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

**Part 2:  
Performance testing of the motor  
system**

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# Contents

|                                                          | Page      |
|----------------------------------------------------------|-----------|
| Foreword .....                                           | iv        |
| <b>1 Scope .....</b>                                     | <b>1</b>  |
| <b>2 Normative references .....</b>                      | <b>1</b>  |
| <b>3 Terms and definitions .....</b>                     | <b>1</b>  |
| <b>4 Abbreviated terms .....</b>                         | <b>1</b>  |
| <b>5 Tests .....</b>                                     | <b>1</b>  |
| 5.1 Measurement of total loss and total efficiency ..... | 1         |
| 5.1.1 General .....                                      | 1         |
| 5.1.2 Test diagram .....                                 | 1         |
| 5.1.3 Test conditions .....                              | 2         |
| 5.1.4 Test procedure .....                               | 3         |
| 5.2 Temperature rise test .....                          | 3         |
| 5.2.1 General .....                                      | 3         |
| 5.2.2 Test diagram .....                                 | 3         |
| 5.2.3 Test conditions .....                              | 4         |
| 5.2.4 Test procedure .....                               | 5         |
| 5.3 Torque characteristic test .....                     | 5         |
| 5.3.1 General .....                                      | 5         |
| 5.3.2 Test diagram .....                                 | 5         |
| 5.3.3 Test conditions .....                              | 6         |
| 5.3.4 Test procedure .....                               | 7         |
| 5.4 Torque ripple test .....                             | 7         |
| 5.4.1 General .....                                      | 7         |
| 5.4.2 Test diagram .....                                 | 7         |
| 5.4.3 Test conditions .....                              | 7         |
| 5.4.4 Test procedure .....                               | 8         |
| <b>6 Test reports .....</b>                              | <b>8</b>  |
| <b>Annex A (informative) Test reports .....</b>          | <b>9</b>  |
| <b>Bibliography .....</b>                                | <b>12</b> |

## 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](http://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](http://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](http://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](http://www.iso.org/members.html).

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

## Part 2: Performance testing of the motor system

### 1 Scope

This document specifies the performance tests for the motor system 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 in 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, *Electrically propelled road vehicles — Test specification for electric propulsion components — Part 1: General test conditions and definitions*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions 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 Abbreviated terms

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

### 5 Tests

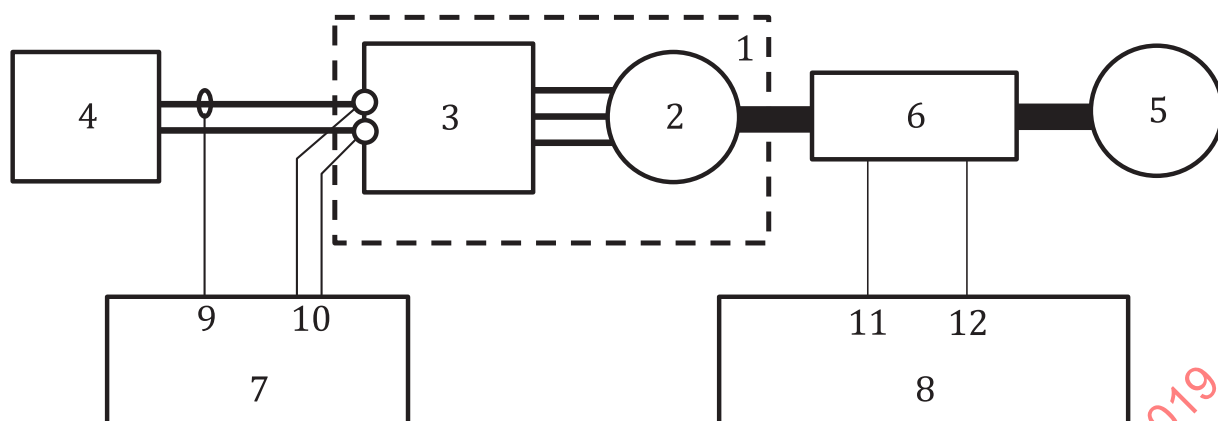
#### 5.1 Measurement of total loss and total efficiency

##### 5.1.1 General

Under the conditions of the paired inverter and motor combination, this test measures total loss and total efficiency between the input power of the inverter and the output power of the motor in order to ensure that the performance of the motor system is as designed.

##### 5.1.2 Test diagram

The test diagram is shown in [Figure 1](#).

**Key**

- 1 DUT
- 2 test motor
- 3 test inverter
- 4 DC power supply
- 5 load
- 6 torque/speed detector
- 7 spectrum analyser/power meter
- 8 torque/speed meter
- 9 inverter input current (in A)
- 10 inverter input voltage (in V)
- 11 motor torque (in Nm)
- 12 motor speed (in min<sup>-1</sup>)

**Figure 1 — Diagram for total loss and total efficiency test of the motor system**

### 5.1.3 Test conditions

The test conditions are shown in [Table 1](#).

**Table 1 — Conditions for total loss and total efficiency test of the motor system**

| Test conditions       | Value                                                                   | Remark                                                                                                                                                                                                                                                                                                                 |
|-----------------------|-------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DC input voltage      | Rated voltage as defined in ISO 21782-1:2019, 3.22.                     | For the DC input voltage tolerance, see ISO 21782-1:2019, 5.3.                                                                                                                                                                                                                                                         |
| Ambient conditions    | Room temperature (RT) and humidity as defined in ISO 21782-1:2019, 5.4. |                                                                                                                                                                                                                                                                                                                        |
| Coolant temperature   | Maximum temperature for unlimited operating capability                  | <ul style="list-style-type: none"> <li>— In case of liquid cooling</li> <li>— Ethylene glycol and propylene glycol as examples of coolant</li> <li>— If technically feasible, the tests shall be performed at coolant temperature of 65 °C. Otherwise the deviation shall be documented in the test report.</li> </ul> |
| Coolant flow rate     | Minimum flow rate for unlimited operating capability                    | In case of liquid cooling                                                                                                                                                                                                                                                                                              |
| Cooling air flow rate | Minimum flow rate for unlimited operating capability                    | In case of air cooling                                                                                                                                                                                                                                                                                                 |

Table 1 (continued)

| Test conditions | Value                                                                                                                                                                                                                                                                                                                                                                                         | Remark                                                                                                             |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Operating point | Test points as defined in ISO 21782-1:2019, Figure 1<br>— "a", "a'", "b", "p <sub>1</sub> " to "p <sub>10</sub> " (optional "e", "e'", "f", "p <sub>1</sub> '" to "p <sub>10</sub> '")                                                                                                                                                                                                        |                                                                                                                    |
| Operating time  | — The operating points "a", "a'", "p <sub>1</sub> ", "p <sub>3</sub> ", "p <sub>5</sub> ", "p <sub>7</sub> ", "p <sub>9</sub> ", "p <sub>10</sub> ": 2 s, 10 s (optional 30 s, 60 s)<br>— The operating point "b": 1 800 s<br>— The operating points "p <sub>2</sub> ", "p <sub>4</sub> ", "p <sub>6</sub> ", "p <sub>8</sub> ": 1 800 s or maximum allowable time for temperature protection | For regenerative operating points, the same operating time applies as for corresponding motoring operating points. |
| Measuring time  | Average of the last one second                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |

### 5.1.4 Test procedure

If technically feasible the cooling flow path should be connected between inverter and motor and the coolant should flow from inverter to motor and the tests shall be performed at coolant temperature of 65 °C. Otherwise the cooling configuration and/or temperature deviation shall be documented in the test report.

Under specified operating points, the input power and the output torque and speed of motor shall be measured. Inverter input power, motor output torque and speed shall be recorded. Each average of the last one second of the records shall be used.

The total loss and total efficiency shall be calculated by using [Formulae \(1\)](#) and [\(2\)](#):

$$P_{sl} = P_{ii} - P_{mo} \quad (1)$$

$$\eta_s = \frac{P_{mo}}{P_{ii}} \times 100 \quad (2)$$

where

$P_{sl}$  is the total loss of the motor system (in W);

$P_{ii}$  is the inverter input power (in W);

$P_{mo}$  is the motor output power (in W);

$\eta_s$  is the total efficiency of the motor system (in %).

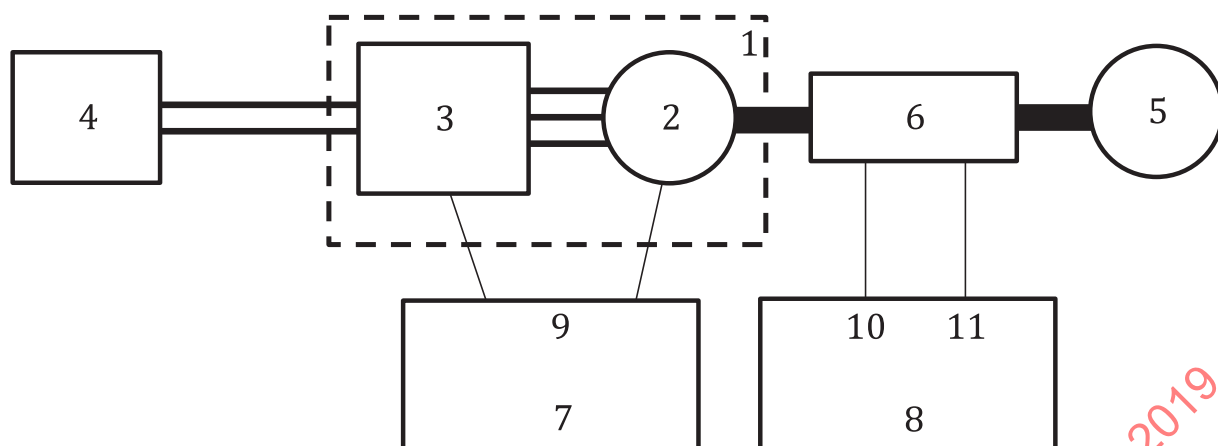
## 5.2 Temperature rise test

### 5.2.1 General

Under the conditions of the paired inverter and motor combination, this test investigates the temperature rise characteristics of each part of the motor system within the specified range in order to ensure that the performance of the motor system is as designed.

### 5.2.2 Test diagram

The test diagram is shown in [Figure 2](#).

**Key**

- 1 DUT
- 2 test motor
- 3 test inverter
- 4 DC power supply
- 5 load
- 6 torque/speed detector
- 7 thermometer
- 8 torque/speed meter
- 9 measurement point of temperature (in °C)
- 10 motor torque (in Nm)
- 11 motor speed (in min<sup>-1</sup>)

**Figure 2 — Diagram for temperature rise test of the motor system**

### 5.2.3 Test conditions

The test conditions are shown in [Table 2](#).

**Table 2 — Conditions for temperature rise test of the motor system**

| Test conditions       | Value                                                  | Remark                                                                                                                                                                                                                                                                                                                 |
|-----------------------|--------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DC input voltage      | Rated voltage as defined in ISO 21782-1:2019, 3.22.    | For the DC input voltage tolerance, see ISO 21782-1:2019, 5.3.                                                                                                                                                                                                                                                         |
| Ambient conditions    | RT and humidity as defined in ISO 21782-1:2019, 5.4.   |                                                                                                                                                                                                                                                                                                                        |
| Coolant temperature   | Maximum temperature for unlimited operating capability | <ul style="list-style-type: none"> <li>— In case of liquid cooling</li> <li>— Ethylene glycol and propylene glycol as examples of coolant</li> <li>— If technically feasible, the tests shall be performed at coolant temperature of 65 °C. Otherwise the deviation shall be documented in the test report.</li> </ul> |
| Coolant flow rate     | Minimum flow rate for unlimited operating capability   | In case of liquid cooling                                                                                                                                                                                                                                                                                              |
| Cooling air flow rate | Minimum flow rate for unlimited operating capability   | In case of air cooling                                                                                                                                                                                                                                                                                                 |

Table 2 (continued)

| Test conditions | Value                                                                                          | Remark                                           |
|-----------------|------------------------------------------------------------------------------------------------|--------------------------------------------------|
| Operating point | Test points as defined in ISO 21782-1:2019, Figure 1<br>—"a", "b"                              | Can be set after consultation with the customer. |
| Operating time  | —The operating point "a": 2 s, 10 s (optional 30 s, 60 s)<br>—The operating point "b": 1 800 s |                                                  |
| Measuring time  | Average of the last one second                                                                 |                                                  |

#### 5.2.4 Test procedure

If technically feasible the cooling flow path should be connected between inverter and motor, the coolant should flow from inverter to motor and the tests shall be performed at a coolant temperature of 65 °C. Otherwise the cooling configuration and/or temperature deviation shall be documented in the test report.

The test motor system shall be operated at specified operating points, and the temperature at the measurement points shall be recorded. At each operating point, after the specified time passes, the temperature shall be recorded.

The temperature of coil of test motor shall be measured at the points assumed as the highest. The measurement points in the coil and other measurement points can be added by the agreement between the supplier and customer.

The temperature of test inverter shall be measured at the measurement points shown below:

- electrode part of power semiconductor or specified point of the cooling components closely connected to these parts;
- inlet and outlet of coolant.

Additional measurement points can be added by the agreement between the supplier and customer.

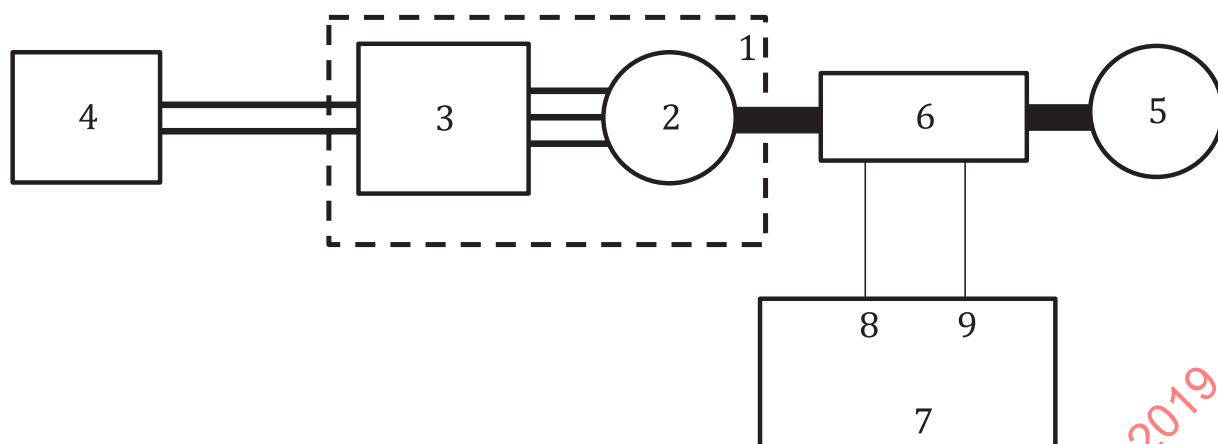
### 5.3 Torque characteristic test

#### 5.3.1 General

Under the conditions of the paired inverter and motor combination, this test measures the torque characteristics specified in the specifications of the motor system in order to ensure that the performance of the motor system is as designed.

#### 5.3.2 Test diagram

The test diagram is shown in [Figure 3](#).

**Key**

- 1 DUT
- 2 test motor
- 3 test inverter
- 4 DC power supply
- 5 load
- 6 torque/speed detector
- 7 torque/speed meter
- 8 motor torque (in Nm)
- 9 motor speed (in min<sup>-1</sup>)

**Figure 3 — Diagram for torque characteristic test of the motor system****5.3.3 Test conditions**

The test conditions are shown in [Table 3](#).

**Table 3 — Conditions for torque characteristic test of the motor system**

| Test conditions       | Value                                                                         | Remark                                                                                                                                                                                                                                                                                                                 |
|-----------------------|-------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DC input voltage      | Rated voltage as defined in ISO 21782-1:2019, 3.22.                           | For the DC input voltage tolerance, see ISO 21782-1:2019, 5.3.                                                                                                                                                                                                                                                         |
| Ambient conditions    | RT and humidity as defined in ISO 21782-1:2019, 5.4.                          |                                                                                                                                                                                                                                                                                                                        |
| Coolant temperature   | Maximum temperature for unlimited operating capability                        | <ul style="list-style-type: none"> <li>— In case of liquid cooling</li> <li>— Ethylene glycol and propylene glycol as examples of coolant</li> <li>— If technically feasible, the tests shall be performed at coolant temperature of 65 °C. Otherwise the deviation shall be documented in the test report.</li> </ul> |
| Coolant flow rate     | Minimum flow rate for unlimited operating capability                          | In case of liquid cooling                                                                                                                                                                                                                                                                                              |
| Cooling air flow rate | Minimum flow rate for unlimited operating capability                          | In case of air cooling                                                                                                                                                                                                                                                                                                 |
| Operating point       | Test points as defined in ISO 21782-1:2019, Figure 1<br>— "a", "a'", "c", "d" |                                                                                                                                                                                                                                                                                                                        |

Table 3 (continued)

| Test conditions | Value                                                                      | Remark |
|-----------------|----------------------------------------------------------------------------|--------|
| Operating time  | The operating points "a", "a'", "c", "d'": 2 s, 10 s (optional 30 s, 60 s) |        |
| Measuring time  | Average of the last one second                                             |        |

### 5.3.4 Test procedure

The test motor system shall be operated at specified operating points and the values of motor torque and motor speed shall be recorded.

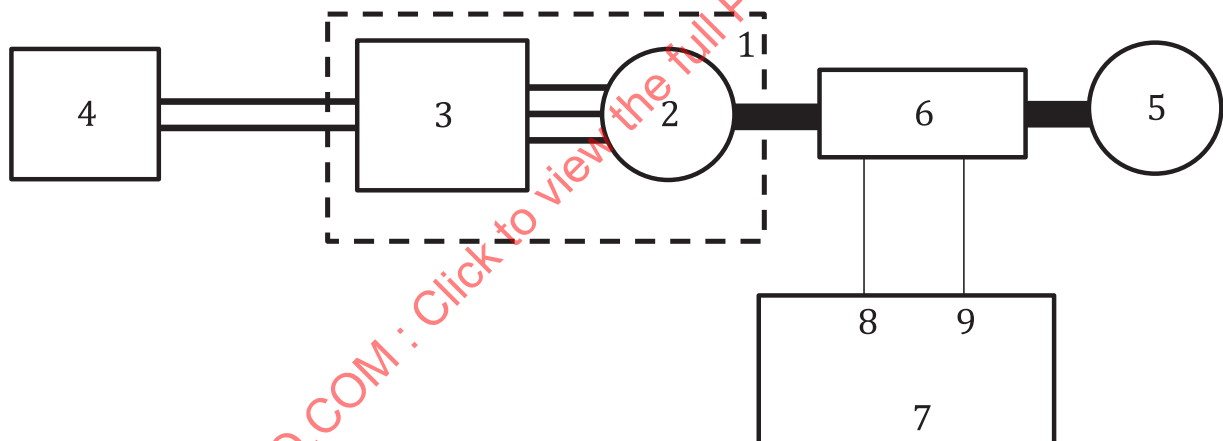
## 5.4 Torque ripple test

### 5.4.1 General

Under the conditions of the paired inverter and motor combination, this test measures the torque ripple of the motor system in order to ensure that the performance of the motor system is as designed.

### 5.4.2 Test diagram

The test diagram is shown in [Figure 4](#).



#### Key

- 1 DUT
- 2 test motor
- 3 test inverter
- 4 DC power supply
- 5 load
- 6 torque/speed detector
- 7 torque/speed meter
- 8 motor torque (in Nm)
- 9 motor speed (in min<sup>-1</sup>)

Figure 4 — Diagram for torque ripple test of the motor system

### 5.4.3 Test conditions

The test conditions are shown in [Table 4](#).

**Table 4 — Conditions for torque ripple test of the motor system**

| Test conditions       | Value                                                         | Remark                                                                                                                                                                                                                                                                                                                 |
|-----------------------|---------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DC input voltage      | Rated voltage as defined in ISO 21782-1:2019, 3.22.           | For the DC input voltage tolerance, see ISO 21782-1:2019, 5.3.                                                                                                                                                                                                                                                         |
| Ambient conditions    | RT and humidity as defined in ISO 21782-1:2019, 5.4.          |                                                                                                                                                                                                                                                                                                                        |
| Coolant temperature   | Maximum temperature for unlimited operating capability        | <ul style="list-style-type: none"> <li>— In case of liquid cooling</li> <li>— Ethylene glycol and propylene glycol as examples of coolant</li> <li>— If technically feasible, the tests shall be performed at coolant temperature of 65 °C. Otherwise the deviation shall be documented in the test report.</li> </ul> |
| Coolant flow rate     | Minimum flow rate for unlimited operating capability          | In case of liquid cooling                                                                                                                                                                                                                                                                                              |
| Cooling Air flow rate | Minimum flow rate for unlimited operating capability          | In case of air cooling                                                                                                                                                                                                                                                                                                 |
| Operating point       | Test points as defined in ISO 21782-1:2019, Figure 1<br>— "d" | If the speed of 'd' is not technically feasible, the speed shall be decided by the supplier and customer considering frequency bandwidth of torque/speed meter.                                                                                                                                                        |
| Operating time        | The operating point "d": 2 s, 10 s (optional 30 s, 60 s)      |                                                                                                                                                                                                                                                                                                                        |
| Measuring time        | Average of the last one second                                |                                                                                                                                                                                                                                                                                                                        |

#### 5.4.4 Test procedure

The test motor shall be operated under specified operating points, and the value output waveform from torque meter shall be recorded. The torque ripple shall be the peak to peak value.

## 6 Test reports

Each test shall be reported with a test report, containing sufficient information on test conditions and results. Examples for a test reports on conditions and results are is given in [Annex A](#).

## Annex A (informative)

### Test reports

#### A.1 Total loss and total efficiency of the motor system

**Table A.1 — Total loss and total efficiency of the motor system**

| 1. Common conditions                 |                                  |          |  |                   |                |                |                |                |                 |                |  |
|--------------------------------------|----------------------------------|----------|--|-------------------|----------------|----------------|----------------|----------------|-----------------|----------------|--|
|                                      | Items                            |          |  | Value             |                |                |                |                | Remark          |                |  |
|                                      | Ambient temperature (in °C)      |          |  |                   |                |                |                |                |                 |                |  |
|                                      | Ambient humidity (in %)          |          |  |                   |                |                |                |                |                 |                |  |
|                                      | Cooling type                     |          |  | Liquid/Air/Others |                |                |                |                |                 |                |  |
|                                      | Coolant temperature (in °C)      |          |  |                   |                |                |                |                |                 |                |  |
|                                      | Coolant flow rate (in l/min)     |          |  |                   |                |                |                |                |                 |                |  |
| 2. Results and individual conditions |                                  |          |  |                   |                |                |                |                |                 |                |  |
|                                      | Items                            |          |  | Value             |                |                |                |                |                 | Remark         |  |
|                                      | Operating points                 |          |  | a                 | a'             | b              | p <sub>1</sub> | p <sub>2</sub> | p <sub>3</sub>  | p <sub>4</sub> |  |
| Operating time (in s)                |                                  |          |  |                   |                |                |                |                |                 |                |  |
| Input                                | Current (in A)                   |          |  |                   |                |                |                |                |                 |                |  |
|                                      | Voltage<br>(in V)                | Target   |  |                   |                |                |                |                |                 |                |  |
|                                      |                                  | Measured |  |                   |                |                |                |                |                 |                |  |
|                                      | Power (in kW)                    |          |  |                   |                |                |                |                |                 |                |  |
| Output                               | Torque<br>(in Nm)                | Target   |  |                   |                |                |                |                |                 |                |  |
|                                      |                                  | Measured |  |                   |                |                |                |                |                 |                |  |
|                                      | Speed<br>(in min <sup>-1</sup> ) | Target   |  |                   |                |                |                |                |                 |                |  |
| Operating points                     |                                  |          |  | p <sub>5</sub>    | p <sub>6</sub> | p <sub>7</sub> | p <sub>8</sub> | p <sub>9</sub> | p <sub>10</sub> |                |  |
| Operating time (in s)                |                                  |          |  |                   |                |                |                |                |                 |                |  |
| Input                                | Current (in A)                   |          |  |                   |                |                |                |                |                 |                |  |
|                                      | Voltage<br>(in V)                | Target   |  |                   |                |                |                |                |                 |                |  |
|                                      |                                  | Measured |  |                   |                |                |                |                |                 |                |  |
|                                      | Power (in kW)                    |          |  |                   |                |                |                |                |                 |                |  |
| Output                               | Torque<br>(in Nm)                | Target   |  |                   |                |                |                |                |                 |                |  |
|                                      |                                  | Measured |  |                   |                |                |                |                |                 |                |  |
|                                      | Speed<br>(in min <sup>-1</sup> ) | Target   |  |                   |                |                |                |                |                 |                |  |

## A.2 Temperature rise test of the motor system

Table A.2 — Temperature rise test of the motor system

| 1. Common conditions                 |                                  |          |                  |   |        |
|--------------------------------------|----------------------------------|----------|------------------|---|--------|
|                                      | Items                            |          | Value            |   | Remark |
|                                      | DC input voltage (in V)          |          |                  |   |        |
|                                      | Ambient temperature (in °C)      |          |                  |   |        |
|                                      | Ambient humidity (in %)          |          |                  |   |        |
|                                      | Cooling type                     |          | Liquid/Air/Other |   |        |
|                                      | Coolant temperature (in °C)      |          |                  |   |        |
|                                      | Coolant flow rate (in l/min)     |          |                  |   |        |
| 2. Results and individual conditions |                                  |          |                  |   |        |
|                                      | Items                            |          | Value            |   | Remark |
|                                      | Operating points                 |          | a                | b |        |
|                                      | Operating time (in s)            |          |                  |   |        |
|                                      | Torque<br>(in Nm)                | Target   |                  |   |        |
|                                      |                                  | Measured |                  |   |        |
|                                      | Speed<br>(in min <sup>-1</sup> ) | Target   |                  |   |        |
|                                      |                                  | Measured |                  |   |        |
|                                      | Temperature<br>(in °C)           | Point 1  |                  |   |        |
|                                      |                                  | Point 2  |                  |   |        |
|                                      |                                  | Point 3  |                  |   |        |
|                                      |                                  | Point 4  |                  |   |        |
|                                      |                                  | Point 5  |                  |   |        |
| .....                                |                                  |          |                  |   |        |

## A.3 Torque characteristic test of the motor system

Table A.3 — Torque characteristic test of the motor system

| 1. Common conditions                 |                                  |          |                  |    |   |        |        |
|--------------------------------------|----------------------------------|----------|------------------|----|---|--------|--------|
|                                      | Items                            |          | Value            |    |   | Remark |        |
|                                      | DC input voltage (in V)          |          |                  |    |   |        |        |
|                                      | Ambient temperature (in °C)      |          |                  |    |   |        |        |
|                                      | Ambient humidity (in %)          |          |                  |    |   |        |        |
|                                      | Cooling type                     |          | Liquid/Air/Other |    |   |        |        |
|                                      | Coolant temperature (in °C)      |          |                  |    |   |        |        |
|                                      | Coolant flow rate (in l/min)     |          |                  |    |   |        |        |
| 2. Results and individual conditions |                                  |          |                  |    |   |        |        |
|                                      | Items                            |          | Value            |    |   |        | Remark |
|                                      | Operating points                 |          | a                | a' | c | d      |        |
|                                      | Operating time (in s)            |          |                  |    |   |        |        |
|                                      | Torque<br>(in Nm)                | Target   |                  |    |   |        |        |
|                                      |                                  | Measured |                  |    |   |        |        |
|                                      | Speed<br>(in min <sup>-1</sup> ) | Target   |                  |    |   |        |        |
|                                      |                                  | Measured |                  |    |   |        |        |