National Measurement Office

NMO GUIDANCE NOTE FOR RETAIL FUEL DISPENSERS (PETROL PUMPS) AND ROAD TANKER MOUNTED METER MEASURING SYSTEMS FITTED WITH STANDARD TEMPERATURE ACCOUNTING (STA) DISPLAYS - ADVICE FOR RETAILERS, MANUFACTURERS, LOCAL AUTHORITY TRADING STANDARDS AND APPROVED VERIFIERS

1 BACKGROUND

Under the Weights and Measures Act 1985 (and the Units of Measurement Directive transposed by the Units of Measurement Regulations 1986 (SI 1986/1082) as amended), the litre is expressed as a dimensional quantity and is equal to 1 cubic decimetre. The quantity is not defined at any specified temperature. The temperature of the liquid fuel dispensed can vary due to the influence of various factors, for example the temperature of the underground or lorry mounted storage tanks, the temperature of the fuel delivered from the refineries, and the temperature of the equipment itself. The legal tolerances for the equipment (the maximum permissible errors) have been agreed at national[1], European[2], and International[3] levels. The magnitude of tolerance is chosen to provide an acceptable level of accuracy while providing a similarly acceptable allowance for the uncertainties of the measurement being made (which can include the temperature of the fuel being measured).

For environmental, health and safety and business reasons, the Retail Petroleum industry is obliged to monitor the quantity of fuel in the delivery chain to maintain accurate stock control and to check for potentially damaging leaks in storage tanks. The changes in volume due to the fuel being measured at different temperatures could be addressed by standardising the measured volume at a fixed temperature i.e. 15 °C and taking readings of temperature of the delivered fuel, in tank and at the meter. However, whilst it is not the intention to introduce regulations to prescribe such temperature readings, metrology law permits the use of equipment that corrects physically dispensed volume to a set temperature volume reading. In the petroleum industry a litre at 15 °C is referred to as a “standard litre” and the process of converting the volume in litres at a given temperature is known as “standard temperature accounting” often abbreviated to “STA”. Currently, most fuel metering systems deliver a litre of fuel by volume with no reference to temperature.

Will the consumer lose out by using equipment which has the STA function enabled?

With equipment that does not have the STA function or does not have the STA function enabled (i.e. traditional) there will be a variation in total energy content depending on whether the temperature of the fuel is greater or less than 15 °C. The variation in energy content is dependent upon the change in temperature and the density of the fuel. In any case the dispensed volume must still meet the legal tolerances.

[1] The Measuring Equipment (Liquid Fuel and Lubricants) Regulations SI 1995/1014 as amended, The Measuring Equipment (Liquid Fuel Delivered from Road Tankers) Regulations 1983 SI 1983/1390 as amended

[2] The Measuring Instruments Directive 2004/22/EC as implemented by The Measuring Instruments (Liquid Fuel and Lubricants) Regulations SI 2006/1266, The Measuring Instruments (Liquid Fuel Delivered from Road Tankers) Regulations 2006 SI 2006/ 1269, The Measuring Instruments (EEC Requirements) Regulations 1988 SI 1988/186

[3] OIML R-117 2007 Measuring systems for liquids other than water

The volume displayed on equipment that has the STA function enabled is corrected to a reference temperature of 15 °C. The temperature corrected volume of fuel dispensed must meet the legal tolerances.

2 ADVICE FOR RETAIL FORECOURT OPERATORS AND FUEL OIL DELIVERY COMPANIES

Subject to type approval, equipment may incorporate standard temperature accounting, STA such that the volume display is corrected to 15 °C. This type of display on equipment is legal although it is important to note that it is NOT mandatory under UK legislation - it is optional.

However, equipment that is verified with the STA function enabled should remain STA enabled throughout the whole year to avoid consistently favouring either the seller or the buyer, even if the equipment has been appropriately re-verified. Alternatively if the STA function is disabled then it should remain STA disabled for the same reason. Switching the STA function 'on and off' throughout the year to gain a commercial advantage from seasonal changes in fuel temperature is considered by Trading Standards Practitioners to be an offence under consumer and business protection legislation.

On a retail forecourt, there is no legal metrological requirement that would prevent STA from being enabled on one dispenser and not on another, providing that the correct markings are shown on the dispenser.

3 ADVICE FOR EQUIPMENT MANUFACTURERS

Approval of equipment incorporating a display with STA is permitted under current legislation which implements the Measuring Instruments Directive "The Measuring Instruments (Liquid Fuel and Lubricants) Regulations 2006 (SI 2006/1266)" and "The Measuring Instruments (Liquid Fuel Delivered from Road Tankers) Regulations 2006 (SI 2006/1269)". For equipment approved under previous Weights and Measures legislation, it is possible that a modification to incorporate STA could be approved, provided that the existing certificate of approval has not expired. All STA equipment must be suitably marked as delivering STA litres. It is recommended that you note the guidance given in the WELMEC WG10 guide.

For further advice on how to obtain approval, please contact the type examination team at NMO.

4 INSPECTION ADVICE FOR TRADING STANDARDS OFFICERS (TSOs)

For equipment having a display which incorporates standard temperature accounting, it must first be approved. Normally this will be done via a type or design examination. During this process the temperature conversion device of the equipment will be checked and approved. Therefore there is no need for this device to be checked again during inspections. The equipment should of course conform to type and have the temperature conversion device as approved at type or design examination. You should also check that any software version is either approved in the certificate, such as for a retrofitted device, or is an approved standard configurable feature in a dispenser's software, from a certain version onwards.

To test the accuracy of the STA corrected volume, one way of doing this is by following the testing procedure given in the Annex of this document.

5 VERIFICATION ADVICE FOR TSOs & APPROVED VERIFIERS

The testing method outlined in section 4 above is suitable for inspection purposes because the testing error is small in relation to the legal tolerances allowed for equipment in-service. For verification purposes, the legal tolerances are sufficiently similar to allow the same method to be

used. TSOs and Approved Verifiers are of course free to use an alternative testing method provided it is suitable for the purpose and has a sufficiently small error in relation the legal tolerances for verification.

6 FREQUENTLY ASKED QUESTIONS

- Can calibration and verification be carried out at the same time?

  Bearing in mind that verification of STA equipment should be carried out with the STA facility active it may not be possible on all makes/types of equipment to verify on the basis of the calibration tests. Where calibration has to be carried out with the STA facility disabled then further tests will need to be carried out with the STA enabled for verification purposes.

- Can all types of contents measures be used to test STA forecourt equipment?

  All measures can normally be used although some will be better suited and not involve further calculations to establish the result. Measures with a calibrated neck will be able to provide an indication of the excess or deficiency due to any measurement error plus the temperature correction in relation to the full delivery. For large temperature differences on a measure with a calibrated neck and for ‘strike’ measures an alternative approach may be required where the delivered volume into the measure is the basis for the calculation. For the modern ‘pump watch’ measure with an internal weir and measurement tube extra care will need to be taken to establish the extent of any extra volume due to warm fuel to prevent any overflow from the measurement tube.

- Will the STA equipment remain correct if the type of fuel in a storage tank is changed?

  If the fuel dispensed from a forecourt dispenser is changed to one with a different density then the STA calculation will be incorrect e.g. petrol to diesel. The STA equipment should be reconfigured with the correct parameters for the new fuel and re-verified (re-qualified) as the change will have affected both the accuracy and function of the measuring system. The type approval certificate should specify what needs to be sealed. It would normally be expected that access to reconfigure the equipment for a different fuel is sealed.

  On a road tanker mounted meter measuring system, the initial verification should have included the STA correction parameters for all fuels that will be dispensed. If a new fuel is to be carried and metered, the STA equipment should be reconfigured with the correct parameters for the new fuel and re-verified (re-qualified) as the change will have affected both the accuracy and function of the measuring system.

Annex A: Testing Procedure for Forecourt Dispensers

1. Introduction

This document offers guidance on a simple method of testing equipment with temperature conversion devices which display volume at 15 °C, and uses existing capacity measures which have been calibrated at 20 °C. Other methods may be devised which are equally satisfactory. This method is for verification, re-verification and field inspection; not for type approval.

This guidance does not contain sufficient detail to be used as an operator instruction.

The same principle can be applied to larger deliveries of fuel and some data is included in appendix A for kerosene and gas oil.

This guidance does not address Health and Safety matters which need to be considered before any work is carried out.

2. Equipment

Working standards of capacity (2 L, 5 L, 10 L, and 20 L as necessary)

Metal contents measure	NWML Specification 7321
Integrated measure	NWML Specification 7323

Measures with a calibrated neck or measurement tube are easier to use for this application rather than ‘strike’ measures.

Thermometer Accuracy ± 0.2 °C

3. Test Method

a. Wet and drain the measure.
b. Deliver the fuel into the measure at the required flow rate.
c. Note the measure reading.
d. Insert the thermometer so that it is supported near the centre of the liquid.
e. Note the equipment indication of litres at 15 °C.
f. When stable, read the temperature of the fuel in the measure.
g. Correct the measure reading to volume at 15 °C using Appendix A and compare with the equipment indication of litres at 15 °C. If the result is near the limit of allowable error, carry out a further correction for the measuring can using Appendix B.

4. Temperature Conversion Data

Appendix A is a table of Temperature Conversion Multipliers which is based on the Petroleum Measurement Tables; as issued by the ASTM, API and IP which have been adopted by ISO 91-1 and OIML R 63; and data issued by DECC. For other products and temperatures outside of the range covered by Appendix A, the Petroleum Measurement Tables should be used in combination with fuel density data issued by DECC or direct density measurement.

Density figures have been provided by UKPIA from data gathered throughout 2010 for use in 2011 and issued by DECC Oil and Gas division.	Density kg/m^3
Petrol - Unleaded Super	738.0
- Unleaded Premium	735.1
Marked Kerosene	804.2
Diesel - Sulphur free	839.3
Gas Oil & Marine Diesel	864.9

These figures are issued annually by DECC, normally in December. NMO will update this guidance when necessary.

Temperature of the fuel is the most significant factor and has a much greater effect than the expected density changes and the temperature effect on the measuring can. For example, the following changes cause the following change in volume:

Change	Size of Change	Volume effect on 20L
Temperature of fuel	2 °C	48 ml
Temperature of measure	2 °C	1.9 ml
Fuel density	2 kg/m^3	1 ml

5. Temperature correction of measuring can

Appendix B details the change in volume for the temperature of the measuring can where the measure has been calibrated at 20 °C. This is small compared to the temperature effect on the fuel. It can also be shown that the temperature of the fuel is much more significant than the temperature of the material of the test measure and that the two will fairly quickly stabilise near the fuel temperature.

Note: The tolerance on the test measure calibration is 1ml/Litre. Therefore a 20 L measure has a calibration maximum permissible error of $\pm$ 20 ml.

Example: A 20 L stainless steel measuring can, calibrated at 20 °C, is used to measure fuel at 12 °C. Assuming the can and fuel have stabilised at 12 °C (T °C), the measuring can has shrunk and will appear to contain more than if it were at 20 °C.

From appendix B the change in volume for T °C = 12 is -7.7 ml
If the measure appeared to contain exactly 20 L the corrected volume is:

20,000 ml - 7.7 ml = 19,992.3 ml

Example: A 20 L stainless steel measuring can will change approximately 1 ml for 1 °C change from its calibration temperature of 20 °C. If the temperature is LESS than 20 °C – SUBTRACT; if the temperature is MORE than 20 °C – ADD.

Other sizes will change proportionately e.g. a 10 L stainless steel measuring can will change approximately 0.5 ml for 1 °C change from its calibration temperature of 20 °C.

Annex B: Testing Procedure for Road Tanker Mounted Meter Measuring Systems

1. The recommended methodology for testing a temperature compensating system is to test the system for accuracy when not temperature compensating, then to switch on the compensating mode and conduct a further two test runs on each fuel to ensure the quantity delivered is correctly converted. For this method, test runs of 1000 litres will simplify the mathematics.

2. Temperature correction calculations may be made to the Reference Meter reading in one of 2 ways.

   Either:-
   a. The Temperature Conversion Multipliers from Appendix A may be used, or

   b. The test sheet in Appendix C may be used. For the test methodology as described in 1 above for 1000 litres, the volume / temperature correction factor (CT) for insertion in the test sheet, can be taken to be the 'factor' γ (the coefficient of cubical thermal expansion) multiplied by 1000.

      Coefficients of cubical thermal expansion, γ (litres /ºC), for the usual 'bulk fuels' have been determined based on the data set out in Appendix A below as:-

Kerosene	0.00092 litres/°C
Gas Oil	0.00081 litres/°C

      It can therefore be seen that for kerosene, the volume / temperature correction factor (CT) is 0.92 litres /°C, and for gas oil it is 0.81 litres /°C, for a test run of 1000 litres.

3. The coefficient of cubical thermal expansion of the reference meter is believed to be in the order of 0.00002 litre/°C at most. This would make a difference in any calculations of 0.02 litres/°C for a test run of 1000 litres, and may be considered to be sufficiently small to be ignored.

Temperature Conversion Multipliers — Appendix A

Use the multiplier in the table below to convert fuel at the temperature listed in the left column to volume 15°C.

Example: A measuring can contains 20.15L of Sulphur Free Diesel and its temperature is 11°C. From the table below for 11°C the multiplier in the Sulphur Free Diesel column is 1.0034. The equivalent volume at 15°C is:

20.15 L x 1.0034 = 20.218 L at 15°C

Temperature compensated equipment which delivered the 20.15 L into the measure should indicate 20.218 L at 15°C subject to indicator limitations and allowable errors.

Temp	Petrol		Diesel	Gas Oil	Kerosene
°C	Unleaded	Super	Sulphur free	Gas Oil & Marine Diesel	Marked Kerosene
0	1.0185	1.0184	1.0126	1.0121	1.0137
0.2	1.0182	1.0181	1.0125	1.0120	1.0135
0.4	1.0180	1.0179	1.0123	1.0118	1.0134
0.6	1.0177	1.0176	1.0121	1.0117	1.0132
0.8	1.0175	1.0174	1.0120	1.0115	1.0130
1	1.0172	1.0171	1.0118	1.0113	1.0128
1.2	1.0170	1.0169	1.0116	1.0112	1.0126
1.4	1.0167	1.0166	1.0114	1.0110	1.0125
1.6	1.0165	1.0164	1.0113	1.0108	1.0123
1.8	1.0163	1.0162	1.0111	1.0107	1.0121
2	1.0160	1.0159	1.0109	1.0105	1.0119
2.2	1.0158	1.0157	1.0108	1.0104	1.0117
2.4	1.0155	1.0154	1.0106	1.0102	1.0115
2.6	1.0153	1.0152	1.0104	1.0100	1.0114
2.8	1.0150	1.0149	1.0103	1.0099	1.0112
3	1.0148	1.0147	1.0101	1.0097	1.0110
3.2	1.0145	1.0145	1.0099	1.0096	1.0108
3.4	1.0143	1.0142	1.0098	1.0094	1.0106
3.6	1.0141	1.0140	1.0096	1.0092	1.0104
3.8	1.0138	1.0137	1.0094	1.0091	1.0103
4	1.0136	1.0135	1.0093	1.0089	1.0101
4.2	1.0133	1.0132	1.0091	1.0087	1.0099
4.4	1.0131	1.0130	1.0089	1.0086	1.0097
4.6	1.0128	1.0127	1.0088	1.0084	1.0095
4.8	1.0126	1.0125	1.0086	1.0083	1.0093
5	1.0123	1.0123	1.0084	1.0081	1.0092
5.2	1.0121	1.0120	1.0083	1.0079	1.0090
5.4	1.0118	1.0118	1.0081	1.0078	1.0088
5.6	1.0116	1.0115	1.0079	1.0076	1.0086
5.8	1.0113	1.0113	1.0078	1.0075	1.0084
6	1.0111	1.0110	1.0076	1.0073	1.0083
6.2	1.0109	1.0108	1.0074	1.0071	1.0081
6.4	1.0106	1.0105	1.0072	1.0070	1.0079

Temp	Petrol		Diesel	Gas Oil	Kerosene
°C	Unleaded	Super	Sulphur free	Gas Oil & Marine Diesel	Marked Kerosene
6.6	1.0104	1.0103	1.0071	1.0068	1.0077
6.8	1.0101	1.0101	1.0069	1.0066	1.0075
7	1.0099	1.0098	1.0067	1.0065	1.0073
7.2	1.0096	1.0096	1.0066	1.0063	1.0072
7.4	1.0094	1.0093	1.0064	1.0062	1.0070
7.6	1.0091	1.0091	1.0062	1.0060	1.0068
7.8	1.0089	1.0088	1.0061	1.0058	1.0066
8	1.0086	1.0086	1.0059	1.0057	1.0064
8.2	1.0084	1.0083	1.0057	1.0055	1.0062
8.4	1.0082	1.0081	1.0056	1.0054	1.0061
8.6	1.0079	1.0079	1.0054	1.0052	1.0059
8.8	1.0077	1.0076	1.0052	1.0050	1.0057
9	1.0074	1.0074	1.0051	1.0049	1.0055
9.2	1.0072	1.0071	1.0049	1.0047	1.0053
9.4	1.0069	1.0069	1.0047	1.0045	1.0051
9.6	1.0067	1.0066	1.0046	1.0044	1.0050
9.8	1.0064	1.0064	1.0044	1.0042	1.0048
10	1.0062	1.0061	1.0042	1.0041	1.0046
10.2	1.0059	1.0059	1.0040	1.0039	1.0044
10.4	1.0057	1.0057	1.0039	1.0037	1.0042
10.6	1.0054	1.0054	1.0037	1.0036	1.0040
10.8	1.0052	1.0052	1.0035	1.0034	1.0039
11	1.0049	1.0049	1.0034	1.0032	1.0037
11.2	1.0047	1.0047	1.0032	1.0031	1.0035
11.4	1.0045	1.0044	1.0030	1.0029	1.0033
11.6	1.0042	1.0042	1.0029	1.0028	1.0031
11.8	1.0040	1.0039	1.0027	1.0026	1.0029
12	1.0037	1.0037	1.0025	1.0024	1.0028
12.2	1.0035	1.0034	1.0024	1.0023	1.0026
12.4	1.0032	1.0032	1.0022	1.0021	1.0024
12.6	1.0030	1.0030	1.0020	1.0019	1.0022
12.8	1.0027	1.0027	1.0019	1.0018	1.0020
13	1.0025	1.0025	1.0017	1.0016	1.0018
13.2	1.0022	1.0022	1.0015	1.0015	1.0017
13.4	1.0020	1.0020	1.0014	1.0013	1.0015
13.6	1.0017	1.0017	1.0012	1.0011	1.0013
13.8	1.0015	1.0015	1.0010	1.0010	1.0011
14	1.0012	1.0012	1.0008	1.0008	1.0009
14.2	1.0010	1.0010	1.0007	1.0006	1.0007
14.4	1.0007	1.0007	1.0005	1.0005	1.0006
14.6	1.0005	1.0005	1.0003	1.0003	1.0004
14.8	1.0002	1.0002	1.0002	1.0002	1.0002
15	1.0000	1.0000	1.0000	1.0000	1.0000
15.2	0.9998	0.9998	0.9998	0.9998	0.9998
15.4	0.9995	0.9995	0.9997	0.9997	0.9996
15.6	0.9993	0.9993	0.9995	0.9995	0.9994
15.8	0.9990	0.9990	0.9993	0.9994	0.9993
16	0.9988	0.9988	0.9992	0.9992	0.9991
16.2	0.9985	0.9985	0.9990	0.9990	0.9989

Temp	Petrol		Diesel	Gas Oil	Kerosene
°C	Unleaded	Super	Sulphur free	Gas Oil & Marine Diesel	Marked Kerosene
16.4	0.9983	0.9983	0.9988	0.9989	0.9987
16.6	0.9980	0.9980	0.9986	0.9987	0.9985
16.8	0.9978	0.9978	0.9985	0.9985	0.9983
17	0.9975	0.9975	0.9983	0.9984	0.9982
17.2	0.9973	0.9973	0.9981	0.9982	0.9980
17.4	0.9970	0.9970	0.9980	0.9980	0.9978
17.6	0.9968	0.9968	0.9978	0.9979	0.9976
17.8	0.9965	0.9966	0.9976	0.9977	0.9974
18	0.9963	0.9963	0.9975	0.9976	0.9972
18.2	0.9960	0.9961	0.9973	0.9974	0.9971
18.4	0.9958	0.9958	0.9971	0.9972	0.9969
18.6	0.9955	0.9956	0.9970	0.9971	0.9967
18.8	0.9953	0.9953	0.9968	0.9969	0.9965
19	0.9950	0.9951	0.9966	0.9967	0.9963
19.2	0.9948	0.9948	0.9964	0.9966	0.9961
19.4	0.9945	0.9946	0.9963	0.9964	0.9960
19.6	0.9943	0.9943	0.9961	0.9963	0.9958
19.8	0.9940	0.9941	0.9959	0.9961	0.9956
20	0.9938	0.9938	0.9958	0.9959	0.9954
20.2	0.9936	0.9936	0.9956	0.9958	0.9952
20.4	0.9933	0.9933	0.9954	0.9956	0.9950
20.6	0.9931	0.9931	0.9953	0.9954	0.9948
20.8	0.9928	0.9928	0.9951	0.9953	0.9947
21	0.9926	0.9926	0.9949	0.9951	0.9945
21.2	0.9923	0.9924	0.9948	0.9950	0.9943
21.4	0.9921	0.9921	0.9946	0.9948	0.9941
21.6	0.9918	0.9919	0.9944	0.9946	0.9939
21.8	0.9916	0.9916	0.9942	0.9945	0.9937
22	0.9913	0.9914	0.9941	0.9943	0.9936
22.2	0.9911	0.9911	0.9939	0.9941	0.9934
22.4	0.9908	0.9909	0.9937	0.9940	0.9932
22.6	0.9906	0.9906	0.9936	0.9938	0.9930
22.8	0.9903	0.9904	0.9934	0.9937	0.9928
23	0.9901	0.9901	0.9932	0.9935	0.9926
23.2	0.9898	0.9899	0.9931	0.9933	0.9924
23.4	0.9896	0.9896	0.9929	0.9932	0.9923
23.6	0.9893	0.9894	0.9927	0.9930	0.9921
23.8	0.9891	0.9891	0.9926	0.9928	0.9919
24	0.9888	0.9889	0.9924	0.9927	0.9917
24.2	0.9886	0.9886	0.9922	0.9925	0.9915
24.4	0.9883	0.9884	0.9920	0.9923	0.9913
24.6	0.9881	0.9881	0.9919	0.9922	0.9912
24.8	0.9878	0.9879	0.9917	0.9920	0.9910
25	0.9876	0.9876	0.9915	0.9919	0.9908

Appendix B

Correction for Expansion of Stainless Steel Fuel Test Can per degree C

Note - Cubical coefficient of expansion β[1] varies with actual construction material. This value from NMO 7231 for stainless steel.

Stainless steel	T°C	β	2 Litre	5 Litre	10 Litre	20 litre
			Correction in ml			
	0	0.000048	-1.9	-4.8	-9.6	-19.2
	1	0.000048	-1.8	-4.6	-9.1	-18.2
	2	0.000048	-1.7	-4.3	-8.6	-17.3
	3	0.000048	-1.6	-4.1	-8.2	-16.3
	4	0.000048	-1.5	-3.8	-7.7	-15.4
	5	0.000048	-1.4	-3.6	-7.2	-14.4
	6	0.000048	-1.3	-3.4	-6.7	-13.4
	7	0.000048	-1.2	-3.1	-6.2	-12.5
	8	0.000048	-1.2	-2.9	-5.8	-11.5
	9	0.000048	-1.1	-2.6	-5.3	-10.6
	10	0.000048	-1.0	-2.4	-4.8	-9.6
	11	0.000048	-0.9	-2.2	-4.3	-8.6
	12	0.000048	-0.8	-1.9	-3.8	-7.7
	13	0.000048	-0.7	-1.7	-3.4	-6.7
	14	0.000048	-0.6	-1.4	-2.9	-5.8
	15	0.000048	-0.5	-1.2	-2.4	-4.8
	16	0.000048	-0.4	-1.0	-1.9	-3.8
	17	0.000048	-0.3	-0.7	-1.4	-2.9
	18	0.000048	-0.2	-0.5	-1.0	-1.9
	19	0.000048	-0.1	-0.2	-0.5	-1.0
	20	0.000048	0	0	0	0
	21	0.000048	0.1	0.2	0.5	1.0
	22	0.000048	0.2	0.5	1.0	1.9
	23	0.000048	0.3	0.7	1.4	2.9
	24	0.000048	0.4	1.0	1.9	3.8
	25	0.000048	0.5	1.2	2.4	4.8

Carbon Fibre has a very low coefficient of expansion, of the order of $1x10^{-6}$, and will therefore cause changes of less than 1 mL for the expected range of temperatures. The temperature effect on the test measure can therefore be ignored for carbon fibre measures.

[1] The expected symbol for the coefficient of cubic expansion per ^{o}C is *'γ'*. In this case *'β'* is used to align with the OIML R-118 1995 Test procedures and test format for pattern examination of equipment for motor vehicles measuring systems for liquids other than water.

Appendix C

			TEST FUEL TYPE		INSERT FUEL TYPE					
	Temp. of fuel	Reference Meter	Volume/ Temp. Correction Factor	Temp. difference from 15°C	Ref. Meter reading compensated to 15°C	Ref. Meter error Correction Factor	Ref. Meter Corrected Reading at 15°C	Meter Under Test Reading	Error	%age Error
	(T)	(RM)	(CT)	(ΔT)	CR15	(CF)	(CR)	(MUT)	(E)	
	°C	Litres	Litres/°C	°C	Litres		Litres	Litres	Litres	%
Test				(15 – T)	(RM + (CT x ΔT))	(From table above)	(CR15 + (CR15 x CF))		(CR-MUT)	(E/CR) x100
Maximum Flow rate - Wet line										
			TEST FUEL TYPE		INSERT FUEL TYPE					
Maximum Flow rate - Wet line										

**CT is taken to be 0.92 litres per 1000 litres for Kerosene and 0.81 litres per 1000 litres for Gas Oil*