

## **Electromagnetic compatibility and Radio spectrum Matters (ERM); RF conformance testing of radar level gauging applications in still pipes**

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## Reference

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# Contents

Intellectual Property Rights .....	5
Foreword.....	5
Introduction .....	5
1 Scope .....	6
2 References .....	6
2.1 Normative references .....	6
2.2 Informative references .....	7
3 Definitions, symbols and abbreviations .....	7
3.1 Definitions .....	7
3.2 Symbols .....	8
3.3 Abbreviations .....	8
4 General testing requirements .....	9
4.1 Presentation of equipment for testing purposes .....	9
4.2 Choice of model for testing .....	9
4.2.1 Declarations by the manufacturer .....	9
4.2.2 Marking and equipment identification .....	9
4.3 Mechanical and electrical design .....	9
4.3.1 General .....	9
4.4 Interpretation of the measurement results .....	10
4.4.1 Measurement uncertainty is equal to or less than maximum acceptable uncertainty .....	10
4.4.2 Measurement uncertainty is greater than maximum acceptable uncertainty .....	10
5 Test conditions, power sources and ambient temperatures .....	11
5.1 Normal conditions .....	11
5.2 External test power source .....	11
5.2.1 Internal test power source .....	11
5.3 Normal test conditions .....	11
5.3.1 Normal temperature and humidity .....	11
5.3.2 Normal test power source .....	11
5.3.2.1 Mains voltage .....	11
5.3.2.2 Other power sources .....	11
6 General conditions .....	12
6.1 Radiated measurement arrangements .....	12
6.2 Modes of operation of the transmitter .....	12
6.3 Measuring receiver .....	12
7 Interpretation of results .....	12
7.1 Measurement uncertainty .....	12
8 Methods of measurement and limits for transmitter parameters .....	13
8.1 General .....	13
8.2 Permitted range of operating frequencies .....	13
8.2.1 Definition .....	13
8.2.2 Method of measurement .....	14
8.2.3 Limits Frequency range .....	15
8.3 Emissions .....	15
8.3.1 Definition .....	15
8.3.2 UWB emissions .....	15
8.3.2.1 Method of measurement .....	15
8.3.2.2 Limits .....	16
8.3.3 Other Emissions (OE) .....	17
8.3.3.1 Definition .....	17
8.3.3.2 Method of measurement .....	17
8.3.3.3 Limits .....	18

8.4	Mitigation techniques .....	18
8.4.1	Shielding effects .....	19
8.4.2	Frequency domain mitigation .....	19
8.4.3	Thermal Radiation .....	19
<b>Annex A (normative): Radiated measurements .....</b>		<b>20</b>
A.1	Test sites and general arrangements for measurements involving the use of radiated fields .....	20
A.1.1	Anechoic Chamber .....	20
A.1.2	Anechoic Chamber with a conductive ground plane .....	21
A.1.3	Open Area Test Site (OATS) .....	22
A.1.4	Test antenna .....	23
A.1.5	Substitution antenna .....	23
A.1.6	Measuring antenna .....	24
A.2	Guidance on the use of radiation test sites .....	24
A.2.1	Verification of the test site .....	24
A.2.2	Preparation of the EUT .....	24
A.2.3	Power supplies to the EUT .....	24
A.2.4	Range length .....	24
A.2.5	Site preparation .....	25
A.3	Coupling of signals .....	26
A.3.1	General .....	26
<b>Annex B (normative): Installation requirements for radar level gauging applications in still pipes .....</b>		<b>27</b>
<b>Annex C (normative): Requirements on a test pipe .....</b>		<b>28</b>
C.1	General .....	28
C.2	Measurement setup .....	29
<b>Annex D (informative): Measurement antenna and preamplifier specifications .....</b>		<b>31</b>
History .....		32

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## Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

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## Introduction

The radar level gauges covered by the present document do not use the time domain UWB short pulses. Instead the radar level gauges covered by the present document use the frequency domain FMCW and/or SFCW. Thus the emission bandwidth generated by the FMCW and/or SFCW radars is strictly controlled.

The specified requirements in the present document describe the worst case scenario (i.e. the highest emissions to the environment) and shall be seen as a feasible test method to prove compliance of radar level gauging applications in still pipes.

The background and related applications have been described in TR 102 750 [i.2] where the applications have been considered indoor like systems.

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# 1 Scope

The present document specifies the requirements for radar level gauging applications in still pipes using UWB technology operating in the 9 to 10,6 GHz frequency range.

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## 2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
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### 2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

- [1] CISPR 16-1 (2003): "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1: Radio disturbance and immunity measuring apparatus".
- [2] ANSI C63.5 (2006): "American National Standard for Electromagnetic Compatibility - Radiated Emission Measurements in Electromagnetic Interference (EMI) Control - Calibration of Antennas (9 kHz to 40 GHz)".
- [3] Commission Decision 2007/131/EC of 21 February 2007 on allowing the use of the radio spectrum for equipment using ultra-wideband technology in a harmonised manner in the Community.
- [4] ISO 4266-1 (2002): "Petroleum and liquid petroleum products -- Measurement of level and temperature in storage tanks by automatic methods -- Part 1: Measurement of level in atmospheric tanks".
- [5] API MPMS 3.1A and 3.1B: "Manual of Petroleum Measurement Standards Chapter 3 - Tank Gauging, Section 1A - Standard Practice for the Manual Gauging of Petroleum and Petroleum Products, published on 1 of August 2005 / Tank Gauging Section 1B - Standard Practice for Level Measurement of Liquid Hydrocarbons in Stationary Tanks by Automatic Tank Gauging, published on 1 of June 2001".
- [6] ITU-R Recommendation P.526-10 (02/07): "Propagation by diffraction".
- [7] ETSI TR 100 028 (all parts) (V1.4.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".

- [8] ETSI TR 102 273 (all parts) (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties".

## 2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area. For non-specific references, the latest version of the referenced document (including any amendments) applies.

- [i.1] ITU-R Recommendation SM.1754: "Measurement techniques of ultra-wideband transmissions".
- [i.2] ETSI TR 102 750: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radar level gauging applications in still pipes".

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

**dedicated waveguide antenna:** device/structure to excite a certain waveguide mode that propagates inside a waveguide only

**duty cycle:** ratio of the total on time of the transmitter to the total time

**emissions:** signals that leaked or are scattered into the air within the frequency range (that includes harmonics) which depend on equipment's frequency band of operation

**equivalent isotropically radiated power (e.i.r.p.):** total power transmitted, assuming an isotropic radiator

**EUT:** radar level gauge with a dedicated waveguide antenna on a dedicated still pipe

**Frequency Modulated Continuous Wave (FMCW) radar:** radar where the transmitter power is fairly constant but possibly zero during periods giving a big duty cycle (such as 0,1 to 1)

NOTE: The frequency is modulated in some way giving a very wideband spectrum with a power versus time variation which is clearly not pulsed.

**operating frequency (operating centre frequency):** nominal frequency at which equipment is operated

**pulsed radar:** radar where the transmitter signal has a microwave power consisting of short RF pulses

**radiated measurements:** measurements that involve the absolute measurement of a radiated field

**radiation:** signals emitted intentionally inside a tank for level measurements

**Stepped Frequency Continuous Wave (SFCW) radar:** radar where the transmitter sequentially generates a number of frequencies with a step size

NOTE: At each moment of transmission, a monochromatic wave is emitted. It is distinguished from FMCW that has the instantaneous frequency band rather than a single frequency wave. The SFCW radar bandwidth is synthesized by signal processing to achieve required resolution bandwidth.

**still pipe:** still-well, stilling-well, guide pole: Vertical, perforated pipe built into a tank to reduce measurement errors arising from liquid turbulence, surface flow or agitation of the liquid

NOTE: Any equipment made of a perforated steel pipe with diameters varying from a few centimetres up to several decimetres. The perforations enable the liquid to freely flow into and out of the still pipe at all levels in a tank. Still pipes are the preferred installation point of a Tank Level Probing Radar inserted inside a floating or open roof tanks.

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

c11	cable loss 1
c12	cable loss 2
dB	deciBel
dB <sub>i</sub>	gain in deciBel relative to an isotropic antenna
dB <sub>m</sub>	deciBel reference to 1 mW
E	Electrical field strength
E <sub>R</sub>	relative dielectric constant of earth materials
E <sub>rms</sub>	Average electrical field strength measured as root mean square
f	frequency
f <sub>c</sub>	frequency at which the emission is the peak power at maximum
G	Efficient antenna gain of radiating structure
GLNA	Gain of the measurement LNA
G <sub>A</sub>	Gain of the measurement antenna
G(f)	Antenna gain over frequency
f <sub>H</sub>	Highest frequency of the frequency band of operation
f <sub>L</sub>	Lowest frequency of the frequency band of operation
k	Boltzmann constant
P	Power
P <sub>e.i.r.p.</sub>	power spectral density
P <sub>m</sub>	measured spectral power
P <sub>wall, e.i.r.p.</sub>	unwanted power spectral density
R	Distance
rms	Root mean square
t	time
T	Temperature
T <sub>p</sub>	pulse rise time
Z <sub>F0</sub>	Free space wave impedance
λ	wavelength
c	velocity of light in a vacuum
δR	range resolution
δt	time interval between the arrivals of two signals from targets separated in range by δR
D	Duty cycle
P <sub>s</sub>	Output power of the signal generator measured by power meter
Δf	Bandwidth
X	Minimum radial distance (m) between the EUT and the test antenna
λ	Wavelength

## 3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

e.i.r.p.	equivalent isotropically radiated power
EUT	Equipment Under Test
FMCW	Frequency Modulated Continuous Wave
IT	Information Technology
LNA	Low Noise Amplifier
OATS	Open Area Test Site
OE	Other Emissions
RBW	Resolution BandWidth
RF	Radio Frequency
RMS	Remote Management System
SFCW	Stepped Frequency Continuous Wave
TLPR	Tank Level Probing Radar



TP	Total Power
UWB	Ultra WideBand
VBW	Video BandWidth
VSWR	Voltage Standing Wave Ratio

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## 4 General testing requirements

### 4.1 Presentation of equipment for testing purposes

The manufacturer shall submit one or more samples of the equipment as appropriate for testing.

Additionally, technical documentation and operating manuals, sufficient to allow testing to be performed, shall be supplied.

The performance of the equipment submitted for testing shall be representative of the performance of the corresponding production model. In order to avoid any ambiguity in that assessment, the present document contains instructions for the presentation of equipment for testing purposes (see clause 4), conditions of testing (see clauses 5 and 6), interpretation of results (see clause 7) and the measurement methods (see clause 8).

The manufacturer shall offer equipment complete with any auxiliary equipment needed for testing.

### 4.2 Choice of model for testing

One or more samples of the EUT, as described in annex C, shall be tested.

#### 4.2.1 Declarations by the manufacturer

The manufacturer shall submit the necessary information regarding the equipment with respect to all technical requirements set by the present document.

#### 4.2.2 Marking and equipment identification

The equipment shall be marked in a visible place. This marking shall be legible and durable.

The marking shall include as a minimum:

- The name of the manufacturer or his trademark.
- The type designation. This is the manufacturer's numeric or alphanumeric code or name that is specific to particular equipment.

### 4.3 Mechanical and electrical design

#### 4.3.1 General

The equipment submitted by the manufacturer shall be designed, constructed and manufactured in accordance with good engineering practice and with the aim of minimizing harmful interference to other equipment and services.

## 4.4 Interpretation of the measurement results

The interpretation of the results recorded on the appropriate test report for the measurements described in the present document shall be as follows:

- the measured value relating to the corresponding limit together with the appropriate mitigation factors as described in clause 8.4 shall be used to decide whether an equipment meets the requirements of the present document;
- the measurement uncertainty value for the measurement of each parameter shall be included in the test report.

The measurement uncertainty is explained in clause 7. Additionally, the interpretation of the measured results depending on the measurement uncertainty is described in clauses 4.4.1 and 4.4.2.

For radiated UWB emissions measurements below 9 GHz and above 10,6 GHz it may not be possible to reduce measurement uncertainty to the levels specified in clause 7, table 2 (due to the very low signal level limits and the consequent requirement for high levels of amplification across wide bandwidths). In these cases alone it is acceptable to employ the alternative interpretation procedure specified in clause 4.4.2.

### 4.4.1 Measurement uncertainty is equal to or less than maximum acceptable uncertainty

The interpretation of the results when comparing measurement values with specification limits shall be as follows:

- a) When the measured value does not exceed the limit value the equipment under test meets the requirements of the present document.
- b) When the measured value exceeds the limit value the equipment under test does not meet the requirements of the present document.
- c) The measurement uncertainty calculated by the test technician carrying out the measurement shall be recorded in the test report.
- d) The measurement uncertainty calculated by the test technician may be a maximum value for a range of values of measurement, or may be the measurement uncertainty for the specific measurement undertaken. The method used shall be recorded in the test report.

### 4.4.2 Measurement uncertainty is greater than maximum acceptable uncertainty

The interpretation of the results when comparing measurement values with specification limits should be as follows:

- a) When the measured value plus the difference between the maximum acceptable measurement uncertainty and the measurement uncertainty calculated by the test technician does not exceed the limit value the equipment under test meets the requirements of the present document.
- b) When the measured value plus the difference between the maximum acceptable measurement uncertainty and the measurement uncertainty calculated by the test technician exceeds the limit value the equipment under test does not meet the requirements of the present document.
- c) The measurement uncertainty calculated by the test technician carrying out the measurement shall be recorded in the test report.
- d) The measurement uncertainty calculated by the test technician may be a maximum value for a range of values of measurement, or may be the measurement uncertainty for the specific measurement undertaken. The method used shall be recorded in the test report.

## 5 Test conditions, power sources and ambient temperatures

### 5.1 Normal conditions

All testing shall be made under normal test conditions.

The test conditions and procedures shall be as specified in clause 5.2.

### 5.2 External test power source

During tests, the power source of the equipment shall be an external test power source, capable of producing normal voltages. The internal impedance of the external test power source shall be low enough for its effect on the test results to be negligible.

The test voltage shall be measured at the point of connection of the power cable to the equipment.

During tests, the external test power source voltages shall be within a tolerance of  $\pm 1$  % relative to the voltage at the beginning of each test. The level of this tolerance can be critical for certain measurements. Using a smaller tolerance provides a reduced uncertainty level for these measurements.

The test power source used shall be stated in the test report.

#### 5.2.1 Internal test power source

For radiated measurements on portable equipment with integral antenna, fully charged internal batteries should be used. The batteries used should be as supplied or recommended by the manufacturer. If internal batteries are used, at the end of each test the voltage shall be within a tolerance of less than  $\pm 5$  % relative to the voltage at the beginning of each test.

### 5.3 Normal test conditions

#### 5.3.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges:

- temperature + 15 °C to + 35 °C;
- relative humidity 20 % to 75 %.

When it is impracticable to carry out tests under these conditions, a note to this effect, stating the ambient temperature and relative humidity during the tests, shall be added to the test report.

#### 5.3.2 Normal test power source

##### 5.3.2.1 Mains voltage

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages, for which the equipment was designed.

##### 5.3.2.2 Other power sources

For operation from other power sources (primary or secondary), the normal test voltage shall be that declared by the equipment manufacturer and agreed by the test laboratory. Such values shall be stated in the test report.