PD CISPR/TR 16-2-5:2008

BSI British Standards

Specification for radio disturbance and immunity measuring apparatus and methods —

Part 2-5: In situ measurements of disturbing emissions produced by physically large equipment

National foreword

This Published Document is the UK implementation of CISPR/TR 16-2-5:2008.

The UK Committee is concerned that the wording in the Note in Subclause 4.4 restricts the application of the 'far field' formula. In its opinion it does not take account of the possible large size of the equipment under test (EUT), and so could allow inaccurate extrapolation using the formula.

The UK Committee considers that, as well as the scenario outlined in the Note in Subclause 4.4, another scenario is also feasible when applying equation (1) where, for large-size EUTs, equation (1) is only applicable if D_{meas} is in the 'far field'. This is the region where the relative distance from the centre and edge of the EUT causes a phase difference of less than pi/8 radians (22.5 degrees). This boundary is at the 'Rayleigh Distance'.

In this case Equation (1) should only be applied if

$D_{meas} > 2D_{source}2$ / lambda

where;

D_{source} = largest dimension in metres between synchronous noise sources within the EUT as seen from the measuring point.

lambda = wavelength = 300/ megahertz

For each EUT the value of D_{source} is to be determined by the test authority and justified in the test report.

When only a small dimension D_{source} is identified, the value used in the above equation should be D_{source} =0.28 * lambda. The choice of this dimension (= lambda/(2* root(pi)) will ensure that measurement is only made in the region where the 'far field' component exceeds the reactive 'near field', i.e. D_{meas} is greater than lambda/(2*pi).

The UK participation in its preparation was entrusted by Technical Committee GEL/210, EMC – Policy committee, to Subcommittee GEL/210/12, EMC basic, generic and low frequency phenomena Standardization.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

ISBN 978 0 580 60177 4

ICS 33.100.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 July 2009

Amendments issued since publication

Amd. No.	Date	Text affected

CISPR/TR 16-2-5

Edition 1.0 2008-07

TECHNICAL REPORT

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

Specification for radio disturbance and immunity measuring apparatus and methods –
Part 2-5: In situ measurements of disturbing emissions produced by physically large equipment

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE P

ICS 33.100.10

ISBN 2-8318-9894-3

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 2-5: *In situ* measurements of disturbing emissions produced by physically large equipment

FOREWORD

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CISPR 16-2-5, which is a technical report, has been prepared by CISPR subcommittee H: Limits for the protection of radio services.

The text of this standard is based on the following documents:

Enquiry draft	Report on voting
CISPR/H/161/DTR	CISPR/H/172/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the CISPR 16 series, published under the general title *Specification for radio disturbance and immunity measuring apparatus and methods,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 2-5: *In situ* measurements of disturbing emissions produced by physically large equipment

1 Scope

This part of CISPR 16 deals with *in situ* electromagnetic disturbance measurements in any environment from physically large equipment and systems excluding networks.

It covers both radiated and conducted emission phenomena, and does not deal with immunity tests.

This technical report is intended to be applied primarily to such physically large equipment which are not under the scope of any existing emission standards (as for example CISPR 11 and CISPR 22). It serves only as a guideline on how to deal with emissions of that equipment at the particular location of installation. It does not establish any emission requirements.

NOTE 1 Although this technical report is intended to be applied to equipment which is not under the scope of any existing emission standards, it may be used also in such cases in order to serve as additional information for carrying out *in situ* measurements for any type of large equipment.

NOTE 2 Examples of large equipment are: production machines, conveyors, large displays, aircraft simulators, traffic control equipment, etc.

Due to the severe impact of the conditions existing at a particular location of operation and the use of the respective large equipment, however, it is not intended to use the measurements in the frame of type testing.

NOTE 3 In general, type testing on large equipment is only possible at standardized test sites in a controlled environment. The assessment results obtained under in situ conditions are only valid for the respective individual large equipment actually measured at its particular place of installation. These results cannot be transposed to other equipment of the same type, but installed at other locations.

Reference in-situ measurement distances will be given. This allows comparison of the measurement results with limits from existing relevant standards.

The frequency range under consideration is from 9 kHz to 18 GHz.

Dealing with biological effects on living matter is excluded from this document.

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.

CISPR 16-1-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-2, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances*

CISPR 16-1-4, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Radiated disturbances*

CISPR 16-2-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

CISPR 16-2-3, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

NOTE See also the Bibliography

3 Terms and definitions

For the purposes of this document, the terms and definitions contained in IEC 60050-161 as well as the following terms and definitions apply.

NOTE See particularly electromagnetic disturbance (IEV 161-01-05) and electromagnetic interference (IEV 161-01-06).

3.1
boundary
for physically large equipment: imaginary straight line periphery describing a simple geometric configuration encompassing the equipment or system under consideration. All interconnecting cables inside the physically large equipment should be included within this boundary

3.2
antenna reference point
the reference point referred to in the antenna calibration procedure, which is used to determine the measurement distance between the equipment under test and the antenna

3.3
characterised interference
interference with an origin from an identified electromagnetic phenomenon, and for which the disturbance level at a given point is characterised by a collection of technical data, for example the spectrum

3.4
deviation from intended use regarding EMC
installation and/or operation of a device, equipment or system, deviating from the instructions of the manufacturer given in the user's manual

NOTE The installation refers to both the defined environment and electrical conditions including cabling.

3.5
distribution point
point on a data and communication network inside a system or an installation, electrically nearest to a particular communication equipment or terminal, at which other equipment or terminals are, or could be, connected

3.6
in-plant point of coupling
IPC
point on a network inside a system or an installation, electrically nearest to a particular load, at which other loads are, or could be, connected

NOTE The IPC is usually the point for which electromagnetic compatibility is to be considered.

[IEC 61000-2-4, definition 3.1.7]

3.7
point of common coupling
PCC
point on a public power supply network, electrically nearest to a particular load, at which other loads are, or could be, connected

[IEC 61000-2-4, definition 3.1.6]

3.8
reference point (for *in situ* measurement)
point at which *in situ* measurement is performed

NOTE 1 In case of radiated measurements, it is measured along a perpendicular line from the boundary to the antenna reference point.

NOTE 2 Different reference points might be defined according to the frequency range.

NOTE 3 The boundary to be taken into account for measurement depends on the actual *in situ* conditions

3.9
physically large equipment
a group of items of equipment functionally connected to form a commercially specified physically large equipment considered in a defined context as a whole and separated from their environment

NOTE 1 An equipment can be considered as physically large when it has a total dimension exceeding that which is practical for testing on a conventional 10 m test site.

NOTE 2 The physically large equipment is considered to be separated from the environment and from the other external systems by an imaginary surface, which cuts the links between them and the physically large equipment.

NOTE 3 For the purpose of this document, the elements of the physically large equipment are objects such as devices, items of equipment or sub-systems. They are interrelated for achieving an objective which is the performance of a function or a set of functions.

3.10
victim equipment
interfered equipment having caused a complaint

3.11
equipment under test
EUT
the equipment (devices, appliances and systems) subjected to tests

4 Methodology

4.1 Structure of each measurement

The investigated EUT shall be checked and measured at each type of port for which EMC requirements are defined. In case of interference complaints this may be restricted to those ports which cause the interference situation. Each measurement may be separated according to the following steps.

- A preliminary measurement of the investigated port is carried out to detect the frequencies with the highest emissions by a measurement method which may deviate from the measurement method on the standardized test site as described in the relevant part of CISPR 16-2.
- Frequently appearing operating modes of the EUT have to be checked in order to find the mode with the highest disturbance emission (see 4.3).
- For each investigation the reference point has to be selected at the EUT and has to be used for the final measurements (see also 4.3).

- The measurement quantity has to be identified under environmental conditions for the final measurement. This value may have to be transferred to the standard conditions if necessary. In case of interference complaint, the value of the measurement quantity needs only be determined in the direction in which compatibility is required. This value may have to be transferred to the standard conditions if necessary.

4.2 Preliminary measurements and selection of measurement method

It is useful to apply different approaches for the detection of the frequencies with the highest emissions. One approach could be to check the technical documentation of the EUT with respect to such emissions; another approach could involve checking the highest emission at a closer distance to the EUT than that used for the final measurements.

The measurement method depends on the frequency range and EUT port under consideration.

Radiated emissions should be assessed by measurements of the electromagnetic field strength only, see CISPR 16-2-3.

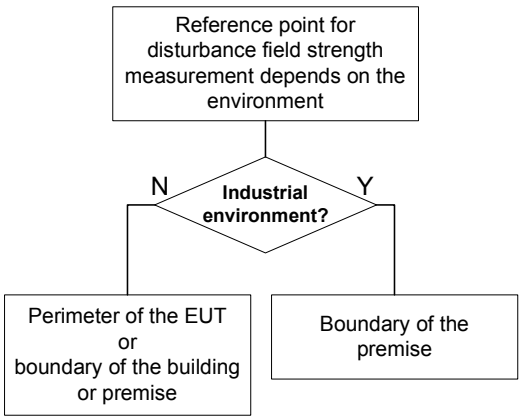
Four measurement procedures are taken into account for telecommunication ports and AC mains ports as follows:

– measurement with the voltage probe according to CISPR 16-1-2;
– measurement with the capacitive voltage probe (CVP) according to CISPR 16-1-2;
– measurement with the current probe according to CISPR 16-1-2;
– measurement with a high impedance voltage probe via an *in-situ* produced capacity for the measurement of the asymmetrical voltage according to CISPR 16-1-2.

4.3 Selection of the EUT mode of operation and the reference point depending on the environment

CISPR 16-2-3 requires the mode with the highest emission for the measurements. If it is possible to select this mode from different modes, this shall be done.

The selection of the reference point for the measurements is different for the ports and depends on the environments. Figure 1 shows the different approaches.



IEC 1188/08

NOTE It is recommended to choose the appropriate requirements (for example limits to be met) with respect to the characteristics of the interference victim.

Figure 1 – Enclosure port

4.4 Assessment of measurement results

It should be understood that measurement results obtained *in situ* are not comparable with any other results which are obtained on standardized test sites. For the results of in situ measurements it must be taken into account that they are only valid for the place of installation of the individual large equipment actually assessed. These results do not have any validity for similar large equipment installed at other places.

In most cases such results will only be obtained if an interference case has occurred. The question how much lower the emission has to be in order not to cause interference definitely depends on the source and the victim again. Considering both sides (source and victim), it may be possible to consult standards which are applicable to these products for further assessment.

Also it is understood that in most cases it is not possible to measure in a standardized measurement distance.

Two approaches are possible for normalization of obtained measured data to the standardized test distance.

The first possibility is the calculation as described in CISPR 16-2-3 for an EUT inside of buildings or premises.

The second possibility (in case there are no obstacles between the antenna and the EUT) is to use the distance between measurement antenna and interference source, and to convert the measured field strength to the value referring to a standardized measurement distance. In this case the following equation is recommended:

$$E_{\text{std}}\,[\text{dB}\mu\text{V/m}] = E_{\text{mea}}\,[\text{dB}\mu\text{V/m}] + 20\log\frac{d_{\text{mea}}}{d_{\text{std}}}\,[\text{dB}] \qquad (1)$$

where d_{mea} is the actual measurement distance and d_{std} is a standardized measurement distance (both in meters) and where E_{mea} is the field strength at an actual measurement distance and E_{std} is the field strength at a standardized measurement distance.

NOTE Equation (1) should not be applied if frequencies below 30 MHz and if distances smaller than 30 m are used for the assessments.

5 Method of *in situ* measurement of conducted disturbance

5.1 General

In situ measurements might be performed because of two reasons: for the investigation of an interference problem at a particular location or for the evaluation of compliance with the relevant technical requirements. Depending on the actual reason, some of the conditions to be considered for the measurements might be different.

The method of measurement for *in situ* conducted emission at any mains and telecommunication/signal ports of physically large equipment is proposed as follows.

Testing should be performed at the points of measurement indicated below. Excluded from *in situ* measurements of conducted emissions are internal ports of large equipment such as internal mains or internal telecommunication ports or mains connections above 1 kV.

Both the large equipment and its location are considered as the equipment under test (EUT). The emission results are unique to the site because site containment properties affect the measurement.

The choice of the point of measurement between PCC or IPC is defined by the interfered area in which complaints are raised:

– PCC if the interfered area is outside the installation which contains the source of the emission;
– IPC if the interfered area is inside the installation which contains the source of the emission; in addition, the disturbance level at the PCC should be considered.

In the frequency range from 9 kHz to 30 MHz the conducted emission from mains is measured either at or near the point of coupling of the source of the emission.

5.2 Conducted emission measurement procedure

5.2.1 Connection conditions

The disturbance voltage and current shall be measured under the existing connection conditions, with voltage and current probes specified in CISPR 16-1-2, see also 4.2. The connection conditions and measurement results are affected by the following:

– the existing ground according to the given installation. No changes shall be made to the existing ground system which might influence the performance of this system. In particular artificial mains networks are not to be used;
– the RF characteristics and load conditions for the power mains;
– the ambient RF environment; and
– the input impedance of the probes and their possible connection to ground.

5.2.2 Reference ground for *in situ* measurements

A comprehensive description of reference ground systems is given in CISPR 16-2-1.

The following particularity is to be considered for *in situ* testing.

If no suitable reference ground is available *in situ* (in the surroundings of the test object or at the place of measurement), a sufficiently large (for example 1 m square) conductive structure such as metal foil, a metal sheet or wire mesh set up in the proximity can be used as reference ground for the measurement. Care should be taken not to influence the behaviour of the EUT if such a measure is needed.

5.2.3 Disturbance voltage/current measurements on cables which carry wanted symmetrical signals

The testing of conducted disturbance voltage and current of cables is done with a capacitive voltage probe and a current probe respectively.

The following cases have to be considered.

Mains cables carrying communication signals and telecom cables are to be measured during operation (i.e. when they carry the wanted symmetrical signal). Both the voltage probe and the current probe measurements shall be performed to be able to compare the results with limits existing in product standards.

The following particularities have to be considered for *in situ* measurements.

– cables are not to be cut or disconnected;
– metallic contact of the probes is not allowed.

The current probe shall be placed at the selected reference point for the measurement. Only if this is not possible, the measurement may be undertaken by placing the probe as close as possible to the chosen reference point.

The capacitive voltage probe should be placed next to the current probe, but separated by at least 10 cm ± 1 cm.

In the case of non-shielded and shielded signal, control and load cables with non-grounded shield leaving the boundaries, the asymmetric disturbance voltage and current shall be measured with the capacitive voltage probe and the current probe against reference ground.

5.2.4 Disturbance voltage measurements on cables which do not carry wanted symmetrical signals

The testing of conducted disturbance voltage is done with a voltage probe. This measurement is done at AC mains cables which do not carry wanted symmetrical signals or at AC mains cables where transmission of data is currently not in use. The applicable measurement procedure is given in CISPR 16-2-1.

6 Method of *in situ* measurement of radiated disturbance

6.1 General

In situ measurements might be performed because of two reasons: for the investigation of an interference problem at a particular location or for the evaluation of compliance with the relevant technical requirements. Depending on the actual reason, some of the conditions to be considered for the measurements might be different.

In the case of an interference caused by a large installation, the disturbing field strength shall be measured in the direct vicinity of the interfered victim.

In the case of compliance testing, the measurement distance from the applicable product standard shall be used. Only if this is impossible due to the local installation conditions may other distances be considered.

The measurement equipment shall comply with CISPR 16-1-1 and CISPR 16-1-4.

The measurement of radiated emissions should preferably be made at a certain distance (reference distance) between antenna and reference points, whereas the value for the direct distance should be used (see definition 3.8). This allows an easy assessment with respect to the applicable limits. If this is impossible due to local conditions, including safety reasons, measurements can be performed at deviating distances. A procedure to select a different measurement distance is for example defined in CISPR 16-2-3. In case of investigating interference complaints, usage of reference distances is not necessarily the most suitable one in every case. It might rather be more appropriate to use such measurement distances which reflect the spatial situation of the interference case.

NOTE 1 If radio receiving equipment is disturbed which is located for example about 50 m away from a potential interference source, the first step could be to perform measurements at the location of the equipment and to assess the measured field strengths. In a further step then the emissions from the potential interference source might have to be measured for further evaluation and assessment of the interference situation.

In case of using other distances than the reference distances, the measured field strengths have to be converted to the reference distance situation. This should be done according to the methods given in 4.4, whereas the limitations of such a conversion have to be documented and kept in mind.

If the EUT is mounted at greater height (e.g. on the top of a tall building) the actual measurement distance shall be determined by the direct line between the EUT and receiving antenna. In such a case the measurement distance is calculated by equation (2).

$$d_{\text{mea}} = \sqrt{r^2 + h^2} \tag{2}$$

where

r is the horizontal distance from the EUT to the receiving antenna in meters;

h is the height difference between the EUT and the receiving antenna height.

It is recommended to check that for field strength measurements the ambient emissions are at least 6 dB lower than the measured disturbance field strength, i.e. the applicable limits, taking into account any transfer in the field strength levels due to deviating measurement distances. Where this is not possible the contributions due to any other equipment or installations in the environment should be taken into account.

NOTE 2 This requirement can be checked for example by switching off the equipment under test where possible by comparing the shape (i.e. the signature) of the measured field strengths (equipment under test on) with the shape of the ambient emissions (equipment under test off).

In case the equipment under test cannot be switched off, other procedures could be applied, for example the directivity of the antenna can be used to check the maximum and the minimum of the equipment emissions. Another procedure could be a check of the dependence of the field strength variation with regard to the distance from the equipment under test. The signature of the spectrum obtained close to the equipment under test could also be used as a means to distinguish the equipment emissions from the ambient noise.

The effects of the various operational modes of the equipment under test on the radiated emissions should be taken into account. This can be done for example by varying the operating mode while a recording of the field strength spectrum is being performed.

6.2 Measurement conditions

Weather conditions have a significant impact on the measurement results. In order to minimize their effect on the measured field strength levels, measurements should be carried out in dry weather, (after 24 hours during which not more then 0,1 mm rain has fallen), with a temperature of at least 5 °C, and a wind velocity of less than 10 m/s. Since it is often necessary to plan the measurements before the weather conditions can be known, measurement might have to be carried out in weather conditions which do not meet the target conditions. In these circumstances the actual weather conditions should be recorded with the measurement results.

6.3 Measurement methods

6.3.1 Measurement parameters

In case of in-situ radiated measurements the following parameters should be taken into account:

– antenna height,

– antenna placement and orientation, and

– antenna tilting.

The relevance of the above parameters and the appropriate considerations depend on the purpose of the measurements i.e. whether for compliance purposes or for investigating interference complaints.

6.3.2 Measurements in case of interference complaints

Antenna height, placement and tilting should be arranged in such a way as to allow identification of the interference source. Preferably the antenna should be placed at or close to the location of the interference victim in order to measure the field strengths there and to allow for assessing them. It is recommended to vary the orientation and the tilting of the antenna to obtain the maximum reading.

For an assessment of the emissions from the identified interference source or sources, it might be appropriate to perform additional measurements similar to those used for compliance measurements taking into account the practical conditions in-situ. The evaluation of both types of results could assist in deriving appropriate countermeasures, for example under an economic point of view.

6.3.3 Measurements for compliance purposes

It is recommended to carry out measurements of radiated emissions in accordance with CISPR 16-2-3 for distances as mentioned in 6.1 to allow for the assessment with respect to applicable limits.

NOTE 1 Due to imperfections in the measurement set-up compared to the situation on a standard test site, such as the presence of reflecting objects, the obtained measurement results might not be directly related to those theoretically to be expected on a standard test site. This should be considered for assessing the results.

Some further aspects are to be considered:

It is recommended to vary the height of the measurement antenna within a specified range to obtain the maximum reading. The general rule for measurement distances up to and including 10 m is as follows: the antenna height for electromagnetic field measurements shall be varied between 1 m and 4 m. At greater distances of up to 30 m, preferably the height should be varied between 2 m and 6 m. This variation applies for both horizontal and vertical polarization.

In extreme cases, i.e. when the equipment under test is installed at a significant height above ground and when there might be the situation that potential interference victims could be located at a similar height, it might be appropriate to consider this height for the measurement antenna when practical.

In case the equipment under test and the measurement antenna have quite different positions above ground, it might be required to tilt the antenna according to its directivity pattern in order to obtain the maximum reading.

NOTE 2 The tilting angle should not exceed 70°.

It is recommended to carry out measurements at different locations around the equipment under test. The number of locations should be chosen taking into account the in-situ conditions and the physical dimensions of the equipment under test.

6.3.4 Measurements below 30 MHz

In the frequency range below 30 MHz the magnetic field strength should be measured with a loop antenna as described in CISPR 16-1-4 at a height of 1 m (between the ground used for reference and the lowest part of the antenna). The maximum field strength should be determined by rotating the antenna around its vertical axis, see also CISPR 16-2-3.

7 Measurement report

The particular circumstances and conditions of the *in situ* measurements of a large EUT and the operational conditions during the measurements should be documented to allow the repeatability of the test. The documentation should include (see also CISPR 16-2-3):

– reasons for the *in situ* measurement instead of using a standard test site;

– technical documentation with the description of the measured EUT;

– details of all connections between the EUT and its environment: technical data and details of their location/configuration;

– scale drawings of the measurement site, showing the points at which measurements were made and description of why these points are selected;
– description of the operating conditions;
– details concerning the variation of the antenna height;
– details of the measuring equipment (also comprising photographs of the measurement set-up);
– measurement results at the different measurement points and their relation to the selected limits;
– weather conditions.

Bibliography

The references listed hereafter contain literature and further detailed information on the subjects dealt with in the context of this technical report and are recommended for further consideration.

IEC 60050-161, *International electrotechnical vocabulary – Chapter 161: Electromagnetic compatibility*

IEC 61000-2-4, *Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances*

IEC 61800-3:2004, *Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods.*

IEC 62236-2:2003, *Railway applications – Electromagnetic compatibility – Part 2: Emission of the whole railway system to the outside world.*

CISPR 11, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*

CISPR 18-2:1986, *Radio interference characteristics of overhead power lines and high-voltage equipment – Part 2: Methods of measurement and procedure for determining limits.*

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