INTERNATIONAL STANDARD

ISO 21782-6

First edition
2019-08

Electrically propelled road vehicles — Test specification for electric propulsion components —

Part 6: Operating load testing of motor and inverter

Reference number
ISO 21782-6:2019(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword ..... **iv**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 Tests and requirements **1**

4.1 Operation endurance tests of motor 1

4.1.1 High acceleration/deceleration endurance test 1

4.1.2 Maximum torque endurance test 6

4.1.3 Over speed test 10

4.2 Operation endurance test of inverter 14

4.2.1 Cyclic test 14

4.3 Breakdown strength verification test of rotor 17

4.3.1 Spin test 17

5 Test report **18**

Annex A (informative) **Test report** **19**

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO , also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO /IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO /IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO 's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO /TC 22, *Road Vehicles*, Subcommittee SC 37, *Electrically propelled vehicles*.

A list of all parts in the ISO 21782 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Electrically propelled road vehicles — Test specification for electric propulsion components —

Part 6: Operating load testing of motor and inverter

1 Scope

This document specifies operating load tests and test criteria for motor and inverter designed as a voltage class B electric propulsion system for electrically propelled road vehicles.

2 Normative references

The following documents are referred to in the text such a way that some or all of their content constitutes requirements 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.

ISO 21782-1:2019, *Electrically propelled road vehicles — Test specification for components for electric propulsion — Part 1: General test conditions and definitions*

3 Terms and definitions

For the purposes of this document, the terms, definitions and abbreviated terms given in ISO 21782-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Tests and requirements

4.1 Operation endurance tests of motor

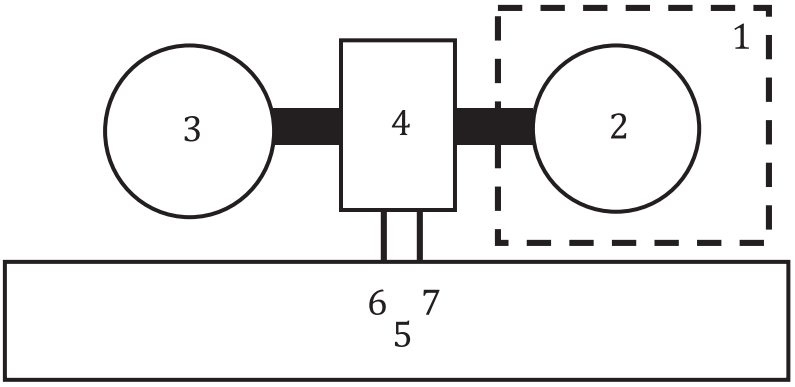
4.1.1 High acceleration/deceleration endurance test

4.1.1.1 General

The purpose of this test is to evaluate and rank the strength for the components – bearing, end ring, motor shaft key, rotor fixture, rotor, and position sensor – which are affected by mechanical fatigue by repeating the intermittent maximum speed of motor. The test is set considering repeated operations at the upper specification limits of the motor. Unless otherwise, the test method can be decided by the supplier and customer.

4.1.1.2 Test diagram

The test diagram is shown in Figure 1. The test motor is operated by opposing dynamometer on the motor test bench.



Key

1 DUT
2 motor
3 dynamometer
4 torque/speed detector
5 torque/speed meter
6 motor torque (in Nm)
7 motor speed (in min^{-1})

Figure 1 — Diagram for high acceleration/deceleration endurance test of motor

4.1.1.3 Test conditions

Test conditions are shown in Table 1.

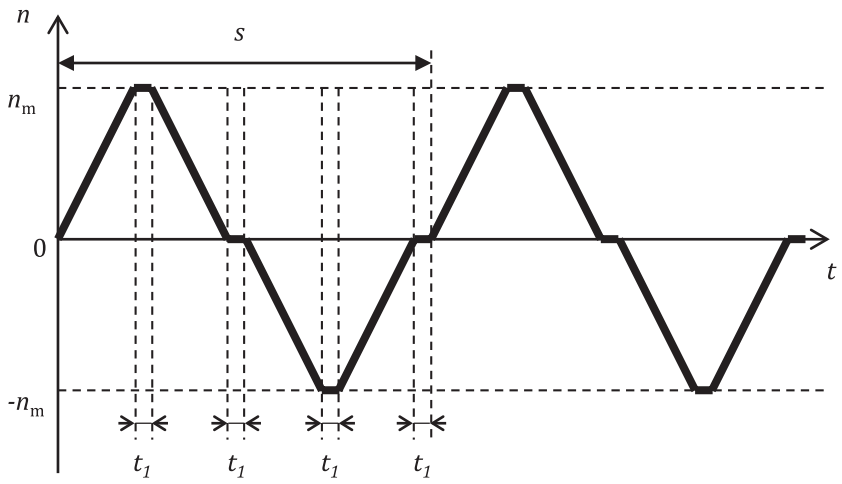
Table 1 — Conditions for high acceleration/deceleration endurance test of motor

Test conditions		Value	Remark
Ambient conditions		Room temperature (RT) and humidity as defined in ISO 21782-1:2019, 5.4.	
Coolant temperature		Maximum temperature for unlimited operating capability	— In case of liquid cooling — Ethylene glycol and propylene glycol as example of coolant
Coolant flow rate	Liquid	Minimum flow rate for unlimited operating capability	
	Air	Minimum flow rate for unlimited operating capability	

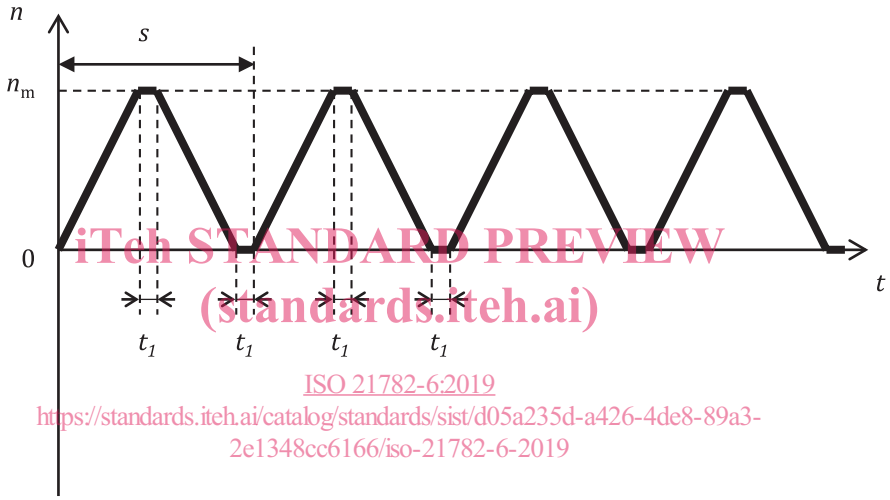
4.1.1.4 Test procedure

The test pattern is shown in Figure 2. Rotation in clockwise and counter-clockwise direction is repeated at the maximum speed of the motor specifications. The load is no load.

The number of cycles shall be decided by agreement between the supplier and customer referring to Table 2 or Table 3.



a) Test pattern for motor with bidirectional rotation



b) Test pattern for motor with single directional rotation

Key

t	time (in s)
n	motor speed (in min^{-1})
n_m	maximum speed (in min^{-1})
s	1 cycle
t_1	holding time (in s)

Figure 2 — High acceleration/deceleration endurance test pattern for motor

The acceleration rate in Figure 2 is equivalent to that of the targeted vehicle and is decided between the supplier and customer. The time "t_1" at the maximum speed and zero speed shall be reduced to a technically possible minimum (e.g. 1 s). In case of a motor with single directional rotation, only the positive speed shall be considered as shown in Figure 2 b).

This test aims to evaluate mechanical endurance. Endurance is displayed according to the rank in Table 2 in case of a motor with bidirectional rotation, and in Table 3 in case of a motor with single directional rotation.

Table 2 — Number of cycles in high acceleration/deceleration endurance test for motor with bidirectional rotation

Ranks	Number of cycles
S	500 000
A	300 000
B	200 000
C	100 000

Table 3 — Number of cycles in high acceleration/deceleration endurance test for motor with single directional rotation

Ranks	Number of cycles
S	1 000 000
A	600 000
B	400 000
C	200 000

4.1.1.5 Test requirements

4.1.1.5.1 General

The cyclic test shall be started from C rank which is listed in Table 2 and Table 3 with the motor phases open. Confirmation by energizing and disassembling shall be conducted after the high acceleration/deceleration endurance test, in order to analyse and confirm that changes before and after energizing are within the respective criteria listed in Table 4. If it is confirmed by agreement between the supplier and customer that this motor is clearly of a higher proof than C rank, continue cyclic test to the next upper rank. If the target cycle has been achieved, disassembling shall be conducted and the criteria for disassembling are listed in Table 5. If failure has occurred during a cyclic test, the motor shall be disassembled and analysed by agreement between the supplier and customer. The rank of the motor shall be decided based on the results of energizing and post-test analysis. If changes before and after energizing are not within the criteria listed in Table 5 or any failure or anomaly occurs post-test analysis, the motor shall belong to a lower rank.

4.1.1.5.2 Energizing

Before conducting this test, the data of the test listed in Table 4 shall be obtained in order to be able to compare the data before and after this test.

— Back electromotive force (back-EMF) measurement

The back-EMF of the motor is measured at the 10 % of maximum speed driven externally. They shall be within ±5 % difference before and after the test.

NOTE If the type of DUT is different from a permanent magnet motor, this measurement can be omitted.

— Measurement of origin position and waveform of position sensor

The difference in the back-EMF waveform of the reference phase and the origin position of the position sensor at the 10 % of maximum speed driven externally shall be measured. They shall be within ±5° difference in electrical angle before and after the test.

— Torque – speed characteristics

The motor torque, motor input voltage, inverter output current, and motor speed shall be measured using the load test bench at the operating point "a" and "c" of ISO 21782-1:2019, Figure 1. The difference in torque before and after the test shall be within ±5 %.

— Measurement of vibration

The generated vibrations of the motor during acceleration by the inverter to the maximum speed shall be measured. The acceleration rate shall be adequately slow. The vibration data before and after the test shall be compared to determine if there has been no significant increase. The changes in the vibration values shall be judged by an agreement between the supplier and customer.

Criteria of energizing is shown in Table 4.

Table 4 — Criteria of energizing

Measurement items	Condition	Criteria
Back-EMF	10 % of maximum speed	Within ±5 % difference before and after the test
Origin position and waveform of position sensor	Specified speed	Within ±5° difference in electrical angle before and after the test
Torque - speed characteristics	Operating point "a" and "c"	Within ±5 % difference in the torque before and after the test
Vibration	During acceleration to the maximum speed by inverter (acceleration rate: adequately slow)	No significant increase

4.1.1.5.3 Disassembling

The motor shall be disassembled, and each part shall be investigated. The items and criteria are shown in Table 5.

Differences which adversely affect motor performance shall not occur after disassembling. Details of criteria shall be agreed by the supplier and customer.

NOTE Disassembling is optional and is agreed by the supplier and customer in case of abnormalities in the non-destructive examinations.

Table 5 — Criteria of disassembling

Parts/places	Details of investigation	Criteria
Bearing	Transferred side scratch, grease degradation, creep	Scratch not leading to noise Grease degradation < reference value No creep
End ring	Deformation, crack	No large deformation No crack
Motor shaft key	Deformation, wear	No large deformation No large wear
Rotor fixture (magnet, cage, etc.)	Peeling off of adhesive deformation	No peeling
Outer circumference of rotor	Deformation, wear	No large deformation No large wear (According to external size)
Position sensor	Deviation of position (number of poles is also indicated)	Allowable thrust displacement Allowable concentricity

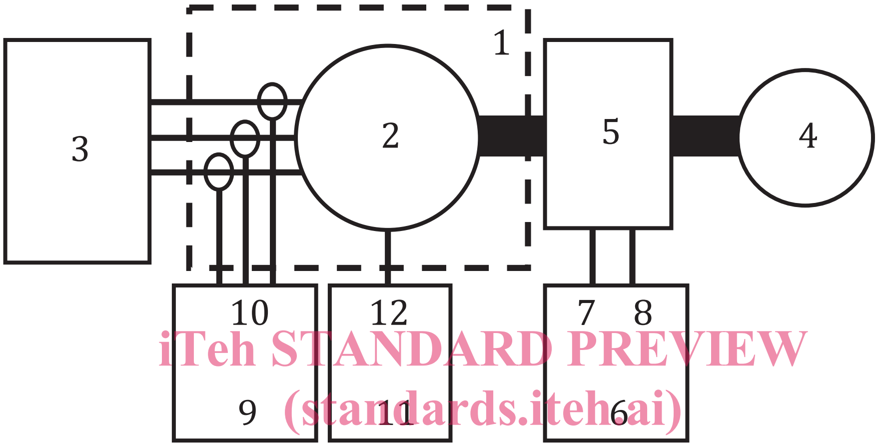
4.1.2 Maximum torque endurance test

4.1.2.1 General

The purpose of this test is to evaluate and rank the strength for the components – motor shaft key, rotor fixture, shaft tightening part, and stator fixtures – which are affected by mechanical fatigue by repeating the intermittent maximum torque of the motor. The test is set considering repeated operations at the upper specification limits of the motor. The test method can be decided by the supplier and customer.

4.1.2.2 Test diagram

The test diagram is shown in Figure 3. The test motor shall be operated at constant speed at the rated voltage outlined in ISO 21782-1 on the motor test bench.



Key

1 DUT
2 motor
3 inverter
4 load
5 torque/speed detector
6 torque/speed meter
7 motor torque (in Nm)
8 motor speed (in min $^{-1}$)
9 power meter
10 motor input current (in A)
11 thermometer
12 motor temperature (in °C)

Figure 3 — Diagram for maximum torque endurance test of motor

4.1.2.3 Test conditions

Test conditions are shown in Table 6.

Table 6 — Conditions for maximum torque endurance test of motor

Test conditions	Value	Remark
Ambient conditions	RT and humidity as defined in ISO 21782-1:2019, 5.4.	
Coolant temperature	Maximum temperature for unlimited operating capability	— In case of liquid cooling — Ethylene glycol and propylene glycol as example of coolant

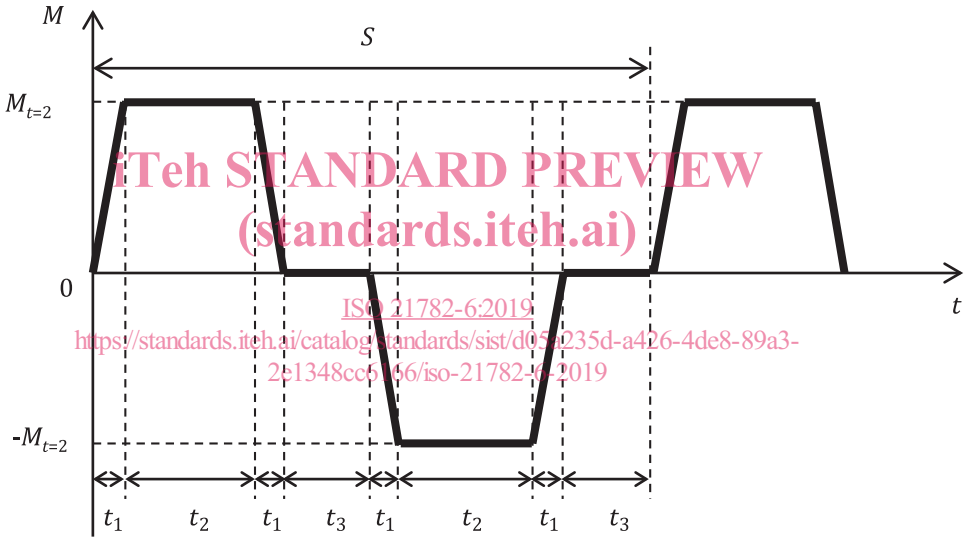
Table 6 *(continued)*

Test conditions		Value	Remark
Coolant flow rate	Liquid	Minimum flow rate for unlimited operating capability	
	Air	Minimum flow rate for unlimited operating capability	

4.1.2.4 Test procedure

The test pattern is shown in Figure 4. The constant speed shall be set between operating point "d" and "a" of ISO 21782-1:2019, Figure 1. The motor torque shall be operated on $M_{t=2}$ and $-M_{t=2}$ as shown in Figure 4. Time parameter t_1, t_2 and t_3 in Figure 4 shall be as listed in Table 7. The tests shall be conducted by repeating the number of cycles according to the corresponding rank shown in Table 8. The temperature of each part of the motor shall be controlled so that they are substantially equal to the saturation temperature during operation at permissible continuous load as shown in Figure 5.

NOTE To protect the torque meter, the test can be performed without it, after setting up the maximum torque. In that case, torque meter can be replaced by power meter to measure motor input currents.



Key

t	time (in s)
M	torque (in Nm)
$M_{t=2}$	maximum motoring torque for duration of t_0 = 2 (in Nm)
$-M_{t=2}$	maximum regenerating torque for duration of t_0 = 2 (in Nm)
s	1 cycle
t_1, t_2, t_3	time parameter

Figure 4 — Maximum torque endurance pattern for motor