Substation Equipment for Imaizumi Traction Power Substation of Haga Utsunomiya Light Rail Transit (LRT)

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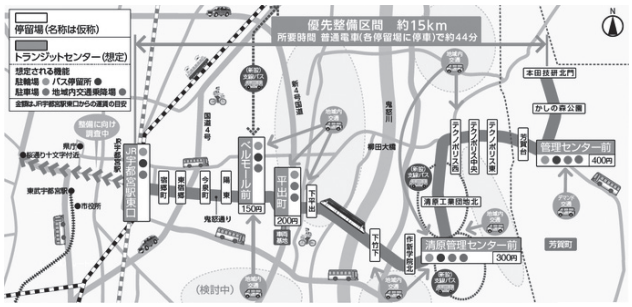
Abstract

Haga Utsunomiya Light Rail Transit (LRT) is a streetcar line in Tochigi Prefecture, Japan and runs from Utsunomiya Station East Gate to an industrial area located at the east of the city (near the north gate of a Honda Motor Co., Ltd. factory). The line is about 15 km long. Seventeen (17) trains of streetcars will be operated on this line with 19 stations. At peak hours, trains will be operated at 6-minute intervals and weekday demand forecast is expected to reach 16,300 people. With the construction of a new street line of this scale and the establishment of a new sales entity, it will be an unprecedented large-scale business in recent years for a track transportation system in Japan. Construction of facilities for this project is currently occurring and the commencement of this line is scheduled in 2022. As part of this project, the Imaizumi Traction Power Substation was newly installed, and we supplied it with a complete set of substation equipment. Our featured products such as medium-voltage power receiving equipment, rectifiers, and DC equipment were also applied.

1 Preface

The Light Rail Transit (LRT) is a track transportation system. Along a total distance of 15 km, 4 traction power substations were newly installed for the Haga Utsunomiya LRT in Tochigi Prefecture, Japan. We received an order to supply and construct new power receiving and substation equipment for the Imaizumi Traction Power Substation. This paper introduces our main substation equipment for the Imaizumi Traction Power Substation. Fig. 1 shows a diagram of the Haga Utsunomiya LRT route.



Source: Utsunomiya City website

Fig. 1 Diagram of Haga Utsunomiya LRT Route

The diagram of the Haga Utsunomiya LRT route is shown.

2 Features of Facilities

The Imaizumi Traction Power Substation receives power through two medium-voltage lines: one as a circuit used to receive regular grid power, and the other one as a backup circuit. There are two banks of rectifier unit, one unit for regular use and the other as a standby bank. The feeder voltage is 750 V DC and the upper/lower gang feeding system is adopted. The traction power substation is accommodated in a two-story building. Fig. 2 shows an overall view of the traction power substation. Our major equipment and units supplied are itemized below.

(1) Medium-voltage panels: 7 panels (installed on the upper floor)
(2) Rectifier facilities: 2 sets (installed on the ground floor)
(3) DC switchgear panels: 6 panels (installed on the upper floor)
(4) Power distribution board: 2 panels (installed on the upper floor)

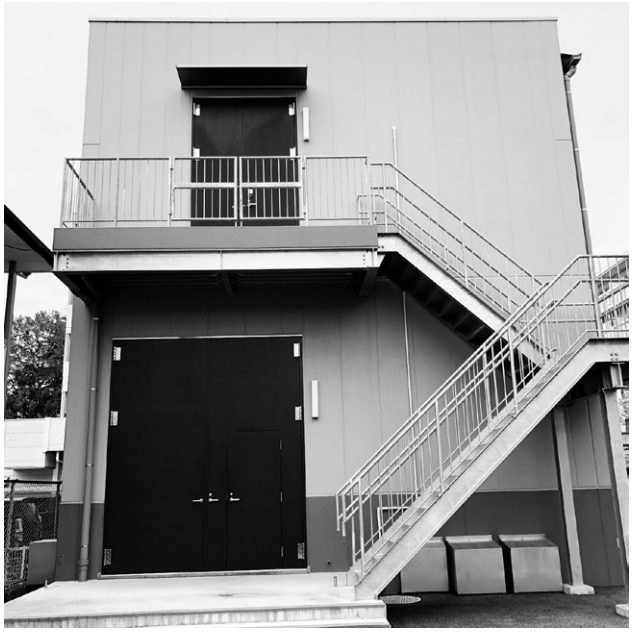


Fig. 2 Overall View of Traction Power Substation

An overall view of the traction power substation is shown. This is a two-story building.

3 Medium-Voltage Panels

According to the original equipment allocation plan, medium-voltage panels were required to install with their backside close to the building's inner wall. For this reason, the dimension in the depth direction had to be minimized as much as possible.

As a result, the VR-1 type was adopted for circuit breakers of medium-voltage panels. Since the VR-1 circuit-breaker is compact and lightweight, maintainability is very high. In particular, an outstanding feature of this type is that its depth size is short and this is an outstanding feature of this type. As a result, the depth size of medium-voltage panels could be effectively reduced.

The main circuit consists of a Voltage and Current Transformer (VCT), incoming panel, rectifier panels, local transformer panel, and local panels. Since the front surface of each panel is provided with necessary functions of operation, display, protection, and telemetry, we can omit a replay panel and a monitor panel. **Fig. 3** shows a medium-voltage panel. Specifications of the installed equipment are shown below.

(1) Rated voltage: 7.2 kV
(2) Rated current: 600 A
(3) No. of panels: 7 panels

Fig. 3 Medium-Voltage Panel

An external appearance of the medium-voltage panel is shown. Functions of operation, display, protection, and telemetry are accommodated.

4 Rectifier Facilities

Rectifier facilities are composed of a rectifier transformer and rectifier banks. These facilities are used to transform an incoming medium-voltage of 6.6 kV AC to a feeder voltage of 750 V DC.

As for the rectifier transformer, a self-cooled molded transformer is accommodated in a panel. Safety is ensured as the energized part of the transformer is not exposed.

For rectifier unit, a self-cooled heat-pipe system has been adopted. Since pure water used as a coolant is employed for heat pipes, this type of equipment is an eco-friendly product. This is our eye-catching featured product. Bus ducts are used for main-circuit connections between the rectifier transformer and rectifier unit.

Since both the rectifier transformer and rectifier unit are of the self-cooled type, maintenance manpower can be reduced. **Fig. 4** shows a rectifier transformer and **Fig. 5** shows a rectifier unit. Specifications of equipment are itemized below.

(1) Rectifier transformers: 2 units
  (a) Rated capacity: 1620 kVA
  (b) Rated primary voltage: 6.6 kV
  (c) Rated secondary voltage: 835 V
  (d) Cooling system: Self-cooled mold type
(2) Rectifier unit: 2 units
  (a) Rated capacity: 1500 kW
  (b) Rated DC-side voltage: 750 V DC
  (c) Type of rating: Class D
  (d) Total DC voltage regulation: 6%
  (e) Cooling system: Self-cooled heat pipe system
  (f) Connection system: 3-phase double bridge

Fig. 4 Rectifier Transformer

An external appearance of the rectifier transformer is shown. A molded transformer is accommodated in this panel enclosure.

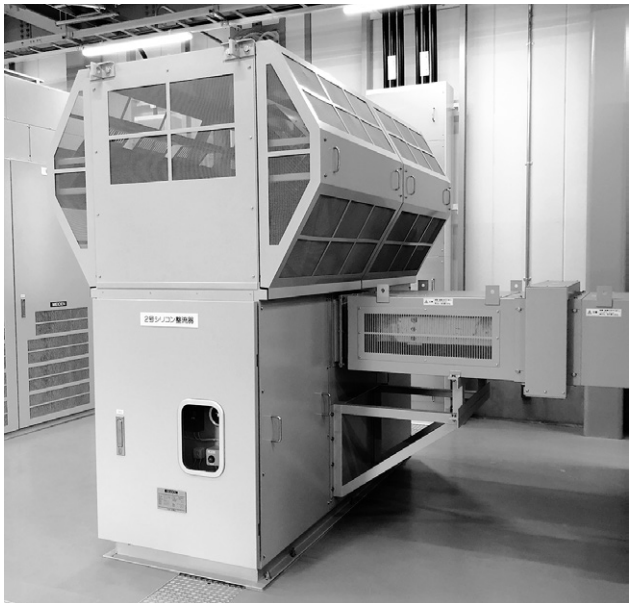


Fig. 5 Rectifier Unit

An external appearance of rectifier unit is shown. The external structure is unique with a high heat dissipation effect.

5 DC Switchgears

DC switchgears are composed of a High-Speed Circuit-Breaker (HSCB) (that connects with rectifier units and feeder circuits) and disconnecting switches. The feeder circuit uses the upper and lower batch method, and the feeder circuit has three lines including the backup line. The Magnet Latch

Fig. 6 DC Switchgears

An external appearance of DC Switchgears is shown. Functions of operation, display, protection, and telemetry are accommodated here.

(ML) type HSCB is adopted. The mechanism of this HSCB is an electromagnetic closing, permanent magnet holding, and spring tripping. Since an ML is applied to the holding system, this type of HSCB is called the “ML type HSCB”. Compared with a conventional mechanical holding system, the overall mechanism is very simple, with fewer parts, and improved reliability. The current breaking characteristics of the ML type HSCB are ranked at H1 stipulated by JIS E 2501. Since the short-circuit current specified by the rating can be interrupted by the actual current, a possible accidental current can be interrupted regardless of the inrush rate.

In addition, the ML type HSCB offers a feature that a current of 142 kAp/100 kA can be interrupted. Despite the contact block of the main circuit having no arcing contacts, current can be interrupted only with the main contacts. In other words, this HSCB assures a long operational life, and though contact polishing was required after each current interruption for conventional HSCBs it is unnecessary for this one. In addition, maintainability is high. Regarding the contact life, the replacement of contact points is not required up to 10 times of 100 kA interruption or 100 times of 50 kA interruption. The operational life is 20,000 switching operations. For this reason, running costs can be reduced, as switchgear panels, functions of operation, display, protection (self-breaking), and telemetry are provided like medium-voltage panels. **Fig. 6** shows a DC Switchgears. Major specifications of HSCB are itemized below.

Fig. 7 **Power Distribution Board**

An external appearance of power distribution board is shown. Equipment is compactly accommodated in a 2-panel configuration.

(1) Rated voltage: 1800 V DC
(2) Rated current: 3000 A
(3) Rated breaking current: 142 kAp/100 kA
(4) Breaking characteristics: H1
(5) Operational life: 20,000 operations
(6) Quantity: 3 units
(7) No. of panels: 6 panels

6 Power Distribution Board

The power distribution board is composed of two panels: an interface panel and a feeder protection panel. Since the functions of operation, display, protection, and telemetry are already possessed by the medium-voltage panel and the DC switchgear, we successfully reduced the relay panels.

The interface panel functions to divide sections of signal exchanges between the remote terminal unit and the substation equipment. When an operation signal is received from the direction center, it is transferred to substation equipment. Display signals and telemetry signals from substation equipment are transferred to the remote terminal unit.

The feeder protection panel, specific apparatus for DC power feeding, is used for protection. This panel involves reverse current relays and failure selection equipment. **Fig. 7** shows the power distribution board.

7 Postscript

We expect that our most recent equipment delivered contributes to the safe and smooth operation of the Haga Utsunomiya LRT.

Lastly, we express our sincere gratitude to many project related people for their kind guidance and cooperation during the stages of production and supply of the substation facilities.