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Foreword

This standard is drafted in accordance with the rules given in the GB/T 1.1–2009.

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Technical specification of system for the levitation control of medium-low speed maglev transportation vehicle

1 Scope

This standard specifies the system composition, environment conditions, requirements, inspection and test methods, inspection rules, marking, packaging, storage, and quality assurance of the levitation control system of the medium and low speed maglev vehicle.

This standard is applicable to the manufacturing, test and acceptance of the levitation control system of medium and low speed maglev vehicle *(hereinafter referred to as "the vehicle")*.

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 4208–2008, *Degrees of Protection Provided by Enclosure (IP code)*

GB/T 13306, *Plates*

GB/T 21414, *Railway Applications–Rolling Stock–Protective Provisions Against Electrical Hazards*

GB/T 21563–2008, *Railway Applications–Rolling Stock Equipment–Shock and Vibration Tests*

GB/T 24338.4, *Railway Applications–Electromagnetic Compatibility–Part 3–2: Rolling Stock–Apparatus*

GB/T 25119–2010, *Railway Applications–Electronic Equipments Used on Rail Vehicles*

CJ/T 375, *General Technical Specification for Medium and Low Speed Maglev Vehicles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CJ/T 375 and the following apply.

3.1

levitation bogie

A mechanical structure that supports the vehicle body and transfers levitation, guidance, traction and braking force, and has function of mechanical decoupling ability to adapt to the curve and irregularity of track.

3.2

levitation module

A basic unit with functions of levitation, guidance, and traction of the vehicle. The levitation module is mainly composed of support arms, longitudinal beam, electromagnet and traction motor, and two such modules are connected by anti–rolling beams to form a levitation bogie.

3.3

levitation control system

A system that achieves vehicle levitation function. It is composed of levitation controllers, levitation electromagnets and levitation sensors.

3.4

levitation controller

An electrical device that control the gap between levitation electromagnet and the track so as to stabilize the levitation of the electromagnet. It includes a power unit and a control unit.

3.5

control unit

A unit that receives signals from levitation sensors, power unit and levitation instructions, and processes them to generate control signals.

3.6

power unit

A unit that amplifies the power of the control signals from the control unit, and drives the levitation electromagnet.

3.7

magnetic levitation

A control to keep the levitation gap stable and to achieve noncontact between the vehicle and the track by means of controlling the current through the levitation electromagnet.

3.8

levitation gap

The vertical distance between the upper surface of the magnetic pole of the levitation electromagnet and the bottom surface of the F–shaped rail when the vehicle is levitated.

3.9

levitation gap deviation

The deviation between actual levitation gap and nominal levitation gap.

3.10

levitation and guidance control

The control to keep allowable levitation gap by controlling the exciting current of the levitation electromagnet based on feed backs of the levitation gap signal, the vertical acceleration of the electromagnet, etc. When the electromagnet transversely deviates from the F–shaped rail, the lateral component of levitation force would guide the magnet to follow the rail.

3.11

levitation electromagnet

An electromagnet that generates controlled electromagnetic force to achieve levitation and guidance function under the action of exciting current. It is mainly composed of exciting coil, polar plates and iron core.

3.12

levitation sensor

A device that measures specific state variables of a levitation control system, such as levitation gap, vertical acceleration of the electromagnet, etc., and converts them into electrical signals.

3.13

exciting current

The current that flows through a levitation electromagnet.

3.14

levitating up

The process that the levitation electromagnet rises up to reach the nominal levitation gap from the landing

status under the control of levitation controller.

3.15

landing

The process for the levitation electromagnet to fall from the levitation state to landing state under the control of levitation controller.

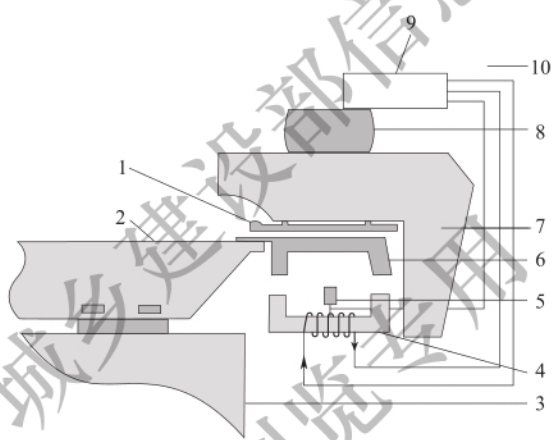
4 System compositions

The levitation control system is composed of the following devices, as shown in Figure 1.

—Levitation sensor;

—Levitation controller;

—Levitation electromagnet.



Key:

1—linear motor;
2—sleeper;
3—concrete beam;
4—levitation electromagnet;
5—levitation sensor;
6—F-shaped rail;
7—support arm/longitudinal beam;
8—air spring;
9—levitation controller;
10—car body.

Figure 1 Levitation system of the maglev vehicle

5 Environmental conditions

5.1 Altitude: ≤ 1 400m.

5.2 Ambient temperature: −25℃ to +40℃.

5.3 Maximum relative humidity (the monthly average minimum temperature of this month is 25℃): ≤ 90%.

5.4 The levitation control system shall withstand the inroads of wind, sand, rain, snow, and the corrosion caused by cleaning agent when the vehicle is washed.

6 Requirements

6.1 Levitation control system

6.1.1 The levitation control system shall ensure normal levitation state of the vehicle under various loads, and the nominal levitation gap is 8mm.The levitation gap deviation shall be within ± 0.2mm when the vehicle is in standstill condition; and the levitation gap deviation shall not exceed ± 4mm when the vehicle runs.

6.1.2 The levitation control system shall adapt to the vehicle operation from empty to the maximum load.

6.1.3 The levitation control system shall adapt to the change of vehicle speed from zero to maximum running speed.

6.1.4 The levitation control system shall pass a slope with a maximum gradient of 70‰, and enable the vehicle to levitate up and run on a slope with gradient of 70‰ under the maximum load.

6.1.5 The levitation control system shall pass the curve with the minimum radius of 50m, and to enable the vehicle to levitate up and run on the curve under the maximum load.

6.1.6 The continuous working time shall not be less than 18h under the maximum load.

6.1.7 The levitation control system shall be with the function of information transmission, which can transmit the levitating up/landing and failure states of the levitation control system to the monitoring equipment.

6.1.8 When the levitation control of one levitation bogie of any vehicle fails, the levitation system of the remaining levitation bogies shall maintain the running of the train to an next station.

6.1.9 Protective provisions against potential hazards of electrical equipment shall comply with the requirements given in GB/T 21414.

6.1.10 The tests of the levitation control system should be carried out on the maglev train.

6.2 Levitation sensor

6.2.1 The levitation sensor shall be mounted on the levitation electromagnet to measure the levitation gap between the levitation electromagnet and the track, as well as the vertical acceleration of the levitation electromagnet.

6.2.2 The working temperature of the levitation sensors shall range from −25℃ to 85℃ .

6.2.3 The probes of the levitation sensor shall have redundant capacity in order to adapt the application situation of passing rail joints. When the vehicle passes through the rail joint with a maximum width of 40mm, and when the levitation gap is 0mm to 12mm, the sensor shall ensure that at least 2 output gap signals whose deviation shall not exceed 0.5mm.

6.2.4 The vertical acceleration measurement of the levitation sensor shall have redundant capacity to ensure that the performance of the levitation system will not be affected when one acceleration sensor fault occurs.

6.2.5 Over the full measuring range, the maximum deviation of levitation gap detections shall not exceed 1% of the measuring range, and the differences among the detection outputs of the probes at the same detection displacement shall not exceed 2% of the measuring range.

6.2.6 The temperature drift of the detected gap when the levitation gap ranges from 0mm to 12mm shall not exceed 0.1% measuring range /℃ .

6.2.7 The annual stability deviation of each levitation gap output signal shall not exceed ± 0.5mm. The sensor shall be checked every year, and calibration shall be given if the deviation exceeds this range.

6.2.8 The annual stability deviation at zero point of acceleration signals shall not exceed ± 0.02g, and temperature drift shall not exceed 0.02% measuring range /℃ .

6.2.9 The protection degree shall meet IP66 given in GB/T 4208–2008.

6.2.10 The electromagnetic compatibility performance shall comply with provisions given in 12.2.6, 12.2.7 and 12.3.8 in GB/T 25119–2010.

6.2.11 The vibration and shock indexes shall comply with 1/2 of the class Ⅱ amplitude given in GB/T 21563–2008.

6.2.12 The maximum weight of the levitation sensor shall not exceed 3kg.

6.2.13 The service life of levitation sensor shall not be less than 8 years.

6.3 Levitation controller

6.3.1 The levitation controller shall keep the maglev vehicle levitates stably and enable the vehicle to adapt to various operating conditions. And the levitation controller shall transmit the working state information of the levitation control system to the control and diagnosis system of the train, and possess fault-tolerant control function.

6.3.2 When the levitation control system fails, the levitation controller shall timely send out the failure information, and take corresponding actions according to the failure level.

6.3.3 The electromagnetic compatibility performance shall comply with the provisions given in GB/T 24338.4.

6.3.4 The protection degree shall comply with the provisions of IP54 given in GB/T 4208–2008.

6.3.5 The vibration and shock indexes shall comply with the provisions of A Class Ⅰ given in GB/T 21563–2008.

6.3.6 The rated main input voltage of the levitation controller is DC330 V with a fluctuation range of –30% to 20%; the rated input control voltage is DC110 V with a fluctuation range of –30% to 25%.

6.3.7 The maximum output current of the levitation controller shall not be less than 4 times of the rated output current, and the duration of which shall not be less than 10s.

6.3.8 The maximum weight of the levitation controller shall not exceed 50kg.

6.3.9 The service life of the levitation controller shall not be less than 8 years.

6.4 Levitation electromagnet

6.4.1 Each levitation electromagnet should consist of 4 magnetic yokes, 4 coils, and internal and external polar plates.

6.4.2 The levitation electromagnet shall be provided with anti-absorption sliding plates.

6.4.3 The connection between the external connecting wires and the binding posts of the levitation electromagnet shall be waterproof.

6.4.4 The insulation grade shall be C.

6.4.5 The protection degree shall be IPX5 given in GB/T 4208–2008.

6.4.6 The rated carrying capacity shall not be less than 3.5t.

6.4.7 The vibration and shock indexes shall comply with the provisions of 1/2 of the Class Ⅱ amplitude given in GB/T 21563–2008.

6.4.8 The maximum weight of levitation electromagnet shall not exceed 420kg.

6.4.9 The service life of the levitation electromagnet shall not be less than 3 years.

7 Inspection and test methods

7.1 Inspection items

7.1.1 Inspection items of the levitation sensors, the levitation controllers and the levitation electromagnets shall meet the requirements in 7.2 to 7.9.

7.1.2 Product certifications issued by manufactures shall be checked before the the levitation sensors, levitation controllers and the levitation electromagnets are installed on the vehicles.

7.2 Vehicle levitation test

7.2.1 Test method: Under no–load state, the train levitates up/lands for 100 times consecutively with each interval of 30s. Visually check the action of levitating up/landing as well as the values on monitoring equipment.

7.2.2 Test judgment: the test result is considered to be qualified if: no failure occurs during the test, the levitating up/landing motion is smooth, and the stable levitation gap shown on levitation control monitoring device is 8mm, and the time interval between levitating up/landing actions are consistent with the display values on monitoring equipment.

7.3 Static load test

7.3.1 Test method: when the vehicle carries its maximum load of 35t, the train levitates up/landing for 100 times consecutively with each interval of 30s:

a) Visually check the actions of levitating up/landing and the communicative display;

b) Two vernier calipers shall be placed respectively at 10mm from the edge of both ends of each levitation electromagnet;

c) Record the static levitation gap values measured by each vernier caliper as well as the static levitation gaps displayed on the levitation control and monitor equipment after the train levitates up.

7.3.2 Test judgment: the test result is considered to be qualified if: the levitating up/landing motion is smooth, and the levitation gap shown on the levitation control monitoring device is 8mm, the time interval between levitating up/landing action is consistent with the display on monitoring equipment, and the static levitation gap deviation after the train levitates up is within ± 0.2mm.

7.4 Dynamic load test

7.4.1 Test method:

a) The dynamic load test should be carried out on level and straight track;

b) The train runs in no–load condition at 35km/h, 60km/h and the maximum operating speed respectively. Check the values displayed on the levitation monitoring equipment, and record the state of levitation control system and levitation gap changes of each levitation electromagnet;

c) The train runs at 35km/h, 60km/h and the maximum operating speed respectively with all its vehicles carry their rated load. Check the display on the levitation monitoring equipment; record the state of levitation control system and levitation gap changes of each levitation electromagnet;

d) The train runs at 35km/h, 60km/h and the maximum operating speed respectively with all its vehicles carries their maximum load. Check the display on the levitation monitoring equipment; record the state of levitation control system and levitation gap changes of each levitation electromagnet.

7.4.2 Test judgment: the test results shall be considered to be qualified if: the levitation monitoring equipment shows correctly for all values, and the levitation gap changes are within the allowable range (dynamic gap deviation is not greater than ± 4mm).

7.5 Curve passing test

7.5.1 Test method:

a) The vehicle passes through the 50m–radius curve in no–load condition with a specified speed;

check the display on levitation monitoring equipment; record the state of levitation control system and levitation gap changes of each levitation electromagnet;

b) The vehicle passes through the 100m–radius curve with maximum load with a specified speed; check the display on levitation monitoring equipment; record the state of levitation control system and levitation gap changes of each levitation electromagnet;

c) The vehicle lands at the center of a 100m–radius curve with the maximum load, levitates in 20s later; test staff visually check the action of levitating ,observe the display on the levitation monitoring equipment, record the state of levitation control system meanwhile.

7.5.2 Test judgment: the test result will be considered qualified if: no fault of levitation control system is displayed; all the levitation gap changes when passing through the curve meet the requirements in 6.1.1; all levitation electromagnets levitate normally when the vehicle is on the curve (the levitation gap of each electromagnet is able to reach 8mm within 8s after the levitation), and the vehicle can move normally after levitation.

7.6 Slope passing test

7.6.1 Test method:

a) The vehicle passes through a 70‰ slope with a specified speed at maximum load; check the display on the levitation monitoring equipment; record the state of levitation control system and levitation gap changes of each levitation electromagnet;

b) The vehicle lands on a 70‰ slope at maximum load, and levitates up again 20s later. Check the display on the vehicle diagnosis and control system; record the state of levitation control system.

7.6.2 Test judgment: the test result will be considered qualified if: no fault of the levitation control system is displayed; all levitation gap changes during passing through the curve meet the requirements in 6.1.1;and the train runs normally after levitation.

7.7 Duration test

7.7.1 Test method: the train runs continuously at a speed no less than the average official operational speed for 18 hours consecutively at its maximum load. Check the display on the levitation monitoring equipment; record the state of levitation control system and levitation gap changes of each levitation electromagnet.

7.7.2 Test judgment: the test result should be considered qualified if: no fault of levitation control system is displayed, and all levitation gap changes meet the requirements in 6.1.1.

7.8 Eccentricity test

7.8.1 Test method: 1/2 of the rated load is placed on each vehicle, and the entire load is placed on the same side beyond its longitudinal central axis, then the train runs for 4 hours consecutively at a speed which is no less than the average official operational speed. Check the display on the levitation monitoring equipment; record the state of levitation control system and levitation gap changes of each levitation electromagnet.

7.8.2 Test judgment: the test result will be considered to be qualified if: no fault of levitation control system is displayed; and all levitation gap changes meet the requirements in 6.1.1.

7.9 Fault–simulating test

7.9.1 Test method: with maximum load, the train levitates up and keeps in standstill for 20 seconds, and then the levitation monitoring equipment sends an instruction to the levitation system to make one levitation bogie of each

vehicle to land while to keep the others remain levitated; consequently, the train runs at the speed specified for fault state. Check the display on levitation monitoring equipment; and record the state of levitation control system.

7.9.2 Test judgment: the test result should be considered qualified if: the train can run at a specified speed for a certain distance (the longest distance between all adjacent stations), all levitation bogies, except the one landed intentionally, remain in normal levitating state; and the train control system displays with fault, but the levitation control system indicates no fault.

8 Inspection rules

8.1 Inspection classification

The levitation control equipment shall pass the inspection to prove that it meets the requirements of this standard and relevant current national standards. The inspection classification is listed as follows:

a) Type test: it is used to examine the design of designated products to make sure they are in accordance with this standard and relevant product standard;

b) Routine test: it is used to detect material and process faults and confirm the normal function of levitation system equipment. Inspection items shall be carried out in accordance with Table 1.

Table 1 Inspection items of levitation control system

No.	Inspection items	Type test	Routine test	Inspection rules
1	Levitation test	√	√	7.2
2	Static load test	√		7.3
3	Dynamic load test	√		7.4
4	Curve passing test	√	√	7.5
5	Slope passing test	√	√	7.6
6	Duration test	√		7.7
7	Eccentricity test	√		7.8
8	Fault–simulating test	√		7.9

8.2 Routine test

8.2.1 Before vehicles leave the factory, the manufacturer shall conduct routine test on their levitation control system in accordance with the items specified in Table 1. If any single item fails in the routine test, the levitation control system will be deemed as unqualified. The technical inspection department shall inspect the whole levitation control system item by item according to this standard before releasing it for acceptance.

8.2.2 Upon negotiations between the user and the manufacturer, the user may conduct sampling inspection to verify the routine test results.

8.3 Type test

8.3.1 The type tests shall be carried out according to Table 1.

8.3.2 The type tests shall be undertaken by qualified organizations and be issued with corresponding inspection reports.

8.3.3 Under one of the following conditions, the type tests shall be carried out:

a) It is necessary to evaluate standardization of trail production of new products or improved existing products;

b) Major changes made in the product design, producing process, production equipment and management of the product after it is produced in a normal condition can affect the performance of the product;

c) The product is produced again after it is out of production for more than 2 years;

d) The delivery test result is significantly different from that of the last type test;

e) The national quality supervision agency puts forward the requirement of type test.

9 Marking

The marking of levitation control system equipment shall comply with the provisions given in GB/T 13306.

10 Packaging, storage and quality assurance

10.1 The package of the equipment of levitation control system shall comply with the provisions of moisture, dust and transportation damage prevention.

10.2 When the levitation control system equipment leaves the factory, relevant technical documents, maintenance drawings and specifications, spare parts and special tools shall be attached.

10.3 The levitation control equipment shall be stored in a dry and clean place without acid and alkali or without corrosive gas as per manufacturer instruction, and the storage temperature shall be no lower than –40℃ .

10.4 The warranty period of levitation control equipment shall not be less than 18 months after acceptance of delivery. While the user follows the maintenance instructions, the failure or damage still occurs due to poor manufacturing quality of the vehicle or its main parts within the warranty period. The manufacturer, therefore, shall be responsible for repairing or replacing the parts, installing and commissioning and restoring operation in a free and timely manner.