

INTERNATIONAL
RECOMMENDATION

OIML R 85-1 & 2

Edition 2008 (E)

Automatic level gauges for measuring the level
of liquid in stationary storage tanks

Part 1: Metrological and technical requirements

Part 2: Metrological control and tests

Jaugeurs automatiques pour le mesurage des niveaux de liquide
dans les réservoirs de stockage fixes

Partie 1: Exigences métrologiques et techniques

Partie 2: Contrôles métrologiques et essais



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Foreword

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Automatic level gauges for measuring the level of liquid in stationary storage tanks

Part 1: Metrological and technical requirements

1 Introduction

The most important changes made in the present edition of R 85 compared to the 1998 edition are:

- R 85:1998 also included requirements concerning the tank. Edition 2008 only deals with the level gauge itself;
- The format of Edition 2008 has been brought into line with OIML B 6-2: *Directives for the technical work. Part 2: Guide to the drafting and presentation of OIML International Recommendations and Documents*;
- The performance tests have been updated according to OIML D 11:2004 *General requirements for electronic measuring instruments*. The latest editions of the referred IEC standards have been applied;
- Edition 2008 has been split into Parts 1 *Metrological and technical requirements* and 2 *Metrological control and tests*, and Part 3 *Test report format*.

With respect to the application of R 85:2008 within the scope of the OIML Certificate System, the consequence is that Certificates of Conformity issued according to R 85:2008 will cover a more precisely defined measuring instrument, i.e. an electronic level gauge. In practice the automatic level gauge (ALG) will be installed on a tank according to OIML R 71.

The differences between R 85:1998 and R 85:2008 are thus far-reaching, notably in that ALGs that comply with the 1998 edition can not be presumed to comply with this new edition, unless the compliance is confirmed by new tests.

2 Scope

This Recommendation specifies the metrological and technical requirements and test procedures for automatic level gauges for storage tanks. Storage tanks include all the shapes referenced in OIML R 71 [5] e.g. vertical and cylindrical storage tanks, and pressurized storage tanks (spheres, spheroid, bullets). The storage tanks may be refrigerated or heated.

The metrological purpose of tank level measurements is the application in conjunction with tank calibration tables for the determination of liquid volume received from, delivered to, or contained in stationary storage tanks.

3 Terminology

The terminology used in this Recommendation is applicable to Parts 1, 2 and 3 of OIML R 85.

It conforms to the *International Vocabulary of Basic and General Terms in Metrology* (VIM) [1], to the *International Vocabulary of Terms in Legal Metrology* (VIML) [2], and to OIML D 11 *General requirements for electronic measuring instruments* [3] (see also Figure 1 in clause 4).

In addition, for the purposes of this Recommendation, the definitions below apply.

3.1 Automatic level gauge (ALG)

Instrument intended to measure automatically and display the level of the liquid contained in a tank with respect to a fixed reference.

An automatic level gauge includes at least a liquid level sensor, a transducer, and an indicating device.

3.2 Electronic automatic level gauge

Automatic level gauge using electronic means and/or equipped with electronic devices.

3.3 Ancillary device

Device intended to perform a particular function, directly involved in elaborating, transmitting or displaying measurement results.

Examples:

- repeating indicating device;
- printing device;
- memory device;
- conversion device.

Note: For the purpose of this Recommendation ancillary equipment, in so far as it is subject to metrological control, is considered to be part of the ALG.

3.4 Liquid level sensor

Element that senses the presence of the liquid surface and gives information on its level.

3.5 Transducer

Device that provides an output quantity, having a determined relationship to the input quantity.

3.6 Correction sensor

Sensor that measures a relevant property of the liquid and/or the medium above the liquid level for the purpose of applying a correction to the liquid level measurement.

3.7 Calculator

Part of the ALG that receives the output signals from the transducer and, if applicable, from ancillary devices and/or other devices, processes them and, if appropriate, stores the results in memory until they are used. In addition, the calculator may be capable of communicating both ways with other devices.

3.8 Indicating device

Part of the ALG that displays or prints the measuring result.

Note: For the application of this Recommendation the meaning of “indicating device” is broader than the general meaning in other OIML Recommendations (a printing device is considered as such).

3.9 Repeating indicating device

Additional device (ancillary device) repeating the indication of the indicating device.

3.10 Checking facility

Facility incorporated in an electronic automatic level gauge that enables:

- significant faults; and/or
- incorrect functioning of a specific device of the ALG; and/or
- disturbed communication between specific devices of the ALG

to be detected and acted upon.

Note: “Acted upon” refers to any adequate response by the ALG (luminous signal, acoustic signal, prevention of the measurement process, etc.).

3.11 Automatic checking facility

Checking facility that operates without the intervention of an operator.

3.12 Permanent automatic checking facility (type P)

Automatic checking facility that operates at each measurement cycle.

3.13 Intermittent automatic checking facility (type I)

Automatic checking facility that operates at certain time intervals or per fixed number of measurement cycles.

3.14 Dip plate

Horizontal plate located along the vertical axis descending from the upper reference point, providing a fixed contact surface from which manual liquid depth measurements are made.

Note: The term “datum plate” is synonymous.

3.15 Principal gauge hatch

Gauge hatch which has been designated for the principal measurements and is situated at a convenient, accessible and stable position.

3.16 Dipping datum point

Intersection of the vertical measurement axis with the upper surface of the dip plate, or with the bottom surface of the tank if a dip plate is not provided. It constitutes the origin for the measurement of liquid levels (zero reference or dipping reference point).

3.17 Upper reference point

Point clearly marked on the principal gauge hatch located along the vertical axis ascending from the dipping datum point to indicate the reference position to which ullage is measured.

3.18 Gauge reference length

Distance between the dipping datum point and the zero point of the ALG.

3.19 Dip

Vertical distance between the dipping datum point and the liquid level.

Note: The term “innage” is synonymous.

3.20 Ullage

Distance between the liquid level and the upper reference point, measured along the vertical measurement axis.

Note: The term “outage” is synonymous.

3.21 Rated operating conditions

Conditions of use, giving the range of values of influence quantities for which the metrological characteristics are intended to lie within the specified permissible errors.

Note: The rated operating conditions generally specify intervals of values for the quantity being measured and for any influence quantity.

3.22 Reference conditions

Set of specified values of influence factors fixed to ensure valid intercomparisons of the results of measurements.

Note: Reference conditions generally specify intervals of values for any influence quantity.

3.23 Influence quantity

Quantity which is not the subject of the measurement but which influences the value of the measurand or the indication of the ALG.

3.24 Influence factor

Influence quantity having a value within the specified rated operating conditions of the ALG.

3.25 Disturbance

Influence quantity having a value within specified limits, but outside the specified rated operating conditions of the ALG.

3.26 Performance

Ability of the ALG to accomplish the intended functions.

3.27 Durability

Ability of the ALG to maintain its performance characteristics over a period of use.

3.28 Error (of indication)

Indication of an ALG minus a true value of the corresponding input quantity.

3.29 Maximum permissible error

Extreme permitted value by the present Recommendation for the error of indication.

3.30 Intrinsic error

Error of an ALG determined under reference conditions.

3.31 Initial intrinsic error

Intrinsic error of an ALG as determined prior to performance tests and durability evaluations.

3.32 Fault

Difference between the error of indication and the intrinsic error of an ALG.

Note: Principally a fault is the result of an undesired change of data contained in or flowing through an ALG.

3.33 Significant fault

Fault greater than the maximum permissible error specified in Table 2 (see 6.2.2).

The following faults are considered not to be significant, even when they exceed the value defined above:

- (a) faults arising from simultaneous and mutually independent causes in the ALG itself or in its checking facilities;
- (b) faults implying the impossibility to perform any measurement;
- (c) transitory faults being momentary variations in the indication, which cannot be interpreted, memorized or transmitted as a measurement result;

- (d) faults giving rise to variations in the measurement results so serious that they are bound to be noticed by all those interested in the result of the measurement.

3.34 Discrimination

Largest change in a stimulus that produces no detectable change in the response of a measuring instrument, the change in the stimulus taking place slowly and monotonically.

3.35 Abbreviations

AC	Alternating Current
ALG	Automatic Level Gauge
AM	Amplitude Modulation
ASD	Acceleration Spectral Density
DC	Direct Current
EM	Electromagnetic
EMC	Electromagnetic Compatibility
e.m.f.	Electromotive force
ESD	Electrostatic Discharge
EUT	Equipment Under Test
GSM	Global System for Mobile communication
IEC	International Electrotechnical Commission
I/O	Input / Output (refers to ports)
ISO	International Organization for Standardization
MPE	Maximum Permissible Error
N.A.	Not Applicable
OIML	International Organization of Legal Metrology
PC	Personal Computer
RH	Relative Humidity
RMS	Root Mean Square

4 Description of the category of instrument

An automatic level gauge comprises at least a liquid-level sensor, a transducer, and an indicating device.

The general configuration of an automatic level gauge is given in Figure 1.

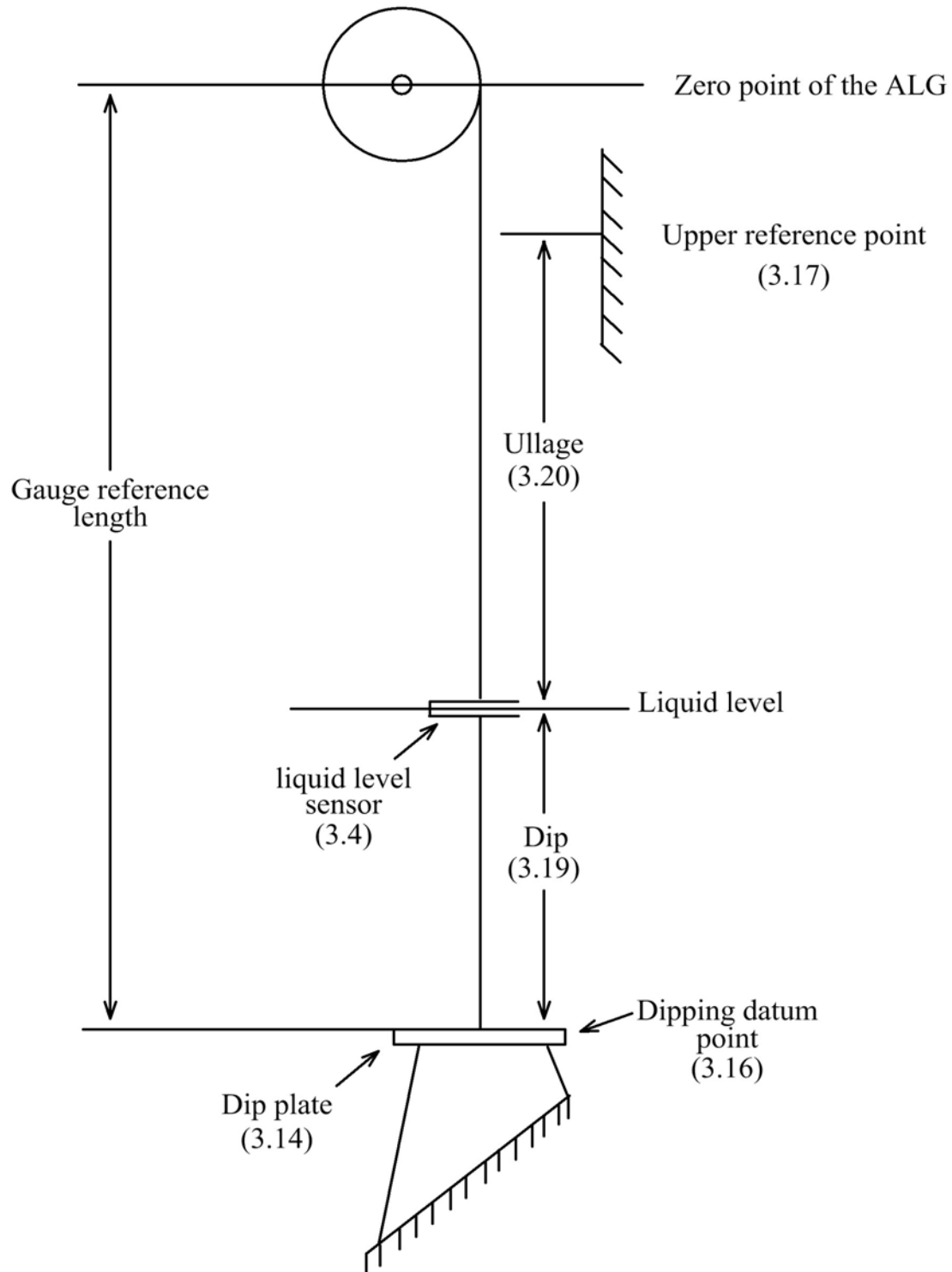


Figure 1 Some of the principal elements of an ALG, with reference to their definitions

5 Units of measurement

The authorized units of measurement are those of the International System of Units (SI).

If, in any country, units of measurement outside the SI are authorized, the legal units of measurement of that country may be used. In international trade, the officially agreed equivalents between these units of measurement and those of the SI shall be applied.

Indications of the dip or, if applicable, the ullage shall be in legal units of length and shall be accompanied by the name or symbol of the unit.

Indication of information that is not subject to metrological control is allowed, provided that it cannot be confused with metrological information.

6 Metrological requirements

6.1 Rated operating conditions

Automatic level gauges shall be designed and manufactured such that their errors do not exceed the maximum permissible errors under the following rated operating conditions:

(a)	Ambient temperature	low	+ 5 °C, – 10 °C, – 25 or – 40 °C (**)
		high	+ 30 °C, + 40 °C, + 55 or + 70 °C (**)
(b)	Relative humidity	up to 93 %	
(c)	DC mains voltage (*)	As specified by the manufacturer	
(d)	AC mains voltage (*)	$U_{nom} - 15 \%$ to $U_{nom} + 10 \%$	
(e)	The minimum and maximum temperatures of the liquid and the medium above the liquid	As specified by the manufacturer	
(f)	The minimum and maximum pressures in the tank		
(g)	The characteristics of the liquid and of the medium above the liquid		
(h)	The minimum and maximum densities of the liquid and of the medium above the liquid		
(*)	Whatever is applicable		
(**)	This value is to be decided by the national authority as it depends on the climatic conditions and the expected conditions of application (indoors, outdoors, etc.) that are different in different countries.		

Table 1 Rated operating conditions

If national regulations allow the use of an ALG under conditions outside the rated operating conditions, the manufacturer of the ALG shall supply the user with all necessary information to make the required corrections.

6.2 Maximum permissible errors

6.2.1 General

The maximum permissible error (MPE) of an ALG before installation is determined by testing under controlled conditions. The MPE of an ALG after installation is verified by comparing the ALG readings to the manual reference level measurement.

6.2.2 The maximum permissible errors, positive and negative, under rated operating conditions to be applied for the relevant indications are specified in Table 2.

Description	MPE
Prior to installation	1 mm
After installation	4 mm

Table 2 Maximum permissible errors (MPE)

The maximum permissible errors of Table 2 apply to the indication of a dip or an ullage according to the measuring principle of the ALG.

Note: The volume in the tank, calculated from the level measured and the tank calibration table, could be adversely affected by various factors. These factors include: tank bottom deformation, roof stability, and tank shell bulging that cannot be compensated.

6.2.3 The hysteresis error when changing the direction of the movement of the level shall not exceed 1 mm (see 8.1.5.4 in Part 2).

6.2.4 The MPE for the ALG prior to installation applies to the ALG itself, before being installed on the tank, for type approval and for initial verification.

The MPE “after installation” applies to the ALG after installation on the storage tank, for initial and subsequent verification.

6.2.5 The discrimination of the ALG itself shall be such that level measurements are in all cases within 1 mm.

6.3 Presumption of compliance

An automatic level gauge is presumed to comply with the provisions in 6.1 and 6.2 if it passes the relevant tests specified in Part 2 of this Recommendation.

7 Technical requirements

7.1 Indicating device

7.1.1 For an analog indication, the distance between successive marks on the scale shall be not less than 1 mm.

7.1.2 An indicating device can be either a local indicating device which is a part of the body or located in the immediate vicinity of the level gauge, respectively, or a repeating indicating device located at a distance more or less far away from the level gauge. A repeating indicating device is often used for observation of the ALG indication in an easily accessible location (such as a control room).

If there are more than one indicating devices, each of them shall comply with the maximum permissible error specified in 6.2.2. The difference between any two indicating devices shall not be greater than 1 mm (or the digital scale equivalent) under stable level conditions.

The local indicating device or the repeating indicating device shall sound an alarm when the operational limits of the level gauge are reached (maximum and minimum heights).

Indicating devices that are not subject to legal metrological control may be connected, but it must be clearly marked that they are not subject to legal control and they must not have an interaction with the electronics of the ALG.

7.1.3 An additional indicating device may be common when connected to more than one ALG.

7.1.4 A remote indication on an indicating device shall be unambiguously identified with respect to the ALG it belongs to.

7.1.5 An ALG shall indicate the innage (dip). Other measured values, such as ullage, may be indicated on the same display but these indications shall be replaced by the innage within 10 s.

For metrological purposes, an indication of the ullage shall either be permanently available or be available on demand, together with the indication that the ullage is presented and, if applicable, which ALG is presented.

7.1.6 Reading of the results shall be reliable, easy and unambiguous under conditions of normal use.

The figures forming the results shall be of a size, shape and clarity for reading to be easy.

The scales, numbering and printing shall permit the figures which form the results to be read by simple juxtaposition.

7.1.7 The presentation of the measurement results shall contain the names or symbols of the units of length in which they are expressed.

The scale interval of each display or print must be in the form 1×10^n , 2×10^n , or 5×10^n units of length, n being a whole positive or negative number, or zero.

7.1.8 A digital indication shall display at least one figure beginning at the extreme right.

A decimal fraction shall be separated from its integer by a decimal sign (in general a comma or in English speaking countries a dot on the line), with the indication showing at least one figure to the left of the sign and all figures to the right.

Zero may be indicated by one zero to the extreme right, without a decimal sign.

The unit shall be chosen so that the displayed or printed values have not more than one non-significant zero to the right. For values with decimal sign, the non-significant zero is allowed only in the third position after the decimal sign.

7.1.9 Subclauses 7.1.2 through 7.1.8 are also applicable to printing devices, as appropriate.

7.2 Additional technical requirements for ALGs with movable sensor

7.2.1 Suspension mechanism

In order to facilitate checks on the mechanism of the gauge, where applicable, the ALG shall be provided with means allowing to impart on request a movement to the working parts of the gauge.

Note: An example of a situation where this is applicable, is a dipstick having a movable part (the float) but the gauge does not have the possibility to force a movement.

7.2.2 Static position

If the level sensor can be statically positioned above or below the liquid level, it shall be made unambiguously clear that the indication is not presenting an actual measurement.

7.3 Installation requirements

7.3.1 General

7.3.1.1 ALGs shall be installed in such a way that the requirements of 7.3 through 7.7 are fulfilled.

The indication shall be easily accessible and legible.

7.3.1.2 For metrological purposes, ALGs shall be equipped and installed in such a way that they can be verified when mounted on the tank and with the tank in service.

7.3.1.3 The liquid level sensor shall be in close proximity to the official gauge hatch if present.

The ALG shall be installed in such a way that the operation of the liquid level sensor, or the measurement by the ALG, shall not be obstructed by obstacles.

7.3.1.4 If the procedure during verification, sampling, etc. affects the ALG measurement such that a significant fault occurs, this shall be clearly indicated.

7.3.1.5 The ALG shall be installed in such a way that the influence of eddies, currents, turbulence, foam, condensation, variation of process conditions, asymmetrical heating, wind and other effects have a negligible effect on the performance of the ALG.

If applicable, adequate protection shall be provided.

7.3.1.6 The ALG shall be installed on the tank in such a way that the deviation of the gauge reference length plus level due to movement of the tank shell, tank bottom, tank roof or stilling well remains within the MPE after installation (4 mm).

For construction details refer to applicable standards, which are listed in the Bibliography (Annex A).

7.3.1.7 If provided, the correction sensor shall be situated in such a way that a reliable value of the properties intended to be measured is obtained. If necessary, more than one sensor shall be installed in order to obtain a correct average value.

7.3.1.8 The thermal expansion of the tank shell or, if applicable, the support pipe, shall be such that the total deviation for temperature changes will fall within the maximum permissible errors for the installed ALG, or if necessary compensated for.

Note: This requirement may be verified by calculation.

7.4 Ancillary devices

Ancillary devices shall not affect the measurement and shall have no characteristics that facilitate fraudulent use.

7.5 Markings

7.5.1 ALGs shall be legibly and clearly marked with the following information:

- name of the manufacturer or trademark;
- type designation;
- serial number and year of manufacture;
- type approval mark;
- any information required by national legislation.

7.5.2 The repeating indicating device(s) shall be marked with the following information:

- type approval number;
- identifications of the tanks.

7.5.3 The descriptive markings shall be indelible and of a size, shape and clarity allowing easy reading under operating conditions of the ALG. They shall be grouped together in a clearly visible place on the ALG itself or on a data plate fixed to it.

7.6 Verification marks

ALGs shall have a place for the verification marks which is visible and which allows easy application of the marks. It shall be impossible to remove the marks without damaging them.

Note: This requirement is only applicable in those countries having mandatory verification marks for ALGs.

7.7 Sealing

It shall be possible to seal the data plate mentioned in 7.5.3 bearing the markings, unless this plate cannot be removed without being destroyed.

Sealing means shall be provided for those parts that can affect the accuracy of the measurement and which are not intended to be accessible by the user.

Sealing may be carried out with metal, plastic or other suitable material as long as it is sufficiently durable and provides evidence of tampering.

When access to parameters that participate in the determination of results of measurements is not protected by mechanical sealing devices, an electronic sealing can be applied. The software sealing shall fulfill the following provisions:

- (a) access shall only be allowed to authorized persons, e.g. by using a “password” and, after changing parameters, the ALG may be put into use “in sealed condition” again without any restriction;
or
access is allowed without restrictions (similar to classical sealing) but, after changing parameters, the ALG shall only be put into use “in sealed condition” again by authorized persons, e.g. by using a “password”;
- (b) the “password” must be changeable;
- (c) the device shall either clearly indicate when it is in the configuration mode (not under legal metrological control), or it shall not operate while in this mode. This status shall remain until the ALG has been put into use “in sealed condition”;
- (d) for identification, data concerning the latest intervention shall be recorded in an event logger. The record shall include at least:
 - an event counter;
 - the date the parameter was changed;
 - the new value of the parameter; and
 - an identification of the person that implemented the intervention.
- (e) the traceability of the last intervention shall be assured for at least two years, if it is not over-written on the occasion of a further intervention.

If it is possible to store more than one intervention, and if deletion of a previous intervention must occur to permit a new record, the oldest record shall be deleted.

7.8 Safeguarding the integrity of the measurement

7.8.1 General requirements

ALGs shall be designed and manufactured such that their metrological functions are safeguarded and their errors do not exceed the limits of the maximum permissible errors under rated operating conditions.

It shall be possible to determine the presence and correct functioning of the checking facilities.

The checking facilities shall be of type I or P.

7.8.2 Prevention or signaling of significant faults

7.8.2.1 ALGs shall be designed and manufactured such that when they are exposed to the following disturbances, either:

- (a) significant faults do not occur; or
- (b) significant faults are detected and acted upon by means of a checking facility:
 - during the following disturbances:

- (1) radiated, radio-frequency, electromagnetic fields;
 - (2) conducted radio-frequency fields;
 - (3) electrostatic discharge;
 - (4) bursts (transients) on signal, data and control lines;
 - (5) surges on signal, data and control lines;
 - (6) AC mains voltage dips, short interruptions and voltage variations;
 - (7) bursts (transients) on AC and DC mains;
 - (8) voltage dips, short interruptions and voltage variations on DC mains power;
 - (9) ripple on DC mains power.
- and after the following disturbances:
 - (10) damp heat cyclic (condensing);
 - (11) surges on AC and DC mains power.

Note: A fault equal to or smaller than the significant fault according to 3.32 is allowed irrespective of the value of the error of indication.

7.8.2.2 The provisions in 7.8.2.1 (a) and 7.8.2.1 (b) may be applied separately to:

- (a) each individual cause of significant fault; and/or
- (b) each part of the ALG.

Note: In case of a disturbance, a fault equal to or smaller than the MPE as specified in Table 1 is allowed, irrespective of the value of the error of indication.

7.8.2.3 The provisions in 7.8.1 and 7.8.2 shall be met durably.

ALGs shall be designed and manufactured such that either:

- (a) significant durability errors do not occur; or
- (b) significant durability errors are detected and acted upon by means of a durability protection facility.

7.8.2.4 The choice of whether 7.8.2.1 (a) or (b) and whether 7.8.2.3 (a) or (b) is applied, is left to the manufacturer.

7.8.2.5 If a significant fault is detected by a checking facility, a visual and/or audible indication shall automatically occur and shall continue until the user takes action or the fault is corrected.

7.8.2.6 The type of an ALG is presumed to comply with the provisions in 7.8.2.1 if it passes the relevant examination and tests specified in Part 2 of this Recommendation.

7.8.3 Signaling the loss or distortion of data

7.8.3.1 The loss or distortion of data shall be signaled by one or more checking facilities enabling:

- (a) incorrect functioning of a specific device of the ALG; and
- (b) disturbed communication between specific devices of the ALG

to be detected and acted upon.

If a risk of loss or distortion of data is detected by a checking facility, a visual and/or audible indication shall automatically occur and shall continue until the user takes action or the fault is corrected.

7.8.3.2 The design of the ALG shall ensure that permanently memorized instructions and data are correct¹⁾.

7.8.3.3 All relevant measurement data shall be checked for correct value whenever they are transferred or stored internally or transmitted to peripheral equipment by interface, by such means as:

- parity bit;
- check sum;
- independent double storage; or
- other handshake-routine with retransmission.

7.8.3.4 Checking facilities of the calculator

The objective of checking the functioning of the calculator is to verify that the values of all permanently memorized instructions and data are correct, and all procedures of internal transfer and storage of data relevant to the measurement result are performed correctly.

The objective is to check the correct value of all data related to the measurement whenever these data are internally stored or transmitted to an ancillary device through an interface. In addition, the calculation system shall be provided with a means of controlling the continuity of the calculation program (“watch-dog”).

7.8.3.5 Checking facilities of the indicating device

The instrument shall automatically check the data transmitted to the indicating device and the electronic circuits used for the indicating device, except the driving circuits of the display itself.

The display may be checked either automatically or manually.

If the failure of an indicator display element can cause a false indication then the instrument shall have a display test facility which on demand will show all relevant signs of the indicator display in their active and non-active states for a sufficient time to be easily observed by the operator.

If a PC is used as a common indication device, and the communication with the transducer is digital, it is assumed that the device meets the requirements for the checking facilities.

¹⁾ Acceptable solution:

- summing up of all instruction and data codes and comparing the sum with a fixed value;
 - line and column parity bits;
 - cyclic redundancy check;
 - multiple storage of data, both in the same code;
 - multiple storage of data, second in inverse or shifted coding; or
 - storage of data in “safe coding”, for example protected by check sum, line and parity bits.
-

7.8.3.6 Checking facilities of ancillary devices

Devices intended to perform a particular function, involved in elaborating and transmitting measurement results for custody transfer purposes, shall be checked for presence and correct operation.

Devices intended to perform a particular function, involved in transmitting or displaying measurement results for custody transfer purposes, shall also comply with 7.8.3.

The object of this checking facility is to verify the presence of the ancillary device, and to verify the correct transmission of data from the calculator to the ancillary device.

Note: The use of parity bit alone is not sufficient in case of storing or reading metrological data for an electronic ALG.

Automatic level gauges for measuring the level of liquid in stationary storage tanks

Part 2: Metrological controls and tests

8 Metrological controls

8.1 Type evaluation

8.1.1 Number of units submitted to type test

The applicant for the type test shall supply at least one production sample of the instrument for type testing.

In case the applicant wants to have several versions or measuring ranges approved, the national metrological service or related organization decides which version(s) and range(s) shall be supplied.

Several tests can be carried out in parallel on different specimens. In this case, the national metrological service or related organization decides which version or measuring range will be subjected to a specific test.

If a specimen does not pass a specific test and as a result has to be modified or repaired, the applicant shall carry out this modification to all the instruments supplied for test. If the testing laboratory has sound reasons to fear that the modification has a negative influence on tests that already had a positive result, these tests shall be repeated.

8.1.2 Documentation

The documentation submitted with the application for type approval shall include:

- (a) a list of the electronic sub-assemblies with their essential characteristics;
- (b) a description of the electronic devices with drawings, diagrams and general software information explaining their characteristics and operation;
- (c) mechanical drawings;
- (d) installation and security sealing plan;
- (e) operating instructions;
- (f) test outputs, their use, and their relationships to the parameters being measured; and
- (g) documentation or other evidence that supports the assumption that the design and characteristics of the measuring instrument comply with the requirements of this Recommendation.

8.1.3 Equipment under test (EUT)

As a rule, tests will be carried out on the complete automatic level gauge.

Simulation of any part of the automatic level gauge tested should be avoided. If this is not possible, all parts of the automatic level gauge that can be affected by the influence factor or disturbance shall play an active role in the measurements.

If the size or configuration of the automatic level gauge does not lend itself to testing as a whole unit, or if only a separate device of the measuring instrument is concerned, the tests, or certain tests, shall be carried out on the devices (modules) separately, provided that, in case of tests with the devices in operation, these devices are included in a simulated setup, sufficiently representative of its normal operation.

Note: As a general rule, the dismantling of the automatic level gauge or devices for the tests is not intended.

8.1.4 Reference conditions

Except for the parameter being tested, the following reference conditions shall be kept by the testing laboratory during the tests:

	Influence	Value
a)	Temperature	20 °C ± 5 °C
b)	Relative humidity	< 85 %
c)	DC mains voltage (*)	Less than 10 % of the variation specified by the manufacturer of the EUT
d)	AC mains voltage (*)	$U_{nom} \pm 1 \%$
e)	AC mains frequency (*)	$f_{nom} \pm 0.5 \%$
(*) whatever is applicable		

Tests are carried out under atmospheric pressure

8.1.5 Tests under reference conditions

8.1.5.1 General

The procedures described in 8.1 pertain to the tests to be carried out prior to installation of the ALG on the tank.

The equipment under test shall be clean and free of moisture. It shall be mounted and put into operation in accordance with the manufacturer's specifications before the test is started. The EUT shall be in normal operation throughout the test. The EUT shall be thoroughly checked after the termination of each test and sufficient time shall be allowed for recovery.

Tests shall be performed under normal test conditions. When the effect of one influence factor or disturbance is being evaluated, all other factors have to be held relatively constant, at values within the reference conditions defined in 8.1.4. The electromagnetic environment of the laboratory shall not influence the test results.

The temperature is considered to be constant when the difference between the extreme temperatures noted during the test does not exceed 5 °C, and the rate of change does not exceed 5 °C per hour.

When subjected to the effect of influence factors as provided for in 8.1.6, the instrument shall continue to operate correctly and the indications shall be within the maximum permissible errors.

8.1.5.2 Accuracy

Consecutive levels rising from zero to a value close to the measuring range and similarly descending shall (as far as possible) be equally distributed over the measuring range.

The number of levels shall be at least as follows:

- when determining the initial intrinsic error: at least 10 levels;

For other determinations:

- influence tests: at least 3 levels;
- disturbance tests: at least 1 level (at about 50 % of the measuring range).

8.1.5.3 Discrimination

ALGs without a movable liquid level detecting element are presumed to comply with the provisions in 6.2.5, without being subjected to this test. This justification shall be mentioned in the test report.

To test compliance with 6.2.5, constitute three different levels, (as far as possible) equally distributed over the measuring range, rising and descending. From a stable position, the level shall be changed in the same direction with the value of 6.2.5 (1 mm). The change of the indication is noted.

8.1.5.4 Hysteresis

ALGs without a movable liquid level detecting element are presumed to comply with the provisions in 6.2.3, without being subjected to this test. This justification shall be mentioned in the test report.

To test compliance with 6.2.3, this test shall be performed at three different levels, equally distributed between the first point of verification and the limit of the measuring range, upper or lower height according to the movement of the ALG.

Starting from the first point of verification, raise the level over a distance of about 1/3 of the measuring range, allow stabilization and read the indication. Then change the level about 1/10 of the measuring range and after that change the level until the first stabilized level is reached. Again allow stabilization and read the indication. Carry out this sequence two more times, now starting from the previous stabilized level.

Repeat these measurements starting from a value close to the measuring range and proceed inverting the direction of the movements. Evaluate the error.

8.1.5.5 Instruments with more than one indicating device

If the instrument has more than one indicating device, the indications of the various devices shall be compared during the performance tests and shall comply with 7.1.2.

8.1.6 Influence factor tests

The type of an automatic level gauge is presumed to comply with the provisions specified in 6.1 if it passes the tests in 8.1.6.1 to 8.1.6.4.

8.1.6.1 Maximum permissible error under reference conditions

Before, during, and after the tests 8.1.6.2–8.1.6.4, all functions shall operate as designed and the error of the ALG shall not exceed the limits of the maximum permissible error “before installation” specified in 6.2 under the reference conditions in 8.1.4.

8.1.6.2 Static temperatures

8.1.6.2.1 Dry heat (non condensing)

This test is applied to verify compliance with the provisions in 6.1 (a) under condition of dry heat (high environmental temperature).

Applicable standards:	IEC 60068-2-2 [8] IEC 60068-3-1 [10]				
Test procedure in brief:	<p>The test consists of exposure to the specified high temperature under “free air” conditions for the time specified (the time specified is the time after the EUT has reached temperature stability).</p> <p>The change of temperature shall not exceed 1 °C/min during heating up and cooling down.</p> <p>The absolute humidity of the test atmosphere shall not exceed 20 g/m³.</p> <p>When testing is performed at temperatures lower than 35 °C, the relative humidity shall not exceed 50 %.</p> <p>After stabilization at the relevant temperature, the following tests shall be carried out:</p> <ul style="list-style-type: none"> ▪ an accuracy test at three different levels equally spaced in the measuring range; ▪ a discrimination test at one level; ▪ an hysteresis test at one level. 				
Test severities:	The following severities may be specified ⁽¹⁾ :				
Severity level:	1	2	3	4	Unit
Temperature:	30	40	55	70	°C
Duration:	2	2	2	2	h
Condition of the EUT:	Normal power supplied and “on” for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be “on” for the duration of the test.				
Stabilization:	2 hours at each temperature under “free air” conditions.				
Requirement:	All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 6.2; see 8.1.6.1.				
Note:	⁽¹⁾ The applicable severity level is to be decided by the national authority as it depends on the climatic conditions and the expected conditions of application (indoors, outdoors, etc.) that are different in different countries. (See also the note in 6.1).				

8.1.6.2.2 Cold

This test is applied to verify compliance with the provisions in 6.1 (a) under condition of cold (low environmental temperature).

Applicable standards:	IEC 60068-2-1 [7] IEC 60068-3-1 [10]				
Test procedure in brief:	<p>The test consists of exposure to the specified low temperature under “free air” conditions for the time specified (the time specified is the time after the EUT has reached temperature stability).</p> <p>The change of temperature shall not exceed 1 °C/min during heating up and cooling down.</p> <p>IEC specifies that the power to the EUT shall be switched off before the temperature is raised.</p> <p>After stabilization at the relevant temperature, the following tests shall be carried out:</p> <ul style="list-style-type: none"> ▪ an accuracy test at three different levels equally spaced in the measuring range; ▪ a discrimination test at one level; ▪ an hysteresis test at one level. 				
Test severities:	The following severities may be specified ⁽¹⁾ :				
Severity level:	1	2	3	4	Unit
Temperature:	+5	–10	–25	–40	°C
Duration:	2	2	2	2	h
Condition of the EUT:	Normal power supplied and “on” for a time period equal to or greater than the warm-up time specified by the manufacturer. Power is to be “on” for the duration of the test.				
Stabilization:	2 hours at each temperature under “free air” conditions.				
Requirement:	All functions shall operate as designed. All errors shall be within the maximum permissible errors specified in 6.2; see 8.1.6.1.				
Note:	⁽¹⁾ The applicable severity level is to be decided by the national authority as it depends on the climatic conditions and the expected conditions of application (indoors, outdoors, etc.) that are different in different countries. (See also the note in 6.1).				

8.1.6.3 DC mains voltage variation

This test is only applicable for ALGs powered by DC networks and is applied to verify compliance with the provisions in 6.1 (c) under condition of DC mains voltage variation.

In case this test is not applicable, the justification shall be mentioned in the test report.

Applicable standard:	IEC 60654-2 [12]
Test procedure in brief:	The test consists of exposure to the specified power supply condition for a period sufficient for establishing stability. For both the upper and the lower limit of DC level, an accuracy test at three different levels equally spaced in the measuring range shall be carried out.
Test severity:	The upper limit will be the DC level at which the EUT has been manufactured to automatically detect high-level conditions. The lower limit will be the DC level at which the EUT has been manufactured to automatically detect low-level conditions.
Requirement:	The EUT shall comply with the specified maximum permissible errors. This applies at all voltage levels between the two levels; see 8.1.6.1.

8.1.6.4 AC mains voltage variation

This test is only applicable for ALGs powered by public AC networks and is applied to verify compliance with the provisions in 6.1 (d) under condition of AC mains voltage variation.

In case this test is not applicable, the justification shall be mentioned in the test report.

Applicable standards:	IEC/TR3 61000-2-1 [13] IEC 61000-4-1 [14]	
Test procedure in brief:	The test consists of exposure to the specified power condition for a period sufficient for achieving temperature stability and for performing the required measurements. For both the upper and the lower limit of AC level, an accuracy test at three different levels equally spaced in the measuring range shall be carried out.	
Mains voltage : (1), (2)	Upper limit	$U_{nom} + 10 \%$
	Lower limit	$U_{nom} - 15 \%$
Notes:	(1) In the case of three-phase mains power, the voltage variation shall apply for each phase successively. (2) The values of U_{nom} are those marked on the measuring instrument. In case a range is specified, the “-” relates to the lowest value and the “+” to the highest value of the range.	
Requirement:	The EUT shall comply with the specified maximum permissible errors; see 8.1.6.1. This applies at all voltage levels between the two levels.	

8.1.7 Disturbances

The type of ALG is presumed to comply with the provisions specified in 7.8.2.1, if it passes the following tests:

8.1.7.1 Damp heat, cyclic (condensing)

This test is applied to verify compliance with the provisions in 7.8.2.1 (10) after condition of condensing humidity, combined with cyclic temperature changes.

Applicable standards:	IEC 60068-2-30 [9] IEC 60068-3-4 [11]	
Test procedure in brief:	<p>The test consists of exposure to cyclic temperature variation between 25 °C and a temperature of + 55 °C, maintaining the relative humidity above 95 % during the temperature change and low temperature phases, and at 93 % at the upper temperature phases.</p> <p>Condensation should occur on the EUT during the temperature rise.</p> <p>The 24 h cycle consists of:</p> <ol style="list-style-type: none"> (1) temperature rise during 3 h; (2) temperature maintained at upper value until 12 h from the start of the cycle; (3) temperature lowered to lower value within 3 h to 6 h, the rate of fall during the first hour and a half being such that the lower value would be reached in 3 h; (4) temperature maintained at lower value until the 24 h cycle is completed; (5) immediately after the 24 h cycle, the ALG shall be switched on and an accuracy test shall be carried out for at least one level at about 50 % of the measuring range. <p>The stabilizing period before and recovery after the cyclic exposure shall be such that all parts of the EUT are within 3 °C of their final temperature.</p> <p>During the disturbance, the ALG shall be switched off.</p>	
Severity level:	2	unit
Upper temperature:	55	°C
Duration:	2	cycles
Requirement:	<p>After the disturbance, either:</p> <ol style="list-style-type: none"> (a) Significant faults do not occur; or (b) Significant faults are detected and acted upon by means of a checking facility. 	

Note: This test shall not be confused with the temperature test.

8.1.7.2 Electromagnetic susceptibility

8.1.7.2.1 Radiated, radio-frequency, electromagnetic fields

For instruments containing electronics, this test is applied to verify compliance with the provisions in 7.8.2.1 (1) under conditions of radiated electromagnetic fields.

Instruments that do not contain any active electronic circuits (transistors, ICs, radio tubes), are presumed to comply with the provisions in 7.8.2.1 (1), without being subjected to this test.

In case this test is not applicable, the justification shall be mentioned in the test report.

Applicable standard:	IEC 61000-4-3 [16]
Test procedure in brief:	<p>The EUT shall be exposed to electromagnetic field strength as specified by the severity level (10 V/m) and a field uniformity as defined by the referred standard.</p> <p>The frequency ranges to be considered are swept with the modulated signal, pausing to adjust the RF signal level or to switch oscillators and antennas as necessary. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value.</p> <p>The dwell time of the amplitude modulated carrier at each frequency shall not be less than the time necessary for the EUT to be exercised and to respond, but shall in no case be less than 0.5 s.</p> <p>The sensitive frequencies (e.g. clock frequencies) shall be analyzed separately. ⁽¹⁾</p> <p>During the disturbance, an accuracy test shall be carried out for at least one level at about 50 % of the measuring range.</p>
Severity level:	3
Field strength:	10 V/m
Frequency range:	80 MHz – 2 GHz ⁽²⁾
	26 MHz – 2 GHz
Modulation:	80 % AM, 1 kHz, sine wave
Requirement:	<p>During the disturbance, either:</p> <p>(a) Significant faults do not occur; or</p> <p>(b) Significant faults are detected and acted upon by means of a checking facility.</p>
Notes:	<p>⁽¹⁾ Usually, these sensitive frequencies can be expected to be the frequencies emitted by the EUT.</p> <p>⁽²⁾ IEC 61000-4-3 [16] only specifies test levels above 80 MHz. For frequencies in the lower range the test methods for conducted radio frequency disturbances (8.1.7.2.2) are recommended.</p>

8.1.7.2.2 Conducted, radio-frequency, electromagnetic fields

For instruments containing electronics, this test is applied to verify compliance with the provisions in 7.8.2.1 (2) under conditions of conducted electromagnetic fields.

Instruments that do not contain any active electronic circuits (transistors, ICs, radio tubes) and/or mains or other input or output port, are presumed to comply with the provisions in 7.8.2.1 (2), without being subjected to this test.

In case this test is not applicable, the justification shall be mentioned in the test report.

Applicable standard:	IEC 61000-4-6 [19]	
Test procedure in brief: ⁽¹⁾	Radio frequency EM current, simulating the influence of EM fields shall be coupled or injected into the power ports and I/O ports of the EUT using coupling/decoupling devices as defined in the referred standard. During the disturbance, an accuracy test shall be carried out for at least one level at about 50 % of the measuring range.	
Severity level:	3	unit
RF amplitude (50 Ω):	10	V (e.m.f.)
Frequency range: ⁽²⁾	0.15 – 80	MHz
Modulation:	80 % AM, 1 kHz sine wave	
Notes:	⁽¹⁾ If the EUT is composed of several elements, the tests shall be performed at each extremity of the cable if both of the elements are part of the EUT. ⁽²⁾ For the frequency range 26 – 80 MHz, the testing laboratory can either carry out the test according to 8.1.7.2.1 or according to 8.1.7.2.2. But in case of a dispute, the results according to 8.1.7.2.2 shall prevail.	
Requirement:	During the disturbance, either: (a) Significant faults do not occur; or (b) Significant faults are detected and acted upon by means of a checking facility.	

8.1.7.2.3 Electrostatic discharge

For instruments containing electronics, this test is applied to verify compliance with the provisions in 7.8.2.1 (3) under conditions of electrostatic discharges.

Instruments that do not contain any active electronic circuits (transistors, ICs, radio tubes), are presumed to comply with the provisions in 7.8.2.1 (3), without being subjected to this test.

In case this test is not applicable, the justification shall be mentioned in the test report.

Applicable standard:	IEC 61000-4-2 [15]		
Test procedure in brief:	<p>An ESD generator shall be used with a performance as defined in the referred standard.</p> <p>At least 10 discharges shall be applied. The time interval between successive discharges shall be at least 10 seconds.</p> <p>For EUT not equipped with a ground terminal, the EUT shall be fully discharged between discharges.</p> <p>Contact discharge is the preferred test method. Air discharge shall be used where contact discharge cannot be applied.</p> <p>Direct application: In the contact discharge mode to be carried out on conductive surfaces, the electrode shall be in contact with the EUT.</p> <p>In the air discharge mode on insulated surfaces, the electrode is approached to the EUT and the discharge occurs by spark.</p> <p>Indirect application: The discharges are applied in the contact mode to coupling planes mounted in the vicinity of the EUT.</p> <p>During the disturbance, an accuracy test shall be carried out for at least one level at about 50 % of the measuring range.</p>		
Severity level:	3		unit
Test voltage: ⁽¹⁾	Contact discharge	6	kV
	Air discharge	8	kV
Notes:	⁽¹⁾ Contact discharges shall be applied on conductive surfaces. Air discharges shall be applied on non-conductive surfaces.		
Requirement:	<p>During the disturbance, either:</p> <p>(a) Significant faults do not occur; or</p> <p>(b) Significant faults are detected and acted upon by means of a checking facility.</p>		

8.1.7.2.4 Bursts (transients) on signal, data and control lines

For instruments containing electronics and provided with I/O or communication ports, this test is applied to verify compliance with the provisions in 7.8.2.1 (4) under conditions where electrical bursts are superimposed on I/O and communication ports.

Instruments that do not contain any active electronic circuits (transistors, ICs, radio tubes), or not being provided with external signal, data or control lines, are presumed to comply with the provisions in 7.8.2.1 (4), without being subjected to this test.

In case this test is not applicable, the justification shall be mentioned in the test report.

Applicable standard:	IEC 61000-4-4 [17]	
Test procedure in brief:	<p>A burst generator shall be used with the performance characteristics as specified in the referred standard.</p> <p>The test consists of exposure to bursts of voltage spikes for which the output voltage on 50 Ω and 1 000 Ω load are defined in the referred standard.</p> <p>Both positive and negative polarity of the bursts shall be applied.</p> <p>The duration of the test shall not be less than 1 min for each amplitude and polarity.</p> <p>For the coupling of the bursts into the I/O and communication lines, a capacitive coupling clamp as defined in the standard shall be used.</p> <p>During the disturbance, an accuracy test shall be carried out for at least one level at about 50 % of the measuring range.</p>	
Severity level:	3	unit
Amplitude (peak value):	1	kV
Repetition rate:	5	kHz
Requirement:	<p>During the disturbance, either:</p> <p>(a) Significant faults do not occur; or</p> <p>(b) Significant faults are detected and acted upon by means of a checking facility.</p>	

8.1.7.2.5 Surges on signal, data and control lines

For instruments containing electronics and provided with I/O or communication ports this test is applied to verify compliance with the provisions in 7.8.2.1 (5) under conditions where electrical surges are superimposed on I/O and communication ports.

Instruments that do not contain any active electronic circuits (transistors, ICs, radio tubes), and/or not being provided with external signal, data or control lines, are presumed to comply with the provisions in 7.8.2.1 (5), without being subjected to this test.

In case this test is not applicable, the justification shall be mentioned in the test report.

Applicable standard:	IEC 61000-4-5 [18]		
Test procedure in brief:	<p>A surge generator shall be used with the performance characteristics as specified in the referred standard. The test consists of exposure to surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and minimum time interval between two successive pulses are defined in the referred standard.</p> <p>The characteristics of the generator shall be verified before connecting the EUT.</p> <p>At least 3 positive and 3 negative surges shall be applied. The injection network depends on the lines the surge is coupled into and is defined in the referred standard.</p> <p>During the disturbance, an accuracy test shall be carried out for at least one level at about 50 % of the measuring range.</p>		
Severity level:	(Installation class)	2	unit
Unbalanced lines:	Line to line	0.5	kV
	Line to ground	1.0	kV
Balanced lines:	Line to line	N.A.	kV
	Line to ground	1.0	kV
Requirement:	<p>During the disturbance, either:</p> <p>(a) Significant faults do not occur; or</p> <p>(b) Significant faults are detected and acted upon by means of a checking facility.</p>		

8.1.7.2.6 AC mains voltage dips, short interruptions and voltage variations

For instruments containing electronics, and powered by AC mains, this test is applied to verify compliance with the provisions in 7.8.2.1 (6) under conditions of short time mains voltage reductions.

In case this test is not applicable, the justification shall be mentioned in the test report.

Applicable standards:		IEC 61000-4-11 [20] IEC 61000-6-1 [23]		
Test procedure in brief:		<p>A test generator suitable to reduce, for a defined period of time, the amplitude of the AC mains voltage is used.</p> <p>The performance of the test generator shall be verified before connecting the EUT.</p> <p>The mains voltage reductions shall be repeated 10 times with an interval of at least 10 seconds.</p> <p>During the disturbance, an accuracy test shall be carried out for at least one level at about 50 % of the measuring range.</p>		
Severity level:		3		unit
Voltage dips:	Test a	Reduction to	0	%
		Duration	0.5	cycles
	Test b	Reduction to	0	%
		Duration	1	cycles
	Test c	Reduction to	40	%
		Duration	10/12 ⁽¹⁾	cycles
	Test d	Reduction to	70	%
		Duration	25/30 ⁽¹⁾	cycles
	Test e	Reduction to	80	%
		Duration	250/300 ⁽¹⁾	cycles
Short interruptions:	Reduction to		0	%
	Duration		250/300 ⁽¹⁾	cycles
Note:	⁽¹⁾ These values are for 50 Hz / 60 Hz respectively.			
Requirement:	<p>During tests a, b, c, d, and e and after the short interruption, either:</p> <p>(a) Significant faults do not occur; or</p> <p>(b) Significant faults are detected and acted upon by means of a checking facility.</p>			

8.1.7.2.7 Bursts (transients) on AC and DC mains

For instruments containing electronics, and powered by AC or DC mains voltage, this test is applied to verify compliance with the provisions in 7.8.2.1 (7) under conditions where electrical bursts are superimposed on the mains voltage.

In case this test is not applicable, the justification shall be mentioned in the test report.

Applicable standards:	IEC 61000-4-1 [14] IEC 61000-4-4 [17]	
Test procedure in brief:	<p>A burst generator shall be used with the performance characteristics as specified in the referred standard.</p> <p>The test consists of exposure to bursts of voltage spikes for which the output voltage on 50 Ω and 1 000 Ω load are defined in the referred standard.</p> <p>Both positive and negative polarity of the bursts shall be applied.</p> <p>The duration of the test shall not be less than 1 min for each amplitude and polarity. The injection network on the mains shall contain blocking filters to prevent the burst energy being dissipated in the mains.</p> <p>During the disturbance, an accuracy test shall be carried out for at least one level at about 50 % of the measuring range.</p>	
Severity level:	3	unit
Amplitude (peak value):	2	kV
Repetition rate:	5	kHz
Requirement:	<p>During the disturbance, either:</p> <p>(a) Significant faults do not occur; or</p> <p>(b) Significant faults are detected and acted upon by means of a checking facility.</p>	

8.1.7.2.8 Voltage dips, short interruptions and voltage variations on DC mains power

For instruments containing electronics, and powered by DC mains voltage, this test is applied to verify compliance with the provisions in 7.8.2.1 (8) under conditions where electrical bursts are superimposed on the mains voltage.

In case this test is not applicable, the justification shall be mentioned in the test report.

Applicable standard:	IEC 61000-4-29 [22]		
Test procedure in brief:	<p>A test generator as defined in the referred standard shall be used. Before starting the tests, the performance of the generator shall be verified.</p> <p>The voltage dips and short interruptions shall be tested on the EUT, for each selected combination of test level and duration, with a sequence of three dips/interruptions with intervals of 10 s minimum between each test event.</p> <p>The EUT shall be tested for each of the specified voltage variations, three times at 10 s intervals in the most representative operating modes.</p> <p>During the disturbance, an accuracy test shall be carried out for at least one level at about 50 % of the measuring range.</p>		
Voltage dips:	Severity level	1	unit
	Test levels	40 and 70	% of the rated voltage
	Duration	0.1	s
Short interruptions:	Test condition	High impedance and/or low impedance	
	Test level	0	% of the rated voltage
	Duration	0.01	s
Voltage variations:	Severity level	1	
	Test levels	85 and 120	% of the rated voltage
	Duration	10	s
Requirement:	<p>During the disturbance, either:</p> <p>(a) Significant faults do not occur; or</p> <p>(b) Significant faults are detected and acted upon by means of a checking facility.</p>		

8.1.7.2.9 Ripple on DC mains power

For instruments containing electronics, and powered by DC mains voltage, this test is applied to verify compliance with the provisions in 7.8.2.1 (9) under conditions of ripple on the low voltage DC mains power.

This test does not apply to instruments connected to battery charger systems incorporating switch mode converters.

In case this test is not applicable, the justification shall be mentioned in the test report.

Applicable standard	IEC 61000-4-17 [21]
Test procedure in brief:	<p>A test generator as defined in the referred standard shall be used. Before starting the tests, the performance of the generator shall be verified.</p> <p>The test consists of subjecting the EUT to ripple voltages such as those generated by rectifier systems and/or auxiliary service battery chargers overlaying on DC power supply sources. The frequency of the ripple is the power frequency. The waveform of the ripple, at the output of the test generator, has a sinusoid-linear character.</p> <p>The test shall be applied for at least 10 min or for the period time necessary to allow a complete verification of the EUT's operating performance.</p> <p>During the disturbance, an accuracy test shall be carried out for at least one level at about 50 % of the measuring range.</p>
Severity level:	1
Percentage of the nominal DC voltage: ⁽¹⁾	2
Note:	⁽¹⁾ The test level is a peak-to-peak voltage expressed as a percentage of the nominal DC voltage.
Requirement:	<p>During the disturbance, either:</p> <p>(a) Significant faults do not occur; or</p> <p>(b) Significant faults are detected and acted upon by means of a checking facility.</p>

8.1.7.2.10 Surges on AC and DC mains power lines

For instruments containing electronics, and powered by AC or DC mains voltage, this test is applied to verify compliance with the provisions in 7.8.2.1 (11) after conditions where electrical surges were superimposed on the mains voltage.

In case this test is not applicable, the justification shall be mentioned in the test report.

Applicable standard:	IEC 61000-4-5 [18]	
Test procedure in brief:	<p>A surge generator shall be used with the performance characteristics as specified in the referred standard. The test consists of exposure to surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and minimum time interval between two successive pulses are defined in the referred standard.</p> <p>The characteristics of the generator shall be verified before connecting the EUT.</p> <p>On AC mains supply lines, at least 3 positive and 3 negative surges shall be applied synchronously with AC supply voltage in angles 0°, 90°, 180° and 270°.</p> <p>On DC power lines, at least 3 positive and 3 negative surges shall be applied.</p> <p>The injection network depends on the lines the surge is coupled into and is defined in the referred standard.</p> <p>Immediately after the disturbance, an accuracy test shall be carried out for at least one level at about 50 % of the measuring range.</p>	
Severity level (installation class):	3	unit
Line to line:	1.0	kV
Line to ground:	2.0	kV
Requirement:	<p>After the disturbance, either:</p> <p>(a) Significant faults do not occur; or</p> <p>(b) Significant faults are detected and acted upon by means of a checking facility.</p>	

8.2 Initial verification

Initial verification is carried out in two stages, as follows.

8.2.1 Before installation

For the examination and testing of the ALG before installation on the tank (preliminary examination), the ALG shall be checked for conformity with the approved type.

Tests have to be done on accuracy, discrimination and hysteresis (see 8.1.5.2 through 8.1.5.5) to verify compliance with the requirements.

Tests shall be carried out within the rated operating conditions.

The ALG shall be sealed according the Certificate.

8.2.2 After installation

For the examination of installation and adjustment of the ALG on the tank:

- check that the requirements of 7.1–7.3 are met;
- check that the conditions of the tank match with the rated operating conditions specified according to 6.1.

If national regulations allow the use of an ALG under conditions outside the rated operating conditions (see 6.1), the metrological service shall ascertain that all necessary information to make the required corrections is available to the user and that this information is correct.

The errors of the instrument shall be within the limits of the maximum permissible errors specified for ALGs installed on tanks (see 6.2.2).

The instrument shall be stamped and sealed in accordance with national regulations.

8.3 Maintenance

The owner of the ALG shall ensure that the ALG continues to function properly while in service and shall ensure and document regular inspections of the ALG by the instrument manufacturer or another competent expert.

8.4 Subsequent verification

8.4.1 Subsequent verification is to verify the accuracy of an ALG mounted on a tank “in use”, thus in general a partly filled tank. Therefore this is in practice only possible at one single level within the normal operating range. In general, this will be the actual level of the fluid in the tank at the moment of the verification.

Subsequent verification with a period of validity of 2 years or less is recommended.

Note: In practice, subsequent verification of an ALG used in a pressurized tank is only possible after removing the ALG from the tank. This can lead to considerable practical problems when subsequent verification is prescribed at fixed periodic intervals.

8.4.2 If subsequent verification is required by national legislation, this shall be carried out according to 8.2.2.

The maximum permissible errors to be applied for subsequent verification shall be in accordance with 6.2.2 “after installation”.

If an ALG is adjusted or “reset” to match the manual gauge (dip), the ALG should be verified following the “initial field verification” procedure – if ISO 4266 is followed.

8.5 Metrological supervision

Countries not having a system of mandatory subsequent verification according to 8.4 are suggested to employ a system of metrological supervision of measuring instruments in use.

This can consist of randomly checking the presence of the right and valid and undamaged verification marks and seals.

Annex A

Bibliography ²⁾

Ref.	ISO / IEC Standard	Abstract
[1]	ISO Guide 99 ISO/IEC VIM OIML V 2 International Vocabulary of Basic and General Terms in Metrology (1993)	An international agreement on terminology, prepared as a collaborative work of experts appointed by BIPM, IEC, IFCC, ISO, IUPAC, IUPAP and OIML. This Vocabulary covers subjects relating to measurement and includes information on the determination of physical constants and other fundamental properties of materials and substances.
[2]	OIML V 1:2000 International Vocabulary of Terms in Legal Metrology (VIML)	The VIML includes only the concepts used in the field of legal metrology. These concepts concern the activities of the legal metrology service, the relevant documents as well as other problems linked with this activity. Also included in this Vocabulary are certain concepts of a general character which have been drawn from the VIM.
[3]	OIML D 11:2004 General requirements for electronic measuring instruments	The primary aim of this International Document is to provide OIML Technical Committees and Subcommittees with guidance for establishing appropriate metrological performance testing requirements for influence quantities that may affect the measuring instruments covered by International Recommendations.
[4]	OIML B 3:2003 OIML Certificate System for Measuring Instruments (formerly OIML P 1) Including Amendment 2006	The OIML Certificate System for Measuring Instruments is a system for issuing, registering and using OIML Certificates of Conformity for types of measuring instruments based on the requirements of OIML Recommendations.
[5]	OIML R 71:2008 Fixed storage tanks - General requirements	This Recommendation specifies the general requirements for all stationary storage tanks onshore with fixed or floating roofs including pressured, non-pressured, refrigerated and non refrigerated. Additional information for the different types of tanks are stated in chapter 9.
[6]	IEC 60068-1 (1988-6), Appendix B (including Amendment 1, 1992-4) Environmental testing. Part 1: General and guidance	Enumerates a series of environmental tests and appropriate severities, and prescribes various atmospheric conditions for measurements for the ability of specimens to perform under normal conditions of transportation, storage and operational use.

²⁾ These references apply to all three Parts of OIML R 85.

[7]	<p>IEC 60068-2-1 (2007) Environmental testing, Part 2: Tests, Test A: Cold</p>	<p>Deals with cold tests applicable to both non heat-dissipating and heat-dissipating specimens. For non heat-dissipating specimens, Tests Ab and Ad do not deviate essentially from earlier issues. Test Ae has been added primarily for testing equipment that requires being operational throughout the test, including the conditioning periods.</p> <p>The object of the cold test is limited to the determination of the ability of components, equipment or other articles to be used, transported or stored at low temperature.</p> <p>Cold tests covered by this standard do not enable the ability of specimens to withstand or operate during the temperature variations to be assessed. In this case, it would be necessary to use IEC 60068-2-14.</p> <p>The cold tests are subdivided as follows: - Cold tests for non heat-dissipating specimens * with gradual change of temperature, Ab; - Cold test for heat-dissipating specimens * with gradual change of temperature, Ad, * with gradual change of temperature, specimen powered throughout, Ae.</p> <p>The procedures given in this standard are normally intended for specimens that achieve temperature stability during the performance of the test procedure.</p> <p>Temperature chamber(s) are constructed and verified in accordance with specifications IEC 60068-3-5 and IEC 60068-3-7.</p> <p>Further guidance for dry heat and cold tests can be found in IEC 60068-3-1 and general guidance in IEC 60068-1. This sixth edition deals with cold tests applicable both to non heat-dissipating and heat-dissipating specimens. For non heat-dissipating specimens, Tests Ab and Ad do not deviate essentially from earlier issues. Test Ae has been added primary for testing equipment that requires being operational throughout the test including the conditioning periods.</p>
[8]	<p>IEC 60068-2-2 (1974-01), with Amendments 1 (1993-02) and 2 (1994-05) Environmental testing, Part 2: Test, test B: Dry heat</p>	<p>Contains Test Ba: Dry heat for non-heat-dissipating specimen with sudden change of temperature; Test Bb: Dry heat for non-heat-dissipating specimen with gradual change of temperature; Test Bc: Dry heat for heat-dissipating specimen with sudden change of temperature; Test Bd: Dry heat for heat-dissipating specimen with gradual change of temperature.</p> <p>The 1987 reprint includes IEC No. 62-2-2A.</p>
[9]	<p>IEC 60068-2-30 (2005-08) Environmental testing Part 2-30: Tests, test Db a Damp heat, cyclic (12+12 hour cycle)</p>	<p>Determines the suitability of components, equipment or other articles for use, transportation and storage under conditions of high humidity - combined with cyclic temperature changes and, in general, producing condensation on the surface of the specimen. If the test is being used to verify the performance of a specimen whilst it is being transported or stored in packaging then the packaging will normally be fitted when the test conditions</p>

		are being applied. For small, low mass specimens, it may be difficult to produce condensation on the surface of the specimen using this procedure; users should consider the use of an alternative procedure such as that given in IEC 60068-2-38. The main changes with respect to the previous edition are listed below: - editorial changes, - addition of normative references, - addition of guidance for temperature tolerances, - period for recovery has been extended.
[10]	IEC 60068-3-1 (1974-01) + Supplement A (1978-01) Environmental testing Part 3: Background information, Section 1: Cold and dry heat tests	Gives background information for Tests A: Cold (IEC 68-2-1), and Tests B: Dry heat (IEC 68-2-2). Includes appendices on the effect of: chamber size on the surface temperature of a specimen when no forced air circulation is used; airflow on chamber conditions and on surface temperatures of test specimens; wire termination dimensions and material on surface temperature of a component; measurements of temperature, air velocity and emission coefficient.
[11]	IEC 60068-3-4 (2001-08) Environmental testing- Part 3-4: Supporting documentation and guidance – Damp heat tests	Provides the necessary information to assist in preparing relevant specifications, such as standards for components or equipment, in order to select appropriate tests and test severities for specific products and, in some cases, specific types of application. The object of damp heat tests is to determine the ability of products to withstand the stresses occurring in a high relative humidity environment, with or without condensation, and with special regard to variations of electrical and mechanical characteristics. Damp heat tests may also be utilized to check the resistance of a specimen to some forms of corrosion attack.
[12]	IEC 60654-2 (1979-01), with Amendment 1 (1992-09) Operating conditions for industrial-process measurement and control equipment. Part 2: Power	Gives the limiting values for power received by land-based and offshore industrial-process measurement and control systems or parts of systems during operation. Maintenance and repair conditions are not considered.
[13]	IEC/TR3 61000-2-1 (1990-05) Electromagnetic compatibility (EMC), Part 2: Environment, Section 1: Description of the environment – Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems.	Has the status of a technical report, and gives information on the various types of disturbances that can be expected on public power supply systems. The following disturbance phenomena are considered: - harmonics - inter-harmonics - voltage fluctuations - voltage dips and short supply interruptions - voltage unbalance - mains signalling - power frequency variation - DC components.
[14]	IEC 61000-4-1 (2006-10)	The object of this part of IEC 61000 is to give applicability

	Electromagnetic compatibility (EMC), Part 4-1: Testing and measurement techniques - Overview of IEC 61000-4 series	<p>assistance to the technical committees of IEC or other bodies, users and manufacturers of electrical and electronic equipment on EMC standards within the IEC 61000-4 series on testing and measurement techniques and to provide general recommendations concerning the choice of relevant tests.</p> <p>This standard has the status of a Basic EMC Publication in accordance with IEC Guide 107.</p>
[15]	<p>IEC 61000-4-2 (1995-01) with Amendment 1 (1998-01), Basic EMC Publication</p> <p>Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques, Section 2: Electrostatic discharge immunity test.</p> <p>Consolidated Edition: IEC 61000-4-2 (2001-04) Ed. 1.2</p>	<p>This publication is based on IEC 60801-2 (second edition: 1991). It relates to the immunity requirements and test methods for electrical and electronic equipment subjected to static electricity discharges, from operators directly, and to adjacent objects. It additionally defines ranges of test levels which relate to different environmental and installation conditions and establishes test procedures. The object of this standard is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment when subjected to electrostatic discharges. In addition, it includes electrostatic discharges which may occur from personnel to objects near vital equipment.</p>
[16]	<p>IEC 61000-4-3 (2006-02) Electromagnetic compatibility (EMC) Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test.</p>	<p>Applicable to the immunity requirements of electrical and electronic equipment to radiated electromagnetic energy. It establishes test levels and the required test procedures.</p> <p>The object of this standard is to establish a common reference for evaluating the immunity of electrical and electronic equipment when subjected to radiated, radio-frequency electromagnetic fields. The test method documented in this part of IEC 61000 describes a consistent method to assess the immunity of an equipment or system against a defined phenomenon.</p> <p>This part deals with immunity tests related to the protection against RF electromagnetic fields from any source.</p> <p>Particular considerations are devoted to protection against radio-frequency emissions from digital radiotelephones and other RF emitting devices.</p> <p>It has the status of a basic EMC Publication.</p>
[17]	<p>IEC 61000-4-4 (2004-07), plus Corr.1 (2006-08)</p> <p>Electromagnetic compatibility (EMC) – Part 4-4: Testing and Measurement techniques - Electrical fast transient/burst immunity test. Basic EMC</p>	<p>Establishes a common and reproducible reference for evaluating the immunity of electrical and electronic equipment when subjected to electrical fast transient/bursts on supply, signal, control and earth ports. The test method documented in this part of IEC 61000-4 describes a consistent method to assess the immunity of an equipment or system against a defined phenomenon.</p> <p>The standard defines:</p> <ul style="list-style-type: none"> ▪ test voltage waveform;

	Publication.	<ul style="list-style-type: none"> ▪ range of test levels; ▪ test equipment; ▪ verification procedures of test equipment; ▪ test set-up; ▪ test procedure. <p>The standard gives specifications for laboratory and post-installation tests.</p> <p>This second edition cancels and replaces the first edition published in 1995 and its Amendments 1 (2000) and 2 (2001) and constitutes a technical revision.</p>
[18]	IEC 61000-4-5 (2005-11) Electromagnetic compatibility (EMC) – Part 4-5: Testing and Measurement techniques – Surge immunity test	<p>Relates to the immunity requirements, test methods, and range of recommended test levels for equipment to unidirectional surges caused by over-voltages from switching and lightning transients. Several test levels are defined which relate to different environment and installation conditions. These requirements are developed for and are applicable to electrical and electronic equipment.</p> <p>The object of this standard is to establish a common reference for evaluating the immunity of electrical and electronic equipment when subjected to surges. The test method documented in this part of IEC 61000 describes a consistent method to assess the immunity of an equipment or system against a defined phenomenon.</p> <p>This standard defines:</p> <ul style="list-style-type: none"> ▪ a range of test levels; ▪ test equipment; ▪ test setups; ▪ test procedures. <p>The task of the described laboratory test is to find the reaction of the EUT under specified operational conditions, to surge voltages caused by switching and lightning effects at certain threat levels.</p> <p>It is not intended to test the capability of the EUT's insulation to withstand high-voltage stress. Direct injections of lightning currents, i.e. direct lightning strikes, are not considered in this standard.</p> <p>It has the status of a basic EMC Publication in accordance with IEC Guide 107.</p>
[19]	IEC 61000-4-6 (2003-05) with Amendment 1 (2004-10) and Amendment 2 (2006-03) Electromagnetic compatibility (EMC) Part	<p>This part of IEC 61000-4 relates to the conducted immunity requirements of electrical and electronic equipment to electromagnetic disturbances coming from intended radio-frequency (RF) transmitters in the frequency range 9 kHz up to 80 MHz. Equipment not having at least one conducting cable (such as mains supply, signal line or earth connection)</p>

	<p>4-6 Testing and measurement techniques - Immunity to conducted disturbances, induced by radio frequency fields.</p> <p>Consolidated edition 2006-05</p>	<p>which can couple the equipment to the disturbing RF fields is excluded.</p> <p>The object of this standard is to establish a common reference for evaluating the functional immunity of electrical and electronic equipment when subjected to conducted disturbances induced by radio-frequency fields. The test method documented in this part of IEC 61000 describes a consistent method to assess the immunity of an equipment or system against a defined phenomenon.</p>
[20]	<p>IEC 61000-4-11 (2004-03)</p> <p>Electromagnetic compatibility (EMC) - Part.4-11: Testing and Measuring techniques – Voltage dips, short interruptions and voltage variations immunity tests.</p>	<p>This part of IEC 61000 defines the immunity test methods and range of preferred test levels for electrical and electronic equipment connected to low-voltage power supply networks for voltage dips, short interruptions, and voltage variations.</p> <p>This standard applies to electrical and electronic equipment having a rated input current not exceeding 16 A per phase, for connection to 50 Hz or 60 Hz AC networks.</p> <p>It does not apply to electrical and electronic equipment for connection to 400 Hz AC networks. Tests for these networks will be covered by future IEC standards.</p> <p>The object of this standard is to establish a common reference for evaluating the immunity of electrical and electronic equipment when subjected to voltage dips, short interruptions and voltage variations.</p> <p>This second edition cancels and replaces the first edition published in 1994 and its Amendment 1 (2000). This second edition constitutes a technical revision in which:</p> <ol style="list-style-type: none"> 1) preferred test values and durations have been added for the different environment classes; 2) the tests for the three-phase systems have been specified. <p>It has the status of a Basic EMC Publication in accordance with IEC Guide 107.</p>
[21]	<p>IEC 61000-4-17 (1999-06), Am. 1 (2001-07)</p> <p>Electromagnetic compatibility (EMC) – Part 4-17: Testing and measurement techniques – Ripple on DC input power port immunity test.</p> <p>Consolidated edition (2002-07) Ed. 1.1</p>	<p>Defines test methods for immunity to ripple at the DC input power port of electrical or electronic equipment. Applies to low-voltage DC power ports of equipment supplied by external rectifier systems, or batteries which are being charged.</p> <p>This standard defines</p> <ul style="list-style-type: none"> ▪ test voltage waveform; ▪ range of test levels; ▪ test generator; ▪ test set-up; ▪ test procedure.
[22]	<p>IEC 61000-4-29 (2000-08)</p>	<p>Establishes a common and reproducible basis for testing electrical and electronic equipment when subjected to</p>

	<p>Electromagnetic compatibility (EMC) – Part 4-29: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations on DC input power port immunity tests</p>	<p>voltage dips, short interruptions or voltage variations on DC power ports.</p> <p>This standard defines:</p> <ul style="list-style-type: none"> ▪ the range of test levels; ▪ the test generator; ▪ the test set-up; ▪ the test procedure.
[23]	<p>IEC 61000-6-1 (2005-03) Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments</p>	<p>Applies to electrical and electronic apparatus intended for use in residential, commercial and light-industrial environments. Immunity requirements in the frequency range 0 Hz to 400 GHz are covered. No tests need to be performed at frequencies where no requirements are specified.</p> <p>This generic EMC immunity standard is applicable if no relevant dedicated product or product-family EMC immunity standard exists.</p> <p>This standard applies to apparatus intended to be directly connected to a low-voltage public mains network or connected to a dedicated DC source which is intended to interface between the apparatus and the low-voltage public mains network. This standard applies also to apparatus which is battery operated or is powered by a non-public, but non-industrial, low-voltage power distribution system if this apparatus is intended to be used in the locations described below.</p> <p>The environments encompassed by this standard are residential, commercial and light-industrial locations, both indoor and outdoor. The following list, although not comprehensive, gives an indication of locations which are included:</p> <ul style="list-style-type: none"> ▪ residential properties, for example houses, apartments; ▪ retail outlets, for example shops, supermarkets; ▪ business premises, for example offices, banks; ▪ areas of public entertainment, for example cinemas, public bars, dance halls; ▪ outdoor locations, for example petrol stations, car parks, amusement and sports centres; ▪ light-industrial locations, for example workshops, laboratories, service centres. <p>Locations which are characterised by being supplied directly at low voltage from the public mains network are considered to be residential, commercial or light-industrial.</p> <p>The immunity requirements have been selected to ensure an</p>

		<p>adequate level of immunity for apparatus at residential, commercial and light-industrial locations. The levels do not, however, cover extreme cases, which may occur at any location, but with an extremely low probability of occurrence. Not all disturbance phenomena have been included for testing purposes in this standard but only those considered as relevant for the equipment covered by this standard. These test requirements represent essential electromagnetic compatibility immunity requirements.</p> <p>Test requirements are specified for each port considered.</p>
[24]	<p>IEC 61000-6-2 (2005-01) Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments</p>	<p>Applies to electrical and electronic apparatus intended for use in industrial environments, as described below. Immunity requirements in the frequency range 0 Hz to 400 GHz are covered. No tests need to be performed at frequencies where no requirements are specified.</p> <p>This generic EMC immunity standard is applicable if no relevant dedicated product or product-family EMC immunity standard exists.</p> <p>This standard applies to apparatus intended to be connected to a power network supplied from a high or medium voltage transformer dedicated to the supply of an installation feeding manufacturing or similar plant, and intended to operate in or in proximity to industrial locations, as described below. This standard applies also to apparatus which is battery operated and intended to be used in industrial locations.</p> <p>The environments encompassed by this standard are industrial, both indoor and outdoor.</p> <p>The immunity requirements have been selected to ensure an adequate level of immunity for apparatus at industrial locations. The levels do not, however, cover extreme cases, which may occur at any location, but with an extremely low probability of occurrence. Not all disturbance phenomena have been included for testing purposes in this standard, but only those considered as relevant for the equipment covered by this standard. These test requirements represent essential electromagnetic compatibility immunity requirements.</p>
[25]	<p>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</p>	<p>ISO 4266-1 gives guidance on the accuracy, installation, commissioning, calibration and verification of automatic level gauges (ALGs), of both intrusive and non-intrusive types, for measuring the level of petroleum and petroleum products having a Reid vapor pressure less than 100 kPa, stored in atmospheric storage tanks.</p> <p>This part of ISO 4266 is not applicable to the measurement of level in refrigerated storage tanks with ALG equipment.</p>
[26]	<p>ISO 4266-2 (2002) Petroleum and liquid</p>	<p>ISO 4266-2 gives guidance on the accuracy, installation, calibration and verification of automatic level gauges (ALGs), both intrusive and non-intrusive, for measuring the</p>

	petroleum products -- Measurement of level and temperature in storage tanks by automatic methods -- Part 2: Measurement of level in marine vessels	level of petroleum and liquid petroleum products having a Reid vapor pressure less than 100 kPa, transported aboard marine vessels (i.e. tankers and barges). ISO 4266-2 gives guidance for buyers and sellers who mutually agree to use marine ALGs for either fiscal and/or custody transfer applications. ISO 4266-2 is not applicable to the measurement of level in refrigerated cargo tanks.
[27]	ISO 4266-3 (2002) Petroleum and liquid petroleum products -- Measurement of level and temperature in storage tanks by automatic methods -- Part 3: Measurement of level in pressurized storage tanks (non-refrigerated)	ISO 4266-3 gives guidance on the accuracy, installation, commissioning, calibration and verification of automatic level gauges (ALGs) both intrusive and non-intrusive, for measuring the level of petroleum and petroleum products having a vapor pressure less than 4 MPa, stored in pressurized storage tanks. ISO 4266-3 gives guidance on the use of ALGs in custody transfer application. ISO 4266-3 is not applicable to the measurement of level in caverns and refrigerated storage tanks with ALG equipment.
[28]	ISO 4266-4 (2002) Petroleum and liquid petroleum products -- Measurement of level and temperature in storage tanks by automatic methods -- Part 4: Measurement of temperature in atmospheric tanks	ISO 4266-4 gives guidance on the selection, accuracy, installation, commissioning, calibration and verification of automatic tank thermometers (ATTs) in fiscal/custody transfer applications in which the ATT is used for measuring the temperature of petroleum and liquid petroleum products having a Reid vapor pressure less than 100 kPa, stored in atmospheric storage tanks. ISO 4266-4 is not applicable to the measurement of temperature in caverns or in refrigerated storage tanks.
[29]	ISO 4266-5 (2002) Petroleum and liquid petroleum products -- Measurement of level and temperature in storage tanks by automatic methods -- Part 5: Measurement of temperature in marine vessels	ISO 4266-5 gives guidance on the selection, accuracy, installation, commissioning, calibration and verification of automatic tank thermometers (ATTs) in fiscal/custody transfer applications in which the ATT is used for measuring the temperature of petroleum and liquid petroleum products having a Reid vapor pressure less than 100 kPa, stored in cargo tanks on board marine vessels. ISO 4266-5 is not applicable to the measurement of temperature in refrigerated storage tanks, or pressurized cargo tanks on board marine vessels.

[30]	ISO 4266-6 (2002) Petroleum and liquid petroleum products -- Measurement of level and temperature in storage tanks by automatic methods -- Part 6: Measurement of temperature in pressurized storage tanks (non-refrigerated)	ISO 4266-6 gives guidance on the selection, accuracy, installation, commissioning, calibration and verification of automatic tank thermometers (ATTs) in fiscal/custody transfer applications in which the ATT is used for measuring the temperature of petroleum and liquid petroleum products stored in pressurized storage tanks. ISO 4266-6 is not applicable to the measurement of temperature in caverns or in refrigerated storage tanks.
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