

ICS 29.28
CCS S35



**NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA**

GB/T 36287-2018

**Urban rail transit - Ground systems for the utilization of vehicle
braking regenerative energy**

城市轨道交通 列车再生制动能量地面利用系统

Issued on: June 7, 2018

Implemented on: January 1, 2019

**Issued by: State Administration for Market Regulation;
Standardization Administration of the PRC**

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1 Scope

China's national standard for the trackside systems that capture regenerative braking energy on urban rail. It specifies the terms and definitions, the environmental and power supply conditions, the system composition, the technical requirements and the inspection methods. A metro train braking regeneratively turns its motors into generators and pushes power back into the conductor rail, and if another train is accelerating nearby it uses that power directly - which is the cheapest energy recovery there is. The problem is timing: if no train is drawing power at that instant the line voltage rises, the train's control detects it and reverts to friction braking, and the energy becomes brake dust and heat in the tunnel. Ground systems close that gap. They either store the surplus - in supercapacitors or flywheels beside the substation - or invert it back into the utility supply. Either recovers energy that would otherwise be lost, and both reduce the tunnel ventilation load, which is a second saving that is often larger than expected.

This Standard specifies environmental conditions, power supply conditions, system composition, technical requirements, inspection methods, inspection rules and so on of

ground system for vehicle braking regenerative energy utilization of urban rail transit. This Standard is applicable to ground system for vehicle braking regenerative energy utilization of urban rail transit (including feedback-type, storage-type and hybrid-type regenerative braking energy ground utilization system). Similar systems other than rail transit can be implemented by reference.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 1094.3-2003, Power transformers - Part

3 Terms and definitions

For the purposes of this document, the terms and definitions defined in GB/T 2900.1-2008, GB/T 2900.95-2015, GB/T 2900.33-2004, GB/T 3859.1-2013, utilization system or dual quadrant converter. For storage-type regenerative braking energy ground utilization system, system efficiency refers to the product of charging efficiency and discharging efficiency.

3.9 energy storage module Small energy storage unit composed of super capacitors in series and parallel.

3.10 voltage balancing unit Used with the module, it mainly completes the voltage equalization function of the super capacitor in the module.

3.11 control unit of capacitor management system (CMS) The control and management unit of the energy storage power supply, which mainly completes the control of the voltage equalization unit and external communication functions and so on.

3.12 energy storage unit Energy storage component that is composed of CMS control unit and energy storage modules in series and parallel.

3.13 ripple voltage (on the d.c. side) The AC voltage component in the DC side voltage of the regenerative braking energy ground utilization system for rectifying operation or releasing electric energy.

4 Environmental conditions

4.1 Temperature The ambient temperature is -10°C~40°C. The storage and transportation temperature is -25°C~55°C.

4.2 Altitude The altitude is not higher than 2500m.

4.3 Relative humidity Daily average value is not more than 95%. Monthly average value is not more than 90% (25°C). Condensation occurs. system, protection system and so on

shall be DC 220V or DC 110V power supply. The auxiliary power required for anti-condensation heating and lighting shall be AC 220V power supply. The auxiliary power supply required by the cooling fan (if any) shall be AC 380V power supply. AC220V power supply shall be used for the auxiliary power supply voltage level required by the transformer thermostat.

5 Emission and immunity of fixed power supply installations and apparatus

GB/T 25122.1-2010, Railway applications - Power convertors installed on board rolling stock - Part

6 System composition

6.1 Overview The ground system for vehicle braking regenerative energy utilization of urban rail transit is divided into. - feedback-type ground system for vehicle braking regenerative energy utilization; - storage-type ground system for vehicle braking regenerative energy utilization; - hybrid-type ground system for vehicle braking regenerative energy utilization.

6.2 Feedback-type ground system for vehicle braking regenerative energy utilization The feedback-type ground system for vehicle braking regenerative energy utilization is composed of energy-fed transformer, AC (low voltage) circuit breaker, double quadrant converter, DC isolating switch, DC reactor, measurement and control system and so on. The typical topological structure of the main circuit is shown in Figure 1. The energy-fed transformer completes the electrical isolation between the double-quadrant converter and the AC grid and the functions of step-up and step-down. AC (low-voltage) circuit breaker realizes protection and isolation between the double-quadrant converter and the energy-fed transformer. The dual-quadrant converter realizes the conversion function of electric energy from AC to DC or from DC to AC. The DC isolating switch realizes the isolation of the double-quadrant converter and the DC negative bus. The DC reactor completes the filtering and current limiting functions with the DC bus. The measurement and control system complete the measurement, protection and control of the entire system.

7.1 Functional requirements

7.1.1 Energy recovery function The ground system for vehicle braking regenerative energy utilization shall be able to recover the braking energy generated during regenerative braking of the train to the AC grid or energy storage unit.

7.1.2 Stable DC network voltage function Within its power range, the ground system for vehicle braking regenerative energy utilization shall be able to stabilize the DC bus voltage at a preset value.

7.1.3 Rectification function The feedback-type ground system for vehicle braking

regenerative energy utilization shall be able to convert AC grid power into DC power for train traction. NOTE. The rectification function of the feedback-type ground system for vehicle braking regenerative energy utilization is a special requirement. If necessary, it shall be negotiated by both parties.

7.1.4 Communication function The measurement and control device of the ground system for vehicle braking regenerative energy utilization shall adopt a standard data communication interface. The data communication protocol adopts a good versatility and open protocol. Example

1.The physical interface is RS485 interface, and the communication protocol is Modbus_RTU. Example

2.The physical interface is an Ethernet interface, and the communication protocol is TCP/IP protocol. The measurement and control device shall be able to realize the remote signal function of switch status and fault signal; the remote measurement function of data such as current, voltage and electric energy. The measurement and control device shall be able to upload system fault information to the integrated automation system of the substation, and it shall be time stamped. At the same time, it has the function of clock synchronization with the integrated automation system, and the time synchronization method is software time synchronization. - DC current overcurrent protection; - Control equipment failure protection; - AC overcurrent protection; - Overheating protection; - AC (low voltage) circuit breaker fault protection; - Frame leakage protection and so on. The ground system for vehicle braking regenerative energy utilization shall be able to upload fault information to the integrated automation system of the substation. When a serious fault occurs in the ground system for vehicle braking regenerative energy utilization, the corresponding AC switch cabinet circuit breaker and/or DC feeder cabinet circuit breaker shall be actively disconnected. The ground system for vehicle braking regenerative energy utilization shall be equipped with a DC reactor to meet the requirements of DC side filtering. At the same time limit the short-circuit current rise rate when a short-circuit fault occurs on the DC side.

7.1.9 Safety interlock function In order to ensure the safety of operators and maintenance personnel and ensure the safe operation of all equipment in the ground system for vehicle braking regenerative energy utilization, interlocking, interlocking, locking and safe voltage detection functions shall be set between each component equipment. The equipment auxiliary power supply loss or comprehensive fault signal of ground system for vehicle braking regenerative energy utilization shall have hard contact signal output. At least one pair of contacts for tripping shall be provided. The ground system for vehicle braking regenerative energy utilization shall provide external fault joint jump contact, so that when other equipment (or parts) outside the system has a serious failure, it shall combinedly jump to the ground system for vehicle braking regenerative energy utilization.

7.1.10 Debug function When the ground system for vehicle braking regenerative energy utilization only provides secondary power, it shall be able to achieve system simulation