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Leak detection systems

Part 5: Requirements and test/assessment methods for in-tank gauge systems and pressurised pipework systems

bsi.

National foreword

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European foreword

This document (EN 13160-5:2016) has been prepared by Technical Committee CEN/TC 393 “Equipment for storage tanks and for filling stations”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2017, and conflicting national standards shall be withdrawn at the latest by April 2018.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13160-5:2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

According to EN 13160-5:2004 the following fundamental changes are given:

— Requirement for a device for simulating a leak deleted;

— requirements from EN 13160-1:2003 included, which are no longer contained in EN 13160-1:2016;

— Pressure line leak detection kits included.

This European Standard, *Leak detection systems,* consists of 7 parts:

— *Part 1: General principles*

— *Part 2: Requirements and test/assessment methods for pressure and vacuum systems*

— *Part 3: Requirements and test/assessment methods for liquid systems for tanks*

— *Part 4: Requirements and test/assessment methods for sensor based leak detection systems*

— *Part 5: Requirements and test/assessment methods for in-tank gauge systems and pressurized pipework systems*

— *Part 6: Sensors in monitoring wells*

— *Part 7: Requirements and test/assessment methods for leak detection linings*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard gives requirements and corresponding test\assessment methods applicable to leak detection kits, based on volumetric loss from within the tank and/or pipework system. The kits usually comprise:

— Measuring Device

— Evaluation Device

— Alarm Device

Intended use:

Leak Detection kits are intended to be used in\with single or double skin underground tanks or single or double skin underground and/or aboveground pipework designed for flammable liquids having a flash point not exceeding 100 °C.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 228, *Automotive fuels — Unleaded petrol — Requirements and test methods*

EN 590, *Automotive fuels — Diesel — Requirements and test methods*

EN 976-1, *Underground tanks of glass-reinforced plastics (GRP) — Horizontal cylindrical tanks for the non-pressure storage of liquid petroleum based fuels — Part 1: Requirements and test methods for single wall tanks*

EN 981:1996+A1:2008, *Safety of machinery — System of auditory and visual danger and information signals*

EN 12285-1, *Workshop fabricated steel tanks — Part 1: Horizontal cylindrical single skin and double skin tanks for the underground storage of flammable and non-flammable water polluting liquids*

EN 13160-1:2016, *Leak detection systems — Part 1: General principles*

EN 13160-2, *Leak detection systems — Part 2: Requirements and test/assessment methods for pressure and vacuum systems*

EN 13352:2012, *Specification for the performance of automatic tank contents gauges*

EN 14879-4:2007, *Organic coating systems and linings for protection of industrial apparatus and plants against corrosion caused by aggressive media — Part 4: Linings on metallic components*

EN 60296, *Fluids for electrotechnical applications — Unused mineral insulating oils for transformers and switchgear (IEC 60296)*

EN 60529, *Degrees of protection provided by enclosures (IP Code) (IEC 60529)*

EN 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications (IEC 61672-1)*

ISO 8601, *Data elements and interchange formats — Information interchange — Representation of dates and times*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13160-1:2016 and the following apply.

3.1.1
quantitative output
numerical indication of the leak rate

3.1.2
qualitative output
pass/fail indication for a given test with reference to a specified leak rate

3.2 Symbols and abbreviated terms

B	is the bias
LL	is the lower confidence bound for probability of detection
UL	is the upper confidence bound for probability of detection
MSE	is the mean squared error
PD	is the probability of detection
PFA	is the probability of false alarm
PI (all)	is the proportion of invalid records for all records
PI (leak)	is the proportion of invalid records for leaking tanks
PI (tight)	is the proportion of invalid records for tight tanks
R	is the simulated leak rate
C	is the criterion or threshold for indicating a leak
B	is the estimated bias of the system
SD	is the standard deviation
t_b	is the two-sample *t*-test bias

4 Requirements

4.1 Effectiveness of leak detection kits

4.1.1 General

This type of leak detection kit is classified according to EN 13160-1:2016 as class IV.

The general requirements on leak detection systems according to Clause 5 of EN 13160-1:2016 shall be met.

The measuring device shall fulfil the requirements according to 5.1of EN 13352:2012.

The level to volume conversion methodology shall fulfil the requirements according to Annex B of EN 13352:2012.

A complete documentation shall be provided by the manufacturer. The documentation shall contain the technical values according to 4.1.2 to 4.1.8 and 4.2.

4.1.2 Electrical or signal cable of the measuring device

In the event of disconnection of the electrical or signal cable or malfunction of the measuring device an alarm condition shall result.

4.1.3 Leak detection kit

The leak detection kit shall consist of:

— measuring device;

— evaluation device;

— alarm device.

4.1.4 Measures volumetric loss

4.1.4.1 General

Table 1 — Performance requirements for categories of leak detection

Category	**Type**	**Alarm threshold leak rate** $l \cdot h^{-1}$	**Maximum time of detection** h
A Dynamic leak detection using the comparison of sales data with tank volume changes	Type 2	≥ 0,8	336
	Type 1	≥ 0,4	336
B(1) Static leak detection	Type 2	≥ 0,8	4
	Type 1	≥ 0,4	8
B(2) Statistical quiet period detection	Type 2	≥ 0,8	24
C Pressure line leak detection (catastrophic loss)	Type 3	≥ 12	1
C Pressure line leak detection	Type 2	≥ 0,8	12
C Pressure line leak detection	Type 1	≥ 0,4	12

Any gauge system to be used for category A, B(1) and B(2) of leak detection shall have water detection capability.

The operating condition of the evaluation device shall be clearly indicated, i.e. through the provision of a fault, light or similar indicator.

For categories A and B, the requirements of a gauge control device as defined in EN 13352 shall be met. An alarm shall be activated whenever a leak rate for Type 1 is detected at the specified rate or above, in accordance with Table 1.

Where performance in accordance with Table 1 for category A and category B is not achievable within the required levels of probability, the results shall be reported as inconclusive.

The leak detection kit shall have a device for automatically shut-off the submersible pump in the event of an alarm condition.

4.1.4.2 Category A – Dynamic leak detection

4.1.4.2.1 Type 2

For this type, the system shall communicate with the metering system, associated with the withdrawal of product from the storage tank, in order to receive details of all volumes dispensed from the tank. At the specified leak rate according to Table 1, the system shall have a probability of detection of at least 95 % while a false alarm rate shall not exceed 5 %.

4.1.4.2.2 Type 1

For this type, the system shall communicate with the metering system, associated with the withdrawal of product from the storage tank, in order to receive details of all volumes dispensed from the tank. At the specified leak rate according to Table 1, the system shall have a probability of detection of at least 95 % while a false alarm rate shall not exceed 5 %.

4.1.4.3 Category B (1) – Static leak detection

4.1.4.3.1 Type 2

For this type, the system shall be capable of detecting the specified leak rate according to Table 1 with a probability of at least 95 % while operating at a false alarm rate of 5 % or less.

4.1.4.3.2 Type 1

For this type, the system shall be capable of detecting the specified leak rate according to Table 1 with a probability of at least 95 % while operating at a false alarm rate of 5 % or less.

4.1.4.4 Category B (2) – Statistical quiet period detection – Type 2

For this type, the system shall communicate with the metering system, associated with the withdrawal of product from the storage tank, in order to receive details of all volumes dispensed from the tank. At the specified leak rate according to Table 1, the system shall have a probability of detection of at least 95 % while a false alarm rate shall not exceed 5 %.

4.1.4.5 Category C – Pressure line leak detection – Type 1

For this type, the system shall be capable, when no product is being dispensed of detecting the specified leak rate according to Table 1 with a probability of 99 %.

4.1.4.6 Category C – Pressure line leak detection - Type 2

For this type, the system shall be capable, when no product is being dispensed of detecting the specified leak rate according to Table 1 with a probability of 99 %.

4.1.4.7 Category C – Pressure line leak detection - Type 3

For this type, the system shall be capable, when no product is being dispensed of detecting the specified leak rate according to Table 1 with a probability of99 %.

4.1.5 Requirements for software

The software, where provided, shall have a facility for self-checking by fulfilling the following requirements:

— a self-diagnostic mode to test the integrity of the system at start up and periodically during use. A negative result of self-diagnostic mode shall result in an alarm condition;

— a facility to check the consistency of the input and output data, malfunction shall result in an alarm condition.

The software shall also provide an algorithmic determination of volumetric loss.

4.1.6 Mechanical construction

Ingress protection for the measuring device shall be at least IP 68 according to EN 60529.

4.1.7 Effects of thermal contraction

The evaluation device for category C shall feature a provision to filter the effects of expansion\contraction resulting from thermal volume change of the fluid and associated vessels and pipework systems.

4.1.8 Alarm device

The alarm device shall generate an audible and visible alarm. The audible alarm shall have a sound level of ≥ 70 dB (A) in a distance of minimum 1 m with a signal according to Table 1 of EN 981:1996+A1:2008 which shall be maintained for a minimum period of 36 h. The audible alarm may be able to be switched off, but the status off should be visible.

The visible alarm shall be clearly indicated. The visible alarm shall have no switch off option.

The alarm device should be designed for connecting an additional alarm device, e.g. signal horn. The output parameter shall be stated.

A test possibility shall be provided to test the functionality of the audible and visible alarm.

4.2 Durability of effectiveness

4.2.1 Durability of effectiveness against temperature

The components of a leak detection system shall meet the requirement as given in EN 13352.

4.2.2 Durability of effectiveness against chemical attack

Parts of leak detection kits which can come into contact with the stored liquid/water or its vapour shall be resistant.

4.2.3 Durability of effectiveness against hydraulic shock (only for measuring devices used on pressurized line)

The measuring devices shall withstand a transient pressure not less than 1,4 MPa.

4.2.4 Durability of effectiveness against fatigue and mechanical wear\degradation, (only for measuring devices used on pressurized line)

At a temperature of (20 ± 5) °C the measuring device shall continue to operate according to Table 1, Category C after 50 000 cycles at a pressure range from 0 kPa to 350 kPa.

4.2.5 Durability of effectiveness against microbiological growth on critical surfaces involved in the measurement process

Microbiological growth is generated based on the presence of water. To minimize the effect of microbial growth on the measurement process a means of detecting water shall be provided.

5 Testing, assessment and sampling methods

5.1 Effectiveness of leak detection kits

5.1.1 General

For the tests the following documentation shall be provided by the manufacturer:

— manual(s);

— datasheet of the parts of the leak detection kit;

— electrical diagrams of the parts of the leak detection kit;

— design and application drawings;

— parts lists of the used components including material data;

— and shall be inspected visually.

5.1.2 Disconnection of the electrical or signal cable of the measuring device

The measuring device shall be disconnected.

The disconnection of the measuring device shall result in an alarm.

5.1.3 Leak detection kit

Visual test shall be carried out that the leak detection kit consists of measuring device, evaluation device, alarm device and shut-off device for the submersible pump.

5.1.4 Measures volumetric loss

5.1.4.1 General

The test shall be carried out at a temperature of (20 ± 5) °C.

The test liquid shall be diesel according to EN 590 or transformer oil according to EN 60296.

5.1.4.2 Category A - Dynamic leak detection

5.1.4.2.1 Type 2

5.1.4.2.1.1 Test equipment

The manufacturer shall supply the algorithmic method representative of the system under test in the form of software loaded onto a computer which is capable of reading in and processing files from the standard test database previously collected from representative locations. These files shall be provided in a standard format according to Annex A and shall be accepted without any pre-processing.

The manufacturer shall state the initialization period required for the system under test, which shall not exceed 28 days.

A computer and associated data transfer peripherals.

Dispenser with digital data connection to transmit the volume withdrawn from the storage tank

5.1.4.2.1.2 Preparation

In each case, tests shall be performed following an initialization period equivalent to a maximum of 28 days operation, during which the system under test processes normal operational data without induced leaks.

A set of files shall be selected from the standard database, according to the details given in A.1.

For each type of draw-off system and fuel, the files selected shall meet the following conditions:

For each of the draw-off methods and each fuel listed in A.1, between 25 % and 75 % of the data files selected should be taken from tanks where that type of draw-off system or fuel is in use. The same data file may cover two or more uses, for example a manifolded tank using pressurized draw-off via multiple dispensers.

Leak detection systems to be tested will provide a quantitative or a qualitative output. A qualitative output will indicate a pass/fail result in accordance with Table 1.

The minimum sample sizes for data files, which shall be collected for each of these types, are:

— Systems with a Quantitative Output: ≥ 100 files (not more than 15 from the same tank);

— Systems with a Qualitative Output: ≥ 240 files (not more than 36 from the same tank).The database files shall be sorted to form an ordered data set which is divided into 5 equal groups according to the 20th, 40th, 60th and 80th percentiles of the recorded range of shade temperature. Each of the five groups shall be further divided into 3 equal sub-groups, according to the 33rd and 67th percentiles of the recorded range of tank sizes, such that sub-groupings are determined independently for each of the five groups.

For systems with a quantitative output, three files shall be selected at random from each of the 15 sub-sets, to provide a sample of 45 files for subsequent evaluation.

For systems with a qualitative output, eight files shall be selected at random from each of the 15 sub-sets, to provide a sample of 120 files for subsequent evaluation.

For example, for data collected over the ranges of shade temperature and tank capacity as defined in A.1, the files would be sorted as shown in Table 2, and *n* files selected from each sub-set as shown, where *n* = 3 for a quantitative system and *n* = 8 for a qualitative system:

Table 2 — Selection of data files according to tank capacity and ambient temperature during collection of the data

Tank Capacity	**Shade Temperature**				
	-5 °C to 20th Percentile	**20th to 40th Percentile**	**40th to 60th Percentile**	**60th to 80th Percentile**	**80th Percen-tile to 30 °C**
10 000 l to 33rd Percentile	Select *n* files at random	Select *n* files at random	Select *n* files at random	Select *n* files at random	Select *n* files at random
33rd to 67th Percentile	Select *n* files at random	Select *n* files at random	Select *n* files at random	Select *n* files at random	Select *n* files at random
67th Percentile to 50 000 l	Select *n* files at random	Select *n* files at random	Select *n* files at random	Select *n* files at random	Select *n* files at random

5.1.4.2.1.3 Procedure

A software tool shall be provided to simulate the following:

Tank leaks (constant)

Leaks from tanks are simulated as a continuous loss of product from the tank at a constant leak rate. The figure in a record representing the volume of stored product is reduced by a value equivalent to the quantity of product that would be lost at the specified rate during the time period between the record and its predecessor. The simulated losses for all previous time periods are accumulated and the total subtracted from the figure representing stored volume. These accumulated losses are also carried forward through each delivery event such that the subtracted figure increases monotonous.

Therefore, the volume figure, v_i, of the *i*th record is replaced by v_i', calculated according to Formula (1):

$$v'_i = v_i - \sum_{j=1}^{i} \left(t_j - t_{j-1} \right) R \qquad (1)$$

where

R = simulated leak rate in litre per hour;

t_j = time stamp of *j*th record;

t_{j-1} = time stamp of predecessor to *j*th record.

Where tanks are connected via a siphon, the quantity of product corresponding to the leak over the specified time interval is divided by the number of tanks in the siphon arrangement and this quantity subtracted from the records for each of the tanks connected via the siphon.

Tank leaks (variable)

Leaks from tanks are simulated as a continuous loss of product from the tank at a variable leak rate which reduces as the quantity of stored product is reduced. The figure in a record representing the volume of stored product is reduced by a value equivalent to the quantity of product which would be lost at a rate specified for the time period between the record and its predecessor. The records in a file are divided into sets, each of which comprises all the records between one delivery and the next. Successive records in a set therefore always exhibit a decrease in stored volume. Where there are n records in a set, and the stored volume of the *j*th record is v_j, the leak rate r_j for that record is found as a function of the nominal leak rate to be simulated R, according to Formula (2):

$$r_j = \frac{n \sqrt{v_j}}{\sum_{k=1}^{n} \sqrt{v_k}} R \qquad (2)$$

Therefore, the volume figure, v_i, of the *i*th record is replaced by v_i', calculated according to Formula (3):

$$v'_i = v_i - \sum_{j=1}^{i} \left(t_j - t_{j-1} \right) r_j \qquad (3)$$

The simulated losses for prior periods are accumulated and similarly subtracted from the figure representing stored volume. These accumulated losses are also carried forward through each delivery event such that the subtracted figure increases monotonous.

Where tanks are connected via a siphon, the quantity of product corresponding to the leak over the specified time interval is divided by the number of tanks in the siphon arrangement and this quantity subtracted from the records for each of the tanks connected via the siphon.

Pipe leaks (suction and pressurized draw-off)

Leaks from draw-off pipes are simulated as a loss of product from the pipe at a constant leak rate but only while dispensers are idle and the pipe is pressurized where applicable. Each data file is first processed to accumulate the total time that fuel is being drawn from the pipe. The total volume of product which would be lost over the period(T) covered by data set within the file at a constant leak rate, R, is calculated and divided by the total dispensing time to give a leak rate, R', during dispensing, see Formula (4):

$$R' = \frac{R \cdot T}{\sum_{j=1}^{n}(te_j - ts_j)} \quad (4)$$

where

t_{ej} = end time of the jth dispensing transaction;

t_{sj} = start time of the jth dispensing transaction;

n = total number of dispensing transactions in the file;

T = elapsed time from start to end of file in minutes.

The figure in a record representing the volume of stored product is reduced by a value equivalent to the quantity of product which would be lost at the rate R' during the time period between the record and its predecessor, but only when a dispenser was drawing fuel during that period. The simulated losses for all previous time periods are accumulated and the total subtracted from the figure representing stored volume in this and all subsequent records (including periods where no fuel is drawn from the tank). These accumulated losses are also carried forward over each delivery event such that the subtracted figure increases monotonous.

Therefore, the volume figure, v_i, of the ith record is replaced by v_i', calculated according to Formula (5):

$$v'_i = v_i - \sum_{j=1}^{m}\left(te_j - ts_j \right) R' \quad (5)$$

Where

m number of dispensing transactions whose end time is earlier than the time stamp of the ith record.

Where tanks are connected via a manifold arrangement, the quantity of product corresponding to the leak over the specified time interval is divided by the number of tanks connected to the manifold and this quantity subtracted from the records for each of the tanks so connected

5.1.4.2.1.4 Evaluation

Tests has to be passed if a leak rate of 0,8 $l \cdot h^{-1}$ is detected within 336 h with a probability of detection not less than 95 % and a probability of false alarms not greater than 5 %.

5.1.4.2.2 Type 1

5.1.4.2.2.1 Test equipment

According to 5.1.4.2.1.1

5.1.4.2.2.2 Preparation

According to 5.1.4.2.1.2

5.1.4.2.2.3 Procedure

According to 5.1.4.2.1.3

5.1.4.2.2.4 Evaluation

Tests has to be passed if a leak rate of 0,4 $l \cdot h^{-1}$ is detected within 336 h with a probability of detection not less than 95 % and a probability of false alarms not greater than 5 %.

5.1.4.3 Category B(1) – Static leak detection

5.1.4.3.1 Type 2

5.1.4.3.1.1 Test equipment

— A double wall storage tank with a size and shape that represents the applicable circumstances of usage, according to EN 12285-1 or EN 976-1 of minimum capacity 30 000 l installed underground or that is constructed such that the tank used for test is surrounded with a material having a specific heat capacity of between 0,80 kJ kg^{-1} K^{-1} and 1,48 kJ kg^{-1} K^{-1}.

— The tank shall be fitted with an independent leak detection system according to EN 13160-2 for Class I to prove tightness during test.

— A suitable apparatus fitted to the test tank for the continuous monitoring of product temperature i.e. a temperature measurement device with an accuracy of 1 K. The device consists of a vertical array of temperature sensors over the height of the test tank with a spacing of (300 ± 10) mm between the temperature sensors.

— A second tank (e.g. an above- or underground tank or a tanker truck) having a minimum nominal tank capacity of 15 000 l, together with a pump and suitable hoses for transferring product to and from the test tank.

— A heat exchanger or other suitable heating device capable of heating and cooling the test fluid by ± 5 K, within an uncertainly of ± 1 K, before it is transferred into the test tank.

— A variable-rate peristaltic or other suitable pump capable of withdrawing liquid from the test tank at present rates between 0,2 $l \cdot h^{-1}$ and 0,8 $l \cdot h^{-1}$ within an accuracy of 0,25 %.

— A time measuring device having a time indication in steps of 1 s to a minimum total of 24 h, within an accuracy of ± 1 s.

— Barometric pressure and atmospheric temperature measuring equipment suitable for continuous monitoring of environmental conditions in the areas of the test facility where components of the system under test are installed.

5.1.4.3.1.2 Preparation

The liquid surface in the tank shall be stabilized for a time given by the manufacturer after the last filling and after the last removal from the tank which ever happens later.

5.1.4.3.1.3 Procedure

a) The device which can create a constant leak rate e.g. peristaltic pump, shall create a leak rate of 0,9 l h^{-1} ± 2 %. The measurement shall be carried out according to within the maximum time of detection of Table 1.

b) The device which can create a constant leak rate e.g. peristaltic pump, shall create a leak rate of 0,7 l h^{-1} ± 2 %. The measurement shall be carried out according to within the maximum time of detection of Table 1.

5.1.4.3.1.4 Evaluation

The system has passed the test a) in 5.1.4.3.1.3 if an alarm has been generated within the maximum time of detection according to Table 1.

After the system has generated an alarm the test can be stopped.

The system has passed the test b) in 5.1.4.3.1.3 if no alarm has been generated within the maximum time of detection according to Table 1.

NOTE For more information see Annex C.

5.1.4.3.2 Type 1

5.1.4.3.2.1 Test equipment

According to 5.1.4.3.1.1.

5.1.4.3.2.2 Preparation

According to 5.1.4.3.1.2.

5.1.4.3.2.3 Procedure

a) The device which can create a constant leak rate e.g. peristaltic pump, shall create a leak rate of 0,5 l h^{-1} ± 2 %. The measurement shall be carried out according to within the maximum time of detection of Table 1.

b) The device which can create a constant leak rate e.g. peristaltic pump, shall create a leak rate of 0,3 l h^{-1} ± 2 %. The measurement shall be carried out according to within the maximum time of detection of Table 1.

5.1.4.3.2.4 Evaluation

The system has passed the test a) in 5.1.4.3.2.3 if an alarm has been generated within the maximum time of detection according to Table 1. After the system has generated an alarm the test can be stopped.

The system has passed the test b) in 5.1.4.3.2.3 if no alarm has been generated within the maximum time of detection according to Table 1.

5.1.4.4 Category B(2) – Statistical quiet period detection

5.1.4.4.1 Type 2

5.1.4.4.1.1 Test equipment

The manufacturer shall supply the algorithmic method representative of the system under test in the form of software loaded onto a computer which is capable of reading in and processing files from the standard test database previously collected from representative locations. These files shall be provided in a standard format according to Annex B and shall be accepted without any pre-processing.

The manufacturer shall state the initialization period required for the system under test, which shall not exceed 28 days.

A computer and associated data transfer peripherals.

5.1.4.4.1.2 Preparation

In each case, tests shall be performed following an initialization period equivalent to a maximum of 28 days operation, during which the system under test processes normal operational data without induced leaks.

A set of files shall be selected from the standard database, according to the details given in Annex B.

For each type of draw-off system and fuel, the files selected shall meet the following conditions:

For each of the draw-off methods and each fuel listed in Annex B, between 25 % and 75 % of the data files selected should be taken from tanks where that type of draw-off system or fuel is in use. The same data file may cover two or more uses, for example a manifolded tank using pressurized draw-off via multiple dispensers.

Leak detection systems to be tested will provide a quantitative or a qualitative output. A qualitative output will indicate a pass/fail result in accordance with Table 1.

The minimum sample sizes for data files, which shall be collected for each of these types, are:

— Systems with a Quantitative Output: ≥ 100 files (not more than 15 from the same tank);

— Systems with a Qualitative Output: ≥ 240 files (not more than 36 from the same tank).The database files shall be sorted to form an ordered data set which is divided into 5 equal groups according to the 20th, 40th, 60th and 80th percentiles of the recorded range of shade temperature. Each of the five groups shall be further divided into 3 equal sub-groups, according to the 33rd and 67th percentiles of the recorded range of tank sizes, such that sub-groupings are determined independently for each of the five groups.

For systems with a quantitative output, three files shall be selected at random from each of the 15 sub-sets, to provide a sample of 45 files for subsequent evaluation.

For systems with a qualitative output, eight files shall be selected at random from each of the 15 sub-sets, to provide a sample of 120 files for subsequent evaluation.

For example, for data collected over the ranges of shade temperature and tank capacity as defined in Annex B, the files would be sorted as shown in Table 2, and *n* files selected from each sub-set as shown, where *n* = 3 for a quantitative system and *n* = 8 for a qualitative system:

5.1.4.4.1.3 Procedure

A software tool shall be provided to simulate the following.

Tank leaks (constant)

Leaks from tanks are simulated as a continuous loss of product from the tank at a constant leak rate. The figure in a record representing the volume of stored product is reduced by a value equivalent to the quantity of product that would be lost at the specified rate during the time period between the record and its predecessor. The simulated losses for all previous time periods are accumulated and the total subtracted from the figure representing stored volume. These accumulated losses are also carried forward through each delivery event such that the subtracted figure increases monotonous.

Therefore, the volume figure, v_i, of the *i*th record is replaced by v_i', calculated according to Formula (6):

$$v'_i = v_i - \sum_{j=1}^{i} \left(t_j - t_{j-1} \right) R \qquad (6)$$

where

R = simulated leak rate;

t_j = time stamp of *j*th record;

t_{j-1} = time stamp of predecessor to *j*th record.

Where tanks are connected via a siphon, the quantity of product corresponding to the leak over the specified time interval is divided by the number of tanks in the siphon arrangement and this quantity subtracted from the records for each of the tanks connected via the siphon.

Tank leaks (variable)

Leaks from tanks are simulated as a continuous loss of product from the tank at a variable leak rate which reduces as the quantity of stored product is reduced. The figure in a record representing the volume of stored product is reduced by a value equivalent to the quantity of product which would be lost at a rate specified for the time period between the record and its predecessor. The records in a file are divided into sets, each of which comprises all the records between one delivery and the next. Successive records in a set therefore always exhibit a decrease in stored volume. Where there are n records in a set, and the stored volume of the *j*th record is v_j, the leak rate r_j for that record is found as a function of the nominal leak rate to be simulated R, according to Formula (7):

$$r_j = \frac{n\sqrt{v_j}}{\sum_{k=1}^{n}\sqrt{v_k}} R \qquad (7)$$

Therefore, the volume figure, v_i, of the *i*th record is replaced by v_i', calculated according to Formula (8):

$$v'_i = v_i - \sum_{j=1}^{i}\left(t_j - t_{j-1}\right) r_j \qquad (8)$$

The simulated losses for prior periods are accumulated and similarly subtracted from the figure representing stored volume. These accumulated losses are also carried forward through each delivery event such that the subtracted figure increases monotonous.

Where tanks are connected via a siphon, the quantity of product corresponding to the leak over the specified time interval is divided by the number of tanks in the siphon arrangement and this quantity subtracted from the records for each of the tanks connected via the siphon.

5.1.4.4.1.4 Evaluation

Tests has to be passed if a leak rate of 0,8 $l \cdot h^{-1}$ is detected within 24 h with a probability of detection not less than 95 % and a probability of false alarms not greater than 5 %.

NOTE For more information see Annex B.

5.1.4.5 Category C – Pressure line leak detection

5.1.4.5.1 Test Equipment

— Storage tank with heating and cooling facility;

— three manual valves;

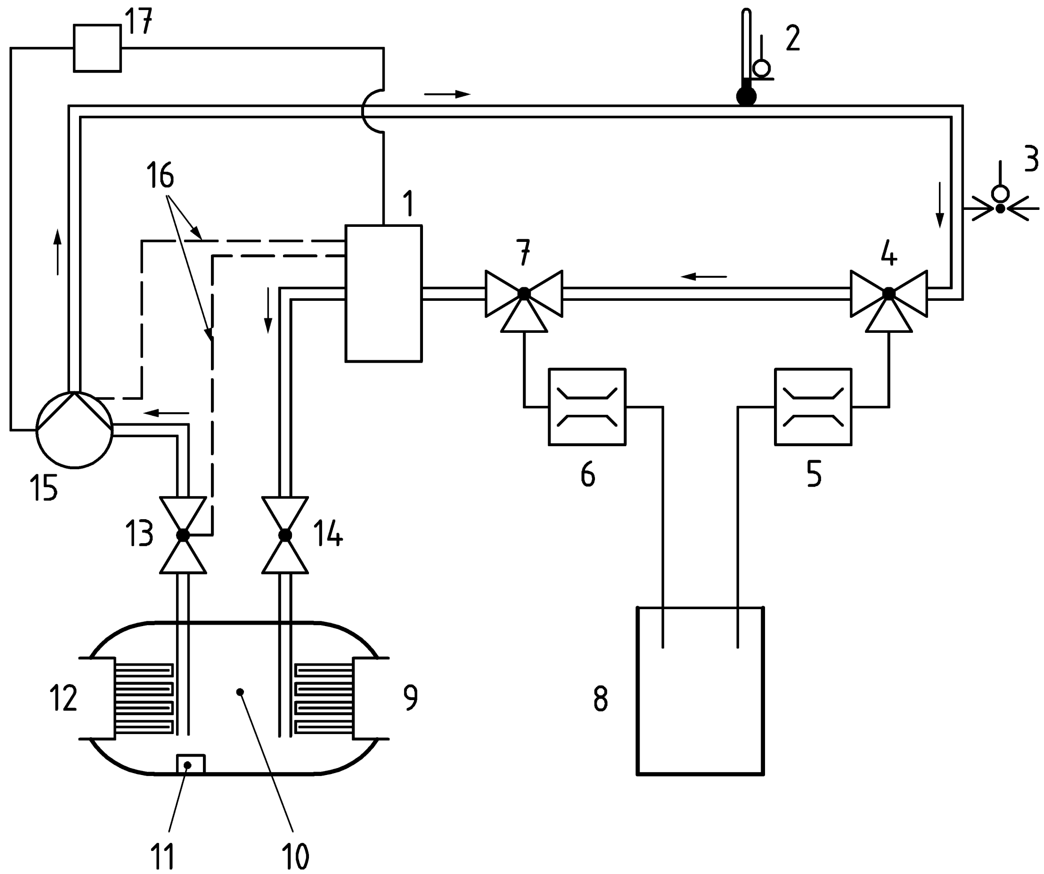
— one solenoid valve;

- circulation pump;
- temperature sensors with an accuracy of ± 0,1 K;
- pressure sensor with an accuracy of ± 1,0 kPa;
- flow meter with full scale of 1 l h^{-1};
- flow meter with full scale of 30 l h^{-1};
- graduated cylinder for 20 ml;
- graduated cylinder for 250 ml;
- collecting facility of at least 20 l;
- pipework with a length of (22 ± 1) m ;
- pipe diameter (50 ± 2) mm;
- test fluid, diesel according to EN 590.

The test apparatus shall be designed in such a way as to avoid the possibility of trapped vapour.

5.1.4.5.2 Preparation

The test apparatus shown in Figure 1 shall be used for the test.



Key

1	line leak detector	10	storage tank
2	temperature sensor	11	temperature sensor
3	pressure sensor	12	heating source
4	valve	13	solenoid valve
5	flow meter	14	valve
6	flow meter	15	circulation pump
7	valve	16	control lines
8	collecting facility	17	command relay of the circulation pump
9	cooling source		

Figure 1 — Test set-up for pressure line leak detection

5.1.4.5.3 Procedure

A series of test according to Table 2 shall be carried out and shall be evaluated according to Table 3.

The solenoid valve (13) and valve (14) shall be opened and the circulation pump shall be started.

Flow meter (5) and valve (6) shall be used for generation of the leak rates according to Table 2. For the adjustment of these leak rates the graduated cylinder of 20 ml shall be used to measure the volume of leak over a time of (60 ± 1) s. When the requested leak rate according to Table 2 is achieved the circular pump (15) shall be stopped and all valves shall be closed.

Then the test fluid in the storage tank shall be heated or cooled to the temperature according to Table 2.

Solenoid valve (13) and valve (14) shall be opened when the requested temperature has been reached.

The circulation pump (15) shall be switched on and shall be run for (60 ± 1) min. Valve (14) and solenoid valve (13) shall be closed considering that valve (13) shall be closed first. Then the circulation pump (15) shall be switched off.

At this point the line leak detector test starts. Valve (4) shall be reopened. During the maximum 24 h test period according to Table 1 the line leak detector (1) shall report correct pass/fail criteria according to Table 3.

During the test period the circulation pump (15) and valve (13) shall be under the control of the line leak detector (1).

Flow meter (6) and valve (7) shall be used for generation of the leak rates according to Table 3.

The circulation pump (15) shall provide a constant pressure of (210,0 ± 10,0) kPa under all leak rate conditions.

The temperature in the storage tank shall be brought to temperatures according to Table 2 by the heating or cooling source. This temperature shall be set at an accuracy of ± 1 K.

Provide that the pipework used for test is surrounded with a material having a specific heat capacity of between 0,80 kJ kg^{-1} K^{-1} and 1,48 kJ kg^{-1} K^{-1}.

5.1.4.5.4 Evaluation

The alarm device shall react according to the pass and fail conditions given in Table 3 for Type 1, Type 2 and Type 3 and the maximum time of detection according to Table 1 and the circulation pump shall be shut-off when a leak is detected.

Table 3 — Result at indicated leak rate

Test run	Temperature range	Result at indicated leak rate $l\ h^{-1}$															
1	ΔT ≤ - 14 K	Indicated Leak Rate	0,9	0,3	0,0	11,0	13,0										
		Test Threshold	0,8	0,4	0,4	12,0	12,0										
		Pass/Fail Indication	**FAIL**	**PASS**	**PASS**	**PASS**	**FAIL**										
2	[- 14 K < ΔT ≤ −8 K]	Indicated Leak Rate	0,8	0,3	0,0	0,9	0,3	0,7	0,3	0,7	0,3	0,0	11,0	13,0			
		Test Threshold	0,8	0,4	0,4	0,8	0,4	0,8	0,4	0,8	0,4	0,4	12,0	12,0			
		Pass/Fail Indication	**FAIL**	**PASS**	**PASS**	**FAIL**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**FAIL**			
3	[- 8 K < ΔT ≤ −3 K]	Indicated Leak Rate	0,9	0,4	0,0	0,8	0,3	0,3	0,9	0,3	0,7	0,3	0,7	0,3	0,0	11,0	13,0
		Test Threshold	0,8	0,4	0,4	0,8	0,4	0,4	0,4	0,4	0,8	0,4	0,8	0,4	0,4	12,0	12,0
		Pass/Fail Indication	**FAIL**	**FAIL**	**PASS**	**FAIL**	**PASS**	**PASS**	**FAIL**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**FAIL**

Test run	**Temperature range**	**Result at indicated leak rate l h⁻¹**															
4	[- 3 K < ΔT ≤ 3 K]	Indicated Leak Rate	0,9	0,4	0,0	0,8	0,3	0,3	0,9	0,3	0,7	0,3	0,7	0,3	0,0	11,0	13,0
		Test Threshold	0,8	0,4	0,4	0,8	0,4	0,8	0,4	0,4	0,8	0,4	0,8	0,4	0,4	12,0	12,0
		Pass/Fail Indication	**FAIL**	**FAIL**	**PASS**	**FAIL**	**PASS**	**PASS**	**FAIL**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**FAIL**
5	[3 K < ΔT ≤ 8 K]	Indicated Leak Rate	0,9	0,4	0,0	0,8	0,3	0,3	0,9	0,3	0,7	0,3	0,7	0,3	0,0	11,0	13,0
		Test Threshold	0,8	0,4	0,4	0,8	0,4	0,8	0,4	0,8	0,4	0,4	0,8	0,4	0,4	12,0	12,0
		Pass/Fail Indication	**FAIL**	**FAIL**	**PASS**	**FAIL**	**PASS**	**PASS**	**FAIL**	**PASS**	**FAIL**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**FAIL**
6	[8K < ΔT ≤ 14K]	Indicated Leak Rate	0,8	0,3	0,0	0,9	0,3	0,7	0,3	0,7	0,3	0,0	11,0	13,0			
		Test Threshold	0,8	0,4	0,4	0,8	0,4	0,8	0,4	0,8	0,4	0,4	12,0	12,0			
		Pass/Fail Indication	**FAIL**	**PASS**	**PASS**	**FAIL**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**FAIL**			

Test run	**Temperature range**	**Result at indicated leak rate l h^{-1}**															
7	ΔT > 14K]	Indicated Leak Rate	0,9	0,3	0,0	11,0	13,0										
		Test Threshold	0,8	0,4	0,4	12,0	12,0										
		Pass/Fail Indication	**FAIL**	**PASS**	**PASS**	**PASS**	**FAIL**										

5.1.5 Software

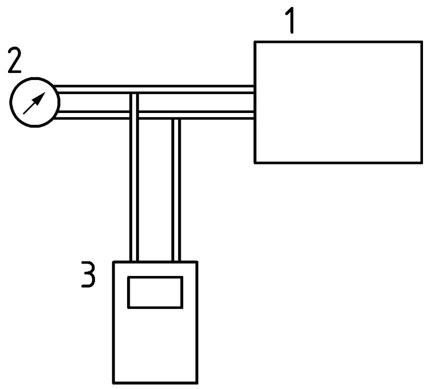
5.1.5.1 Test equipment

— Transformer (variable power supply);

— Measuring device for current/voltage.

5.1.5.2 Preparation

Test set-up according to Figure 2.



Key

1 test sample

2 variable power supply

3 measuring device

Figure 2 — Test set-up for software

The power supply is done over a transformer to vary the power supply.

5.1.5.3 Test method

The test shall be carried out at (20 ± 5) °C.

— Check of the software documentation whether and for which situations the self-diagnostic is defined. Followed by a check on the hardware.

— The input data are modified and in the result shall be an alarm/error message. This alarm condition shall be different from the alarm coming out of the intended use.

5.1.5.4 Evaluation

The test deemed to have been passed if the software

— provides an alarm condition in case of a negative result of self-diagnostic mode;

— has a facility to check the consistency of the input and output data, malfunction shall result in an alarm condition.

5.1.6 Mechanical construction

Measuring device shall be tested according to EN 60529.

5.1.7 Effects of thermal contraction

According to 5.1.4.5.3.

5.1.8 Alarm Device

5.1.8.1 Test equipment

— A solid and reverberant wall, having a surface area of ≥ 1 m^2 and weighs at least 200 kg m^{-2}. The absorption coefficient for sound shall be ≤ 0,05;

— sound level meter class 2 according to EN 61672-1;

— the continuous sound level of the surrounding shall be < 60 dB (A).

5.1.8.2 Preparation

For the purpose of this test the leak detector with the signal device shall be mounted with the fastening device supplied by the manufacturer to a solid and reverberant wall.

5.1.8.3 Test method

The audible signal device shall be sounded continuously for at least 36 h in a fatigue test. On completion of the fatigue test the sound level shall be measured. The arithmetic mean shall be taken from at least three measuring points.

These measuring points shall be located approximately equidistant on a hemisphere extending over the leak detector front. The radius of the hemisphere shall be r = 1 m. The outer measuring points are to be chosen such that the radius describes an angle of 45° referred to the leak detector or indicator front at these points.

5.1.8.4 Evaluation

The test will be deemed to have been passed if the measured value for the continuous sound level is ≥ 70 dB (A) after the fatigue test.

5.2 Durability of Effectiveness

5.2.1 Durability of effectiveness against temperature

According to EN 13352:2012**,** Clause 9**.**

5.2.2 Durability of effectiveness against chemical attack

5.2.2.1 Category A and category B

According to EN 13352:2012**,** Annex E**.**

5.2.2.2 Category C

5.2.2.2.1 Test equipment

— Stored product or the following test liquids:

a) For unleaded petrol: According to EN 228

   1) with maximum 5 % ethanol

      47,5 % (V/V) toluene,

30,4 % (V/V) isooctane (2,2,4-trimethylpentane)

17,1 % (V/V) n-heptane

%3,0 % (V/V) methanol

2,0 % (V/V) butanol

2) with > 5 % (V/V) and ≤ 20 % (V/V) ethanol

20 % (V/V) ethanol

37,7 % (V/V) toluene

24,2 % (V/V) isooctane (2,2,4- trimethylpentane)

13,5 % (V/V) n-heptane

3 % (V/V) methanol

1,6 % (V/V) butanol

The tolerance for the component of the test liquid shall be 0,1 %.

b) for other petroleum products: liquids according to EN 14879-4:2007, Annex C.

5.2.2.2.2 Preparation

The parts of the leak detection kit, which are exposed to the vapour and/or the liquid, shall be identified.

If EN 12285-1 is applicable, the parts of the leak detection kit, which are exposed to the vapour or the liquid may not be tested and the listed materials apply.

5.2.2.2.3 Procedure

— The tests shall be carried out at a temperature of (20 ± 5) °C.

— The parts of the leak detection kit, which are exposed to the vapour or the liquid, shall be complete immersed into the test liquid for 4 weeks. Then an exposition into the saturated vapour over the test liquid for another 4 weeks shall follow.

— After the test duration the parts of the leak detection kit shall be cleaned and dried. The parts shall be checked for damage. Where necessary demounted components shall be reassembled so that the functionality and tightness can be tested.

5.2.2.2.4 Evaluation

The test deemed to have been passed if:

1) the material is in the durability list of the EN 12285-1;

2) no visible failure or deformation after the storage in the test liquid and vapour and the functionality according to 5.1.4.5.2 are given.

5.2.3 Durability of effectiveness against hydraulic shock (only for measuring devices used on pressurized line)

The equipment shall have a certificate for at least PN 16.

5.2.4 Durability of effectiveness against fatigue and mechanical wear\degradation, (only for measuring devices used on pressurized line)

5.2.4.1 Test Equipment

1) Containment system capable of withstanding 500 kPa of pressure and to allow installation of the pressure sensor.
2) Liquid pump supplying sufficient liquid to the containment system under adequate pressure.
3) Pressure indicator reading max 800 kPa.
4) Bleed-off system to allow release of pressure.
5) Programmable cycle generator to automatically generate the needed number of cycles.
6) Sufficient amount of test liquid. As test liquid diesel fuel can be used according EN 590.

The test equipment shall be installed according to Figure 1.

5.2.4.2 Preparation

— Read the manual of the cycle generator to get acquainted with the programming of the load cycles.

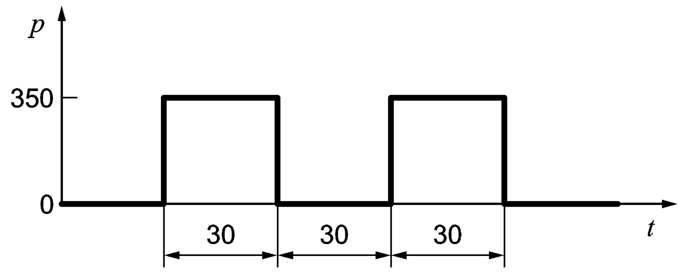
— Install the sensor in the containment system.

— Connect the lines of the liquid pump system to the containment system.

— Fill the system with test liquid.

5.2.4.3 Procedure

Program the cycle generator to run the needs amount of cycles as shown below. One cycle consists of 1 min.



Key

p pressure in kPa

t time in s

Figure 3 — Cycles

The pressure shall be brought up to the maximum pressure to 350 kPa (3,5 bar) the pressure then released.

The device shall be subjected to 50 000 cycles using this test.

5.2.4.4 Evaluation

On completion the sensor device is tested to make sure it still operates within its stated design performance as stated in Table 1, category C.

5.2.5 Durability of effectiveness against microbiological growth on critical surfaces involved in the measurement process

According to EN 13352:2012, Clause 10.

6 Assessment and verification of constancy of performance — AVCP

6.1 General

The compliance of leak detection systems based on in-tank gauge systems and pressurized pipework systems with this standard and with the performances declared by the manufacturer in the DoP shall be demonstrated by:

— determination of the product type;

— factory production control by the manufacturer, including product assessment.

The manufacturer shall always retain the overall control and shall have the necessary means to take responsibility for the conformity of the product with its declared performance(s).

6.2 Type testing

6.2.1 General

All performances related to characteristics included in this standard shall be determined when the manufacturer intends to declare the respective performances unless the standard gives provisions for declaring them without performing tests. (e.g. use of previously existing data, CWFT and conventionally accepted performance).

Assessment previously performed in accordance with the provisions of this standard, may be taken into account provided that they were made to the same or a more rigorous test method, under the same AVCP system on the same product or products of similar design, construction and functionality, such that the results are applicable to the product in question.

For the purposes of assessment, the manufacturer's products may be grouped into families, where it is considered that the results for one or more characteristics from any one product within the family are representative for that same characteristics for all products within that same family.

NOTE Products may be grouped in different families for different characteristics.

Reference to the assessment method standards should be made to allow the selection of a suitable representative sample.

In addition, the determination of the product type shall be performed for all characteristics included in the standard for which the manufacturer declares the performance:

— at the beginning of the production of a new or modified leak detection systems based on in-tank gauge system and pressurized pipework system (unless a member of the same product range), or

— at the beginning of a new or modified method of production (where this may affect the stated properties), or

— they shall be repeated for the appropriate characteristic(s), whenever a change occurs in the leak detection systems based on in-tank gauge system and pressurized pipework system design, in the raw material or in the supplier of the components, or in the method of production (subject to the definition of a family), which would affect significantly one or more of the characteristics.

Where components are used whose characteristics have already been determined, by the component manufacturer, on the basis of assessment methods of other product standards, these characteristics need not be re-assessed. The specifications of these components shall be documented.

Products bearing regulatory marking in accordance with appropriate harmonized European specifications may be presumed to have the performances declared in the DoP, although this does not replace the responsibility on the leak detection systems based on in-tank gauge system and pressurized pipework system manufacturer to ensure that the leak detection systems based on in-tank gauge system and pressurized pipework system as a whole is correctly manufactured and its component products have the declared performance values.

6.2.2 Test samples, testing and compliance criteria

The number of samples of leak detection systems based on an in-tank gauge system and pressurized pipework system to be tested/assessed shall be in accordance with Table 4.

Table 4 — Number of samples to be tested and compliance criteria

Characteristic	Requirement	Assessment method	No. of samples	Compliance criteria
Effectiveness				
— Measuring the volumetric loss;	4.1.4	5.1.4	1	Table 1
— software ;	4.1.5	5.1.5	1	4.1.5
— alarm device	4.1.8	5.1.8	1	4.1.8
Durability of effectiveness				
— against temperature;	4.2.1	5.2.1	1	4.2.1
— against chemical attack;	4.2.2	5.2.2	1	4.2.2
— against hydraulic shock; (only for measuring devices used on pressurized line)	4.2.3	5.2.3	1	4.2.3
— against fatigue and mechanical wear\degradation, (only for measuring devices used on pressurized line)	4.2.4	5.2.4	1	4.2.4
— against microbiological growth on critical surfaces involved in the measurement process	4.2.5	5.2.5	1	4.2.5

6.2.3 Test reports

The results of the determination of the product type shall be documented in test reports. All test reports shall be retained by the manufacturer for at least 10 years after the last date of production of the leak detection systems based on in-tank gauge systems and pressurized pipework systems to which they relate.

6.2.4 Shared other party results

A manufacturer may use the results of the product type determination obtained by someone else (e.g. by another manufacturer, as a common service to manufacturers, or by a product developer), to justify his own declaration of performance regarding a product that is manufactured according to the same design (e.g. dimensions) and with raw materials, constituents and manufacturing methods of the same kind, provided that:

— the results are known to be valid for products with the same essential characteristics relevant for the product performance;

— in addition to any information essential for confirming that the product has such same performances related to specific essential characteristics, the other party who has carried out the determination of the product type concerned or has had it carried out, has expressly accepted[1)] to transmit to the manufacturer the results and the test report to be used for the latter's product type determination, as well as information regarding production facilities and the production control process that can be taken into account for FPC;

— the manufacturer using other party results accepts to remain responsible for the product having the declared performances and he also:

  — ensures that the product has the same characteristics relevant for performance as the one that has been subjected to the determination of the product type, and that there are no significant differences with regard to production facilities and the production control process compared to that used for the product that was subjected to the determination of the product type; and

  — keeps available a copy of the determination of the product type report that also contains the information needed for verifying that the product is manufactured according to the same design and with raw materials, constituents and manufacturing methods of the same kind.

6.2.5 Cascading determination of the product type results

For some construction products, there are companies (often called "system houses") which supply or ensure the supply of, on the basis of an agreement[2)] some or all of the components (e.g. in case of windows: profiles, gaskets, weather strips[3)] to an assembler who then manufactures the finished product (referred to below as the "assembler") in his factory.

Provided that the activities for which such a system house is legally established include manufacturing/assembling of products as the assembled one, the system house may take the responsibility for the determination of the product type regarding one or several essential characteristics of an end product which is subsequently manufactured and/or assembled by other firms in their own factory.

When doing so, the system house shall submit an "assembled product" using components manufactured by it or by others, to the determination of the product type and then make the determination of the product type report available to the assemblers, i.e. the actual manufacturer of the product placed on the market.

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1) The formulation of such an agreement can be done by licence, contract, or any other type of written consent.

2) This can be, for instance, a contract, licence or whatever kind of written agreement, which should also contain clear provisions with regard to responsibility and liability of the component producer (system house, on the one hand, and the assembler of the finished product, on the other hand.

3) These companies may produce components but they are not required to do so.

To take into account such a situation, the concept of cascading determination of the product type might be taken into consideration in the technical specification, provided that this concerns characteristics for which either a notified product certification body or a notified test laboratory intervene, as presented below.

The determination of the product type report that the system house has obtained with regard to tests carried out by a notified body, and which is supplied to the assemblers, may be used for the regulatory marking purposes without the assembler having to involve again a notified body to undertake the determination of the product type of the essential characteristic(s) that were already tested, provided that:

— the assembler manufactures a product which uses the same combination of components (components with the same characteristics), and in the same way, as that for which the system house has obtained the determination of the product type report. If this report is based on a combination of components not representing the final product as to be placed on the market, and/or is not assembled in accordance with the system house's instruction for assembling the components, the assembler needs to submit his finished product to the determination of the product type;

— the system house has notified to the manufacturer the instructions for manufacturing/assembling the product and installation guidance;

— the assembler (manufacturer) assumes the responsibility for the correct assembly of the product in accordance with the instructions for manufacturing/assembling the product and installation guidance notified to him by the system house;

— the instructions for manufacturing/assembling the product and installation guidance notified to the assembler (manufacturer) by the system house are an integral part of the assembler's Factory Production Control system and are referred to in the determination of the product type report;

— the assembler is able to provide documented evidence that the combination of components he is using, and his way of manufacturing, correspond to the one for which the system house has obtained the determination of the product type report (he needs to keep a copy of the system house's determination of the product type report);

— regardless the possibility of referring, on the basis of the agreement signed with the system house, to the latter's responsibility and liability under private law, the assembler remains responsible for the product being in compliance with the declared performances, including both the design and the manufacture of the product, which is given when he affixes the regulatory marking on his product.

6.3 Factory production control (FPC)

6.3.1 General

The manufacturer shall establish, document and maintain an FPC system to ensure that the products placed on the market comply with the declared performance of the essential characteristics.

The FPC system shall consist of procedures, regular inspections and tests and/or assessments and the use of the results to control raw and other incoming materials or components, equipment, the production process and the product.

All the elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic manner in the form of written policies and procedures.

This factory production control system documentation shall ensure a common understanding of the evaluation of the constancy of performance and enable the achievement of the required product performances and the effective operation of the production control system to be checked. Factory production control therefore brings together operational techniques and all measures allowing maintenance and control of the compliance of the product with the declared performances of the essential characteristics.

In case the manufacturer has used shared or cascading product type results, the FPC shall also include the appropriate documentation as foreseen in 6.2.4 and 6.2.5.

6.3.2 Requirements

6.3.2.1 General

The manufacturer is responsible for organizing the effective implementation of the FPC system in line with the content of this product standard. Tasks and responsibilities in the production control organization shall be documented and this documentation shall be kept up-to-date.

The responsibility, authority and the relationship between personnel that manages, performs or verifies work affecting product constancy, shall be defined. This applies in particular to personnel that need to initiate actions preventing product non-constancies from occurring, actions in case of non-constancies and to identify and register product constancy problems.

Personnel performing work affecting the constancy of performance of the product shall be competent on the basis of appropriate education, training, skills and experience for which records shall be maintained.

In each factory the manufacturer may delegate the action to a person having the necessary authority to:

— identify procedures to demonstrate constancy of performance of the product at appropriate stages;

— identify and record any instance of non-constancy;

— identify procedures to correct instances of non-constancy.

The manufacturer shall draw up and keep up-to-date documents defining the factory production control. The manufacturer's documentation and procedures should be appropriate to the product and manufacturing process. The FPC system should achieve an appropriate level of confidence in the constancy of performance of the product. This involves:

a) the preparation of documented procedures and instructions relating to factory production control operations, in accordance with the requirements of the technical specification to which reference is made;

b) the effective implementation of these procedures and instructions;

c) the recording of these operations and their results;

d) the use of these results to correct any deviations, repair the effects of such deviations, treat any resulting instances of non-conformity and, if necessary, revise the FPC to rectify the cause of non-constancy of performance.

Where subcontracting takes place, the manufacturer shall retain the overall control of the product and ensure that he receives all the information that is necessary to fulfil his responsibilities according to this European standard.

If the manufacturer has part of the product designed, manufactured, assembled, packed, processed and/or labelled by subcontracting, the FPC of the subcontractor may be taken into account, where appropriate for the product in question.

The manufacturer who subcontracts all of his activities may in no circumstances pass the above responsibilities on to a subcontractor.

NOTE Manufacturers having an FPC system, which complies with EN ISO 9001 standard and which addresses the provisions of the present European standard are considered as satisfying the FPC requirements of the Regulation (EU) No 305/2011.

6.3.2.2 Equipment

6.3.2.2.1 Testing

All weighing, measuring and testing equipment shall be calibrated and regularly inspected according to documented procedures, frequencies and criteria.

6.3.2.2.2 Manufacturing

All equipment used in the manufacturing process shall be regularly inspected and maintained to ensure use; wear or failure does not cause inconsistency in the manufacturing process. Inspections and maintenance shall be carried out and recorded in accordance with the manufacturer's written procedures and the records retained for the period defined in the manufacturer's FPC procedures.

6.3.2.3 Raw materials and components

The specifications of all incoming raw materials and components shall be documented, as shall the inspection scheme for ensuring their compliance. In case supplied kit components are used, the constancy of performance system of the component shall be that given in the appropriate harmonized technical specification for that component.

6.3.2.4 Traceability and marking

Individual vital components and/or subsystems shall be identifiable and traceable with regard to their production origin. The manufacturer shall have written procedures ensuring that processes related to affixing traceability codes and/or markings are inspected regularly.

6.3.2.5 Controls during manufacturing process

The manufacturer shall plan and carry out production under controlled conditions.

6.3.2.6 Product testing and evaluation

The manufacturer shall establish procedures to ensure that the stated values of the characteristics he declares are maintained. The characteristics, and the means of control, are:

— the ability of the evaluation device to accurate evaluate the measured values from the connected measuring device(s) shall be subject to a simulation of the tests according to 5.1.4.2.1.3, at least at each evaluation device;

— the ability of the measuring system to accurately measure the indicated value changes shall be subject to a simulation of the tests according to 5.1.4.2.1.3 resp. 5.1.4.3.1.3, resp. 5.1.4.3.2.3 resp. 5.1.4.4.1.3 resp. 5.1.4.5.3 every system;

— the ability of the alarm device to generate an audible and visible alarm shall be subject to the tests according to 5.1.8, at least;

6.3.2.7 Non-complying products

The manufacturer shall have written procedures which specify how non-complying products shall be dealt with. Any such events shall be recorded as they occur and these records shall be kept for the period defined in the manufacturer's written procedures.

Where the product fails to satisfy the acceptance criteria, the provisions for non-complying products shall apply, the necessary corrective action(s) shall immediately be taken and the products or batches not complying shall be isolated and properly identified.

Once the fault has been corrected, the test or verification in question shall be repeated.

The results of controls and tests shall be properly recorded. The product description, date of manufacture, test method adopted, test results and acceptance criteria shall be entered in the records under the signature of the person responsible for the control/test.

With regard to any control result not meeting the requirements of this European standard, the corrective measures taken to rectify the situation (e.g. a further test carried out, modification of manufacturing process, throwing away or putting right of product) shall be indicated in the records.

6.3.2.8 Corrective action

The manufacturer shall have documented procedures that instigate action to eliminate the cause of non-conformities in order to prevent recurrence.

6.3.2.9 Handling, storage and packaging

The manufacturer shall have procedures providing methods of product handling and shall provide suitable storage areas preventing damage or deterioration.

6.3.3 Product specific requirements

The FPC system shall address this European Standard and ensure that the products placed on the market comply with the declaration of performance.

The FPC system shall include a product specific FPC, which identifies procedures to demonstrate compliance of the product at appropriate stages, i.e.:

a) the controls and tests to be carried out prior to and/or during manufacture according to a frequency laid down in the FPC test plan,

   and/or

b) the verifications and tests to be carried out on finished products according to a frequency laid down in the FPC test plan.

If the manufacturer uses only finished products, the operations under b) shall lead to an equivalent level of compliance of the product as if FPC had been carried out during the production.

If the manufacturer carries out parts of the production himself, the operations under b) may be reduced and partly replaced by operations under a). Generally, the more parts of the production that are carried out by the manufacturer, the more operations under b) may be replaced by operations under a).

In any case the operation shall lead to an equivalent level of compliance of the product as if FPC had been carried out during the production.

NOTE Depending on the specific case, it can be necessary to carry out the operations referred to under a) and b), only the operations under a) or only those under b).

The operations under a) refer to the intermediate states of the product as on manufacturing machines and their adjustment, and measuring equipment etc. These controls and tests and their frequency shall be chosen based on product type and composition, the manufacturing process and its complexity, the sensitivity of product features to variations in manufacturing parameters etc.

The manufacturer shall establish and maintain records that provide evidence that the production has been sampled and tested. These records shall show clearly whether the production has satisfied the defined acceptance criteria and shall be available for at least three years.

6.3.4 Procedure for modifications

If modifications are made to the product, production process or FPC system that could affect any of the product characteristics declared according to this standard, then all the characteristics for which the manufacturer declares performance, which may be affected by the modification, shall be subject to the determination of the product type, as described in 6.2.1.

Where relevant, a re-assessment of the factory and of the FPC system shall be performed for those aspects, which may be affected by the modification.

All assessments and their results shall be documented in a report.

6.3.5 One-off products, pre-production products (e.g. prototypes) and products produced in very low quantity

The leak detection systems based on in-tank gauge systems and pressurized pipework systems produced as a one-off, prototypes assessed before full production is established, and products produced in very low quantities 25 (per year) shall be assessed as follows.

For type assessment, the provisions of 6.2.1, 3rd paragraph apply, together with the following additional provisions:

— in case of prototypes, the test samples shall be representative of the intended future production and shall be selected by the manufacturer;

— on request of the manufacturer, the results of the assessment of prototype samples may be included in a certificate or in test reports issued by the involved third party.

The FPC system of one-off products and products produced in very low quantities shall ensure that raw materials and/or components are sufficient for production of the product. The provisions on raw materials and/or components shall apply only where appropriate. The manufacturer shall maintain records allowing traceability of the product.

For prototypes, where the intention is to move to series production, the initial inspection of the factory and FPC shall be carried out before the production is already running and/or before the FPC is already in practice. The following shall be assessed:

— the FPC-documentation and

— the factory.

In the initial assessment of the factory and FPC it shall be verified:

a) that all resources necessary for the achievement of the product characteristics included in this European standard will be available, and

b) that the FPC-procedures in accordance with the FPC-documentation will be implemented and followed in practice, and

c) that procedures are in place to demonstrate that the factory production processes can produce a product complying with the requirements of this European standard and that the product will be the same as the samples used for the determination of the product type, for which compliance with this European standard has been verified.

Once series production is fully established, the provisions of 6.3 shall apply.

7 Marking, labelling and packaging

The product shall be marked at least with the following:

— manufacturer;

— year of production;

— unique serial number;

— class IV,

— EN 13160-5;

— category and type of product;

— temperature range;

— type of stored product, the system can be used for;

— design pressure for category C only

All leak detection systems shall be accompanied by instruction as to:

— safe installation, use and maintenance;

— assessment of safe operation condition and possible misuse;

— limitation of equipment, e.g. temperature, pressure regulation;

— essential characteristic of tools used;

— training needed for safe use of equipment;

— the standards for which the system has been tested e.g. for use in hazardous area and/or low voltage directive.

Annex A
(normative)

Acquisition of field data to provide a standard database for testing software leak detection systems Category A

A.1 Objective

The aim of this procedure is to gather data from operational field sites (where petroleum products are dispensed into motor vehicles) for the construction of a standard database to be used to assess the suitability of software-based systems for detecting the loss of stored product from a storage tank and/or draw-off pipework. The level of detail given is intended to be sufficient to fully define the data which shall be gathered for each operational site from which one or more tanks are to be used for data collection. Such a database is for use for type approval testing.

Data are collected per tank over the ranges shown for each of the following parameters as an example:

Ambient temperature during collection of the data:	−5 °C to +30 °C;
Storage tank capacity:	10 000 l to 50 000 l;
Average daily throughput:	1 000 l per day to 12 000 l per day;
Delivery quantity per tank:	2 750 l to 9 500 l;
Delivery temperature:	−5 °C to +25 °C;
Delivery frequency:	minimum 2 per week;
Individual dispenser volumetric accuracy:	±0,25 %.

These parameters are calculated or measured for each tank over a 42 day period in accordance with thresholds defined in A.2.

Data are collected from sites including the following types of draw-off system:

— suction draw-off systems (where a hydraulic pumping unit is incorporated into the dispenser);

— pressurized draw-off systems (where product is transferred from the tank to the dispenser by a remote pumping unit);

— blending dispenser systems (where product from two or more tanks is mixed at the dispenser);

— tank manifolding systems (where two or more tanks are connected together such that fuel may be drawn from the tanks independently);

— tank siphon systems (where two or more tanks are connected together such that fuel cannot be drawn from the tanks independently);

— multiple draw-off (minimum of 2 dispensers per tank, suction or pressure).

Data are collected from tanks supplying gasoline and diesel fuels.

A.2 Requirements

A number of tank gauge systems (meeting the accuracy requirements for the type of tank gauge for which the database is to be collected) are installed on tanks and/or pipework in operational sites in the field. An operational site is one where stored product is delivered into tanks and drawn off on a regular basis such that conditions in A.1 are satisfied.

For each site, the following data are recorded:

a) tanks individual identifications {Tank_ID};

b) nozzle individual identifications {Disp*n*_ID};

c) configuration of siphon connections {Tank1_ID, Tank2_ID....};

d) configuration of manifold connections {Tank1_ID, Tank2_ID....};

e) average daily shade temperature {$T_{av} = (T_{max} + T_{min})/2$};

f) Level of vapour recovery installed {Stage 1B | Stage 2}.

NOTE Values of T_{av} for each day are obtained from meteorological records for the duration of data collection.

For each tank, the following data are recorded:

g) construction {(Steel | Fibreglass), (Single_wall | Double_wall)};

h) tank diameter in metres;

i) tank shell capacity in litres;

j) contained product e.g. unleaded gasoline according to EN 228;

k) normalized thermal coefficient of expansion of contained product (as entered into the tank gauge for calculation of the volume correction factor *VCF*);

l) pumping arrangement {Suction | Pressure};

m) nozzles connected {Disp1_ID, Disp2_ID, Disp3_ID....}.

The tank capacity table used by the level gauge to perform level to volume conversion. This shall contain a minimum of 20 volume increments representing equal divisions of the tank diameter to within the *MPE* figure for the gauge type installed.

Nozzles connected for vapour recovery {Disp1_ID, Disp2_ID, Disp3_ID....}.

Data shall not be collected from tanks where it is anticipated that there will be tidal variations in groundwater level which vary in any seven-day period by greater than 15 % of the diameter of the tank.

For each nozzle, the following data are recorded:

— Meter accuracy {% deviation from calibration certificate (not older than one year)};

— Configuration of blending arrangement {Disp*n*_ID, [Tank1_ID, %], [Tank2_ID, %]...}.

— Operational data are gathered from these systems and collected into files, where each file contains data from one single tank for a minimum of 42 consecutive days (28 days for start-up +14 days for leak detection). Files may overlap chronologically, but for any two files there shall be data from at least 14 consecutive days which does not overlap.

The installation sites chosen for data collection shall be selected such that the data contained in these files satisfies the following conditions with respect to each of the required ranges in A.1:

In ≥ 1 % of all the data records collected (in whatever file) the average value of the said quantity is at or below the lower value stated for each range.

In ≥ 1 % of all the data records collected (in whatever file) the average value of the said quantity is at or above the upper value stated for each range.

In between these values, the distribution of the average parameter value in the records collected should satisfy the criteria according to Table A.1.

Table A.1 — Range of parameters

Range of parameter % of full scale	Minimum proportion of files within range %
100	1
75 to < 100	10
50 to 75	10
25 to 50	10
> 0 to 25	10
0	1

A.3 Equipment

The following equipment is required:

A computer and associated data transfer peripherals.

Data analysis software, as necessary to process submitted data files in order to determine whether the range requirements of A.1 have been satisfied according to criteria 6 in A.2.

A calibrated meter proving vessel, having a minimum capacity in accordance with national calibration standards, which should be calibrated a minimum of once per year against references traceable to national standards.

A sufficient number of tank gauge systems of the required type (in-tank probes may be of different sizes) installed on sites in accordance with the requirements of A.2. This equipment should be fully configured, calibrated via suitable tank capacity tables and operational.

Where the tank gauge system does not incorporate a non-removable data storage device (e.g. a hard disk) of sufficient capacity to record data for the whole test period, a suitable data collection and storage facility should be provided.

A.4 Method

A.4.1 Preparation

Prior to data collection, each tank gauge system should have power applied, have been initialized and be fully operational, with the system time and date set correctly. The information listed in A.2 should be verified and recorded together with the relevant time and date.

It shall be established that all tanks and all pipes connecting to dispensers are free from leaks. Tightness tests using an independent system can provide suitable verification. The method and results of tests carried out should be recorded, together with details of any method of continuous leak detection used (e.g. monitoring of interstitial space of double-walled tanks). Ideally, hydraulic pipe tests and precision tank tests will be carried out. These tests should return 'no leak' results both prior to the start and subsequent to the end of data collection.

A.4.2 Tank contents data recording

Each tank gauge system should be left in an operational state to record the data required for analysis as described hereafter.

For blending dispensers, tank contents records should include the individual meter readings for each product dispensed.

Level, volume and temperature readings should be stored at least once per dispensing transaction (within one minute of the end of the transaction), or at intervals no longer than 0,5 min when no dispensing is taking place. Individual files should be created for each tank for each 42 day period. Records in a file should have comma-delimited fields containing the following data in the format specified:

a) Day number (0 to 41) {DD};

b) Time stamp to 1 s resolution {hhmmss} according to ISO 8601;

c) Volume of product stored in the tank to 0,01 l resolution {VVVVVVVV};

d) Level of stored product to $MPE/10$ mm resolution {LLLLLL};

e) Average temperature of product in the tank to $MPE/10$ °C resolution {TTTT}.

In addition to the average product temperature, individual probe temperature sensor values should be stored, together with the individual sensor positions along the probe.

— number of temperature sensors {SS};

— individual probe temperature sensors positions to 0,1 mm resolution {LLLLL};

— individual probe temperature sensors values to $MPE/10$ °C resolution {TTTT}.

NOTE *MPE* is the maximum permissible error in measurement as specified for the type of tank gauge used for data collection.

Sample Record – Tank Contents

All fields should contain ASCII numeric data, right-justified with leading spaces or zeroes. The following sample represents a record collected at a time of 09:56:30 on day 4, with a product volume of 25 645,88 l, a product level of 1875,25 mm, an average temperature of 8,6 °C, three temperature sensors at positions of 300,0 mm, 1 000,0 mm, 1700,0 mm and with temperatures of 8,4 °C, 8,6 °C, 8,8 °C.

04,095630,02564588,187525,0860,03,03000,10000,17000,0840,0860,0880

Dispensing transactions should be stored as a separate set of records in a separate file for each tank for each 42 day period. Records in a file should have comma-delimited fields containing the following data in the format specified:

— day number (0 to 41) {DD};

— transaction start time to 1 s resolution {hhmmss}, according to ISO 8601;

— transaction stop time to 1 s resolution {hhmmss}, according to ISO 8601;

— nozzle ID {FFFF};

— transaction volume (dispensed product) to 0,01 l resolution {VVVVVV}.

Sample Record – Dispensing Transaction

All fields should contain ASCII numeric data, right-justified with leading spaces or zeroes. The following sample represents a transaction from fuelling position (nozzle) number 17, starting at a time of 11:23:25 on day 12 and stopping at 11:26:52 with a transaction volume of 45,88 l:

12,112325,112652,0017,004588

A.4.3 Delivery records

Delivery status (delivery in progress/no delivery) is not specifically recorded on site. This is identified analytically by the method described in A.4.6.

Data should be stored for each delivery as and when it occurs, and the delivery record should contain:

— delivery start date and time to 1 s resolution;

— delivered volume, as indicated to have left the truck, to 1 l resolution;

— temperature of delivered product, calculated to $MPE/10$ °C resolution.

NOTE The temperature of delivered product is calculated as described in A.4.5.

A.4.4 Data retrieval

It shall be established at the end of data collection that all tanks and all pipes connecting to dispensers are free from leaks. Tests as described in A.4.1 should be repeated. The information listed in A.2 should again be verified and recorded together with the relevant time and date.

A.4.5 Temperature of delivered product

The product temperature and volume just prior to each delivery are obtained from the relevant tank records, together with the delivery quantity. The temperature and volume of the product 30 minutes after the delivery are also obtained from the data files. From the quantity of product in the tank, V_1, at the initial average temperature, T_1, using the delivery quantity, V_d, the quantity, V_2, and average temperature, T_2, of the product in the tank after the delivery, the temperature of the product delivered, T_d, is calculated according to Formula (A.1):

$$T_d = (V_2 T_2 - V_1 T_1)/V_d \qquad \text{(A.1)}$$

It should be noted that the 30 min period is a compromise between an extended temperature equalization time and a reduced time during which V_2 can be reduced significantly by dispensing.

A.4.6 Determination of delivery status

One suggested method for determination of delivery status is given below:

Apply a low pass filter to the acquired fuel height time series data to reduce random and periodic noise. A simple IIR recursive filter or moving window average can be used. An example of an IIR filter for a 30 s sampling rate, see Formula (A.2):

Filtered_Ht = Last_Filtered_Ht + K * (ht - Last_Filtered_Ht) (A.2)

Where

K = 0,2.

The following logical sequence uses the filtered height output from the filter:

Save the lowest height over time (use a minimum detector) in h_{min} and the time of the h_{min} sample in t_{min}.

When the current height exceeds h_{min} by a start threshold, H_s, (where H_s = 10 mm) set deliver status to active, load a peak (maximum) detector, h_{max}, with current height and save time of h_{max} in t_{max}.

Continue to replace h_{max} and t_{max} with the current height and time until current height is less than or equal to h_{max}.

Set delivery status to inactive. The required delivery parameters can then be found as follows:

Delivered volume: $V_{delivery}$ = ((volume at h_{max}) - (volume at h_{min}))

Delivery start time: t_{min}

Delivery end time: t_{max}

Load current height and time into h_{min} and t_{min}, respectively, and repeat logical sequence to detect next delivery.

A.5 Data up-loading and verification

The files recorded by the tank gauge systems typically would be up-loaded into a database pre-configured in the computer to be used for analysis. Any files subject to difficulties in data recording, e.g. hard disk sector corruption, can be discarded, but if these exceed 5 % of the total from any one system, data from that system should be regarded as unreliable and should not be used.

A software analysis of the collected data are carried out, in conjunction with the information recorded in accordance with A.4.1 and A.4.4, to verify that requirements A.2 are satisfied. In the case of A.1, data can be obtained from the appropriate National Meteorological Office for the weather station closest to each test site. In the case 7 of A.1, delivery temperature is calculated using the method described in A.4.5.

Any files exceeding a 42 day recording time may be sectioned into segments of a minimum 42 days duration.

A further software analysis of the collected data are carried out to verify that requirement 7 in A.2 is satisfied for each application as defined in A.1. The database is then suitable for testing systems which are to be qualified for the uses defined in A.1. If any requirement is not then met, data recording (A.4.2 and A.4.3) and data retrieval (A.4.4) should be repeated.

A.6 Induced leak rates – quantitative systems

The selected sample of 45 files is sub-divided at random into four sets, one of 15 files and three of 10 files each. For each specified leak rate to be detected in accordance with Table 1, simulated leaks are induced in these sets on the following basis:

a) 15 files: zero leak rate.

b) 10 files: specified leak rate x 0,5.

c) 10 files: specified leak rate.

d) 10 files: specified leak rate x 1,5.

To prevent the system under test rounding identified leak rates to these values, in each set of files the actual leak rates induced are further randomized in a band of ± 20 % about the leak rates according to a) thru d).

Where both constant and variable leak rates are to be simulated, the same set of original files are used for both simulations at the same leak rate according to a) thru d), to enable subsequent performance comparisons of the different types of leak.

A.7 Induced leak rates – qualitative systems

The selected sample of 120 files is sub-divided at random into two sets, each of 60 files. For each specified leak rate to be detected, simulated leaks are induced in these sets as follows (no further randomization is applied):

a) 60 files: zero leak rate;

b) 60 files: specified leak rate.

A.8 Test sequence

For each test, the files from each set, as defined in A.6 or A.7 as appropriate, shall be submitted in turn to the system under test. The system shall process the files as though these represented data were collected during normal operation and shall produce an estimated leak rate for each file, or a pass/fail indication as appropriate, from data limited to that which would be acquired during the requisite detection period (as defined in 4.1.4.1 Table 1). Prior to each test, files shall be submitted to the system under test, which comprise data from the same tank but without any induced leak. These shall represent an elapsed time equal to the initialization period specified by the manufacturer.

The test sequence shall be according to Table 2 and as follows:

— Test 1: Simulated tank leak (constant) according to 5.1.4.4;

— Test 2: Simulated tank leak (constant) according to 5.1.4.4;

— Test 3: Simulated tank leak (variable) according to 5.1.4.4;

— Test 4: Simulated tank leak (variable) according to 5.1.4.4;

— Test 5: Simulated pipe leak according to 5.1.4.5;

— Test 6: Simulated pipe leak according to 5.1.4.5

Table A.2 — Sequence of tests for leak detection category A

Test Number	**Type of simulated leak**	**Leak rates** $l \cdot h^{-1}$	**Data duration days**
1	Tank (constant)	0; 2,0; 4,0; 6,0	1
2	Tank (constant)	0; 1,0; 2,0; 3,0	7
3	Tank (variable)	0; 0,4; 0,8; 1,2	14
4	Tank (variable)	0; 2,0; 4,0; 6,0	1
5	Line (constant)	0; 1,0; 2,0; 3,0	7
6	Line (variable)	0; 0,4; 0,8; 1,2	14

A.9 Simulated leak test results

The results from the applicable tests 1, 2 and 5 in A.8 (constant leak rate) shall be assessed in accordance with the statistical analysis given in A.11. Tests 3, 4 and 6 in A.8 (variable leak rate) are subjected only to the mean difference test. All applicable tests shall be passed, i.e. the simulated leaks shall be indicated within the required time periods and within the required limits for probability of detection and probability of false alarms. If any of the criteria defined in 4.1.4.1 Table 1 are not met in any relevant test then the system shall not receive type approval. In addition, if the mean of the differences between indicated leak rates for constant and variable leak simulations is less than zero then the system shall not receive type approval. Therefore, the following condition shall be met if the test is to be passed, see Formula (A.3):

$$\bar{r}_v - \bar{r}_c > 0 \quad \text{(A.3)}$$

Where

$\bar{r}_v$ = mean indicated leak rate for the variable leak simulation;

$\bar{r}_c$ = mean indicated leak rate for the constant leak simulation.

The number of correct qualitative system pass/fail results for variable leak rates shall be at least as high as for constant leak rates.

As leaks are defined as positive rates and gains as negative rates, then variable minus constant rate should be greater than zero to pass.

A.10 Qualification for use

On the basis of the selection of files specified according to B.2, those conditions of use defined in B.3, a) to h), which have been applied during testing shall be identified. Type approval shall be restricted to the conditions so determined. For each condition of use, the variances of the standard deviations between leak test results from tanks with and without a particular condition shall meet the criteria defined in A.11.12 or type approval shall not be given for that condition of use. However, where the results for a particular condition of use meet the performance requirements without inclusion of data not having that condition of use, type approval shall be given.

A.11 Statistical analysis

A.11.1 General

The estimated leak rates or pass/fail indications recorded in each simulated leak test are used to predict the performance of the system under test in terms of meeting the criteria for probability of detection and probability of false alarm. Separate subsections are provided describing the data analysis for quantitative and qualitative methods.

A.11.2 Basic statistics for quantitative systems

The *n* pairs of indicated and induced (simulated) leak rate data are used to calculate the mean squared error *MSE*, the bias, and the variance of the system under test as follows.

A.11.3 Inconclusive or invalid results

If a particular test does not produce a valid result; that is, that the leak detection software of the system under test determines that an operational problem has occurred meaning that the data are inadequate so no valid leak rate can be estimated, and consequently that the test is not valid. Such results shall be recorded as an invalid result.

A minimum number of valid tests are required for the evaluation. For systems that report quantitative results, a minimum of 40 valid tests (out of the planned 45) is required. Further, no more than 25 % of the results may be invalid in each nominal leak rate group. For systems that report on a qualitative basis, at least 90 valid tests (out of the planned 120) are required.

A.11.4 Mean squared error

The mean squared error, *MSE*, see Formula (A.4):

$$MSE = \sum_{i=1}^{n} (L_i - S_i)^2 \ / \ n \tag{A.4}$$

where L_i is the indicated leak rate reported by the system under test and S_i is the actual induced leak rate, for *i* from 1 to *n* for the different databases.

The bias, *B*, see Formula (A.5):

$$B = \sum_{i=1}^{n} (L_i - S_i) \ / \ n \tag{A.5}$$

The bias, *B*, is the average difference between the indicated and induced leak rates over the number of tests. The bias is a measure of the accuracy of the system under test and can be either positive or negative.

A.11.5 Variance and standard deviation

The variance is found from the Formula (A.6):

$$\sigma^2 = \sum_{i=1}^{n} [(L_i - S_i) - B]^2 \ / \ (n - 1) \tag{A.6}$$

Denote the standard deviation by *SD*. The standard deviation is the square root of the variance.

A.11.6 Test for zero bias

To test whether the system under test has a bias that is statistically significantly different from zero, the following statistical test on the bias, *B*, calculated above is performed. Compute the *t*-statistic according to Formula (A.7):

$$t = \sqrt{n} \quad B / SD \tag{A.7}$$

From a *t*-table, obtain the critical value corresponding to a *t* with (*n*-1) degrees of freedom and a two-sided 5 % significance level. For example, with *n* = 45, there are 44 degrees of freedom and the two-sided 5 % significance level leads to a critical value of 2,015. Denote this value by t_c. Compare the absolute value of *t* to t_c. If the absolute value of the calculated *t* is less than the critical value, the bias is not significantly different from zero and the system is assumed unbiased. If the absolute value of the calculated value of *t* exceeds the critical value then the method has a significant bias. If the bias, *B*, is positive, the system systematically over-estimates the leak rate. If *B* is negative, the system under-estimates the leak rate.

A.11.7 Probability of false alarm, *PFA*

The probability of false alarm, *PFA*, is the probability that the indicated leak rate will exceed the threshold or criterion for indicating a leak when the tank or pipe is actually tight. Generally, if the estimated leak rate exceeds a specified leak rate or threshold, *C*, (for example 0,9 l/h), the tank is judged by the system under test to be leaking. If *C* denotes the criterion or threshold for indicating a leak, *B*, the estimated bias of the system, *SD*, the standard deviation, then the probability of a false alarm can be written according to Formula (A.8):

$$PFA = P \{ t > (C - B) / SD \} \tag{A.8}$$

where the probability is calculated from a *t*-distribution with the number of degrees of freedom associated with the standard deviation, which would be 44 where the full set of 45 tests is used. This formula assumes that the errors are approximately normally distributed. If the bias, *B*, was not significantly different from zero, *B* is taken to be zero.

A.11.8 Probability of detecting a specific leak rate, *PD*

The probability of detection, *PD*, is the probability that the system will correctly identify a leak of specified size. In general for a leak rate of size *R*, *PD* is given by Formula (A.9):

$$PD = P \{ t > (C - R - B) / SD \} \tag{A.9}$$

where *C*, *B*, and *SD* are as before, and the probability is calculated from the *t*-distribution with degrees of freedom corresponding to the *SD*, which would be 44 if the usual set of 45 records is used.

A.11.9 Mean and standard deviation of the tight tank test

The tests conducted under the condition of no leak (tight tank) provide direct estimates of the performance of the system on a tight tank. Calculate the mean and standard deviation for the tests on the tight tank records by using the formulas above restricting the data to the data from the tight tank records. The sample size, *n*, will also be reduced, to 15 if there are 15 records with no induced leak, for example.

A.11.10 Statistics for qualitative systems

The basic results of the system under test are reports that the tank and/or pipes are tight or leaking. As noted above there is a possibility that some results might be invalid. These results can be tabulated in Table A.3 to summarize the results.

Table A.3 — Summary of results from qualitative evaluation

Actual status	**reported**			
	Tight	Leaking	Invalid	Total ($T_i + L_i + X_i$)
Tight	T_1	L_1	X_1	N_1
Leaking	T_2	L_2	X_2	N_2

The numbers in Table A.3 are used to directly estimate the *PFA* and *PD*. The number of tight results incorrectly identified as leaking, divided by the total number of tight tests estimates the *PFA*, see Formula (A.10):

$$PFA = L_1 \;/\; (N_1 - X_1) \tag{A.10}$$

where the letters in the cells of Table A.3 denote the number of results in the category indicated by the cell label.

Similarly, the *PD* is estimated by the number of leaking test results correctly identified as leaking or, according to Formula (A.11):

$$PD = L_2 \;/\; (N_2 - X_2) \tag{A.11}$$

In Table A.3, N_1 is the number of data records with no induced leak and N_2 is the number of data records with induced leaks. Both numbers are normally 60.

The proportion of records declared invalid shall also be reported separately for the tight and leaking records as well as for all records. These proportions are calculated according to Formula (A.12), (A.13) and (A.14):

$$PI\,(tight) = X_1 \;/\; N_1 \tag{A.12}$$

$$PI\,(leaking) = X_2 \;/\; N_2 \tag{A.13}$$

and

$$PI\,(total) = (X_1 + X_2) \;/\; (N_1 + N_2) \tag{A.14}$$

for the proportion of invalid records among tight, leaking, and all records, respectively. The proportion of invalid records among all tank records provides an estimate of the proportion of tanks in a population represented by the evaluation database for which this method cannot be used.

In order for the method to meet the required performance standard, *PFA* shall be less than or equal to 0,05 (5 %) and *PD* shall be at least 0,95 (95 %). If the number of records (either tight or leaking) were 60, the system under test could make at most 3 mistakes out of the 60 records and still meet these requirements. It is possible that the system might not make any errors, giving an estimated *PFA* of 0 or an estimated *PD* of 1. Since no system is expected to have zero errors in practice, it is important to calculate a confidence interval for the discrete proportion of false alarms or detections to give an indication of what range should be expected for the *PFA* or *PD* in practice.

If no errors occur in the evaluation database, the confidence limit for *PFA* is given by Formula (A.15):

$$UL = 1 - \alpha^{1/N_1} \tag{A.15}$$

where (1 - α) is the confidence coefficient, which is generally set at 0,95. For one or more errors, the confidence limits are calculated from confidence limits for the parameter of a binomial distribution. These can be found in CRC Handbook of Tables for Probability and Statistics, for example.

If no errors occur in the evaluation in detecting leaks, a lower confidence bound for *PD* can be calculated according to Formula (A.16):

$$LL = \alpha^{1/N_2} \tag{A.16}$$

Where again (1 - α) is the confidence coefficient, usually set at 0,95. For one or more errors in detecting leaks, the confidence limits for the binomial are used.

A.11.11 Comparison of variable and constant leak rate pairs

Variable leaks are simulated on all tank records for which mathematical leaks were simulated. Approximately equal numbers of each nominal leak rate are used. It should be re-stated that these variable and constant leak rate simulation pairs are carried out on the same basic tank record data.

The result will be pairs of leak rate estimates by the system. One member of the pair will be the leak rate estimated for a data record with a constant leak rate simulated. The other member of the pair will be the leak rate estimated by the system when a variable leak rate with the same average rate or overall product loss was simulated.

For quantitative systems, compute the differences between these pairs of estimated leak rates under constant and variable leak rates (on the same data record). Subtract the reported leak rate with the constant simulated leak rate from the reported leak rate with a variable simulated leak rate. Calculate the mean of these differences. (Be aware that these differences are not used in computing the *PD* and *PFA*). In order for the quantitative system to receive type approval, the mean of these differences shall be greater than or equal to zero.

For qualitative systems to qualify, the system shall identify at least as many leaks with the variable leak rate simulation as it does with the constant leak rate simulation. That is, the proportion of leaking records that the system correctly identifies shall be at least as large with the variable leak rate as it is with the constant leak rate. This proportion shall be at least 95 %. If there are 60 records with induced leaks, if 3 are misclassified as tight the 95 % criterion will be considered to have been met, but not so if 4 are incorrect.

A.11.12 Validation of conditions of use

If the system is to be validated for a particular condition of use, between 25 % and 75 % of the evaluation data comes from tanks where that condition is applied.

To justify a condition of use, the results for tanks with the condition applied shall be shown to be similar to those from tanks where it is not applied. To make this comparison, divide the data records into two groups based on whether the condition is applied or not. For quantitative systems the number in each group is not critical, but for qualitative systems there shall be at least 21 tight records and 21 records with simulated leaks in each group.

For quantitative systems, calculate the mean and standard deviation separately for the two groups. This can be done by using the Formula in A.11.4 and A.11.5 separately on the two groups. Use a two-sample *F* test to *te*st whether the variances of the two groups are equal, see Formula (A.17):

$$F = (SD_1 / SD_2)^2 \tag{A.17}$$

Where SD_1 and SD_2 are the standard deviations calculated from the two groups.

In forming the *F* ratio, use the standard deviation with the larger calculated value in the numerator. Compare the calculated value of F to the 95th percentile of an *F*-distribution with (n_1 - 1) degrees of freedom in the numerator (corresponding to SD_1) and (n_2 - 1) degrees of freedom in the denominator (corresponding to SD_2). The sample sizes are n_1 and n_2, respectively. If the calculated value of F is less than the tabled value, there is no significant evidence that the two population variances are different. In this case, use of the system is justified both where the condition of use is applied and where it is not.

If the calculated value of F exceeds the tabled value, the two variances are significantly different at the 5 % significance level. This is evidence that the performance of the system is affected under the condition of use in question. In this case, continue the computation of the *PD* and *PFA* separately for the two groups. If both groups meet the performance standards the system may be used whether or not the condition of use is applied. If only one group meets the performance standards, then the use of the system is limited to that group (with the condition applied or without) for which the performance standards are met.

If the standard deviations are not significantly different, test to see if the bias is different for the two groups of tanks. Use a two-sample *t*-test to test whether there is any significant difference in the bias, see Formula (A.18):

$$t_b = (B_1 - B_2) / (S_p \sqrt{(1/n_1 + 1/n_2)}) \qquad (A.18)$$

where S_p is the pooled standard deviation of the two groups and is calculated according to Formula (A.19):

$$S_p = \sqrt{\frac{(n - 1)SD_1^2 + (n_2 - 1)SD_2^2}{(n_1 + n_2 - 2)}} \qquad (A.19)$$

Compare t_b to a two-sided 5 % critical value from a *t*-distribution with (n_1 + n_2 - 2) degrees of freedom. If the absolute value of t_b does not exceed the critical value then there is no evidence that the bias is different with or without the condition of use applied and use of the system is justified in either case.

If the absolute value of t_b does exceed the percentile from the *t*-table, then the system has a significantly different bias in the two cases. In this event, continue the computation of the *PD* and *PFA* separately for the two groups. If both groups meet the performance standards the system may be used whether or not the condition of use is applied. If only one group meets the performance standards, then the use of the system is limited to that group (with the condition applied or without) for which the performance standards are met.

For qualitative systems, compute the *PFA* and *PD*, as described in A.11.7 and A.11.8 respectively for each group. If both groups meet the performance standard, the system may be used whether or not the condition of use is applied. If one of the groups does not meet the performance standard, but the other does, then the results shall be limited to the group (with the condition applied or without) for which the performance standards are met.

Annex B
(informative)

Acquisition of field data to provide a standard database for testing software leak detection systems Category B(2)

B.1 General

The objective of the test schedule is to verify that the system under test will return leak test results in a storage tank when data from the standard test database are processed by the leak detection software following modifications to simulate leaks at various rates. The manufacturer shall supply the system under test in the form of software loaded onto a computer which is capable of reading in and processing files from the standard test database. These files will be provided in a standard format as defined.

The manufacturer shall state the initialization period required for the system under test, which shall not exceed 28 days.

B.2 File sorting and selection

A set of files shall be selected from the standard database, which includes data as defined in B.2 for which the system under test is to be qualified.

For each type of draw-off system and fuel, the files selected shall meet the following conditions:

For each of the draw-off methods, B.3, a) to f), and each fuel listed in g), between 25 % and 75 % of the data files selected should be taken from tanks where that type of draw-off system or fuel is in use. The same data file may cover two or more uses, for example a manifolded tank using pressurized draw-off via multiple dispensers. Leak detection systems to be tested will provide a quantitative or a qualitative output. A qualitative output will indicate a pass/fail result in accordance with Table 1.

The minimum sample sizes for data files, which shall be collected for each of these types, are:

a) Systems with a Quantitative Output: ≥ 100 files (not more than 15 from the same tank);

b) Systems with a Qualitative Output: ≥ 240 files (not more than 36 from the same tank).

B.3 Data set Requirements

Data are collected from sites including the following types of draw-off system:

a) Suction draw-off systems (where a hydraulic pumping unit is incorporated into the dispenser).

b) Pressurized draw-off systems (where product is transferred from the tank to the dispenser by a remote pumping unit).

c) Blending dispenser systems (where product from two or more tanks is mixed at the dispenser).

d) Tank manifolding systems (where two or more tanks are connected together such that fuel may be drawn from the tanks independently).

e) Tank siphon systems (where two or more tanks are connected together such that fuel cannot be drawn from the tanks independently).

f) Multiple draw-off (minimum of 2 dispensers per tank, suction or pressure).

g) The system under test shall be qualified for use with data corresponding to each type of product in which it will detect leaks, such as unleaded fuel according to EN 228, diesel fuel according to EN 590.

h) Data are collected per tank over the ranges shown for each of the following parameters:

Ambient temperature during collection of the data:	−5 °C to +30 °C;
Storage tank capacity:	10 000 l to 50 000 l;
Average daily throughput:	1 000 l per day to 12 000 l per day;
Delivery quantity per tank:	2 750 l to 9 500 l;
Delivery temperature:	−5 °C to +25 °C;
Delivery frequency:	minimum 2 per week;

B.4 Induced leak rates – quantitative systems

The selected sample of 45 files is sub-divided at random into four sets, one of 15 files and three of 10 files each. For each specified leak rate to be detected in accordance with Table 1, simulated leaks are induced in these sets on the following basis:

a) 15 files: zero leak rate.

b) 10 files: specified leak rate x 0,5.

c) 10 files: specified leak rate.

d) 10 files: specified leak rate x 1,5.

To prevent the system under test rounding identified leak rates to these values, in each set of files the actual leak rates induced are further randomized in a band of ± 20 % about the leak rates according to B.4 a) to d).

Where both constant and variable leak rates are to be simulated, the same set of original files are used for both simulations at the same leak rate according to B.4 a) to d) to enable subsequent performance comparisons of the different types of leak.

B.5 Induced leak rates – qualitative systems

The selected sample of 120 files is sub-divided at random into two sets, each of 60 files. For each specified leak rate to be detected, simulated leaks are induced in these sets as follows (no further randomization is applied):

a) 60 files: zero leak rate.

b) 60 files: specified leak rate.

B.6 Test sequence

For each test, the files from each set, as defined in B.4 a) and b) as appropriate, shall be submitted in turn to the system under test. The system shall process the files as though these represented data were collected during normal operation and shall produce an estimated leak rate for each file, or a pass/fail indication as appropriate, from data limited to that which would be acquired during the requisite detection period according to 4.1.4.1, Table 1, category B(2). Prior to each test, files shall be submitted to the system under test, which comprise data from the same tank but without any induced leak. These shall represent an elapsed time equal to the initialization period specified by the manufacturer.

The test sequence shall be as follows:

— Test 1: Simulated tank leak (constant) according to 4.1.4.1, Table 1, category B(2).

— Test 2: Simulated tank leak (variable) according to 4.1.4.1, Table 1, category B(2).

B.7 Evaluation of simulated leak test results

The results from tests 1 and 2 shall be assessed in accordance with the statistical analysis given in B.7. All applicable tests shall be passed, i.e. the simulated leaks shall be indicated within the required time periods and within the required limits for probability of detection and probability of false alarms. If the criteria according to 4.1.4.1, Table 1, category B(2) are not met in any relevant test then the system shall not receive type approval. In addition, if the mean of the differences between indicated leak rates for constant and variable leak simulations is less than zero then the system shall not receive type approval. Therefore, the following condition shall be met if the test is to be passed, see Formula (B.1):

$$\bar{r}_{\mathrm{v}} - \bar{r}_{\mathrm{c}} > 0 \tag{B.1}$$

where

$\bar{r}_{\mathrm{v}}$ = mean indicated leak rate for the variable leak simulation;

$\bar{r}_{\mathrm{c}}$ = mean indicated leak rate for the constant leak simulation.

The number of correct qualitative system pass/fail results for variable leak rates shall be at least as high as for constant leak rates.

As leaks are defined as positive rates and gains as negative rates, then variable minus constant rate should be greater than zero to pass.

B.8 Qualification for use

On the basis of the selection of files specified according to B.2, those conditions of use according to 4.1.4.1, Table 1, category B(2) which have been applied during testing shall be identified. Type approval shall be restricted to the conditions so determined. For each condition of use, the variances of the standard deviations between leak test results from tanks with and without a particular condition shall meet the criteria according to 4.1.4.1, Table1, category B(2) or type approval shall not be given for that condition of use. However, where the results for a particular condition of use meet the performance requirements without inclusion of data not having that condition of use, type approval shall be given.

B.9 Statistical analysis

B.9.1 General

The estimated leak rates or pass/fail indications recorded in each simulated leak test are used to predict the performance of the system under test in terms of meeting the criteria for probability of detection and probability of false alarm. Separate subsections are provided describing the data analysis for quantitative and qualitative methods.

B.9.2 Basic statistics for quantitative systems

The *n* pairs of indicated and induced (simulated) leak rate data are used to calculate the mean squared error *MSE*, the bias, and the variance of the system under test as follows.

B.9.3 Inconclusive or invalid results

If a particular test does not produce a valid result; that is, that the leak detection software of the system under test determines that an operational problem has occurred meaning that the data are inadequate so no valid leak rate can be estimated, and consequently that the test is not valid. Such results shall be recorded as an invalid result.

A minimum number of valid tests are required for the evaluation. For systems that report quantitative results, a minimum of 40 valid tests (out of the planned 45) is required. Further, no more than 25 % of the results may be invalid in each nominal leak rate group. For systems that report on a qualitative basis, at least 90 valid tests (out of the planned 120) are required.

B.9.4 Mean squared error

The mean squared error, *MSE*, see Formula (B.2):

$$MSE = \sum_{i=1}^{n} (L_i - S_i)^2 \; / \; n \tag{B.2}$$

where L_i is the indicated leak rate reported by the system under test and S_i is the actual induced leak rate, for i from 1 to n for the different databases.

The bias, *B*, see Formula (B.3):

$$B = \sum_{i=1}^{n} (L_i - S_i) \; / \; n \tag{B.3}$$

The bias, *B*, is the average difference between the indicated and induced leak rates over the number of tests. The bias is a measure of the accuracy of the system under test and can be either positive or negative.

B.9.5 Variance and standard deviation

The variance is found from the Formula (B.4):

$$\sigma^2 = \sum_{i=1}^{n} \left[(L_i - S_i) - B \right]^2 \; / \; (n - 1) \tag{B.4}$$

Denote the standard deviation by *SD*. The standard deviation is the square root of the variance.

B.9.6 Test for zero bias

To test whether the system under test has a bias that is statistically significantly different from zero, the following statistical test on the bias, *B*, calculated above is performed. Compute the *t*-statistic according to Formula (B.5):

$$t = \sqrt{n} \;\; B \, / \, SD \tag{B.5}$$

From a *t*-table, obtain the critical value corresponding to a t with (n-1) degrees of freedom and a two-sided 5 % significance level. For example, with n = 45, there are 44 degrees of freedom and the two-sided 5 % significance level leads to a critical value of 2,015. Denote this value by t_c. Compare the absolute value of t to t_c. If the absolute value of the calculated t is less than the critical value, the bias is not significantly different from zero and the system is assumed unbiased. If the absolute value of the calculated value of t exceeds the critical value then the method has a significant bias. If the bias, *B*, is positive, the system systematically over-estimates the leak rate. If *B* is negative, the system under-estimates the leak rate.

B.9.7 Probability of false alarm, *PFA*

The probability of false alarm, *PFA*, is the probability that the indicated leak rate will exceed the threshold or criterion for indicating a leak when the tank or pipe is actually tight. Generally, if the estimated leak rate exceeds a specified leak rate or threshold, *C*, (for example 0,9 l/h), the tank is judged by the system under test to be leaking. If *C* denotes the criterion or threshold for indicating a leak, *B*, the estimated bias of the system, *SD*, the standard deviation, then the probability of a false alarm can be written according to Formula (B.6):

$$PFA = P\ \{\ t > (C - B)\ /\ SD\ \} \quad \text{(B.6)}$$

where the probability is calculated from a *t*-distribution with the number of degrees of freedom associated with the standard deviation, which would be 44 where the full set of 45 tests is used. This formula assumes that the errors are approximately normally distributed. If the bias, *B*, was not significantly different from zero, *B* is taken to be zero.

B.9.8 Probability of detecting a specific leak rate, *PD*

The probability of detection, *PD*, is the probability that the system will correctly identify a leak of specified size. In general for a leak rate of size *R*, *PD* is given by Formula (B.7):

$$PD = P\ \{ t > (C - R - B)\ /\ SD \} \quad \text{(B.7)}$$

where *C*, *B*, and *SD* are as before, and the probability is calculated from the *t*-distribution with degrees of freedom corresponding to the *SD*, which would be 44 if the usual set of 45 records is used.

B.9.9 Mean and standard deviation of the tight tank test

The tests conducted under the condition of no leak (tight tank) provide direct estimates of the performance of the system on a tight tank. Calculate the mean and standard deviation for the tests on the tight tank records by using the formulas above restricting the data to the data from the tight tank records. The sample size, *n*, will also be reduced, to 15 if there are 15 records with no induced leak, for example.

B.9.10 Statistics for qualitative systems

The basic results of the system under test are reports that the tank and/or pipes are tight or leaking. As noted above there is a possibility that some results might be invalid. These results can be tabulated in Table B.1 to summarize the results.

Table B.1 — Summary of results from qualitative evaluation

Actual status	**reported**			
	Tight	Leaking	Invalid	Total ($T_i + L_i + X_i$)
Tight	T_1	L_1	X_1	N_1
Leaking	T_2	L_2	X_2	N_2

The numbers in Table B.1 are used to directly estimate the *PFA* and *PD*. The number of tight results incorrectly identified as leaking, divided by the total number of tight tests estimates the *PFA*, see Formula (B.8):

$$PFA = L_1\ /\ (N_1 - X_1) \quad \text{(B.8)}$$

where the letters in the cells of Table B.1 denote the number of results in the category indicated by the cell label.

Similarly, the *PD* is estimated by the number of leaking test results correctly identified as leaking or, according to Formula (B.9):

$$PD = L_2 / (N_2 - X_2) \tag{B.9}$$

In Table B.1, N_1 is the number of data records with no induced leak and N_2 is the number of data records with induced leaks. Both numbers are normally 60.

The proportion of records declared invalid shall also be reported separately for the tight and leaking records as well as for all records. These proportions are calculated according to Formula (B.10), (B.11) and (B.12):

$$PI\ (tight) = X_1 / N_1 \tag{B.10}$$

$$PI\ (leaking) = X_2 / N_2 \tag{B.11}$$

and

$$PI\ (total) = (X_1 + X_2) / (N_1 + N_2) \tag{B.12}$$

For the proportion of invalid records among tight, leaking, and all records, respectively. The proportion of invalid records among all tank records provides an estimate of the proportion of tanks in a population represented by the evaluation database for which this method cannot be used.

In order for the method to meet the required performance standard, *PFA* shall be less than or equal to 0,05 (5 %) and *PD* shall be at least 0,95 (95 %). If the number of records (either tight or leaking) were 60, the system under test could make at most 3 mistakes out of the 60 records and still meet these requirements. It is possible that the system might not make any errors, giving an estimated *PFA* of 0 or an estimated *PD* of 1. Since no system is expected to have zero errors in practice, it is important to calculate a confidence interval for the discrete proportion of false alarms or detections to give an indication of what range should be expected for the *PFA* or *PD* in practice.

If no errors occur in the evaluation database, the confidence limit for *PFA* is given by Formula (B13):

$$UL = 1 - \alpha^{1/N_1} \tag{B.13}$$

where (1 - α) is the confidence coefficient, which is generally set at 0,95. For one or more errors, the confidence limits are calculated from confidence limits for the parameter of a binomial distribution. These can be found in CRC Handbook of Tables for Probability and Statistics, for example.

If no errors occur in the evaluation in detecting leaks, a lower confidence bound for *PD* can be calculated according to Formula (B.14):

$$LL = \alpha^{1/N_2} \tag{B.14}$$

Where again (1 - α) is the confidence coefficient, usually set at 0,95. For one or more errors in detecting leaks, the confidence limits for the binomial are used.

B.10 Comparison of variable and constant leak rate pairs

Variable leaks are simulated on all tank records for which mathematical leaks were simulated. Approximately equal numbers of each nominal leak rate are used. It should be re-stated that these variable and constant leak rate simulation pairs are carried out on the same basic tank record data.

The result will be pairs of leak rate estimates by the system. One member of the pair will be the leak rate estimated for a data record with a constant leak rate simulated. The other member of the pair will be the leak rate estimated by the system when a variable leak rate with the same average rate or overall product loss was simulated.

For quantitative systems, compute the differences between these pairs of estimated leak rates under constant and variable leak rates (on the same data record). Subtract the reported leak rate with the constant simulated leak rate from the reported leak rate with a variable simulated leak rate. Calculate the mean of these differences. (Be aware that these differences are not used in computing the *PD* and *PFA*). In order for the quantitative system to receive type approval, the mean of these differences shall be greater than or equal to zero.

For qualitative systems to qualify, the system shall identify at least as many leaks with the variable leak rate simulation as it does with the constant leak rate simulation. That is, the proportion of leaking records that the system correctly identifies shall be at least as large with the variable leak rate as it is with the constant leak rate. This proportion shall be at least 95 %. If there are 60 records with induced leaks, if 3 are misclassified as tight the 95 % criterion will be considered to have been met, but not so if 4 are incorrect.

B.11 Validation of conditions of use

If the system is to be validated for a particular condition of use, between 25 % and 75 % of the evaluation data comes from tanks where that condition is applied.

To justify a condition of use, the results for tanks with the condition applied shall be shown to be similar to those from tanks where it is not applied. To make this comparison, divide the data records into two groups based on whether the condition is applied or not. For quantitative systems the number in each group is not critical, but for qualitative systems there shall be at least 21 tight records and 21 records with simulated leaks in each group.

For quantitative systems, calculate the mean and standard deviation separately for the two groups. This can be done by using the Formula in B.9.4 and B.9.5 separately on the two groups. Use a two-sample *F* test to *te*st whether the variances of the two groups are equal, see Formula (B.15):

$$F = (SD_1 \ / \ SD_2)^2 \qquad \text{(B.15)}$$

where SD_1 and SD_2 are the standard deviations calculated from the two groups.

In forming the *F* ratio, use the standard deviation with the larger calculated value in the numerator. Compare the calculated value of F to the 95th percentile of an *F*-distribution with (n_1 - 1) degrees of freedom in the numerator (corresponding to SD_1) and (n_2 - 1) degrees of freedom in the denominator (corresponding to SD_2). The sample sizes are n_1 and n_2, respectively. If the calculated value of *F* is less than the tabled value, there is no significant evidence that the two population variances are different. In this case, use of the system is justified both where the condition of use is applied and where it is not.

If the calculated value of *F* exceeds the tabled value, the two variances are significantly different at the 5 % significance level. This is evidence that the performance of the system is affected under the condition of use in question. In this case, continue the computation of the *PD* and *PFA* separately for the two groups. If both groups meet the performance standards the system may be used whether or not the condition of use is applied. If only one group meets the performance standards, then the use of the system is limited to that group (with the condition applied or without) for which the performance standards are met.

If the standard deviations are not significantly different, test to see if the bias is different for the two groups of tanks. Use a two-sample *t*-test to test whether there is any significant difference in the bias, see Formula (B.16):

$$t_b = (B_1 - B_2) / (S_p \sqrt{(1/n_1 + 1/n_2)}) \quad \text{(B.16)}$$

where S_p is the pooled standard deviation of the two groups and is calculated according to Formula (B.17):

$$S_p = \sqrt{\frac{(n - 1)SD_1^2 + (n_2 - 1)SD_2^2}{(n_1 + n_2 - 2)}} \quad \text{(B.17)}$$

Compare t_b to a two-sided 5 % critical value from a t-distribution with $(n_1 + n_2 - 2)$ degrees of freedom. If the absolute value of t_b does not exceed the critical value then there is no evidence that the bias is different with or without the condition of use applied and use of the system is justified in either case.

If the absolute value of t_b does exceed the percentile from the t-table, then the system has a significantly different bias in the two cases. In this event, continue the computation of the *PD* and *PFA* separately for the two groups. If both groups meet the performance standards the system may be used whether or not the condition of use is applied. If only one group meets the performance standards, then the use of the system is limited to that group (with the condition applied or without) for which the performance standards are met.

For qualitative systems, compute the *PFA* and *PD*, as described in B.9.10 separately for each group. If both groups meet the performance standard, the system may be used whether or not the condition of use is applied. If one of the groups does not meet the performance standard, but the other does, then the results shall be limited to the group (with the condition applied or without) for which the performance standards are met.

Annex C
(normative)

Leak detection systems Category B(1)

C.1 Preparation

The sensor shall be installed in the test vessel for the function test in such a way that it can be immersed either by changing the level of the liquid or by raising and lowering of the sensor.

The sensor under test shall be connected to evaluation device and the alarm device.

The gauge sensor under test shall be fitted to the test tank in accordance with the manufacturer's instructions. The manufacturer's fittings should be used wherever possible. The sensor under test is connected to the gauge control device under test that is situated in ambient laboratory conditions.

Power is applied to the gauge system that is then initialized according to the manufacturer's operating instructions such that the system is fully operational.

The atmospheric pressure and temperature monitoring equipment is installed such that these conditions can be monitored in the vicinity of all gauge system components. This equipment is then used throughout the duration of testing to ensure that all tests are conducted within the range of environmental conditions specified in 6.1 of EN 13352:2012, as appropriate to the location in which the components of the system under test are installed.

The independent leak detection system fitted to the test tank is operated throughout the duration of testing to ensure that the tank remains tight at all times. Correct operation is verified by execution of the system's self-check procedures at the beginning and end of each test.

C.2 Stabilization and trial run

Prior to the test schedule, and with the gauge system fully operational, the tank is filled to 95 % of Nominal Tank Capacity with the test liquid. The tank is then left to stabilize for a time period equal to the period for stabilization defined in 5.1.4.3.1. The system under test is then operated in accordance with the manufacturer's instructions such that a leak test is conducted. The purpose of this test is to establish that the system under test is installed and operating correctly, and the test result is discounted. In the event that the system is not functioning correctly, this can be rectified and the trial run repeated.

C.3 Procedure

1) The device which can create a constant leak rate, e.g. peristaltic pump, shall create a leak rate of 0,9 l h^{-1} ± 2 %. The measurement shall be carried out according to within the maximum time of detection of Table 1.

2) The device which can create a constant leak rate e.g. peristaltic pump, shall create a leak rate of 0,7 l h^{-1} ± 2 %. The measurement shall be carried out within the maximum time of detection according to Table 1.

The leak detector shall be tested at a temperature of (20 ± 5) °C. The liquid detection sensor shall be immersed in the test liquid according to EN 228 and/or EN 590 in the test vessel. Then the test liquid level shall be changed where the readings on the evaluation device shall be reordered to meet the requirements according to Table 1 for category B(1) Type 1 and category B(1) Type 2.

Tests are conducted in pairs, interleaved with tank empty/fill cycles. For each test to be conducted, the following procedure is used for each pair of tests:

a) Pump product out of the tank until it is 50 % empty, measure and record the temperature of the remaining product.

b) Re-fill the tank to 95 % of Nominal Tank Capacity with product heated or cooled to the specified test temperature, measure and record the temperature of the product being added.

c) Measure and record the temperature of the product in the test tank then allow the tank to stabilize for the period specified in 5.1.4.3.1.

d) Start the tank product temperature monitoring device.

e) Measure and record the groundwater level in the monitoring well.

f) Set the peristaltic pump to a rate within ± 20 % of the first specified leak rate of the test pair and record the actual pumping rate.

g) Start the peristaltic pump and zero the stop clock.

h) Operate the system under test in accordance with the manufacturer's instructions such that a leak test is initiated.

i) Start the stop clock.

j) At the moment when the gauge control unit first indicates the completion of the leak test, or if the maximum period for detection according to Table 1 for category B(1) Type 1 is exceeded, stop the stop clock.

k) Record the detected leak rate as indicated by the means specified in the manufacturer's instructions or the fact that a leak test was not completed (if this was due to an equipment fault, the test is repeated after this is rectified).

l) Measure and record the temperature of the product in the test tank.

m) Check that the temperature during the test did not vary by more than ± 0,5 K about the value recorded at the start of the test.

n) Stop the peristaltic pump.

o) Set the peristaltic pump to a rate within ± 20 % of the second specified leak rate of the test pair and record the actual pumping rate.

p) Start the peristaltic pump and zero the stop clock.

q) Operate the system under test in accordance with the manufacturer's instructions such that a second leak test is initiated. This shall be achieved within 15 min of the end of the first leak test.

r) Start the stop clock.

s) At the moment when the gauge control unit first indicates the completion of the leak test, or if the maximum period for detection according to Table 1 for category B(1) Type 2 is exceeded, stop the stop clock.

t) Record the detected leak rate as indicated by the means specified in the manufacturer's instructions or the fact that a leak test was not completed (if this was due to an equipment fault, the test is repeated after this is rectified).

u) Measure and record the temperature of the product in the test tank.

v) Check that the temperature during the test did not vary by more than ± 0,5 K about the value recorded at the start of the test.

w) Stop the peristaltic pump.

x) Measure and record the groundwater level in the monitoring well.

If in any test the continuously monitored product temperature varies by more than ± 0,5 K, the test result is discarded and the test repeated.

If the groundwater levels measured at the start and end of any pair of tests differ by more than 10 mm, the test results are discarded and the test pair repeated.

All tests in the following series shall be performed:

Table C.1 — Sequence of tests for leak detection category B(1)

	Test number	Leak rate $l \cdot h^{-1}$ ±20 %	Differential temperature of fill K
Empty/Fill Cycle	1	0,2	0
	2	0,0	0
Empty/Fill Cycle	3	0,4	+3
	4	0,2	+3
Empty/Fill Cycle	5	0,0	+3
	6	0,8	+3
Empty/Fill Cycle	7	0,4	−3
	8	0,0	−3
Empty/Fill Cycle	9	0,2	−3
	10	0,8	−3
Empty/Fill Cycle	11	0,8	+3
	12	0,0	+3
Empty/Fill Cycle	13	0,0	0
	14	0,8	0
Empty/Fill Cycle	15	0,0	−3
	16	0,2	−3
Empty/Fill Cycle	17	0,4	0
	18	0,2	0
Empty/Fill Cycle	19	0,8	0
	20	0,4	0
Empty/Fill Cycle	21	0,2	+3
	22	0,4	+3
Empty/Fill Cycle	23	0,8	−3
	24	0,4	−3

The temperature differentials are calculated as the temperature difference between the product in the tank and the product to be added to the tank.

C.4 Test results

The results from tests 1 through 24 according to Table C.1 shall be assessed in accordance with the statistical analysis given in C.5. The minimum leak rate that can be detected within the required limits for probability of detection and probability of false alarms shall be calculated. If this leak rate is greater than that specified in Table 1 for category B(1), then the system shall not receive type approval. If any test failed to provide a leak rate indication within the specified maximum period for detection, then the system shall not receive type approval.

C.5 Evaluation

C.5.1 General

The system has passed the test a) in 5.1.4.3.1.3 if an alarm has been generated within the maximum time of detection according to Table 1 for category B(1).

After the system has generated an alarm the test can be stopped.

The system has passed the test b) in 5.1.4.3.1.3 if no alarm has been generated within the maximum time of detection according to Table 1 for category B(1).

The estimated leak rates recorded in each leak test are used to predict the performance of the system under test in terms of meeting the criteria for probability of detection and probability of false alarm.

C.5.2 Basic statistics for quantitative systems

The *n* pairs of indicated and induced leak rate data (*n* = 24 for the listed test schedule) are used to calculate the mean squared error, *MSE*, the bias, and the variance of the system under test as follows.

C.5.3 Mean squared error

The mean squared error, *MSE*, is given by Formula (C.1):

$$MSE = \sum_{i=1}^{n} (L_i - S_i)^2 / n \qquad (C.1)$$

where L_i is the indicated leak rate reported by the system under test and S_i is the actual induced leak rate, for i from 1 to *n* through the test schedule. The bias, *B*, is estimated by Formula (C.2):

$$B = \sum_{i=1}^{n} (L_i - S_i) / n \qquad (C.2)$$

The bias, *B*, is the average difference between the indicated and induced leak rates over the number of tests. The bias is a measure of the accuracy of the system under test and can be either positive or negative.

C.5.4 Variance and standard deviation

The variance is found from Formula (C.3):

$$\sigma^2 = \sum_{i=1}^{n} \left[(L_i - S_i) - B \right]^2 / (n - 1) \qquad (C.3)$$

Denote the standard deviation by *SD*. The standard deviation is the square root of the variance.

C.5.5 Test for zero bias

To test whether the system under test system has a bias that is statistically significantly different from zero, the following statistical test on the bias, *B*, calculated above is performed. Compute the *t*-statistic according to Formula (C.4):

$$t = \sqrt{n} \; B / SD \qquad (C.4)$$

From a *t*-table, obtain the critical value corresponding to a t with (n - 1) degrees of freedom and a two-sided 5 % significance level. For example, with *n* = 24, there are 23 degrees of freedom and the two-sided 5 % significance level leads to a critical value of 2,07. Denote this value by t_c. Compare the absolute value of t to t_c.If the absolute value of the calculated t is less than the critical value, the bias is not significantly different from zero and the system is assumed unbiased and is likely to be accurate. If the absolute value of the calculated value of t exceeds the critical value then the method has a significant bias. If the bias, *B*, is positive, the system systematically over-estimates the leak rate. If *B* is negative, the system under-estimates the leak rate.

C.5.6 Probability of false alarm, *PFA*

The probability of false alarm, *PFA*, is the probability that the indicated leak rate will exceed the threshold or criterion for indicating a leak when the tank or pipe is actually tight. Generally, if the estimated leak rate exceeds a specified leak rate or threshold, *C*, (for example 0,9 $l \cdot h^{-1}$), the tank is judged by the system under test to be leaking. If *C* denotes the criterion or threshold for indicating a leak, *B*, the estimated bias of the system, *SD*, the standard deviation, then the probability of a false alarm can be written as given in Formula (C.5):

$$PFA = P \{ t > (C - B) / SD \} \quad \text{(C.5)}$$

where the probability is calculated from a *t*-distribution with the number of degrees of freedom associated with the standard deviation, which would be 23 where the full set of 24 tests is used. This formula assumes that the errors are approximately normally distributed. If the bias, *B*, was not significantly different from zero, *B* is taken to be zero.

C.5.7 Probability of detecting a specific leak rate, *PD*

The probability of detection, *PD*, is the probability that the system will correctly identify a leak of specified size. In general for a leak rate of size *R*, *PD* is given by Formula (C.6):

$$PD = P \{ t > (C - R - B) / SD \} \quad \text{(C.6)}$$

where *C*, *B*, and *SD* are as before, and the probability is calculated from the *t*-distribution with degrees of freedom corresponding to the *SD*, which would be 23 if the usual set of 24 records is used.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive Construction Products Regulation 305/2011/EU

ZA.1 Scope and relevant characteristics

This European Standard has been prepared under Mandate M/ 131 PIPES, TANKS and ANCILLARIES not in contact with water intended for human consumption given to CEN by the European Commission and the European Free Trade Association.

If this European standard is cited in the Official Journal of the European Union (OJEU), the clauses of this standard, shown in this annex, are considered to meet the provisions of the relevant mandate, under the Regulation (EU) No. 305/2011.

This annex deals with the CE marking of the leak detection systems based on volumetric loss from within the tank and/or pipework system intended for the uses indicated in Table ZA.1 and shows the relevant clauses applicable.

This annex has the same scope as in Clause 1 of this standard related to the aspects covered by the mandate and is defined by Table ZA.1.

Table ZA.1 — Relevant clauses for product and intended use

<table>
<tr><td colspan="4">Product: leak detection systems based on volumetric loss from within the tank and/or pipework system
Intended use: in\with single or double skin underground tanks and/or single or double skin underground or aboveground, pipework designed for flammable liquids having a flash point not exceeding 100 °C</td></tr>
<tr><th>Essential Characteristics</th><th>Clauses in this and other European Standard(s) related to essential characteristics</th><th>Regulatory classes</th><th>Notes</th></tr>
<tr><td>Effectiveness
— Measuring the volumetric loss;
— software</td><td>4.1.4
4.1.5.</td><td>—
—</td><td>—
—</td></tr>
<tr><td rowspan="5">Durability of effectiveness
— against temperature;
— against chemical attack;
— against hydraulic shock;
— against fatigue and mechanical wear/degradation;
— against microbiological growth;</td><td>4.2.1</td><td>—</td><td>—</td></tr>
<tr><td>4.2.2</td><td>—</td><td>—</td></tr>
<tr><td>4.2.3</td><td>—</td><td>—</td></tr>
<tr><td>4.2.4</td><td>—</td><td>—</td></tr>
<tr><td>4.2.5</td><td>—</td><td>—</td></tr>
</table>

The declaration of the product performance related to certain essential characteristics is not required in those Member States (MS) where there are no regulatory requirements on these essential characteristics for the intended use of the product.

In this case, manufacturers placing their products on the market of these MS are not obliged to determine nor declare the performance of their products with regard to these essential characteristics and the option “No performance determined” (NPD) in the information accompanying the CE marking and in the declaration of performance (see ZA.3) may be used for those essential characteristics.

ZA.2 Procedure for AVCP of leak detection systems based on volumetric loss from within the tank and/or pipework system

ZA.2.1 System(s) of AVCP

The AVCP system(s) of leak detection systems based on volumetric loss from within the tank and/or pipework system indicated in Table(s) ZA.1, established by EC Decision 1999/472/EC published in Official Journal of the European Communities L 184/42 from 17.7.1999 is shown in Table ZA.2 for the indicated intended use(s) and relevant level(s) or class(es) of performance.

Table ZA.2 — System(s) of AVCP

Product(s)	**Intended use(s)**	**Level(s) or class(es) of performance**	**AVCP system(s)**
Leakage alarm systems	In installations for the transport/distribution/st ora-ge of fuel intended for the supply of building heating/cooling systems, from the external storage reservoir to the inlet of the boiler/heater/cooler system of the building	—	3
System 3: See Regulation (EU) No. 305/2011 (CPR) Annex V, 1.4			

The AVCP of the leak detection systems based on volumetric loss from within the tank and/or pipework system in Table ZA.1 shall be according to the AVCP procedures indicated in Tables ZA.3 resulting from application of the clauses of this or other European Standard indicated therein. The content of tasks of the notified body shall be limited to those essential characteristics as provided for, if any, in Annex III of the relevant mandate and to those that the manufacturer intends to declare.

Table ZA.3 — Assignment of AVCP tasks for leak detection systems based on volumetric loss from within the tank and/or pipework system under system 3

Tasks		Content of the task	AVCP clauses to apply
Tasks for the manufacturer	Factory production control (FPC)	— Indicating the correct operating condition of the evaluation device. — Indicating that the measuring system is able to accurately measure value changes — Indicating the ability of the alarm device to indicate an alarm condition	6.3.2.6
Tasks for a notified testing laboratory	Determination of the product-type on the basis of type testing (based on sampling carried out by the manufacturer), type calculation, tabulated values or descriptive documentation of the product	All essential characteristics of Table ZA.1	6.2.2.

ZA.2.2 Declaration of performance (DoP)

ZA.2.2.1 General

The manufacturer draws up the DoP and affixes the CE marking on the basis of the different AVCP systems set out in Annex V of the Regulation (EU) No 305/2011:

In case of products under system 3

— the factory production control carried out by the manufacturer; and

— the determination of the product-type on the basis of type testing (based on sampling carried out by the manufacturer), type calculation, tabulated values or descriptive documentation of the product, carried out by the notified testing laboratory.

ZA.2.2.2 Content

The model of the DoP is provided in Annex III of the Regulation (EU) No 305/2011.

According to this Regulation, the DoP shall contain, in particular, the following information:

— the reference of the product-type for which the declaration of performance has been drawn up;

— the AVCP system or systems of the construction product, as set out in Annex V of the CPR;

— the reference number and date of issue of the harmonized standard which has been used for the assessment of each essential characteristic;

— where applicable, the reference number of the Specific Technical Documentation used and the requirements with which the manufacturer claims the product complies.

The DoP shall in addition contain:

a) the intended use or uses for the construction product, in accordance with the applicable harmonized technical specification;

b) the list of essential characteristics, as determined in the harmonized technical specification for the declared intended use or uses;

c) the performance of at least one of the essential characteristics of the construction product, relevant for the declared intended use or uses;

d) where applicable, the performance of the construction product, by levels or classes, or in a description, if necessary based on a calculation in relation to its essential characteristics determined in accordance with the Commission determination regarding those essential characteristics for which the manufacturer shall declare the performance of the product when it is placed on the market or the Commission determination regarding threshold levels for the performance in relation to the essential characteristics to be declared.

e) the performance of those essential characteristics of the construction product which are related to the intended use or uses, taking into consideration the provisions in relation to the intended use or uses where the manufacturer intends the product to be made available on the market;

f) for the listed essential characteristics for which no performance is declared, the letters "NPD" (No Performance Determined).

Regarding the supply of the DoP, article 7 of the Regulation (EU) No 305/2011 applies.

The information referred to in Article 31 or, as the case may be, in Article 33 of Regulation (EC) No 1907/2006, (REACH) shall be provided together with the DoP.

ZA.2.2.3 Example of DoP

The following gives an example of a filled-in DoP for pressure line leak detector

DECLARATION OF PERFORMANCE

No. 001CPR2015-07-14

1 Unique identification code of the product-type:

Leak Detection Kit Class IV, Category C, Type Y

2 Type, batch or serial number or any other element allowing identification of the construction product as required under Article 11(4):

Pressure line leak detector

3. Intended use or uses of the construction product, in accordance with the applicable harmonized technical specification, as foreseen by the manufacturer:

Leak detector kit Class IV intended to be used in single or double skin underground and/or aboveground pressurized pipework designed for flammable liquids having a flash point not exceeding 100 °C.

4. Name, registered trade name or registered trade mark and contact address of the manufacturer as required under Article 11(5):

AnyCo SA,

PO Box 21

B-1050 Brussels, Belgium

Tel. +32987654321

Fax: +32123456789

Email: anyco.sa@provider.be

5. Where applicable, name and contact address of the authorized representative whose mandate covers the tasks specified in Article 12(2):

Anyone Ltd

Flower Str. 24

West Hamfordshire

UK-589645 United Kingdom

Tel. +44987654321

Fax: +44123456789

e-mail: anyone.ltd@provider.uk

6. System or systems of assessment and verification of constancy of performance of the construction product as set out in CPR, Annex V:

System 3

7. In case of the declaration of performance concerning a construction product covered by a harmonized standard:

   Notified factory production control certification body No. 5678 performed the initial inspection of the manufacturing plant and of factory production control and the continuous surveillance, assessment and evaluation of factory production control and issued the certificate of conformity of the factory production control.

8. Declared performance

Essential characteristics	**Performance**	**Harmonized technical specification**
Measuring the volumetric loss	**Pass**	EN 13160–5:2016
Requirements for software, (only if provided)	**Pass**	
Durability of effectiveness — against temperature	EN 13352 Type 1	
Durability of effectiveness — against chemical attack	Petroleum products	
Durability of effectiveness — against hydraulic shock	Certified for PN 16	
Durability of effectiveness — against fatigue and mechanical wear	50 000 cycles	
Durability of effectiveness — against microbial growth	NPD	

9. The performance of the product identified in points 1 and 2 is in conformity with the declared performance in point 8.

   This declaration of performance is issued under the sole responsibility of the manufacturer identified in point 4.

Signed for and on behalf of the manufacturer by:

……

(name and function)

………………………………………………… …………………………………………………

(place and date of issue) (signature)

ZA.3 CE marking and labelling

The CE marking symbol shall be in accordance with the general principles set out in Article 30 of Regulation (EC) No 765/2008 and shall be affixed visibly, legibly and indelibly:

— to the leak detection systems based on volumetric loss from within the tank and/or pipework system

or

— to a label attached to it.

Where this is not possible or not warranted on account of the nature of the product, it shall be affixed:

— to the packaging

or

— to the accompanying documents.

NOTE In addition to the above, ZA.3 of Annex ZA of the standard could include provisions to be followed where it is intended to split the information accompanying the CE marking and to place them in different locations.

The CE marking shall be followed by:

— the last two digits of the year in which it was first affixed;

— the name and the registered address of the manufacturer, or the identifying mark allowing identification of the name and address of the manufacturer easily and without any ambiguity;

— the unique identification code of the product-type;

— the reference number of the declaration of performance;

— the level or class of the performance declared;

— the dated reference to the harmonized technical specification applied;

— the identification number of the notified body;

— the intended use as laid down in the harmonized technical specification applied.

The CE marking shall be affixed before the construction product is placed on the market. It may be followed by a pictogram or any other mark notably indicating a special risk or use.

In case of Specific Technical Documentation (STD), the reference to be used shall be the number assigned to the STD by the manufacturer.

Figure ZA.1 gives an example of the information related to products subject to AVCP under each of the different systems to be given on the product.

CE 8910	*CE marking, consisting of the "CE"-symbol* *Identification number of the notified test laboratory*
AnyCo Ltd, PO Box 21, B-1050, Brussels, Belgium **16** 00001-CPR-2015/05/12	*name and the registered address of the manufacturer, or identifying mark* *Last two digits of the year in which the marking was first affixed* *Reference number of the DoP*
EN 13160–5:2016 Class IV Category C in\with single or double skin underground tanks and/or single or double skin underground or aboveground, pipework designed for flammable liquids having a flash point not exceeding 100 °C Performance as declared in DoP Software: Version X	*No. of European Standard applied, as referenced in OJEU* *Unique identification code of the product-type* *Intended use of the product as laid down in the European Standard applied* *Level or class of the performance declared*

Figure ZA.1 — Example CE marking information of products under AVCP system 3

Bibliography

[1] BEYER W.H., ed. Handbook of Tables for Probability and Statistics, The Chemical Rubber Co. 1968, ISBN# 0-8493-0692-2

[2] Further information for standard test procedures for evaluating various leak detection methods, see http://www.epa.gov/oust/pubs/protocol.htm

[3] EN ISO 9001, *Quality management systems — Requirements (ISO 9001)*

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