

Foreword

This is a technical paper prepared by the standards committee after deliberation of the standard in accordance with the rules of the standards conference based on the articles of the Japan Automotive Standards Organization.

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(a) Purpose

In 2007, the World Health Organization (**WHO**) recommended that national governments establish guidelines for human body protection from electromagnetic fields, basing those guidelines on information from the International Commission on Non-Ionizing Radiation Protection (**ICNIRP**). The Ministry of Internal Affairs and Communications has formulated radiation protection guidelines in the “Report of the Telecommunications Technology Council of the Ministry of Posts and Telecommunications [June 1990]: Inquiry No. 38 “Human Body Protection Guidelines for the Use of Radio Waves”, in accordance with **ICNIRP** human protection guidelines for high-frequency equipment use in the home. Therefore, a test standard that can determine vehicle compliance with **ICNIRP** guidelines was studied, and a preliminary JASO standard was prepared.

(b) Patent rights information

Conformity with this technical paper could require use of patent rights from the following patentee:

- Name: Narda Safety Test Solutions GmbH
- Address: Sandwiesenstrasse 7, D-72973 Pfullingen, Germany
- Patent Number: P3487824

The above patentee has expressed willingness to grant license to users under non-discriminatory and reasonable terms. The patentee has also made it a condition that other patentees having other patent rights related to this technical paper should be granted licenses with the same terms.

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Portions of this technical paper may conflict with patent rights other than those listed above. The Society of Automotive Engineers of Japan shall not be held responsible for identifying any or all such patent rights. For the purpose of this paper, a patent right is defined as the patent mentioned above, application for such patent right after opening to the public, or any related utility model right.

(c) Supplementary notes

The information in this technical paper was formulated for vehicles equipped with a rechargeable energy storage system (**REESS**) in a standard configuration and does not cover all vehicles equipped with an **REESS**. Consequently, manufacturers of vehicles equipped with an **REESS** are expected to apply this information in light of the structure of the system and its anticipated use.

TECHNICAL PAPER

Measurement methods for electromagnetic field of vehicles with regarding to the human exposure

Introduction

This is a technical paper prepared based on **JIS/TS C 0044** issued in 2010 (corresponding international standard: **IEC 62233**). Vehicle-specific measurement methods were added, but the technical content has not been changed.

1. Scope

This technical paper addresses the measurement frequency range from 10 Hz to 400 kHz, and defines methods for the evaluation of magnetic intensity and magnetic flux density for vehicles with electric propulsion mechanisms with a rechargeable energy storage system (**REESS**).

This technical paper includes specific elements to assess human exposure:

- a) Measuring equipment and measurement environment;
- b) Vehicle operation mode;
- c) Location of measuring probes;
- d) Evaluation method

2. Normative references

This technical paper refers to the following standards. For any undated reference, the latest edition of the referenced document (including any amendments) shall apply.

JIS/TC C 0044	Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure
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Note:

The international equivalent is: **IEC 62233** (Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure).

IEC 60050-161	International Electrotechnical Vocabulary—Chapter 161: Electromagnetic Compatibility
IEC 62226-1	Exposure to electric or magnetic fields in the low and intermediate frequency range - Methods for calculating the current density and internal electric field induced in the human body - Part 1: General
ICNIRP Guidelines	Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)

3. Terms and definitions

3.1 Basic restrictions (basic limitations)

Restrictions on exposure to time-varying electric, magnetic and electromagnetic fields are based on established biological effects and include a safety factor. The basic restriction for the current density is J_{BR} (J Basic Restriction), and the basic restriction for the internal electric field strength is E_{BR} (E Basic Restriction)

3.2 Coupling factor, $a_c(r_1)$

A factor taking into account the irregularities of the fields around the components, the measuring area of the sensor and the dimension of the torso or head of the operator at measuring distance r_1 (see 3.6)

3.3 Fourier transformation

Mathematical procedure that derives a frequency function from a time function

3.4 Fast Fourier transformation, FFT

Speed-optimized Fourier transform

3.5 Hot spot

A localized area with a maximum field strength due to the inhomogeneity of the field distribution

3.6 Measuring distance, r_1

Shortest distance from the surface of the component to the closest point of the sensor surface

3.7 Reference level, maximum permissible exposure level, B_{RL} (B Reference Level)

Field level derived from the basic restrictions under worst case assumptions (e.g. exposure to a homogeneous field)

Note: The reference levels may be exceeded providing that the basic restrictions are met.

3.8 Response time

Time required for a field-measuring instrument to reach some specified percentage of the final value after being placed in the field to be measured

3.9 Weighted result, W

Final result of the measurement, taking the frequency dependent reference level into account

3.10 REESS (rechargeable energy storage system)

A system that provides electric energy for electric propulsion

3.11 Conductive charge

A method to store electrical energy in the auxiliary battery mounted inside the vehicle through metal contacts or connectors outside the vehicle

3.12 Inductive charge

A method to store electrical energy in the auxiliary battery mounted inside the vehicle without relying on metal contacts or connectors outside the vehicle

3.13 Maximum load

Vehicle load under which the greatest amount of electrical power is generated or consumed under normal use conditions

3.14 State of charge (SOC)

The state of the battery mounted in a **REESS** vehicle

3.15 Electromagnetic field

Combination of the electric and magnetic fields in the environment

3.16 Exposure

Condition where a person is subjected to a low frequency field or contact current

3.17 Harmonics

Higher order frequencies which are whole-number multiples of a given frequency

3.18 Root mean square

A value corresponding to the voltage or size of the current in alternating current when converted to voltage or size of current in direct current. This value is known as the root mean square (rms), since it is derived by first squaring the function, then determining the mean value of the squares obtained, and, lastly, taking the square root of that mean value.

3.19 General public

The general public comprises a group consisting of an indeterminate number of individuals of all ages, genders, and varying health statuses. In many cases, members of the public are unaware of their exposure to electromagnetic fields. Moreover, individual members of the public cannot reasonably be expected to take precautions to minimize or avoid exposure.

3.20 Exposure of general public

All exposure to low frequency fields received by members of the general public. This definition excludes occupational exposure and medical exposure.

3.21 Occupational exposure

All exposure to low frequency fields received by workers who are generally exposed under known conditions and are trained to be aware of potential risks and take appropriate precautions.

3.22 Induced current

Electric current caused by electromagnetic field exposure and induced into the body

3.23 Specific energy absorption, SA

The energy absorbed per unit mass of biological tissue, expressed in joules per kilogram (J/kg): specific energy absorption is the time integral of the specific energy absorption rate

3.24 Specific energy absorption rate, SAR

The rate at which energy is absorbed in body tissues. Expressed in watts per kilogram (W/kg), SAR is a dissymmetric measure that has been widely adopted at frequencies above about 100 kHz.

4. Physical quantities and units

This technical paper uses the following units and abbreviations.

Quantity	Symbol	Unit	Dimension
Conductivity	σ	Siemens per meter	S/m
Current density	J	Ampere per square meter	A/m ²
Electric field strength	E	Volt per meter	V/m
Frequency	f	Hertz	Hz
Magnetic field strength	H	Ampere per meter	A/m

Magnetic flux density B Tesla T(Wb/m² or V- s/m²)

5. Measuring equipment and measurement environment

5.1 Frequency range

The frequency range considered is from 10 Hz to 400 kHz. (See Scope 1)

If it is not feasible to cover the frequency range in one measurement, the weighted results of each measured frequency range shall be added.

5.2 Measuring Equipment

5.2.1 Magnetic Field Sensor

The sensor consists of three mutually perpendicular concentric coils with a measuring area of 100 cm² ± 5 cm² to provide isotropic sensitivity.

The outside diameter of the sensor shall not exceed 13 cm.

If performance matches that of this standard sensor, other sizes of sensors are acceptable.

For the determination of coupling factors, as specified in **Annex B**, an isotropic sensor having a measuring area of 3 cm² ± 0.3 cm² is used.

It is permissible to use a single direction sensor (not isotropic) in combination with an appropriate summation method.

Note: The measuring area of the standard sensor is 100 cm². The magnetic induction averaged over the entire area is set as the measurement value. The final value of the magnetic flux density is the vector addition of the values measured in each direction. This ensures that the measured value is independent of the magnetic field vector.

5.2.2 Internal Noise Level of Measuring Equipment

The internal noise level of measuring equipment shall be less than 5% of the limit value.

5.3 Measuring environment

The background noise level shall be less than 5% of the limit value.

6. Vehicle operation mode, location of measuring probes

6.1 Vehicle operation mode

In accordance with vehicle specifications, select one of the three vehicle operation modes below: Modes may be added or modified. Record any mode modifications.

a) Cruising mode

Vehicle speed is 40 km/h. Road load shall be adjusted according to the test vehicle specifications. All electric loads not related to vehicle running shall be turned on. Variable loads shall be adjusted to their maximum position. All electric load conditions during the test shall be recorded.

Examples of electric loads not related to vehicle running: headlamps under maximum power consumption mode, blower at maximum fan speed, rear window defogger, air conditioner electric inverter compressor, and the like

b) Acceleration/deceleration mode

For acceleration, vehicle speed with the throttle fully open ranges from 0 km/h to 90 km/h or the maximum speed of the test vehicle. Deceleration is 2.5 m/s² or higher, starting from a vehicle speed of 90 km/h or the maximum speed of the test vehicle.

In both modes, all electric loads not related to vehicle running shall have the same operation status as cruising mode **a)**.

c) Charging mode

Perform charging mode measurements on test vehicles with a charging apparatus (including removable apparatuses). The charging current and battery state (SOC) shall be recorded.

6.2 Location of measuring probes

6.2.1 Measurement position

Measurement positions are as follows,

a) Passenger car, commercial vehicle and truck

All seat positions (including auxiliary seats)

b) Two-wheeled vehicles

All seat positions

Note: For vehicles where the passenger sits close to the driver (tandem riding) measurement can use the driver seat position as a substitute. For vehicles where the riding position cannot be matched correctly, the information from the riding position shall be recorded. In other cases, measurement positions and measured values shall be recorded.

c) Bus, minibuses

Forward seat, center seat and rear seat

Measurement positions for vehicle charging mode are as follows,

d) Conductive charging

Measuring positions specified by **a)**, **b)**, or **c)**, and a position near the charge gun handle.

e) Inductive charging (floor charging)

Measurement is performed at positions inside the vehicle specified by **a)**, **b)** or **c)**, and the nearest positions to the charging coil indicated in **1)** and **2)**. However, off-limits areas indicated in the user's manual etc., are accepted.

1) When the coil is in normal charging position, electromagnetic field strength measurements are performed at a distance of 0.2 m from the edge of the test vehicle body in each of the four directions (front and rear, right and left) of the coil as shown in **Figure 1** and at a height of 0.5 m, 1.0 m, and 1.5 m respectively as shown in **Figure 2**. The measurement results of each height are averaged.

2) Next, measurements of electromagnetic field strength are performed and compliance is judged under offset coil position. Measuring positions then are at a distance of 0.2 m from the edge of the vehicle body and at a height of 0.5 m, 1.0 m, and 1.5 m respectively in the same way as **1)**. The measurement results at each height are averaged.

f) Inductive charging (side charging)

Measurement is performed at positions inside the vehicle specified by **a)**, **b)** or **c)**, and the nearest positions to the charging coil indicated in **1)** and **2)**. However, off-limits areas indicated in the user's manual etc., are accepted.

1) When the coil is in normal charging position, electromagnetic field strength measurements are performed at a distance of 0.2 m from the outer edge of the power transmission coil as shown in **Figure 3**

and at height of 0.5 m, 1.0 m, and 1.5 m respectively as shown in **Figure 4**. The measurement results of each height are averaged.

2) Next, electromagnetic field strength measurements are performed and compliance is judged under offset coil position. The electromagnetic field strength measurements are performed at a distance of 0.2 m from the outer edge of the power transmission coil as shown in **Figure 3**, and at a height of 0.5 m, 1.0 m, and 1.5 m respectively as shown in **Figure 4**, in the same way as 1). The measurement results at each height are averaged.

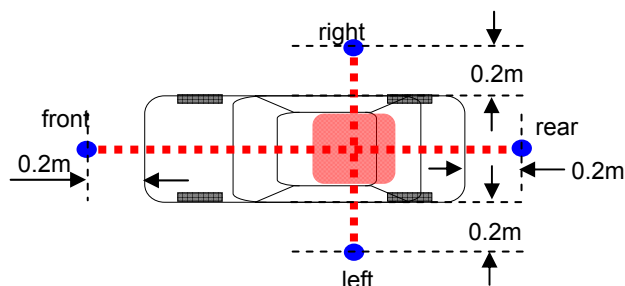


Figure 1 — Inductive charging measurement positions (floor charging): top view

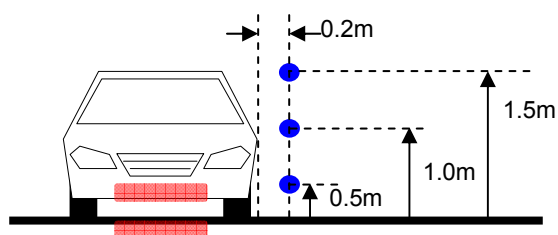


Figure 2 — Inductive charging measurement positions (floor charging): front view

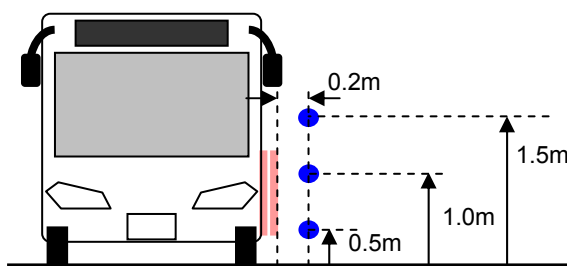


Figure 3 — Inductive charging measurement positions (side charging): front view

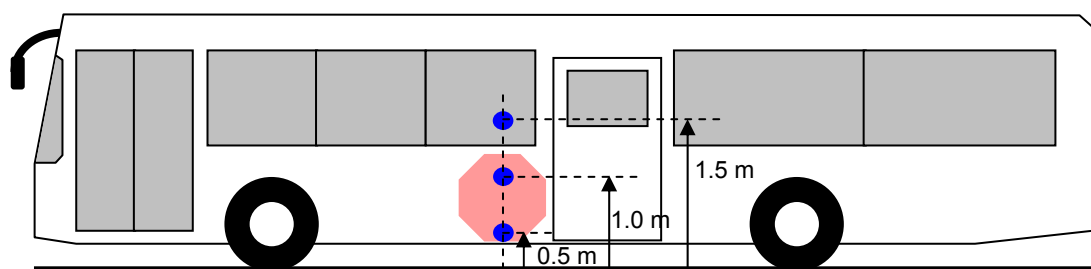


Figure 4 — Measuring inductive charging (side charging): side view

6.2.2 Seat position

The adjustable seat position location during the test is determined as follows:

- a) Back/forth adjustment: adjust the back/forth location such that the seat is in the center position of the seat back/forth adjustment travel range.
- b) Up/down adjustment: adjust the seat up/down location such that the seat is in the center of the up/down adjustment travel range.
- c) Backrest angle: adjust the backrest angle to 15 degrees from the vertical position.
- d) For other adjustments, use the center of the operating range.

A diagram of seat positions **a)**, **b)** and **c)** is shown in **Figure 5**.

If the seat positions above cannot be set, or for seats without an adjustment mechanism, note the seat position as part of the test report.

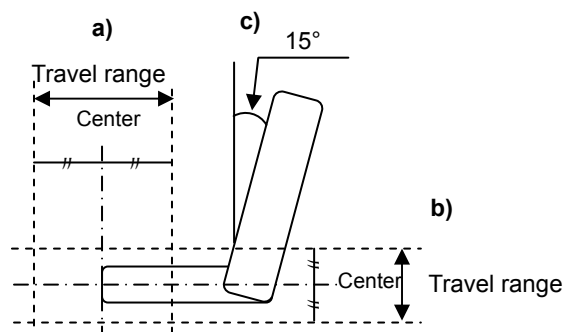


Figure 5 — Seat position

6.2.3 Seat measurement points

In order to measure the human torso locations (brain, heart, reproductive organs), use the following seat measurement points:

- a) the center of the headrest
- b) the center of the seat backrest portion
- c) the center of the seat

A diagram of seat measurement points **a)**, **b)** and **c)** is shown in **Figure 6**.

For two-wheeled vehicles, including those with a side vehicle, the following measurement points apply for both standard and tandem riding positions:

- d) Head
- e) Body center
- f) Seating position center

A diagram of seat measurement points **d)**, **e)** and **f)** is shown in **Figure 7**.

Also, when the electric charging device is located below a seat measurement position, it can be considered as represented by **f)**.

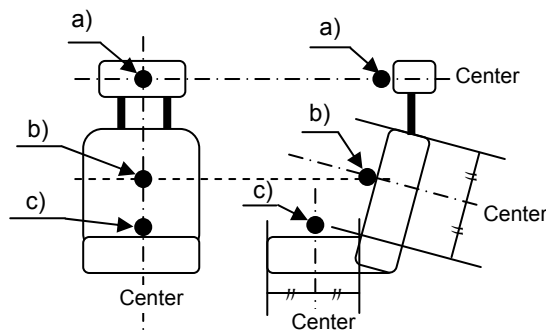


Figure 6 — Seat measurement points

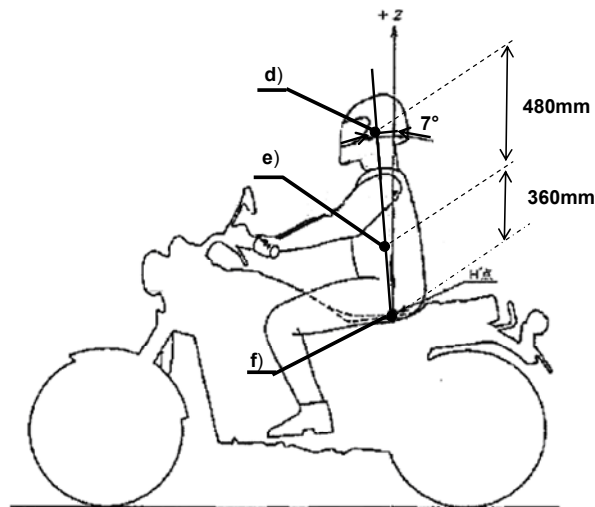


Figure 7 — Measurement points for two-wheeled vehicles

6.2.4 Distance between the measurement points and measurement probe

The phase center of the measurement probe shall be aligned to the measurement point. If the phase center cannot be aligned to the measurement point, it shall be positioned as close to it as possible.

If the measurement probe is covered with an insulator, the probe may be placed in contact with the measurement point (vehicle body, seat, etc.). In such cases, the sinking of an occupied seat cushion is not considered. The position of the measurement probe shall be recorded.

7. Evaluation method

The measuring signal shall be evaluated in relation to the frequency. Taking independent field sources into account, the highest measured value shall be taken. Transient magnetic fields with a duration of less than 200 ms, e.g., switching events, are disregarded. Any measured value below the maximum noise level is disregarded. The response time for the measuring equipment to reach 90 % of the final value is not to exceed 1 s. Magnetic flux density is determined by using an averaging time of 1 s.

Shorter sampling times may be used if the source is known to be constant over a period greater than 1 s for 10 Hz - 400 kHz signals. During the final measurement performed to determine compliance, the sensor should remain stationary.

Figure 8 shows recommendations for the choice of test method.

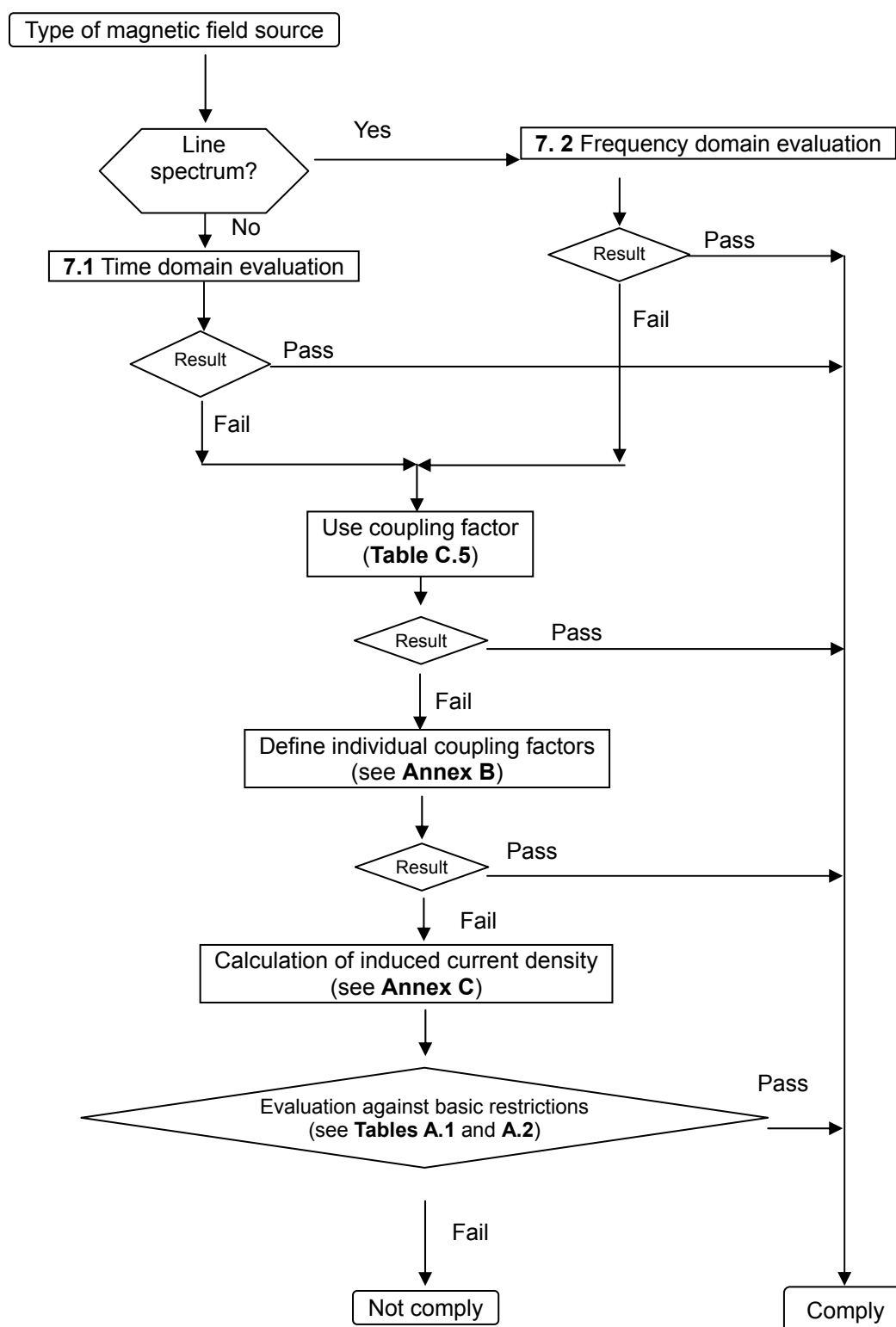


Figure 8 —Recommendations for the choice of the test method starting with the evaluation against the reference levels