4.4.2 Associated Measuring Sensor

An Evaluation Certificate for an associated measuring instrument sensor may be issued according to the third approach, as mentioned in this Guide.
The Certificate should provide information on:

- compatibility or the need for examination of the combination
- special considerations during Initial Verification

Please note that for temperature dependent resistances, if conformity with the applicable ISO, EN, CEN CENELEC norms and/or OIML R84 is demonstrated in an Evaluation Certificate, there is no need for legal metrological “Approval” of such a device. The device’s accuracy class must fit the application.
The suitability of a particular R84 compliant temperature dependent resistance depends on its R117 and R84 Accuracy Class and the liquid temperature range.

Liquid temperature range(s) for compatibility R117 and R84 Accuracy Classes [^{o}C]			
R84 Accuracy Classes		**R117 Accuracy Classes**	
		0.3	**0.5 / 1.0 / 1.5**
PRT	AA	- 176 … + 176	- 176 … + 176
	A	- 125 … + 45 + 51 … + 125	- 125 … + 125
	B	- 20 … - 11	- 20 … + 20
	C	-	-
	D	-	-
CRT	B	- 42 … - 11	- 42 … + 42
	C	-	-
NRT	C (0 … +180 ^{o}C)	0 … + 5	0 … + 25
	C (-60 … 0 ^{o}C)	- 12 … - 11 - 2 … 0	- 12 … 0
	Combined	- 12 … - 11 - 2 … + 5	- 12 … + 25

Abbreviations:
PRT Platinum Resistance Thermometer
CRT Copper Resistance Thermometer
NRT Nickel Resistance Thermometer

Please note that R84 allows temperature dependent resistances to be of the 2-, 3- and 4-wire type.

4.4.3 Conversion device

According to 6.1.8 of OIML R117 a conversion device includes the associated measuring instruments. This means that an Evaluation Certificate for a conversion device can be issued only for the complete device.
For the first approach this is evident, but for the second approach it would be useful to also define compatibility requirements in the Evaluation Certificate for interchanging associated measuring instrument sensors.
The associated measuring instrument sensors, mentioned in this certificate, should be described in general, so approved associated measuring sensors (see 4.4.2) may be part of the conversion device, provided compatibility requirements are met.

5 Maximum Permissible Errors and Significant Faults

The MPE's and SF's stated below are derived either directly from OIML R117, or determined by WELMEC WG 10 . Because all MPE's and SF's depend on the applicable Accuracy Class, they are all expressed as fractions of the applicable MPE, which in turn can be found in tables 2 and 4 of R117, or they are expressed as the difference between the values of lines A and B of table 2. Where possible, the reference to OIML R117 is stated between round brackets by numbers identifying the R117 point, table or definition, where possible. References to OIML R117-1 are given in square brackets, where possible.

<table>
<tr><th rowspan="3">Description</th><th colspan="4">MPE</th><th colspan="4">SF</th></tr>
<tr><th colspan="8">R117-1 Accuracy Classes</th></tr>
<tr><th>0.3</th><th>0.5</th><th>1.0</th><th>1.5</th><th>0.3</th><th>0.5</th><th>1.0</th><th>1.5</th></tr>
<tr><td colspan="9">First Approach: Electronic Conversion Device, with associated measuring devices</td></tr>
<tr><td>Determination of volume (Vt) or mass (M) from simulated signal (e.g. pulse counting) (2.8, table 2, line A), [2.8, table 2, line A]</td><td>0.03 %</td><td>0.05 %</td><td>0.10 %</td><td>0.15 %</td><td>0.03 %</td><td>0.05 %</td><td>0.10 %</td><td>0.15 %</td></tr>
<tr><td>Determination of converted volume (Vb) or mass (M) based on measured characteristic quantities of the liquid (T, P, rho)
MPE = A - B: (2.7.1, table 2), [2.7.1.2, table 2]
SF = 0.2 MPE: (T.3.12, table 2 line A), [2.7.1.3, 2.5.4, table 2]</td><td>0.10 %</td><td>0.20 %</td><td>0.40 %</td><td>0.50 %</td><td>0.06 %</td><td>0.10 %</td><td>0.20 %</td><td>0.30 %</td></tr>
<tr><td colspan="9">Second Approach: Associated Measuring Devices with Conversion Device as Indicator</td></tr>
<tr><td rowspan="3">Associated Measuring Instruments separately, indication ECID / ECD versus reference characteristic quantity (T, P, rho)
MPE: (2.7.2, table 4), [2.7.2.2, table 4.2]
SF: (table 4) (Note 1), [2.7.2.2, table 4.2]</td><td>0.30 °C</td><td colspan="3">0.50 °C</td><td>0.[illegible]0 °C</td><td colspan="3">0.50 °C</td></tr>
<tr><td colspan="4">Less than 1 Mpa: 50 kPa
Between 1 and 4 MPa: 5%
More than 4MPa: 200 kPa</td><td colspan="4">Less than 1 Mpa: 50 kPa
Between 1 and 4 MPa: 5%
More than 4MPa: 200 kPa</td></tr>
<tr><td colspan="2">1 kg/m^3</td><td colspan="2">2 kg/m^3</td><td colspan="2">1 kg/m^3</td><td colspan="2">2 kg/m^3</td></tr>
<tr><td>Determination of volume (Vt) or mass (M) from simulated signal (e.g. pulse counting) (2.8, table 2, line A), [2.8, table 2, line A]</td><td>0.03 %</td><td>0.05 %</td><td>0.10 %</td><td>0.15 %</td><td>0.03 %</td><td>0.05 %</td><td>0.10 %</td><td>0.15 %</td></tr>
<tr><td rowspan="3">AMT, Conversion of simulated signals, representing characteristic quantities of the liquid (T, P, rho), into values indicated by the ECID / ECD, for analogue devices
MPE: [2.7.2.1.1, table 4.1]
SF: (table 4) (Note 1, note 4), [2.7.2.1.1, table 4.1]</td><td>0.18 °C</td><td colspan="3">0.30 °C</td><td>0.18 °C</td><td colspan="3">0.30 °C</td></tr>
<tr><td colspan="4">Less than 1 Mpa: 30 kPa
Between 1 and 4 MPa: 3%
More than 4MPa: 120 kPa</td><td colspan="4">Less than 1 Mpa: 50 kPa
Between 1 and 4 MPa: 5%
More than 4MPa: 200 kPa</td></tr>
<tr><td colspan="2">0.6 kg/m^3</td><td colspan="2">1.2 kg/m^3</td><td colspan="2">0.6 kg/m^3</td><td colspan="2">1.2 kg/m^3</td></tr>
<tr><td>Conversion calculation (Vt, Vb and/or M based on accepted standards, indicated Vt or M and values of characteristic quantities (T, P, rho) offered through simulated signals (Note 2, 3)
MPE: (2.8, table 2 line A), [2.7.1.2, table 2 line A]
SF: 0.1 MPE [2.7.2.1.1, table 2 line A]</td><td>0.03 %</td><td>0.05 %</td><td>0.10 %</td><td>0.15 %</td><td>0.03 %</td><td>0.05 %</td><td>0.10 %</td><td>0.15 %</td></tr>
</table>

<table>
<tr><th colspan="2" rowspan="3">Description</th><th colspan="4">MPE</th><th colspan="4">SF</th></tr>
<tr><th colspan="8">R117-1 Accuracy Classes</th></tr>
<tr><th>0.3</th><th>0.5</th><th>1.0</th><th>1.5</th><th>0.3</th><th>0.5</th><th>1.0</th><th>1.5</th></tr>
<tr><td colspan="10">Third Approach: Associated Measuring Devices and ECID / ECD separately (new in comparison with OIML R117)</td></tr>
<tr><td rowspan="2">General</td><td>Determination of volume (Vt) or mass (M) from simulated signal (e.g. pulse counting)
(2.8, table 2, line A), [2.8, table 2, line A]</td><td>0.03 %</td><td>0.05 %</td><td>0.10 %</td><td>0.15 %</td><td>0.03 %</td><td>0.05 %</td><td>0.10 %</td><td>0.15 %</td></tr>
<tr><td>Conversion calculation (Vt, Vb and/or M), based on accepted standards, indicated Vt or M and values of characteristic quantities (T, P, rho) offered through simulated signals (Note 2, 3)
MPE: (2.8, table 2 line A), [2.7.2.1.2, table 2 line A]
SF: 0.1 MPE [2.7.2.1.2, table 2 line A]</td><td>0.03 %</td><td>0.05 %</td><td>0.10 %</td><td>0.15 %</td><td>0.03 %</td><td>0.05 %</td><td>0.10 %</td><td>0.15 %</td></tr>
<tr><td rowspan="6">Analogue</td><td rowspan="3">AMS, Accuracy of generation of output signal, based on measured quantity (T, P, rho) for analogue devices
MPE: 0.8 MPE (table 4) (Note 4), [2.7.3.2.1, table 4.3]
SF: 0.8 MPE (table 4) (Notes 1 and 4), [2.7.3.2.1, table 4.3]</td><td>0.24 °C</td><td colspan="3">0.40 °C</td><td>0.24 °C</td><td colspan="3">0.40 °C</td></tr>
<tr><td colspan="4">Less than 1 Mpa: 40 kPa
Between 1 and 4 MPa: 4%
More than 4MPa: 160 kPa</td><td colspan="4">Less than 1 Mpa: 40 kPa
Between 1 and 4 MPa: 4%
More than 4MPa: 160 kPa</td></tr>
<tr><td colspan="2">0.8 kg/m³</td><td colspan="2">1.6 kg/m³</td><td colspan="2">0.8 kg/m³</td><td colspan="2">1.6 kg/m³</td></tr>
<tr><td rowspan="3">AMT, Conversion of simulated signals, representing characteristic quantities of the liquid (T, P, rho), into digital values in ECID, for analogue devices
MPE: 0.6 MPE (2.7.3, table 4, note 4), [2.7.3.1, 2.7.2.1.1, table 4.1]
SF: 0.6 MPE (table 4) (Note 1, note 4), [2.7.3.1, 2.7.2.1.1, table 4.1]</td><td>0.18 °C</td><td colspan="3">0.30 °C</td><td>0.18 °C</td><td colspan="3">0.30 °C</td></tr>
<tr><td colspan="4">Less than 1 Mpa: 30 kPa
Between 1 and 4 MPa: 3%
More than 4MPa: 120 kPa</td><td colspan="4">Less than 1 Mpa: 30 kPa
Between 1 and 4 MPa: 3%
More than 4MPa: 120 kPa</td></tr>
<tr><td colspan="2">0.6 kg/m³</td><td colspan="2">1.2 kg/m³</td><td colspan="2">0.6 kg/m³</td><td colspan="2">1.2 kg/m³</td></tr>
<tr><td rowspan="4">Digital</td><td rowspan="3">AMS + AMT, Accuracy of generation of output signal, based on measured quantity (T, P, rho) for digital devices
MPE: table 4), [2.7.3.2.2, table 4.2]
SF: (table 4) (note 1), [2.7.3.2.2, table 4.2]</td><td>0.30 °C</td><td colspan="3">0.50 °C</td><td>0.30 °C</td><td colspan="3">0.50 °C</td></tr>
<tr><td colspan="4">Less than 1 Mpa: 50 kPa
Between 1 and 4 MPa: 5%
More than 4MPa: 200 kPa</td><td colspan="4">Less than 1 Mpa: 50 kPa
Between 1 and 4 MPa: 5%
More than 4MPa: 200 kPa</td></tr>
<tr><td colspan="2">1 kg/m³</td><td colspan="2">2 kg/m³</td><td colspan="2">1 kg/m³</td><td colspan="2">2 kg/m³</td></tr>
<tr><td>Conversion of simulated signals, representing characteristic quantities of the liquid (T, P, rho), into digital values in ECID, for digital devices</td><td colspan="4">Rounding errors only (Note 1)
[2.7.3.2.2]</td><td colspan="4">Rounding errors only (Note 1)
[2.7.3.2.2]</td></tr>
</table>

Notes:

(1) Although not stated in OIML R117, edition 1995; WG10 decision.

(2) Please note that in this Approach the values represented by the simulated signals are the input for the conversion calculation. As such, the analogue to digital conversion and the determination of the conversion factor is included in the stated maximum permissible errors and significant faults.

(3) Please note that when verifying the conversion calculation in all cases the volume indication is assumed to be without error.

(4) Derived from OIML R117, edition 1995, 2.7.3 and table 4 using quadratic addition.

(5) In Oslo the Working Group unanimously agreed on quadratic addition of partial MPE's for Type Aproval.

(6) During disturbance tests on interruptible systems (or components thereof) the error may exceed the significant fault, provided an alarm is generated. On non-interruptible systems these errors shall always be smaller than or equal to the significant fault and alarms shall not occur.

6 Scale Intervals and Uncertainties

Below a problem relating to measurement uncertainties in relation with scale intervals is presented. It is included as a basis for discussion. The given article numbers refer to R117, edition 1995.

3.7.7 In addition to the volume at metering conditions and the volume in base conditions or the mass, which shall be displayed according to 2.9.2, the values of other measured quantities (density, pressure, temperature) shall be accessible for each test measurement. Scale intervals for density, pressure and temperature shall be smaller than or equal to one quarter of the maximum permissible errors fixed in 2.7.2. for associated measuring instruments.

2.7.2 refers to table 4, where the following values are specified:

Maximum permissible errors on measuring:	Accuracy classes of the measuring system				
	0.3	0.5	1.0	1.5	2.5
Temperature	± 0.3 °C	± 0.5 °C			± 1.0 °C
Pressure	less than 1 MPa : ± 50 kPa Pressure between 1 and 4 MPa : ± 5 % more than 4 MPa : ± 200 kPa				
Density	± 1.0 kg/m^3		± 2.0 kg/m^3		± 5.0 kg/m^3

3.2.1.2 The scale interval of indication shall be in the form 1 * 10^n , 2 * 10^n or 5 * 10^n authorized units of volume, where n is a positive or negative whole number, or zero.

Following the philosophy of 3.2.1.2, also indications of temperature, pressure and/or density should be in the form of 1 * 10^n , 2 * 10^n or 5 * 10^n authorized units of temperature, pressure and/or density, where n is a positive or negative whole number, or zero.

Based on the information given above, the maximum values for the smallest scale intervals for temperature, pressure and density are given below:

Maximum value smallest scale interval on:	Accuracy classes of the measuring system				
	0.3	0.5	1.0	1.5	2.5
Temperature	0.05 °C	0.1 °C			0.2 °C
Pressure	less than 1 MPa : 10 kPa Pressure between 1 and 4 MPa : 10 kPa more than 4 MPa : 50 kPa				
Density	0.2 kg/m^3		0.5 kg/m^3		1 kg/m^3

Typically on discontinuous indicting devices, the uncertainty caused by the indication is the same size as these smallest scale intervals.
For some tests on electronic conversion devices one needs to verify that the EUT performs within MPE's or SF's, which are two fifths of the values given in table 4. This leads to the following:

Quantity	Scale interval / uncertainty	Smallest MPE / SF
Temperature	0.05 °C	0.12 °C
	0.1 °C	0.20 °C
	0.2 °C	0.40 °C
Pressure	10 kPa	20 kPa
	10 kPa	20 kPa
	50 kPa	80 kPa
Density	0.2 kg/m^3	0.40 kg/m^3
	0.5 kg/m^3	0.80 kg/m^3
	1 kg/m^3	2.0 kg/m^3

As you can see, the uncertainty in some cases is larger than half the MPE/SF, whereas the opening paragraph of OIML R117 Chapter 6 specifies the following:

When a test is conducted, the expanded uncertainty of the determination of errors on indications of volume or mass shall be less than one-fifth of the maximum permissible error applicable for that test on pattern approval and one-third of the maximum permissible error applicable for that test on other verifications. The estimation of expanded uncertainty is made according to the *Guide to the expression of uncertainty in measurement* (1995 edition) with k = 2.

Obviously the uncertainties due to the indication are not five times smaller than the applicable MPE's / SF's. However, when testing AMT's, one is not testing indications on volume or mass. At this point it may be useful to think why a factor of five would be needed, also for testing AMT's. When uncertainties are expressed using a k-factor of 2, one already has a confidence level of 95% on decisions. If a k-factor of 3 would have been applied, the confidence level is 99%. Moreover, the values given in the table above are equivalent to a k-factor of almost 4 or bigger.
Nevertheless, this only takes the uncertainty due to the indication into account. The "space" for additional uncertainties is very small, even for a confidence level of just 95%. Especially because these are the ones we are primarily interested in.
As long as the test results are within the given MPE's / SF's, the confidence level of decisions based on such values is likely to be 95% or better. If a higher confidence level is desired, the uncertainty due to the indication should be reduced by decreasing the smallest scale interval. In this case it is therefore recommended that during testing a smaller scale interval is used than the ones given above.

7 Acceptable standards for conversion

The calculations given in the following standards may be used for conversion:

ASTM D 1250-80(2002) Petroleum Measurement Tables, Tables 53A, 53B, 54A and 54B. (53A and 54A are for Generalized Crude Oils; 53B and 54B are for Generalized Products). Note: these supersede API Standard 2540 and ISO Recommendation ISO/DIS91/1.2.

See OIML R22 for alcohol.

8 Aspects of Initial Verification of Conversion Devices

This section of the document deals with the initial verification of conversion devices that are type approved according to the First Approach, Second Approach and the Third Approach. This section does not deal with the verification of the volume at metering conditions.

8.1 Performance tests under reference conditions

The maximum permissible errors (MPE) stated in the table below can be found in tables 2, 4.1, 4.2 and 4.3 of OIML R117-1 Committee Draft 1CD. The numbers between brackets identify the R117-1CD point.

Description	Test points	MPE (R117-1CD)
FIRST APPROACH (Conversion devices approved according first approach: ECID/ECD together with AMD)		

Description	Test points	MPE (R117-1CD)
Determination of converted volume (Vt or Vb) or of mass (M) based on measured characteristic quantities of the liquid (T, P, rho) and on (simulated) volume at metering conditions (Vt) or (simulated) mass (M) [Note 1]	2^n points: (T_i , P_i, rho_i) with: i = min, max n = number of characteristic quantities [Note 2]	A-B, specified in Table 2 (2.7.1.2)
SECOND APPROACH (Conversion devices approved according second approach: AMD with ECID/ECD as indicator)		
Analogue Associated Measuring Devices		
First stage, AMT: Conversion of simulated signals, representing characteristic quantities of the liquid (T, P, rho), into values indicated by the ECID/ECD	2 points: T_{min} , T_{max} P_{min} , P_{max} rho_{min} , rho_{max}	Table 4.1 (2.7.2.1.1)
Second stage AMI: Indication, by the ECID/ECD, of the characteristic quantity (T, P, rho) measured by the AMD [Note 3]	2 points, within the rated operating conditions	Table 4.2 (2.7.2.2)
Digital Associated Measuring Devices		
AMS + AMT: Accuracy of generation of output signal, based on measured characteristic quantity (T, P, rho)	2 points: T_{min} , T_{max} P_{min} , P_{max} rho_{min} , rho_{max}	Table 4.2 (2.7.2.2)
THIRD APPROACH (Conversion devices approved according third approach: AMD and ECID/ECD separately)		
Analogue Associated Measuring Devices	**ALTERNATIVE 1**	
First stage, AMT: Conversion of simulated signals, representing characteristic quantities of the liquid (T, P, rho), into values indicated by the ECID/ECD	2 points: T_{min} , T_{max} P_{min} , P_{max} rho_{min} , rho_{max}	Table 4.1 (2.7.3.1)
First stage, AMS : Accuracy of generation of output signal, based on measured characteristic quantity (T, P, rho) [Note 4]	2 points: T_{min} , T_{max} P_{min} , P_{max} rho_{min} , rho_{max}	Table 4.3 (2.7.3.2.1)
Second stage AMI: Indication, by the ECID/ECD, of the characteristic quantity (T, P, rho) measured by the AMD [Note 5]	2 points, within the rated operating conditions	Table 4.2
Analogue Associated Measuring Devices	**ALTERNATIVE 2**	
AMI: Indication, by the ECID/ECD, of the characteristic quantity (T, P, rho) measured by the AMD	2 points: T_{min} , T_{max} P_{min} , P_{max} rho_{min} , rho_{max}	Table 4.2
Digital Associated Measuring Devices		
AMS + AMT: Accuracy of generation of output signal, based on measured characteristic quantity (T, P, rho)	2 points: T_{min} , T_{max} P_{min} , P_{max} rho_{min} , rho_{max}	Table 4.2 (2.7.3.2.2)

Note 1:
Because the conversion device is tested as a whole, the tests can be performed in a laboratory.

Note 2:
The test is performed at all possible combinations of the maximum and minimum values of every characteristic quantity. (Also see the second example in paragraph 8.4.)
The evaluation certificate or the pattern approval certificate that is issued for the conversion device may allow, if justified (by calculation or additional pattern testing), a smaller number of test points.

Note 3:
The second stage of the initial verification is generally done on-site in the measuring system. Where it is difficult to obtain more than one test point on-site in the measuring system, the test could be performed in a laboratory provided that afterwards the verified ECID/ECD and AMS are installed together in the same measuring system.

Note 4:
If the sensor is calibrated these tests do not have to be carried out. The calibration result must be traceable to (inter)national standards. It must be checked, given the calibration results, that the sensor's MPE's are respected at the minimum and maximum value of the application range. Alternatively, an Evaluation Certificate demonstrating conformity with the applicable ISO, EN, CEN CENELEC norms and/or OIML R84, eliminates the need for performing these tests.

Note 5:
The test does not have to be performed if it is proven through calculation, based on the results of the First stage AMT and AMS tests, that the MPE of Table 4.2 are respected.

8.2 Examination

If proven that the software is identical to the Approved one, the conversion calculation is not verified at the initial verification – except for the First Approach where the error on the calculation is a part of the global MPE – since the algorithm is part of the legally controlled software.
The evaluation certificates or pattern approval certificates should state how this conformity check has to be done.

At the initial verification, the compatibility of the devices (AMS, AMT, ECID/ECD) must be checked according to the specifications in the evaluation certificates or pattern approval certificates.

8.3 General prescriptions

Provisions shall be made for installing reference equipment (reference measuring instrument) in the measuring system, to verify the AMD under test (second stage of initial verification, subsequent verification).

Upon successful completion of the initial verification, seals shall be fixed in accordance with the applicable approval documents.

8.4 Examples

Example First Approach: a conversion device Vt to V15, based on measured T and rho; measuring system of ACCURACY CLASS 0.5

The maximum permissible error (MPE) stated in the table below can be found in table 2 of OIML R117-1 Committee Draft 1CD. The numbers between brackets identify the R117-1CD point.

Description	Test points	MPE (R117-1CD)
FIRST APPROACH (Conversion devices approved according first approach: ECID/ECD together with AMD)		
Determination of volume at base conditions (Vb) based on measured temperature (T) and measured density (rho) and on (simulated) volume at metering conditions (Vt) [Note 1]	4 points: (rho_{min} and T_{min}), (rho_{min} and T_{max}), (rho_{max} and T_{max}), (rho_{max} and T_{min})	0,2 % (2.7.1.2)

For further information, see Chapter 14.

Note 1:
Because the conversion device is tested as a whole, the tests can be performed in a laboratory.

Example Second and Third Approach: characteristic quantity TEMPERATURE; measuring system of ACCURACY CLASS 0.5

The maximum permissible errors (MPE) stated in the table below can be found in tables 4.1 to 4.3 of OIML R117-1 Committee Draft 1CD. The numbers between brackets identify the R117-1CD point.

Description	Test points	MPE (R117-1CD)
SECOND APPROACH (Conversion devices approved according second approach: AMD with ECID/ECD as indicator)		
Analogue Associated Measuring Devices		
First stage, AMT: Conversion of simulated signal, representing temperature of the liquid (T), into a value indicated by the ECID/ECD	2 points: T_{min} , T_{max}	0.3 °C (2.7.2.1.1)
Second stage, AMD: Indication, by the ECID/ECD, of the temperature (T) measured by the AMD [Note 1]	2 points, within the rated operating conditions	0.5 °C (2.7.2.2)
Digital Associated Measuring Devices		
AMS + AMT: Accuracy of generation of output signal, based on measured temperature (T)	2 points: T_{min} , T_{max}	0.5 °C (2.7.2.2)
THIRD APPROACH (Conversion devices approved according third approach: AMD and ECID/ECD separately)		
Analogue Associated Measuring Devices **ALTERNATIVE 1**		
First stage, AMT: Conversion of simulated signal, representing temperature of the liquid (T), into a value indicated by the ECID/ECD	2 points: T_{min} , T_{max}	0.3 °C (2.7.3.1)

Description	Test points	MPE (R117-1CD)
First stage, AMS : Accuracy of generation of output signal, based on measured temperature (T) [Note 2]	2 points: T_{min} , T_{max}	0.4 °C (2.7.3.2.1)
Second stage AMI: Indication, by the ECID/ECD, of the temperature (T) measured by the AMD [Note 3]	2 points, within the rated operating conditions	0.5 °C
Analogue Associated Measuring Devices		**ALTERNATIVE 2**
AMI: Indication, by the ECID/ECD, of the temperature (T) measured by the AMD	2 points: T_{min} , T_{max}	0,5 °C
Digital Associated Measuring Devices		
AMS + AMT: Accuracy of generation of output signal, based on measured temperature (T)	2 points: T_{min} , T_{max}	0.5 °C (2.7.3.2.2)

Note 1:
The second stage of the initial verification is generally done on-site in the measuring system. *Where it is difficult to obtain more than one test point on-site in the measuring system, the test could be performed in a laboratory provided that afterwards the verified ECID/ECD and AMS are installed together in the same measuring system.*

Note 2:
If the sensor is calibrated these tests do not have to be carried out. The calibration result must be traceable to (inter)national standards. It must be checked, given the calibration results, that the sensor's MPE's are respected at the minimum and maximum value of the application range. Alternatively, an Evaluation Certificate demonstrating conformity with the applicable ISO, EN, CEN CENELEC norms and/or OIML R84, eliminates the need for performing these tests.

Note 3:
The test does not have to be performed if it is proven through calculation, based on the results of the First stage AMT and AMS tests, that the MPE of Table 4.2 is respected.

EXPLANATORY ANNEXES

This Annex aims to clarify how the Maximum Permissible Errors and Significant Faults given in this document were determined and also what is considered to be the “true value” applicable to each test.

9 First Approach

9.1 MPE on volume determination

The pulse counting function of an ECID is considered to be a calculation function which needs to meet the requirement stated in article 2.8.

> *2.8 Maximum permissible errors on calculators*
> *Maximum permissible errors on quantities of liquid indications applicable to calculators, positive or negative, when they are tested separately, are equal to one-tenth of the maximum permissible error defined in line A of Table 2. However, the magnitude of the maximum permissible error shall not be less than one-half scale interval of the measuring system in which the calculator is intended to be included.*

9.2 Significant Fault on volume determination

The significant fault on volume is defined in OIML R117-1 (2CD) T.3.14:
T.3.14 Significant fault (*)
A fault greater than the value specified in this Recommendation.

The following are not considered to be significant faults:

- transitory faults being momentary variations in the indication, which cannot be interpreted, memorized, or transmitted as a measurement result,
- for interruptible measuring systems only, faults implying the impossibility of performing further measurements (but the measuring system shall be able to determine the fault).

9.3 True value for volume determination

When testing a volume input of an ECID / ECD, the true value is considered to be the volume represented by the simulated signal fed to the device. That volume is determined using reference equipment such as a pulse counter in combination with a calculation based on the pulse value [litres per pulse or pulse per litre].

9.4 MPE on converted volume or mass

The maximum permissible error on converted volume or mass (first approach) is given in 2.7.1.
2.7.1 Maximum permissible errors on conversion devices
When a conversion device for converting into a volume at base conditions or into a mass (including all its components and associated measuring instruments) is verified separately, maximum permissible errors on converted indications due to the conversion device, positive or negative, are equal to ± (A – B), A and B being the values specified in Table 2. However, the magnitude of the maximum permissible error shall not be less than the greater of the two following values:
• one-half scale interval of the indicating device for converted indications,
• half of the value corresponding to the minimum specified volume deviation.

9.5 Significant Fault on converted volume or mass

In the absence of a defined SF for quantities other than the volume under metering conditions, it was proposed and agreed to apply the definition of significant fault also to volume under base conditions and converted mass. Thus being one fifth of the value of the MPE, normally applicable to the volume under metering conditions.

9.6 True values for verification converted volume and/or mass

Under the first approach the true value for the volume under metering conditions is the one indicated by the ECID / ECD. The true values for the characteristic quantities of the liquid are those generated by the reference equipment, in this case the temperature bath, pressure balance and/or reference liquid.

10 Second Approach

10.1 MPE on AMD's

In OIML R117 the second approach is defined and the MPE for this type of test is given in article 2.7.2 and table 4.

10.2 True value for testing AMD's

In this case the true value is the one generated by the reference method used to apply the characteristic quantity of the liquid to the AMD, e.g. temperature bath, pressure balance and/or reference liquid.

10.3 MPE on volume determination

The pulse counting function of an ECID is considered to be a calculation function, which needs to meet the requirement stated in article 2.8.

> *2.8 Maximum permissible errors on calculators*
> *Maximum permissible errors on quantities of liquid indications applicable to calculators, positive or negative, when they are tested separately, are equal to one-tenth of the maximum permissible error defined in line A of Table 2. However, the magnitude of the maximum permissible error shall not be less than one half scale interval of the measuring system in which the calculator is intended to be included.*

10.4 True value for volume determination

When testing a volume input of an ECID / ECD, the true value is considered to be the volume represented by the simulated signal fed to the device. That volume is determined using reference equipment such as a pulse counter in combination with a calculation based on the pulse value [litres per pulse or pulse per litre].

10.5 Significant Fault on volume determination

The significant fault on volume is defined in OIML T.3.12.

Significant fault (SF)

A fault the magnitude of which is greater than the larger of these two values:

- *one fifth of the magnitude of the maximum permissible error for the measured volume,*
- *the minimum specified volume deviation.*

The following are not considered to be significant faults:

- *faults arising from simultaneous and mutually independent causes in the measuring instrument itself or in its checking facilities,*
- *transitory faults being momentary variations in the indication, which cannot be interpreted, memorized or transmitted as a measurement result,*
- *faults implying the impossibility of performing any measurement.*

10.6 MPE on AMT's

In article 2.7.3 of OIML R117-1 the MPE, applicable to this test is defined:

> *2.7.3 Accuracy for calculation of characteristic quantities of the liquid When the calculating function of a conversion device is verified separately, the maximum permissible error for the calculation of each characteristic quantity of the liquid, positive or negative, is equal to three fifths of the value fixed in 2.7.2. However the magnitude of the maximum permissible error shall not be less than one-half scale interval of the indicating device for converted indications.*

10.7 True value for testing AMT's

During these tests the true value is considered to be the characteristic quantity represented by the simulated signals fed to the device. That value is determined using reference equipment such as a Voltage meter, Ampere meter or frequency counter in combination with a calculation based on the settings in the ECID / ECD.

10.8 MPE on conversion calculation

The conversion calculation function of an ECID is considered to be a calculation function, which needs to meet the requirement stated in article 2.8.

> *2.8 Maximum permissible errors on calculators*
> *Maximum permissible errors on quantities of liquid indications applicable to calculators, positive or negative, when they are tested separately, are equal to one-tenth of the maximum permissible error defined in line A of Table 2. However, the magnitude of the maximum permissible error shall not be less than one half scale interval of the measuring system in which the calculator is intended to be included.*

10.9 True values for testing conversion calculations

The true values for testing the converted indications in this case are:

- the values represented by the simulated signals for the characteristic quantities of the liquid, as determined by reference equipment measuring these signals
- the volume under metering conditions indicated by the ECID / ECD
- the calculations performed on the bases of accepted standards.

11 Third Approach

11.1 MPE on output signal for analogue devices

In article 2.7.2 and table 4.2 of OIML R117-1 the MPE for a complete Associated Measuring Device is given. In article 2.7.3 the MPE for the A/D conversion (in this case inside the flowcomputer) is given. These two values were subtracted quadratically to determine the MPE on the generation of the analogue devices, being four fifths of the MPE given in table 4.

11.2 True value for testing output signals of analogue devices

In this case the true value is the one generated by the reference method used to apply the characteristic quantity of the liquid to the AMD, e.g. temperature bath, pressure balance and/or reference liquid.

11.3 MPE on output signal from digital devices

In the case of digital devices the A/D conversion is performed outside the ECID / ECD. Therefore the complete MPE for associated measuring instruments applies as given in article 2.7.2 and table 4.3 of OIML R117-1.
Please also see paragraph 11.7.

11.4 True value for testing on output signals of digital devices

The true value in this case is the one offered by means of the reference method applied to generate the characteristic quantity of the liquid, e.g. the temperature bath, pressure balance and/or reference liquid.

11.5 MPE on Conversion of simulated analogue devices

In article 2.7.3 of OIML R117-1 the MPE, applicable to this test is defined.

> *2.7.3 Accuracy for calculation of characteristic quantities of the liquid When the calculating function of a conversion device is verified separately, the maximum permissible error for the calculation of each characteristic quantity of the liquid, positive or negative, is equal to three fifths of the value fixed in 2.7.2. However the magnitude of the maximum permissible error shall not be less than one-half scale interval of the indicating device for converted indications.*

11.6 True value for testing conversion of simulated analogue devices

During these tests the true value is considered to be the characteristic quantity represented by the simulated signals fed to the device. That value is determined using reference equipment such as a Voltage meter, Ampere meter or frequency counter in combination with a calculation based on the settings in the ECID / ECD.

11.7 MPE on ECID reading signals from digital devices

Because the ECID in this case does not perform an A/D conversion it should read the value sent by the digital AMD correctly. Only rounding errors are allowed.

11.8 True value for correct reading digital devices' signal

The true value during this test is the value offered to the ECID / ECD by the reference equipment simulating the digital device.

11.9 MPE on conversion calculation

The conversion calculation function of an ECID is considered to be a calculation function, which needs to meet the requirement stated in article 2.8.

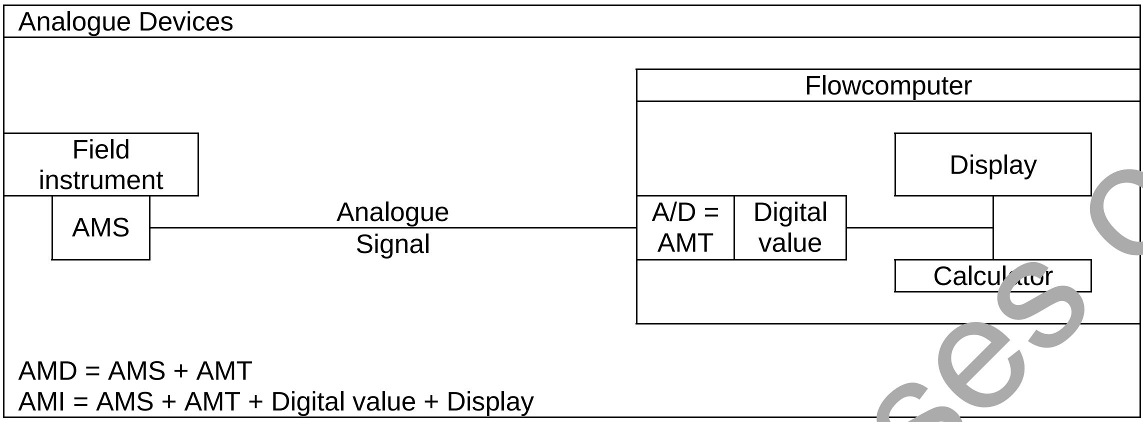
> *2.8 Maximum permissible errors on calculators*
> *Maximum permissible errors on quantities of liquid indications applicable to calculators, positive or negative, when they are tested separately, are equal to one-tenth of the maximum permissible error defined in line A of Table 2. However, the magnitude of the maximum permissible error shall not be less than one half scale interval of the measuring system in which the calculator is intended to be included.*

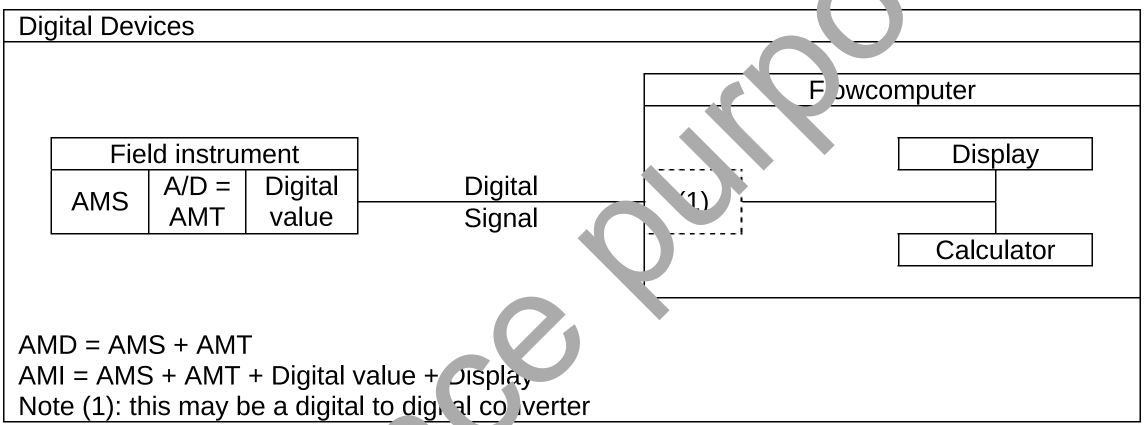
11.10 True values for testing conversion calculations

The true values for testing the converted indications in this case are:

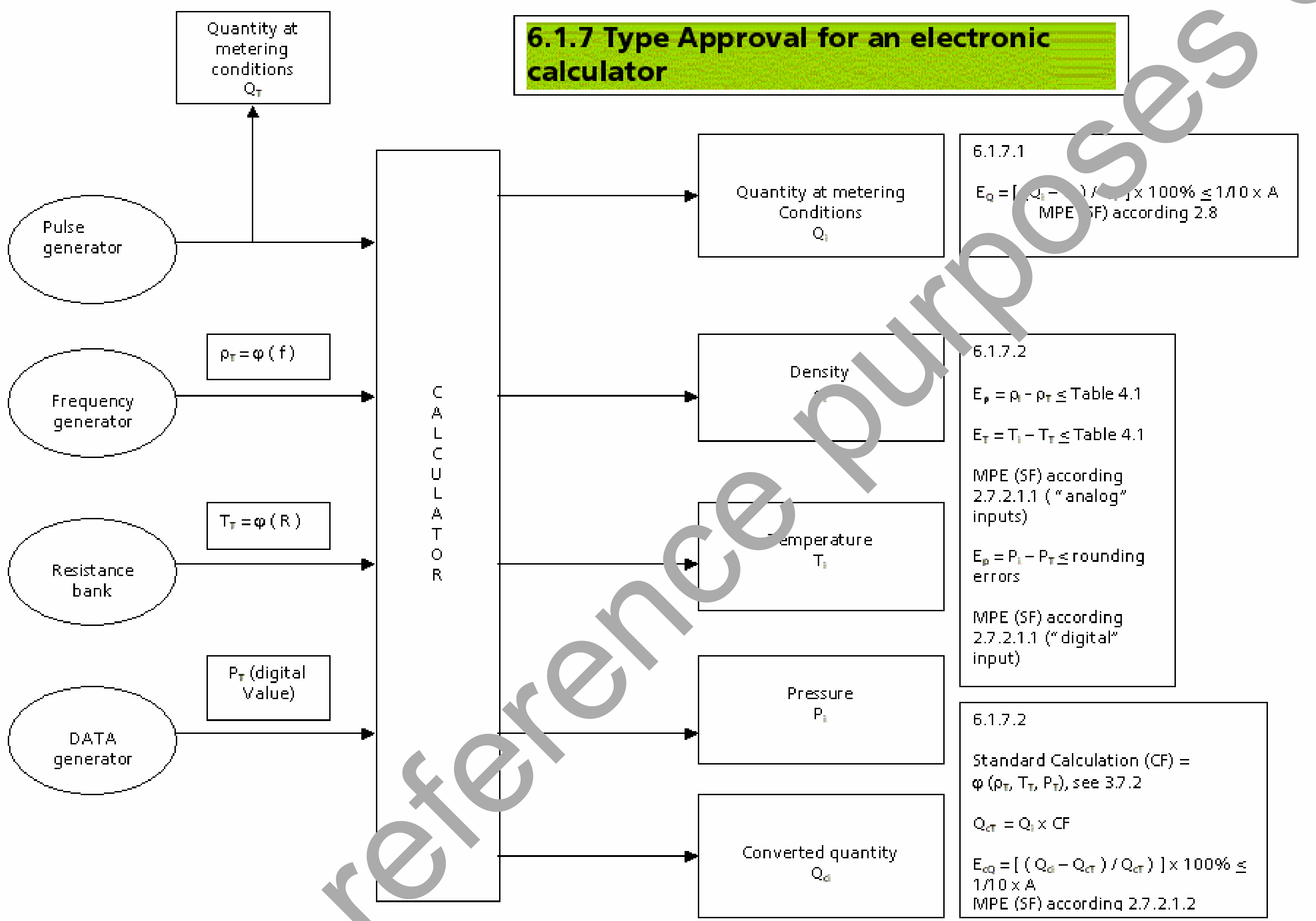
- the values represented by the simulated signals for the characteristic quantities of the liquid, as determined by reference equipment measuring these signals
- the volume under metering conditions indicated by the ECID / ECD
- the calculations performed on the bases of accepted standards

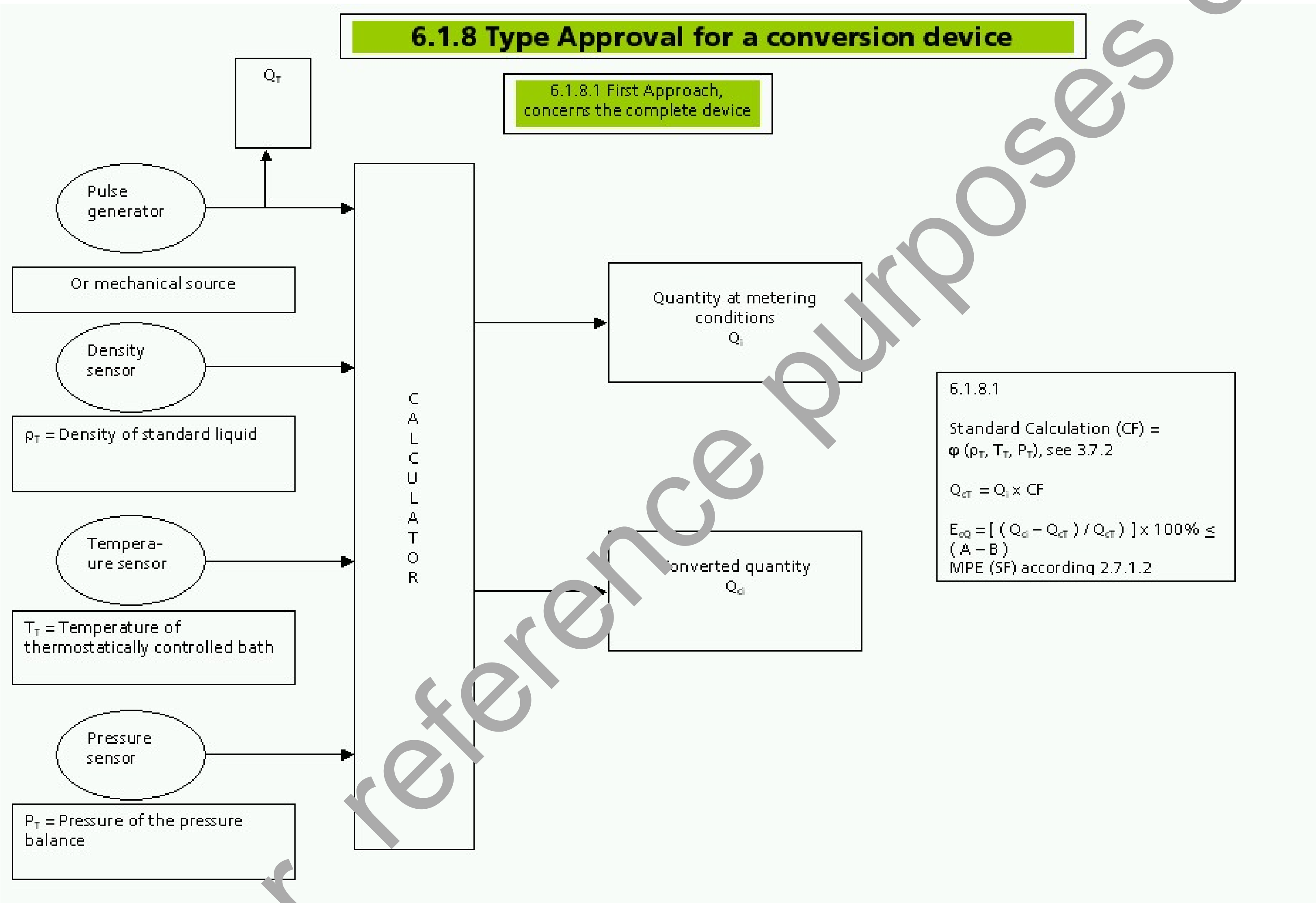
12 Explanatory sketches of Associated Measuring sensors, transducers, devices and instruments

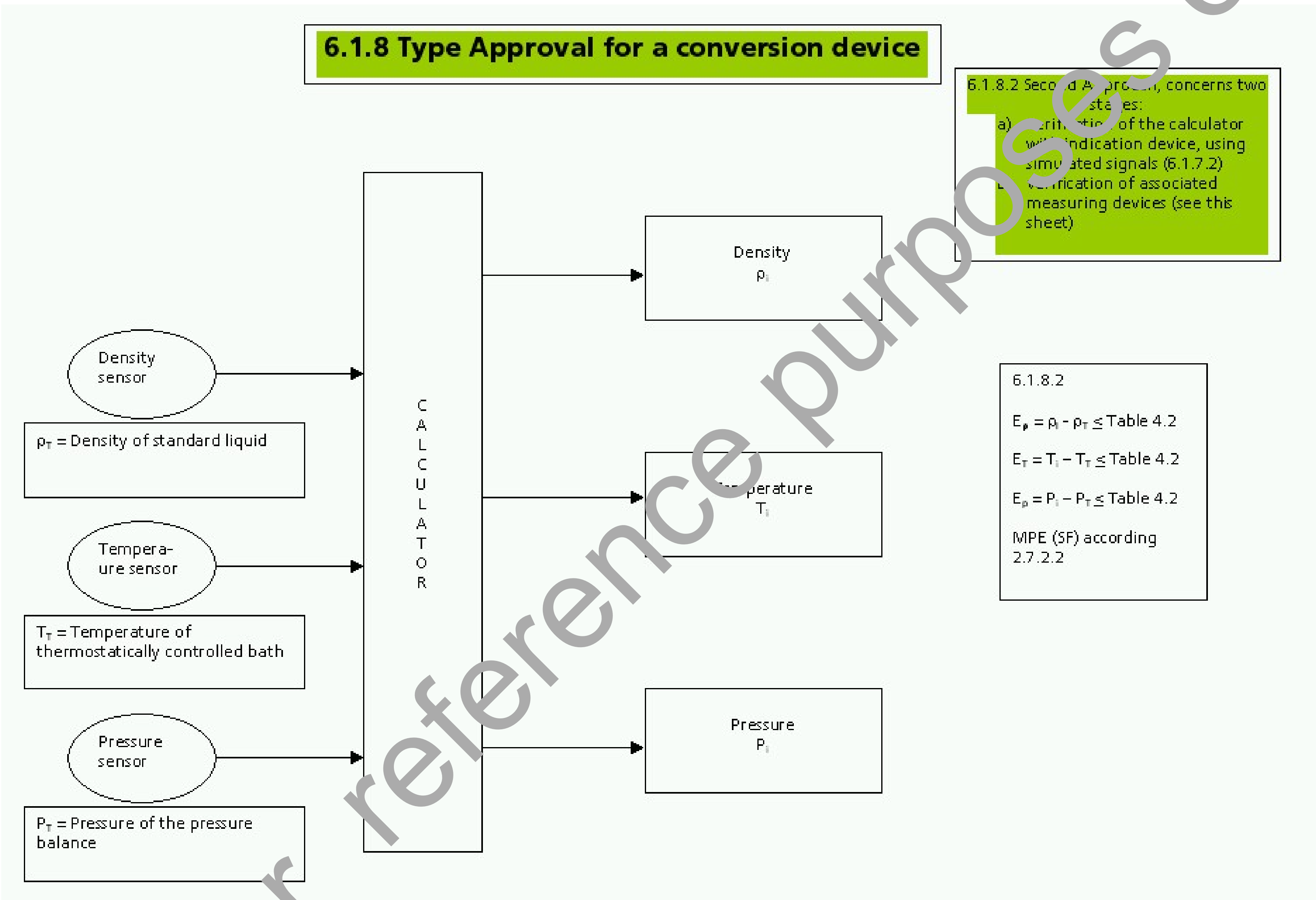


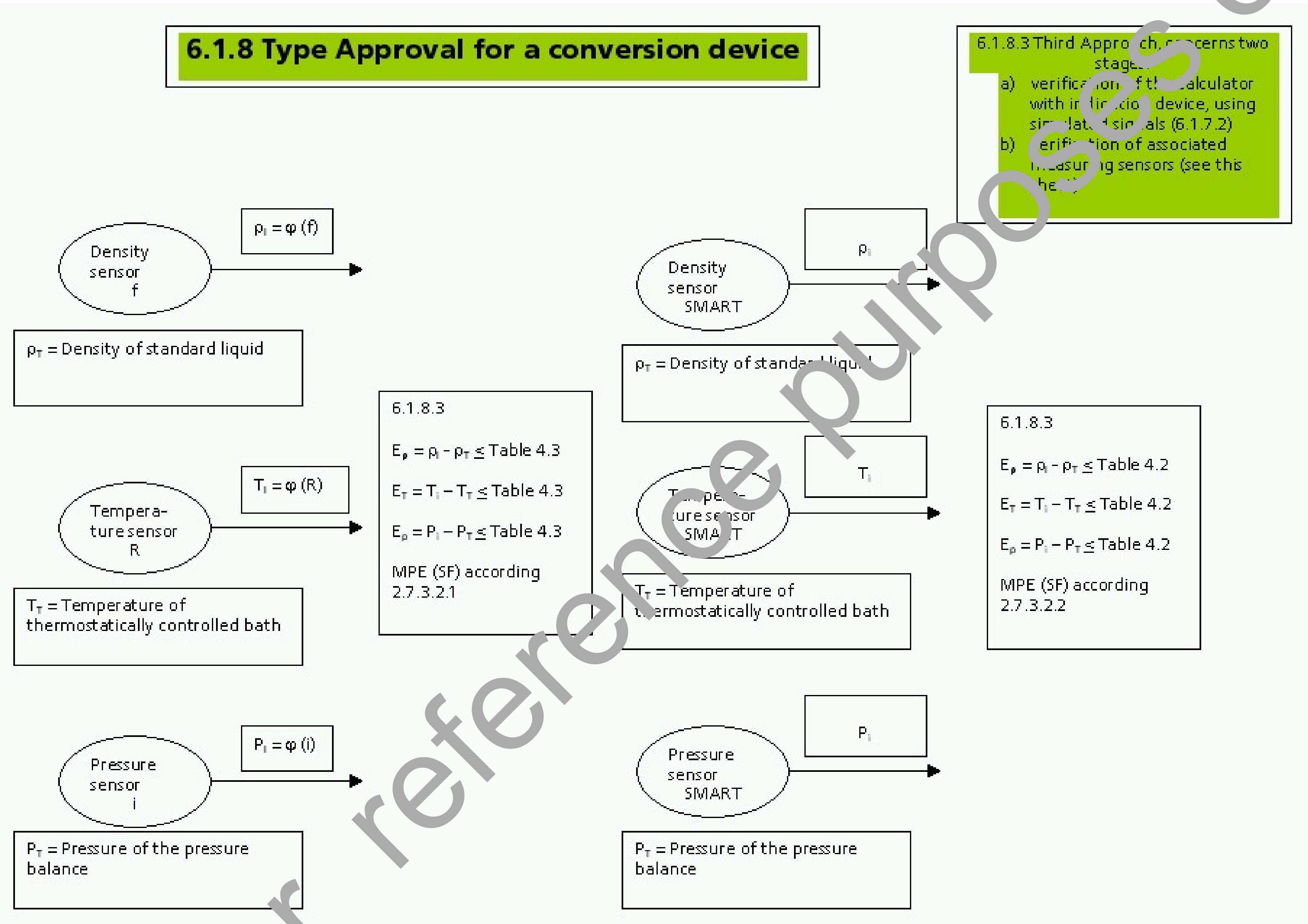


6.1.7 Type Approval for an electronic calculator




6.1.8 Type Approval for a conversion device
6.1.8.1 First Approach, concerns the complete device
QT
Pulse generator
Or mechanical source
Density sensor
ρT = Density of standard liquid
Tempera-ure sensor
TT = Temperature of thermostatically controlled bath
Pressure sensor
PT = Pressure of the pressure balance
CALCULATOR
Quantity at metering conditions Qi
Converted quantity Qci
6.1.8.1
Standard Calculation (CF) =
φ (ρT, TT, PT), see 3.7.2
QcT = Qi x CF
EcQ = [(Qci – QcT) / QcT)] x 100% ≤ (A – B)
MPE (SF) according 2.7.1.2


6.1.8 Type Approval for a conversion device
6.1.8.2
concerns two
of the calculator
indication device, using
signals (6.1.7.2)
measuring devices (see this
sheet)
Density
ρ_i
Density
sensor
ρ_T = Density of standard liquid
C A L C U L A T O R
Tempera-
ure sensor
T_T = Temperature of thermostatically controlled bath
perature
T_i
Pressure
sensor
P_T = Pressure of the pressure balance
Pressure
P_i
6.1.8.2
$E_\rho = \rho_i - \rho_T \leq$ Table 4.2
$E_T = T_i - T_T \leq$ Table 4.2
$E_p = P_i - P_T \leq$ Table 4.2
MPE (SF) according 2.7.2.2


6.1.8 Type Approval for a conversion device
6.1.8.3 Third Approach, concerns two stages:
a) verification of the calculator with indication device, using simulated signals (6.1.7.2)
b) verification of associated measuring sensors (see this sheet)
Density sensor f
$\rho_i = \varphi$ (f)
ρ_T = Density of standard liquid
Tempera-ture sensor R
$T_i = \varphi$ (R)
T_T = Temperature of thermostatically controlled bath
Pressure sensor i
$P_i = \varphi$ (i)
P_T = Pressure of the pressure balance
6.1.8.3
$E_\rho = \rho_i - \rho_T \leq$ Table 4.3
$E_T = T_i - T_T \leq$ Table 4.3
$E_p = P_i - P_T \leq$ Table 4.3
MPE (SF) according 2.7.3.2.1
Density sensor SMART
ρ_i
ρ_T = Density of standard liquid
Tempera-ture sensor SMART
T_i
T_T = Temperature of thermostatically controlled bath
Pressure sensor SMART
P_i
P_T = Pressure of the pressure balance
6.1.8.3
$E_\rho = \rho_i - \rho_T \leq$ Table 4.2
$E_T = T_i - T_T \leq$ Table 4.2
$E_p = P_i - P_T \leq$ Table 4.2
MPE (SF) according 2.7.3.2.2

13 Deliberations applicable to Dry Heat and Cold tests on electronic AMD's

This Chapter deals with specific considerations applicable to electronic AMD's.
Please consider the following:

- the tests specified in Annex A of R117 are intended for electronic devices
- according to article 6.1.5.2.2, the effects of liquid temperature are not taken into consideration when this temperature is between –10 and +50 ^{o}C under OIML R117, edition 1995; or between 0 and +35 ^{o}C under OIML R117-1 and MID

This means that the Annex A tests are intended to verify that the test conditions do not change the EUT's <u>electronic</u> properties too much. However, when submitting electronic AMD's to the Dry Heat and Cold test, also their mechanical properties are changed by the test condition. So when a change in metrological performance is observed, this is likely to be caused by a combination of electrical and mechanical effects.

<u>Example 1</u>: a pressure transmitter, intended for outdoor applications where the liquid temperature is between –10 and +50 ^{o}C resp. 0 and +35 ^{o}C, should have its electronics submitted to ambient temperatures from –25 to +55 ^{o}C. If no precautions are taken, the membrane is submitted to temperatures from –25 to +55 ^{o}C, whereas in practice the membrane's temperature will never exceed –10 to +50 ^{o}C resp. 0 to 35 ^{o}C.
<u>Example 2</u>: a densitometer's vibrational characteristics are likely to be affected by the tube temperature. In practice this will never exceed the liquid temperature.
<u>Example 3</u>: a temperature sensor in a temperature bath during testing, will in fact only be submitted to the temperature of the temperature bath and not the ambient temperature. A secondary, practical problem is the stability of the temperature bath, if placed inside a climate chamber.
Note 1: a combination of practical tests and theoretical analysis has shown that shifts in the behaviour of densitometers during Dry Heat and Cold tests are largely due to mechanical effects.
Note 2: in devices where the electronics and sensing element(s) are situated in a single housing, the liquid temperature is likely to play a far larger role in the temperature of the electronics than the ambient temperature does.

Based on what is given above, one can conclude that changes observed during the Dry Heat and Cold tests are not necessarily caused by changes in the electronics. Moreover in many cases the mechanics cannot be separated from the electronics. Therefore the mechanics are submitted to test conditions which are more severe than those described in art. 6.1.5.2.2, which in fact requires tests at "normal" liquid temperatures only.
What is given above also means that the Dry Heat and Cold test conditions do not represent the actual field conditions.
Therefore the Dry Heat and Cold tests on AMD's need to be performed in a special way which, as closely as possible, represents a "normal" liquid temperature (around 20 ^{o}C) and the required ambient temperature.

13.1 AMS's

This paragraph specifies the test procedures for analogue temperature sensors (first, second and third approach), where the AMT is located inside the flowcomputer.
For all approaches, at some point in time, the AMS must be placed in a temperature bath, connected to a pressure balance or filled with a reference liquid. Because the temperature of the sensor is only determined by the temperature of the liquid and not that of the ambient, the AMS need not be placed inside the climate chamber. The AMS does need to be submitted to the extremes of the liquid temperature.

13.2 AMD's

This paragraph applies to the test procedures for digital associated measuring devices under the first, second and third approach.
In these types of devices both the associated measuring sensor and associated measurement transducer are located in one housing, which is in contact with the liquid. Therefore both the sensor's and electronics' temperature is largely determined by the temperature of the liquid, rather than by the ambient temperature. Therefore, in this case also, the AMD need not be situated inside the climate chamber. The AMD does need to be submitted to the extremes of liquid temperature.

14 ECID's under the First Approach

14.1 Number of testpoints for Initial Verification

This paragraph deals specifically with aspects specific to the Initial Verification for Conversion Devices under the First Approach.

Below a few calculation examples are given showing reasons for using more than two test points during such a test.
All examples apply to a conversion device for Vt to V15 and a measured density (rho) and temperature (T).

<u>Example 1</u>
Densitometer: shift -16 kg/m³
Temperature sensor: shift +1,0 °C

Test	**rho$_{true}$**	**T$_{true}$**	**VCF$_{API}$**	*rho$_{read}$*	*T$_{read}$*	**VCF$_{read}$**	**Error**
	(kg/m³)	**(°C)**		*(kg/m³)*	*(°C)*		
rho$_{min}$ + T$_{min}$	720	-15.0	1.0379	*704*	*-14.0*	1.0379	0.00%
rho$_{max}$ + T$_{max}$	880	45.0	0.9760	*864*	*46.0*	0.9746	-0.14%
rho$_{min}$ + T$_{max}$	720	45.0	0.9613	*704*	*46.0*	0.9585	-0.29%
rho$_{max}$ + T$_{min}$	880	-15.0	1.0236	*864*	*-14.0*	1.0234	-0.02%

<u>Example 2</u>
Densitometer: shift +16 kg/m³
Temperature sensor: shift +1,0 °C

Test	**rho$_{true}$**	**T$_{true}$**	**VCF$_{API}$**	*rho$_{read}$*	*T$_{read}$*	**VCF$_{read}$**	**Error**
	(kg/m³)	**(°C)**		*(kg/m³)*	*(°C)*		
rho$_{min}$ + T$_{max}$	720	45.0	0.9613	*736*	*46.0*	0.9613	0.00%
rho$_{max}$ + T$_{min}$	880	-15.0	1.0236	*896*	*-14.0*	1.0223	-0.13%
rho$_{min}$ + T$_{min}$	720	-15.0	1.0379	*736*	*-14.0*	1.0354	-0.24%
rho$_{max}$ + T$_{max}$	880	45.0	0.9760	*896*	*46.0*	0.9758	-0.02%

Example 3
Densitometer: shift -10 kg/m³
Temperature sensor: shift +1,5 °C

Test	rho_{true} (kg/m³)	T_{true} (°C)	VCF_{API}	*rho_{read} (kg/m³)*	*T_{read} (°C)*	VCF_{read}	Error
rho_{min} + T_{min}	720	-15.0	1.0379	*710*	*-13.5*	1.0368	-0.11%
rho_{max} + T_{max}	880	45.0	0.9760	*870*	*46.5*	0.9744	-0.16%
rho_{min} + T_{max}	720	45.0	0.9613	*710*	*46.5*	0.9584	-0.30%
rho_{max} + T_{min}	880	-15.0	1.0236	*870*	*-13.5*	1.0228	-0.08%

Example 4
Densitometer: shift +10 kg/m³
Temperature sensor: shift +1,5 °C

Test	rho_{true} (kg/m³)	T_{true} (°C)	VCF_{API}	*rho_{read} (kg/m³)*	*T_{read} (°C)*	VCF_{read}	Error
rho_{min} + T_{max}	720	45.0	0.9613	*730*	*46.5*	0.9602	-0.11%
rho_{max} + T_{min}	880	-15.0	1.0236	*890*	*-13.5*	1.0221	-0.15%
rho_{min} + T_{min}	720	-15.0	1.0379	*730*	*-13.5*	1.0352	-0.26%
rho_{max} + T_{max}	880	45.0	0.9760	*890*	*46.5*	0.9752	-0.08%

Notes:

- VCF_{API} is the volume conversion factor from the API table 54B with inputs rho_{true} and T_{true}.
- VCF_{read} is the volume conversion factor given by the conversion device.
- The value of VCF_{read} corresponds to the value taken from the API table 54B with inputs rho_{read} and T_{read}.
- Error = (VCF_{read} - VCF_{API}) / VCF_{API}

Conclusions:

- With only two combined test points, it is possible that an error greater than 0,2 % is not detected.
- This is the case for a conversion device with an important shift in the temperature and density measurement.
- With 4 combined test points, the non-permissible error will be detected.
- The associated measuring instruments (temperature and/or density) can then be adjusted.

14.2 Deliberations regarding fixed Density

This paragraph deals with aspects specific to the Pattern Approval and Initial Verification of conversion Devices, using fixed stored density, under the First Approach.
It is up to national legislation how to deal with the interpretation given in this paragraph.

14.2.1 Introduction

Consider a conversion device Vt to V15 with an associated temperature-measuring device.

The ratio V15 to Vt, called Volume Conversion Factor VCF, is a function of the measured temperature (t) and of the thermal expansion coefficient (k) of the liquid:

VCF = V15 / Vt = 1 / [1 + k x (t-15)]

The value of the expansion coefficient (k) is a function of the temperature (t) and of the density (rho) of the liquid (See API tables 53A, 54A, 53B and 54B):

k = f (t, rho)

In general both temperature and density should be measured to determine the expansion coefficient.
But in a lot of measuring systems the conversion device uses a fixed density (programmed in the conversion device) to make the conversion calculation, instead of a value measured by a density meter.
This means that the expansion coefficient is determined on the basis of a measured temperature (t) and a fixed density (rho15$_{fix}$).
R117-1 Committee Draft 2CD point 3.7.3 allows this practise as long as the total MPE for the conversion device is respected. The total MPE for a conversion device is A-B. (For instance 0,2 % for class 0.5)
It is even allowed by R117 edition 1995 point 3.7.3, but with a smaller margin.

However, there is a problem when this conversion device is tested according the First Approach:
For the First Approach the conversion device is tested as a whole (indicator/calculator + temperature measuring device). The MPE applied for this performance test is A-B.
So the total MPE is used for this test. There is no margin left for the density error.

To solve this problem 'the notified body', that evaluates the test results and issues a pattern approval certificate or an evaluation certificate, should check the test results and calculate the margin that is available for the density variation.
The pattern approval certificate or evaluation certificate has to mention this 'maximum density variation'.

14.2.2 Interpretation of the Maximum Permissible Errors (MPE)

Conversion device Vt to V15 with:
- Measured characteristic quantity: temperature (t)
- Fixed characteristic quantity: density (rho15fix)

The conversion device is intended for use in a measuring system of class 0.5 for gasoline or for diesel.
Total MPE for the conversion: 0,2 % of the converted volume V15

<u>First Approach test</u>

Temperature measuring device + Indicator/calculator (conversion calculation)
MPE: 0,2 % of V15

<u>Second Approach tests</u>

1. Temperature measuring Device
MPE: 0,5 °C
- For gasoline, an error of 0,5 °C leads to a volume error of approximately 0,06% of V15.
- For diesel an error of 0,5 °C leads to a volume error of approximately 0,04% of V15.

2. Indicator/calculator (conversion calculation)
MPE: **0,05 % of V15**

Conclusion:

Since the real density of the liquid differs from the fixed density that the conversion device uses to make the conversion calculation, an additional error is created. In most cases the fixed density that is programmed in the conversion device, is the mean value of (most) possible densities for that liquid.
According to OIML R117 the total error for the conversion – including the error due to the difference between real and fixed density – shall not exceed 0,2 % of the converted volume V15.

In the Second Approach, there is a margin left for the density error:
- for gasoline: a margin of at least 0.09% of V15
- for diesel: a margin of at least 0.11% of V15

In the First Approach, there is no margin left for the density error.
This means that a conversion device Vt to V15 that uses a fixed density and is approved and verified according the First Approach can only be used for a liquid having exactly this density.
In reality the density of the liquid varies from this fixed value and therefore a part of the MPE (for instance 0,1 % of V15) should be reserved for the density error.

14.2.3 Possible Solution

The pattern approval certificate, issued for a conversion device Vt to V15 with fixed density that is approved according the First Approach, shall state:
- the range for the fixed density $rho15_{fix}$,
- the maximum value(s) for the difference(s) between the real density and the fixed density; this value can be expressed as a 'maximum density variation' or as a 'density range' ,
- the corresponding temperature range(s).

The maximum error on the converted volume V15 due to the difference between real and fixed density shall be calculated.

The MPE (0,2% of V15 in case of a measuring system of class 0.5) for the conversion device – while testing it for pattern approval or for initial verification – has to be reduced by this calculated error.
This reduced MPE shall also be stated in the pattern approval certificate so that it can be applied for the initial verification.

Example: The pattern approval certificate states:
"The conversion device Vt to V15 is approved for a fixed density value $rho15_{fix}$ from 700 to 900 kg/m³ and a measured temperature from –10 °C to +40 °C.
The density of the actual liquid shall be in the range given by the following table:

$rho15_{fix}$ (kg/m³)	temperature range	density range (kg/m³)
700 to 770	0 °C to + 30 °C	$rho15_{fix}$ +/- 20 but not above 770
	-10 °C to + 40 °C	$rho15_{fix}$ +/- 10 but not above 770
771 to 787	0 °C to + 30 °C	$rho15_{fix}$ +/- 6 but not below 771 or above 787
	-10 °C to + 40 °C	$rho15_{fix}$ +/- 3 but not below 771 or above 787
788 to 900	0 °C to + 30 °C	$rho15_{fix}$ +/- 30 but not below 788
	-10 °C to + 40 °C	$rho15_{fix}$ +/- 15 but not below 788

During initial verification the following test(s) will be performed: […]
See Chapter 8.

The MPE for the testing of the conversion device is: reduced MPE

reduced MPE =
[MPE given by the WELMEC guide (0,2% of V15 in case of a measuring system of class 0.5) for the initial verification performance test of the conversion device]

minus

[the maximum error on the converted volume V15 due to the density difference (determined by the density range(s) given in the table)]

15 Possible items to be included in future revision of this Guide

Possibility to perform Initial Verification according to Approaches other than the one followed during Type Approval.

Define a maximum sample / calculation time for flowcomputers operating on interrupt base rather than "real time".

Include MPE's and SF's for density used only for conversion from volume at metering conditions to volume at base conditions.

Include MPE's and SF's for the measurement of temperature, pressure, density and viscosity intended for correction devices.

Include more details regarding how to handle temperature wells during Type Approval and Initial Verification in relation to temperature response tests.

Extend the list of Acceptable standards for conversion, Chapter 7.

Discuss and include, if needed, requirements for time response testing under the First Approach.