

Introduction of Series 1000 EMU on Ginza Line of Tokyo Metro



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1. Introduction

The Ginza line of Tokyo Metro is the first subway in the Orient, which has begun commercial service between Asakusa and Ueno in 1927. The old class 1000 EMU (Electric Multiple Unit) was the cars adopted the newest technology such as ATS (Automatic Train stop System) device and all-steel car-body, which were the first in Japan in those days. Presently the length of Ginza line has become 14.3km between Asakusa and Shibuya and it is used by one million people a day. Succeeding series 01 EMUs also have passed a little less than 30 years from their introduction. So the obsolescent technology and the deterioration of equipment have become conspicuous. Then, we have newly manufactured the series 1000 EMU. In this paper, we introduce the series 1000 EMU.

2. Concept

The characteristic of this line is the route which passes through the brighter and more stylish area as Ginza, Shibuya, etc. in Tokyo and has had histories. When we designed the new series EMU for the Ginza line, we adopted the dear design which remembered the old class 1000 EMU on the first subway in the Orient. We also designed it considering that driving conditions of the Ginza line are such severe as the distance between stations is short and there are many sharp curves, and the passenger load factor is high. And we aimed at comfortable and high creative cars while making a plan to fuse retrospective design through stuffing a modern technology into the little car-body to improve comfort and cost performance.

3. Contents of EMU

(1) Car-body

In order to lighten a car-body and save energy, we made the car-body in all double-skin structure with aluminum alloy. The material unifies 6N aluminum alloy to progress in recycling. The joining method has been adopted FSW (Friction Stir Welding). In order to improve the strength in offset collision which is collision in a part of the front of a car, we made the corner posts of the car-body thick and made their cross-sectional form triangle. In addition to them, we joined the side car-body structure and the posts pierced from the under-frame to the roof structure.

(2) Exterior design

Following the image of the old class 1000 EMU, we adopted full-lapping specifications for the car-body. The side of it was lapped with lemon-yellow color and the part of roof was rapped with chocolate color. Further, in order to add accent to the exterior, we applied the three colors based on orange which is the line color of the Ginza line.

About arrangement of the light, we disposed the head light of the leading car on the upper part, and made the tail light the three-dimensional structure like a cylinder and the shape of curved surface in front of it, in order to make appearance retrospective image. By them we produced newness as the new-manufactured cars. Further we adopted the newest LED lighting device to the head light and we get the brightness to be compatible with saving energy and reduction of



Photo 1 Series 1000 and old class 1000 EMUs on Ginza line maintenance.

(3) Interior design

In order to produce the brightness on the subway cars, we made the end part of the car-body and the windscreen of seat side the light pink color with cherry pattern.

Seat faces are the brick pattern imaging Ginza Brick Street and the general seats are the light brown and the priority seat is the red imaging Asakusa Kaminarimon. The seat width a person was spread from former 430mm to 460mm.

We produce the expanse of space in the passenger room by adopting the reinforced glass to luggage rack, windscreen of seat side and gangway door, further making the ceiling height as high as possible.

We adopted LED lighting to the passenger room light so that we got 40% energy saving and the life span of 3.5 times comparing with fluorescent light.

Considering barrier free, we arranged the lamp interlocking with both notice and movement of doors under a threshold at each doorway. So that passengers can perceive the timing of door opening and closing by their sight.

About the priority seat, in order to tell it from general seats we adopted red color for it and orange color for stanchion poles and hand straps. Further the height of hand straps is set 1580mm for the low height passengers. And both leading cars have one wheelchair space



Photo 2 Passenger room

and one emergency call device.

(4) Bogie

For the main purpose of improving the running safety by reduction of lateral force and reducing flange wear, at all bogies of these car sets we adopted the link type single axle steering bogie which automatically steers the axle responding to deviation between the car-body and bogie when the cars run along curved track. By steering the axle like handle operation of an automobile, the wheel base of inner rail side becomes short and the wheel base of outer rail side becomes long so that the cars can run smoothly along curved track, comparing with conventional bogies. Vibration and noise have reduced and riding quality has improved also.

This steering bogie is the single axle steering type. The non-steering axle is the driving axle and the unit brake device is adopted for wheel tread brake. The steering axle is the non-driving axle and the disk brake is adopted which is able to follow the deviation of steering axle. In order to prevent the wheel load reduction at the torsion track, the series 1000 EMU has adopted the bogie with bolster. Then, in the bogie, the countermeasures such as the axle spring with non-linear characteristic, the leveling valve with small flow characteristic and the puncture-stopper considering the air spring puncture have been incorporated for safety. These countermeasures have been fixed in conventional bogies. The Ginza line has adopted the third rail and the collector shoe of the former cars had been attached to the beam between axles. However the series 1000 EMU attaches the small and light collector shoe to the axle box of the non-steering axle, because wheel base of both sides fluctuate during steering.



Photo 3 SC101 single axle steering bogie

(5) Traction motor

PMSM (Permanent Magnet Synchronous Motor) was adopted as a traction motor. PMSM does not need the exciting current being different from an asynchronous motor. So that the efficiency of PMSM gets about 96% comparing with about 91% of an asynchronous motor and it improves 5%.



Photo 4 Traction motor (PMSM)

(6) Power circuit and control equipment of traction motors

The control equipment of the traction motor is 2-level type VVVF inverter (vector control) without resolver signal. The VVVF inverter composes of IGBT devices. The power circuit is the single axle control system of 1 inverter with 1 traction motor, because in PMSM it is necessary to control synchronizing with revolution of the rotor. The characteristic of PMSM is the generation of counter electromotive force by the permanent magnet still in coasting. So that the contactor is connected between VVVF inverter and traction motor,

not to impress the control equipment with counter electromotive force by contactor opening when the VVVF inverter breaks down.

As the series 1000 EMU adopts the single axle steering bogies, it is difficult to equip the steering axle with traction motor so that the EMU is composed of all motor cars which equip the traction motor only with non-steering axle.

(7) Brake operating unit

The series 1000 EMU has adopted the steering bogie. Then, each bogie has both driving axle and non-driving axle, and both unit-brake (wheel tread brake) and disk brake so that the single axle control of air brake is necessary. Since the length of the car is short and the fitting space of the under-floor is narrow, we have developed a very small-sized brake operating unit which makes a receiving device and a working device one-body. The brake operating unit is capable of the single axle control. The 2 brake operating unit a car is mounted and the blending control management system of train set by TIS (Train-control Information management System) is adopted. By TIS, the series 1000 EMU gets the total regenerative brake force of train set and calculates the shortage of it. Then the EMU practices the air supplement control of air brake, however complex the train formation is.

(8) TIS

TIS has 2 networks. One is the control network which transmits the powering and braking command to the control equipment and the brake operating unit, the other is the monitoring network which monitors the equipment. The basic transmission line is composed of the ladder type parallel connection so that, even if a part of transmission line breaks down, the redundant system keeps by-pass function. Three monitor screens are equipped in driving position of the driver's cab. They are able to get the fault information and the monitoring information, and further to fix the destination guide and the working condition of service equipment which are air conditioners and so forth. Taking into consideration of car maintenance reduction, TIS has the recording function in train operation and the on-train inspection function.



Photo 5 Operating center unit (driving position)

(9) Indicator

We have adopted white LED indicators to all outside indicators which are the front destination indicators, the train number indicators and the side destination indicators. In order to advance the passenger service, the new type side indicators adopted this time show the arrival track at Asakusa station as the function of transfer information.

Two kinds of monitors on the top of the door side by side as the displays in the train are mounted and there are 12 displays a car. One indicates the destination and traffic information, etc. and the other indicates the animation advertisement. Monitor screen

is 17-inch width display of full-color liquid crystal. Reinforced glass was adopted as the protective plate against damage and fire countermeasure.

improving the air conditioning ability, we have developed the super-thin type air conditioner for the series 1000 EMU. The thickness of the air conditioner has reduced from 245mm to 210mm, so that we have gotten the high ceiling height.

(10) Air conditioning equipment

In order to spread the overhead space in the passenger room,

Fig. 1 Principal specifications of series 1000

No.	Heading	Tokyo Metro Co., Ltd. the Ginza line series 1000 EMU
1	Car classification	Passenger car DC600V Control motor car, Motor car (All aluminum-alloy body, Two-axle bogie car)
2	Train set	<p>Train set 6M [actual set 2.5M 3.5T] ← Shibuya direction</p> <p>Asakusa direction →</p> <p>Legend +:collector shoe ■:wheelchair space ●:driving axle ○:non-driving axle ⇐:tight lock coupler ++:semi-eternal type coupler</p>
3	Performance	Acceleration:3.3km/h/s Deceleration:4.0 km/h/s (service brake) 4.5 km/h/s (emergency brake) Design maximum speed:80 km/h
4	Gauge	1435mm Distance between two bogies:10500mm Wheelbase:2000mm (straight line)
5	Feeding system	DC600V Third rail
6	Passenger capacity	Leading cars:93(28) Middle cars:106(40) ()seating capacity
7	Car dimensions	Maximum dimensions:16000mm (length) × 2550mm (width(distance between car side pilot lamps 2598 mm)) × 3465mm(roof height above rail level) [floor height above rail level:1060mm]
8	Bogie	Single axle steering bogie with bolster Foundation brake rigging:unit brake + disk brake (combined use in one bogie)
9	Coupler	Yolk style Head:tight lock coupler (Tomlinson style) Other:semi-eternal type coupler
10	Power collector	Collector shoe attached to the axle box 20devices (leading car:2/car, middle car:4/car)
11	Traction motor	Permanent Magnet Synchronous Motor Hourly rating:120kW 400V 198A 1890rpm 10/train set
12	Driving device	Parallel Cardan driving device(WN-style) Gear ratio:7.79(109/14)
13	Control unit	VVVF inverter control 2-level style 1C1M × 4group control(2 units) 1C1M × 2 group control(1 unit) [Gate control part /2MM=1unit]
14	Brake system	Electric command brake equipment interlocked by ATC(regenerative brake) Air supplement control(TIS controls a train set.) Security brake IERV(Integrated Electronic Relay Value) Combined brake Parking brake(preparatory loaded)
15	Air compressor	Scroll air compressor with air dryer (3 devices/1 unit) 2 unit/train set Main power:3 phase 200V · 60Hz Exhaust volume:1600L/min
16	Auxiliary power supply	SIV 140kVA(DC600V → 3 phase AC200V · Single phase AC200V · AC100V · DC100V · DC24V) 2 units/train set Maximum electric current through the third rail about 430A/train set
17	Door operating equipment	Double acting type single cylinder door engine(with door cock) Function of weakening door pressure;
18	Storage battery	Alkali storage battery(sintered type):DC100V DC24V 105Ah 2 units/train set
19	Lighting device	Passenger room lighting device:LED(26 W, 17 W), Head light:LED(main light 32W/sub light 16W) Tail light, Door pilot lamp · Emergency alarm lamp:LED
20	Flow type	Line flow fan type
21	Air conditioning equipment	Distributed ON/OFF control type 23.3kw × 2units(20000 kcal/h × 2units) Automatically operated mode
22	Heating equipment	Passenger room:sheathing wire type(hung from the seat), Driver' s cab:far infrared type, Sheathing wire type
23	Announcement system	Announcement system:AVC distributed charge type(automatic announcement system) Public announcing device(interior and exterior speakers) · Intercom Interactive emergency alarm device 2units/vehicle(Incoming call alert on the TIS display)
24	Train radio	Centralized dual transceiver type(with emergency alarm)
25	ATC	Cab signal, moderate brake, Over Run Protect, Front alarm, Temporally control speed function, Retreat alarm
26	TASC	Train automatic stop control Singlet receiver system 1device/train set Singlet control system 2devices/train set
27	Train destination indicator	Automatic setting type on the TIS monitor Front and side indicator(White LED)
28	Display in the train	LCD(17inch wide) Guide display and Media display 12devices/vehicle
29	TIS	Power running · Brake command(series dual transmission), Destination guide, Operating air conditioner, <u>Systems monitoring</u> and on-train inspection function · Operation record · Maintenance system during running, Speed meter with Cab signal transmitted control information · Pressure gauge and Ammeter display
30	Impediment removal	Law conformity, Identification plate of side sliding door, Indication lamp of open and close door, Yellow commode handle of priority seats, Hanger and luggage rack height makes lower(Floor height above rail level 1700mm)



Photo 6 Display in the train

4. Principal specifications of series 1000 EMU

We adopted the equipment having actual results for others.

5. Conclusion

In April of 2012, the series 1000 EMU has made debut at their blossoms best like the cherry of the pattern in the train and has offered the comfortable traffic service to the passengers.

NEWS

○ Central Japan Railway shows "N700A" in public; from next February to commercial operation

Central Japan Railway disclosed to journalists the first car-set of "N700A" (Series N700 type 1000s) for the Tokaido, Sanyo Shinkansen in Hamamatsu factory on August 21th. It is equipped with the latest technology development result such as the systems which always monitor the state of all bogies and brake disc proud of a stronger brake power, and is the next-generation new vehicle which pursues higher safety. They make a test run from the end of this month and start commercial operation in next February.

N700A adopts a central fastening brake disc to a wheel. A bolt is buried in an action part of linings to put a disk between at the time of braking and raises brake performance in comparison with a current internal fastening brake disc. 15% of brake powers ups against Series N700 and it enables that the urgent stopping distance is approximately shortened by 10% at the time of disasters such as an earthquake.



Up: N700A disclosed to journalists

Down: Symbol mark of side bodies used largely letter "A"



Bogies are equipped with a first bogy vibration detection system in Shinkansen. The vibration sensor which is installed with the body on each bogy always monitors the vibration in running and transmits trouble into the driver's cab through a vibration detection device, when catches abnormality.

Utilizing the information from ATC such as a speed signal, running position and track information, the constant speed running equipment is incorporate to adjust automatically to target speed in consideration of influence of a gradient or air resistance on speed. When a disorder of diagram occurs, the minute control by this device realizes more stable running.

Outside appearance is about the same as Series N700, but both sides of odd number cars have the symbol mark unified with "A" (initials of "Advanced" expressing which "has advanced") and the blue line which is the symbol of the Tokaido Shinkansen. The powerful mark that matched streamlined body gets a lot of looks conspicuously.

The cushion material of seats enables 100% of recycling by changing into polyester from conventional urethane. In green cars weaving up haze pattern of brown-based cloth and in common cars weaving up streaming pattern of blue-based cloth, they directs a feeling of presence of mind and opening. The green car pursues comfort though changing the elbow rest from the product of vinyl to synthetic leather, and though making the reading light more bright and its irradiation range wide.

In addition, as LED for the illumination of a restroom and washing room is took, it is able to save energy by cutting approximately 20% of lighting electricity than Series N700.

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