines, all non-JR railways, and the Aomori and Yamagata shinkansen, which were converted to standard gauge from narrow gauge.)

The three-phase, alternating-current feeding system is used with induction motors in Europe for railways with steep mountain grades, while a 600-V system, featuring speed control by a power converter, is used in Japan for new urban transit systems.

Table 1 World Electric Railway Feeding Systems and Electrified Distances (1996)

System Type		Japan ¹		World (excluding Japan)	
		km	%	km	%
DC	Less than 1,500 V	915	5	5,106	2
	1,500 V to 3,000 V (Mostly 1,500 V)	10,484	61	22,128	9
	3,000 V or more (Mostly 3,000 V)			75,276	33
Single-phase AC	50 Hz	Less than 20 kV		245	0
	60 Hz	20 kV		3,741	20
		25 kV		2,037	12
		50 kV			1,173
	25 Hz	11 kV to 13 kV		1,469	1
		16.66 Hz	11 kV		120
15 kV			35,461	18	
Three-phase AC		30	0	43	0
Unknown				3,668	2
Total		17,207	100	235,816	100

Notes: ¹ Statistics include Japanese subways and Aomori.
² Kazakhstan is 3,500 km (21,000 V AC and 60 Hz 25 kV ac) but details are not known.
 Source: (1) Railway Electrification Meeting Association of Japan, vol. 8, no. 14, pp. 3-5, Oct. 1997
 (2) *Stat., vol. 8, no. 11, pp. 77-78 and pp. 81-83, Nov. 1997*

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