Table of Contents

Section 3.38. Carbon Dioxide Liquid-Measuring Devices

A. Application

A.1. General. – This code applies to liquid-measuring devices used for the measurement of liquid carbon dioxide.

A.2. Exceptions. – This code does not apply to devices used solely for dispensing a product in connection with operations in which the amount dispensed does not affect customer charges.

A.3. Additional Code Requirements. – In addition to the requirements of this code, Carbon Dioxide Liquid-Measuring Devices shall meet the requirements of Section 1.10. General Code.

A.4. Type Evaluation. – The National Type Evaluation Program will accept for type evaluation only those devices that comply with all requirements of this code.

(Added 1998)

S. Specifications

S.1. Design of Indicating and Recording Elements and of Recorded Representations.

S.1.1. Primary Elements.

S.1.1.1. General. – A device shall be equipped with a primary indicating element and may also be equipped with a primary recording element.

S.1.1.2. Units. – A device shall indicate and record, if equipped to record, its deliveries in terms of pounds or kilograms or decimal subdivisions or multiples thereof.

S.1.1.3. Value of Smallest Unit. – The value of the smallest unit of indicated delivery, and recorded delivery, if the device is equipped to record, shall not exceed the equivalent of:

(a) for small delivery devices:

(1) 1 kilogram; or

(2) 1 pound

(b) for large delivery devices:

(1) 10 kilograms; or

(2) 10 pounds

S.1.1.4. Advancement of Indicating and Recording Elements. – Primary indicating and recording elements shall be susceptible to advancement only by the normal operation of the device. However, a device may be cleared by advancing its elements to zero, but only if:

(a) the advancing movement, once started, cannot be stopped until zero is reached; or

(b) in the case of indicating elements only, such elements are automatically obscured until the elements reach the correct zero position.

S.1.1.5. Return to Zero. – Primary indicating and recording elements shall be readily returnable to a definite zero indication. Means shall be provided to prevent the return of primary indicating elements and of primary recording elements beyond their correct zero position.

S.1.2. Graduations.

S.1.2.1. Length. – Graduations shall be so varied in length that they may be conveniently read.

S.1.2.2. Width. – In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations. The width of main graduations shall be not more than 50 % greater than the width of subordinate graduations. Graduations shall in no case be less than 0.2 mm (0.008 in) in width.

S.1.2.3. Clear Interval Between Graduations. – The clear interval shall be not less than 1.0 mm (0.04 in). If the graduations are not parallel, the measurement shall be made:

(a) along the line of relative movement between the graduations at the end of the indicator; or

(b) if the indicator is continuous, at the point of widest separation of the graduations.

(Also see S.1.3.6. Travel of Indicator.)

S.1.3. Indicators.

S.1.3.1. Symmetry. – The index of an indicator shall be of the same shape as the graduations at least throughout that portion of its length associated with the graduations.

S.1.3.2. Length. – The index of an indicator shall reach to the finest graduations with which it is used, unless the indicator and the graduations are in the same plane, in which case the distance between the end of the indicator and the ends of the graduations, measured along the line of the graduations, shall be not more than 1.0 mm (0.04 in).

S.1.3.3. Width. – The width of the index of the indicator in relation to the series of graduations with which it is used shall be not greater than:

(a) *the width of the narrowest graduation;** and
*[*Nonretroactive as of January 1, 2002]*
(Amended 2001)

(b) the width of the minimum clear interval between graduations.

When the index of an indicator extends along the entire length of a graduation, that portion of the index of the indicator that may be brought into coincidence with the graduation shall be of the same width throughout the length of the index that coincides with the graduation.

S.1.3.4. Clearance. – The clearance between the index of an indicator and the graduations shall in no case be more than 1.5 mm (0.06 in).

S.1.3.5. Parallax. – Parallax effects shall be reduced to the practicable minimum.

S.1.3.6. Travel of Indicator. – If the most sensitive element of the primary indicating element utilizes an indicator and graduations, the relative movement of these parts corresponding to the smallest indicated value shall be no less than 5 mm (0.20 in).

S.1.4. Computing-Type Devices.

S.1.4.1. Printed Ticket. – Any printed ticket issued by a device of the computing type on which there is printed the total computed price shall have printed clearly thereon also the total quantity of the delivery and the price per unit.

S.1.4.2. Money-Value Computations. – Money-value computations shall be of the full-computing type in which the money-value at a single unit price, or at each of a series of unit prices, shall be computed for every delivery within either the range of measurement of the device or the range of the computing elements, whichever is less.

The total price shall be computed on the basis of the quantity indicated when the value of the smallest division indicated is equal to or less than the value specified in S.1.1.3. Value of Smallest Unit.

S.1.4.3. Money-Values, Mathematical Agreement. – Any digital money-value indication and any recorded money-value on a computing-type device shall be in mathematical agreement with its associated quantity indication or representation to within 1 cent of money-value.

S.2. Design of Measuring Elements.

S.2.1. Air/Vapor Elimination. – A measuring system shall be equipped with an effective air/vapor eliminator or other automatic means to prevent the passage of air/vapor through the meter. Vent lines from the air/vapor eliminator shall be made of appropriate non-collapsible material. (Also see Section T. Tolerances.)
(Amended 2016 and 2018)

S.2.2. Reverse Flow Measurement. – Effective means, automatic in operation, shall be installed to prevent reverse flow measurement.

S.2.3. Maintenance of Liquid State. – A device shall be so designed that the product being measured will remain in a liquid state during passage through the device.

S.2.4. Automatic Temperature or Density Compensation. – A volumetric device shall be equipped with automatic means for adjusting the indication and recorded representation of the measured quantity of the product to indicate or record the quantity of the product measured in terms of pounds.

S.2.5. Provision for Sealing. – For devices and systems in which the configuration or calibration parameters can be changed by use of a removable digital storage device, security shall be provided for those parameters as specified in G-S.8.2. Devices and Systems Adjusted Using Removable Digital Storage Devices. For parameters adjusted using other means, the following applies.

Adequate provision shall be made for an approved means of security (e.g., data change audit trail) or for physically applying a security seal in such a manner that requires the security seal to be broken before an adjustment or interchange can be made of:

(a) any measuring or indicating element;

(b) any adjustable element for controlling delivery rate when such rate tends to affect the accuracy of deliveries;

(c) any automatic temperature or density compensating system; and

(d) any metrological parameter that will affect the metrological integrity of the device or system.

When applicable any adjusting mechanism shall be readily accessible for purposes of affixing a security seal.

*Audit trails shall use the format set forth in Table S.2.5. Provision for Sealing.**
*[*Nonretroactive as of January 1, 1995]*
(Amended 2006 and 2019)

Table S.2.5.
Categories of Device and Methods of Sealing

Categories of Device	***Methods of Sealing***
Category 1: *No remote configuration capability.*	*Seal by physical seal or two event counters: one for calibration parameters and one for configuration parameters.*
Category 2: *Remote configuration capability, but access is controlled by physical hardware.* *The device shall clearly indicate that it is in the remote configuration mode and record such message if capable of printing in this mode or shall not operate while in this mode.*	*The hardware enabling access for remote communication must be on-site. The hardware must be sealed using a physical seal or an event counter for calibration parameters and an event counter for configuration parameters. The event counters may be located either at the individual measuring device or at the system controller; however, an adequate number of counters must be provided to monitor the calibration and configuration parameters of the individual devices at a location. If the counters are located in the system controller rather than at the individual device, means must be provided to generate a hard copy of the information through an on-site device.*
Category 3: *Remote configuration capability access may be unlimited or controlled through a software switch (e.g., password).* *The device shall clearly indicate that it is in the remote configuration mode and record such message if capable of printing in this mode or shall not operate while in this mode.*	*An event logger is required in the device; it must include an event counter (000 to 999), the parameter ID, the date and time of the change, and the new value of the parameter. A printed copy of the information must be available on demand through the device or through another on-site device. The information may also be available electronically. The event logger shall have a capacity to retain records equal to 10 times the number of sealable parameters in the device, but not more than 1000 records are required. (**Note:** Does not require 1000 changes to be stored for each parameter.)*

[*Nonretroactive as of January 1, 1995*]
(Table Added 2006) (Amended 2016)

S.3. Design of Discharge Lines and Discharge Line Valves.

S.3.1. Diversion of Measured Liquid. – No means shall be provided by which any measured liquid can be diverted from the measuring chamber of the device or the discharge line therefrom, except that a manually controlled outlet that may be opened for purging or draining the measuring system shall be permitted. Effective means shall be provided to prevent the passage of liquid through any such outlet during normal operation of the device and to indicate clearly and unmistakably when the valve controls are so set as to permit passage of liquid through such outlet.

S.3.2. Discharge Hose. – The discharge hose of a measuring system shall be of a wet hose type with a shutoff valve at its outlet end.

S.4. Marking Requirements.

S.4.1. Limitation of Use. – If a measuring system is intended to measure accurately only liquids having particular properties, or to measure accurately only under specific installation or operating conditions, or to measure accurately only when used in conjunction with specific accessory equipment, these limitations shall be clearly and permanently marked on the device.

S.4.2. Discharge Rates. – A meter shall be marked to show its designed maximum and minimum discharge rates. The marked minimum discharge rate shall not exceed 20 % of the marked maximum discharge rate.

Note: Also see example in Section 3.30. Liquid-Measuring Devices Code, paragraph S.4.4.1. Discharge Rates.
(Note Added 2003)

N. Notes

N.1. Test Liquid. – The test liquid shall be carbon dioxide in a compressed liquid state.

N.2. Vaporization and Volume Change. – Care shall be exercised to reduce vaporization and volume changes to a minimum. When testing by weight, the weigh tank and transfer systems shall be pre-cooled to liquid temperature prior to the start of the test to avoid the venting of vapor from the vessel being weighed.

N.3. Test Drafts.

N.3.1. Gravimetric Test. – Weight test drafts shall be equal to at least the amount delivered by the device in 2 minutes at its maximum discharge rate.

N.3.2. Transfer Standard Test. – When comparing a meter with a calibrated transfer standard, the test draft shall be equal to at least the amount delivered by the device in two minutes at its maximum discharge rate.

N.3.3. Volumetric Prover Test Drafts. – Test drafts shall be equal to at least the amount delivered in one minute at its normal discharge rate.

N.4. Testing Procedures.

N.4.1. Normal Tests. – The "normal" test of a device shall be made at the maximum discharge flow rate developed under the conditions of installation. Any additional tests conducted at flow rates down to and including one-half of the sum of the maximum discharge flow rate and the rated minimum discharge flow rate shall be considered normal tests.

N.4.2. Special Tests. – Any test except as set forth in N.4.1. Normal Tests shall be considered a special test. Tests shall be conducted, if possible, to evaluate any special elements or accessories attached to or associated with the device. A device shall be tested at a minimum discharge rate of:

(a) not less than the marked minimum discharge rate or 20 % of the maximum rated discharge rate of the device, whichever is less; or

(b) the lowest discharge rate practicable under the conditions of installation.

"Special" tests may be conducted to develop any characteristics of the device anticipated under the conditions of installation.

N.4.3. Density. – Temperature and pressure of the metered test liquid shall be measured during the test for the determination of density or volume correction when applicable. The appropriate correction values shall apply as specified in Table N.4.4.

N.4.4. Automatic Temperature or Density Compensation. – If a device is equipped with an automatic temperature or density compensator, the compensator shall be tested by comparing the quantity indicated or recorded by the device (with the compensator connected and operating) with the actual delivered quantity. The appropriate correction values shall apply as specified in Table N.4.4.

Table N.4.4.
Automatic Temperature or Density Compensation

Temp °F	Pressure		Liquid Density		Vapor Density		Vapor Displacement %
	PSIA	PSIG	lb/gal	(lb-oz)/gal	lb/cu ft	lb/gal	
− 30.00	177.89	163.19	9.127	9 - 2.0	1.989	0.266	2.9
− 29.75	178.75	164.05	9.122	9 - 2.0	1.999	0.267	2.9
− 29.50	179.62	164.92	9.117	9 - 1.9	2.008	0.268	2.9
− 29.25	180.49	165.79	9.113	9 - 1.8	2.018	0.270	3.0
− 29.00	181.36	166.67	9.108	9 - 1.7	2.028	0.271	3.0
− 28.75	182.24	167.54	9.103	9 - 1.7	2.038	0.272	3.0
− 28.50	183.12	168.42	9.098	9 - 1.6	2.048	0.274	3.0
− 28.25	184.00	169.31	9.094	9 - 1.5	2.058	0.275	3.0
− 28.00	184.89	170.19	9.089	9 - 1.4	2.067	0.276	3.0
− 27.75	185.78	171.08	9.084	9 - 1.3	2.077	0.278	3.1
− 27.50	186.67	171.98	9.080	9 - 1.3	2.087	0.279	3.1
− 27.25	187.57	172.87	9.075	9 - 1.2	2.098	0.280	3.1
− 27.00	188.47	173.77	9.070	9 - 1.1	2.108	0.282	3.1
− 26.75	189.37	174.67	9.065	9 - 1.0	2.118	0.283	3.1
− 26.50	190.28	175.58	9.061	9 - 1.0	2.128	0.284	3.1
− 26.25	191.18	176.49	9.056	9 - 0.9	2.138	0.286	3.2
− 26.00	192.10	177.40	9.051	9 - 0.8	2.148	0.287	3.2
− 25.75	193.01	178.32	9.046	9 - 0.7	2.159	0.289	3.2
− 25.50	193.93	179.23	9.041	9 - 0.7	2.169	0.290	3.2
− 25.25	194.85	180.16	9.037	9 - 0.6	2.179	0.291	3.2
− 25.00	195.78	181.08	9.032	9 - 0.5	2.190	0.293	3.2
− 24.75	196.70	182.01	9.027	9 - 0.4	2.200	0.294	3.3
− 24.50	197.64	182.94	9.022	9 - 0.4	2.211	0.296	3.3
− 24.25	198.57	183.87	9.017	9 - 0.3	2.221	0.297	3.3
− 24.00	199.51	184.81	9.013	9 - 0.2	2.232	0.298	3.3
− 23.75	200.45	185.75	9.008	9 - 0.1	2.243	0.300	3.3
− 23.50	201.39	186.70	9.003	9 - 0.0	2.253	0.301	3.3
− 23.25	202.34	187.64	8.998	9 - 0.0	2.264	0.303	3.4
− 23.00	203.29	188.60	8.993	8 - 15.9	2.275	0.304	3.4
− 22.75	204.25	189.55	8.989	8 - 15.8	2.286	0.306	3.4
− 22.50	205.20	190.51	8.984	8 - 15.7	2.296	0.307	3.4
− 22.25	206.16	191.47	8.979	8 - 15.7	2.307	0.308	3.4

Table N.4.4.
Automatic Temperature or Density Compensation

Temp °F	Pressure		Liquid Density		Vapor Density		Vapor Displacement %
	PSIA	PSIG	lb/gal	(lb-oz)/gal	lb/cu ft	lb/gal	
− 22.00	207.13	192.43	8.974	8 - 15.6	2.318	0.310	3.5
− 21.75	208.09	193.40	8.969	8 - 15.5	2.329	0.311	3.5
− 21.50	209.06	194.37	8.964	8 - 15.4	2.340	0.313	3.5
− 21.25	210.04	195.34	8.959	8 - 15.4	2.351	0.314	3.5
− 21.00	211.02	196.32	8.955	8 - 15.3	2.362	0.316	3.5
− 20.75	212.00	197.30	8.950	8 - 15.2	2.374	0.317	3.5
− 20.50	212.98	198.28	8.945	8 - 15.1	2.385	0.319	3.6
− 20.25	213.97	199.27	8.940	8 - 15.0	2.396	0.320	3.6
− 20.00	214.96	200.26	8.935	8 - 15.0	2.407	0.322	3.6
− 19.75	215.95	201.26	8.930	8 - 14.9	2.419	0.323	3.6
− 19.50	216.95	202.25	8.925	8 - 14.8	2.430	0.325	3.6
− 19.25	217.95	203.25	8.920	8 - 14.7	2.441	0.326	3.7
− 19.00	218.95	204.26	8.915	8 - 14.6	2.453	0.328	3.7
− 18.75	219.96	205.27	8.911	8 - 14.6	2.464	0.329	3.7
− 18.50	220.97	206.28	8.906	8 - 14.5	2.476	0.331	3.7
− 18.25	221.99	207.29	8.901	8 - 14.4	2.488	0.333	3.7
− 18.00	223.01	208.31	8.896	8 - 14.3	2.499	0.334	3.8
− 17.75	224.03	209.33	8.891	8 - 14.3	2.511	0.336	3.8
− 17.50	225.05	210.36	8.886	8 - 14.2	2.523	0.337	3.8
− 17.25	226.08	211.38	8.881	8 - 14.1	2.534	0.339	3.8
− 17.00	227.11	212.42	8.876	8 - 14.0	2.546	0.340	3.8
− 16.75	228.15	213.45	8.871	8 - 13.9	2.558	0.342	3.9
− 16.50	229.18	214.49	8.866	8 - 13.9	2.570	0.344	3.9
− 16.25	230.23	215.53	8.861	8 - 13.8	2.582	0.345	3.9
− 16.00	231.27	216.58	8.856	8 - 13.7	2.594	0.347	3.9
− 15.75	232.32	217.62	8.851	8 - 13.6	2.606	0.348	3.9
− 15.50	233.37	218.68	8.846	8 - 13.5	2.618	0.350	4.0
− 15.25	234.43	219.73	8.841	8 - 13.5	2.630	0.352	4.0
− 15.00	235.49	220.79	8.836	8 - 13.4	2.643	0.353	4.0
− 14.75	236.55	221.86	8.831	8 - 13.3	2.655	0.355	4.0
− 14.50	237.62	222.92	8.826	8 - 13.2	2.667	0.357	4.0
− 14.25	238.69	223.99	8.821	8 - 13.1	2.680	0.358	4.1
− 14.00	239.76	225.07	8.816	8 - 13.1	2.692	0.360	4.1
− 13.75	240.84	226.14	8.811	8 - 13.0	2.704	0.362	4.1
− 13.50	241.92	227.22	8.806	8 - 12.9	2.717	0.363	4.1

Table N.4.4.
Automatic Temperature or Density Compensation

Temp °F	Pressure		Liquid Density		Vapor Density		Vapor Displacement %
	PSIA	PSIG	lb/gal	(lb-oz)/gal	lb/cu ft	lb/gal	
− 13.25	243.00	228.31	8.801	8 - 12.8	2.729	0.365	4.1
− 13.00	244.09	229.39	8.796	8 - 12.7	2.742	0.367	4.2
− 12.75	245.18	230.49	8.791	8 - 12.7	2.755	0.368	4.2
− 12.50	246.28	231.58	8.786	8 - 12.6	2.767	0.370	4.2
− 12.25	247.37	232.68	8.781	8 - 12.5	2.780	0.372	4.2
− 12.00	248.48	233.78	8.776	8 - 12.4	2.793	0.373	4.3
− 11.75	249.58	234.89	8.771	8 - 12.3	2.806	0.375	4.3
− 11.50	250.69	236.00	8.765	8 - 12.2	2.819	0.377	4.3
− 11.25	251.80	237.11	8.760	8 - 12.2	2.832	0.379	4.3
− 11.00	252.92	238.22	8.755	8 - 12.1	2.845	0.380	4.3
− 10.75	254.04	239.34	8.750	8 - 12.0	2.858	0.382	4.4
− 10.50	255.16	240.47	8.745	8 - 11.9	2.871	0.384	4.4
− 10.25	256.29	241.60	8.740	8 - 11.8	2.884	0.386	4.4
− 10.00	257.42	242.73	8.735	8 - 11.8	2.897	0.387	4.4
− 9.75	258.56	243.86	8.730	8 - 11.7	2.911	0.389	4.5
− 9.50	259.70	245.00	8.725	8 - 11.6	2.924	0.391	4.5
− 9.25	260.84	246.14	8.719	8 - 11.5	2.937	0.393	4.5
− 9.00	261.98	247.29	8.714	8 - 11.4	2.951	0.394	4.5
− 8.75	263.13	248.44	8.709	8 - 11.3	2.964	0.396	4.5
− 8.50	264.29	249.59	8.704	8 - 11.3	2.978	0.398	4.6
− 8.25	265.44	250.75	8.699	8 - 11.2	2.991	0.400	4.6
− 8.00	266.60	251.91	8.694	8 - 11.1	3.005	0.402	4.6
− 7.75	267.77	253.07	8.688	8 - 11.0	3.019	0.404	4.6
− 7.50	268.93	254.24	8.683	8 - 10.9	3.032	0.405	4.7
− 7.25	270.11	255.41	8.678	8 - 10.8	3.046	0.407	4.7
− 7.00	271.28	256.59	8.673	8 - 10.8	3.060	0.409	4.7
− 6.75	272.46	257.76	8.668	8 - 10.7	3.074	0.411	4.7
− 6.50	273.64	258.95	8.662	8 - 10.6	3.088	0.413	4.8
− 6.25	274.83	260.13	8.657	8 - 10.5	3.102	0.415	4.8
− 6.00	276.02	261.32	8.652	8 - 10.4	3.116	0.417	4.8
− 5.75	277.21	262.52	8.647	8 - 10.3	3.130	0.418	4.8
− 5.50	278.41	263.72	8.641	8 - 10.3	3.144	0.420	4.9
− 5.25	279.61	264.92	8.636	8 - 10.2	3.159	0.422	4.9
− 5.00	280.82	266.12	8.631	8 - 10.1	3.173	0.424	4.9
− 4.75	282.03	267.33	8.626	8 - 10.0	3.187	0.426	4.9

Table N.4.4.
Automatic Temperature or Density Compensation

Temp °F	Pressure		Liquid Density		Vapor Density		Vapor Displacement %
	PSIA	PSIG	lb/gal	(lb-oz)/gal	lb/cu ft	lb/gal	
− 4.50	283.24	268.55	8.620	8 - 9.9	3.202	0.428	5.0
− 4.25	284.46	269.76	8.615	8 - 9.8	3.216	0.430	5.0
− 4.00	285.68	270.98	8.610	8 - 9.8	3.231	0.432	5.0
− 3.75	286.90	272.21	8.604	8 - 9.7	3.245	0.434	5.0
− 3.50	288.13	273.44	8.599	8 - 9.6	3.260	0.436	5.1
− 3.25	289.37	274.67	8.594	8 - 9.5	3.275	0.438	5.1
− 3.00	290.60	275.91	8.589	8 - 9.4	3.289	0.440	5.1
− 2.75	291.84	277.15	8.583	8 - 9.3	3.304	0.442	5.1
− 2.50	293.09	278.39	8.578	8 - 9.2	3.319	0.444	5.2
− 2.25	294.33	279.64	8.573	8 - 9.2	3.334	0.446	5.2
− 2.00	295.58	280.89	8.567	8 - 9.1	3.349	0.448	5.2
− 1.75	296.84	282.14	8.562	8 - 9.0	3.364	0.450	5.3
− 1.50	298.10	283.40	8.556	8 - 8.9	3.379	0.452	5.3
− 1.25	299.36	284.67	8.551	8 - 8.8	3.395	0.454	5.3
− 1.00	300.63	285.93	8.546	8 - 8.7	3.410	0.456	5.3
− 0.75	301.90	287.21	8.540	8 - 8.6	3.425	0.458	5.4
− 0.50	303.18	288.48	8.535	8 - 8.6	3.440	0.460	5.4
− 0.25	304.46	289.76	8.530	8 - 8.5	3.456	0.462	5.4
0.00	305.74	291.74	8.524	8 - 8.4	3.471	0.464	5.4
0.25	307.03	292.33	8.519	8 - 8.3	3.487	0.466	5.5
0.50	308.32	293.62	8.513	8 - 8.2	3.503	0.468	5.5
0.75	309.61	294.92	8.508	8 - 8.1	3.518	0.470	5.5
1.00	310.91	296.21	8.502	8 - 8.0	3.534	0.472	5.6
1.25	312.21	297.52	8.497	8 - 8.0	3.550	0.475	5.6
1.50	313.52	298.82	8.491	8 - 7.9	3.566	0.477	5.6
1.75	314.83	300.13	8.486	8 - 7.8	3.582	0.479	5.6
2.00	316.15	301.45	8.480	8 - 7.7	3.598	0.481	5.7
2.25	317.46	302.77	8.475	8 - 7.6	3.614	0.483	5.7
2.50	318.79	304.09	8.469	8 - 7.5	3.630	0.485	5.7
2.75	320.11	305.42	8.464	8 - 7.4	3.646	0.487	5.8
3.00	321.45	306.75	8.458	8 - 7.3	3.662	0.490	5.8
3.25	322.78	308.08	8.453	8 - 7.2	3.679	0.492	5.8
3.50	324.12	309.42	8.447	8 - 7.2	3.695	0.494	5.8
3.75	325.46	310.77	8.442	8 - 7.1	3.712	0.496	5.9
4.00	326.81	312.11	8.436	8 - 7.0	3.728	0.498	5.9

Table N.4.4.
Automatic Temperature or Density Compensation

Temp °F	Pressure		Liquid Density		Vapor Density		Vapor Displacement %
	PSIA	PSIG	lb/gal	(lb-oz)/gal	lb/cu ft	lb/gal	
4.25	328.16	313.46	8.431	8 - 6.9	3.745	0.501	5.9
4.50	329.52	314.82	8.425	8 - 6.8	3.761	0.503	6.0
4.75	330.88	316.18	8.420	8 - 6.7	3.778	0.505	6.0
5.00	332.24	317.54	8.414	8 - 6.6	3.795	0.507	6.0
5.25	333.61	318.91	8.408	8 - 6.5	3.812	0.510	6.1
5.50	334.98	320.28	8.403	8 - 6.4	3.829	0.512	6.1
5.75	336.35	321.66	8.397	8 - 6.4	3.846	0.514	6.1
6.00	337.73	323.04	8.392	8 - 6.3	3.863	0.516	6.2
6.25	339.12	324.42	8.386	8 - 6.2	3.880	0.519	6.2
6.50	340.51	325.81	8.380	8 - 6.1	3.897	0.521	6.2
6.75	341.90	327.20	8.375	8 - 6.0	3.915	0.523	6.3
7.00	343.30	328.60	8.369	8 - 5.9	3.932	0.526	6.3
7.25	344.70	330.00	8.363	8 - 5.8	3.949	0.528	6.3
7.50	346.10	331.41	8.358	8 - 5.7	3.967	0.530	6.3
7.75	347.51	332.82	8.352	8 - 5.6	3.984	0.533	6.4
8.00	348.92	334.23	8.346	8 - 5.5	4.002	0.535	6.4
8.25	350.34	335.65	8.341	8 - 5.4	4.020	0.537	6.4
8.50	351.76	337.07	8.335	8 - 5.4	4.038	0.540	6.5
8.75	353.19	338.49	8.335	8 - 5.4	4.038	0.540	6.5
9.00	354.62	339.92	8.323	8 - 5.2	4.073	0.545	6.5
9.25	356.06	341.36	8.318	8 - 5.1	4.091	0.547	6.6
9.50	357.49	342.80	8.312	8 - 5.0	4.110	0.549	6.6
9.75	358.94	344.24	8.306	8 - 4.9	4.128	0.552	6.6
10.00	360.38	345.69	8.300	8 - 4.8	4.146	0.554	6.7
10.25	361.84	347.14	8.295	8 - 4.7	4.164	0.557	6.7
10.50	363.29	348.60	8.289	8 - 4.6	4.183	0.559	6.7
10.75	364.75	350.06	8.283	8 - 4.5	4.201	0.562	6.8
11.00	366.22	351.52	8.277	8 - 4.4	4.220	0.564	6.8
11.25	367.68	352.99	8.271	8 - 4.3	4.238	0.567	6.8
11.50	369.16	354.46	8.266	8 - 4.2	4.257	0.569	6.9
11.75	370.64	355.94	8.260	8 - 4.2	4.276	0.572	6.9
12.00	372.12	357.42	8.254	8 - 4.1	4.295	0.574	7.0
12.25	373.60	358.91	8.248	8 - 4.0	4.314	0.577	7.0
12.50	375.09	360.40	8.242	8 - 3.9	4.333	0.579	7.0
12.75	376.59	361.89	8.236	8 - 3.8	4.352	0.582	7.1

Table N.4.4.
Automatic Temperature or Density Compensation

Temp °F	Pressure		Liquid Density		Vapor Density		Vapor Displacement %
	PSIA	PSIG	lb/gal	(lb-oz)/gal	lb/cu ft	lb/gal	
13.00	378.09	363.39	8.230	8 - 3.7	4.371	0.584	7.1
13.25	379.59	364.89	8.224	8 - 3.6	4.390	0.587	7.1
13.50	381.10	366.40	8.219	8 - 3.5	4.410	0.589	7.2
13.75	382.61	367.91	8.213	8 - 3.4	4.429	0.592	7.2
14.00	384.13	369.43	8.207	8 - 3.3	4.449	0.595	7.2
14.25	385.65	370.95	8.201	8 - 3.2	4.468	0.597	7.3
14.50	387.17	372.48	8.195	8 - 3.1	4.488	0.600	7.3
14.75	388.70	374.01	8.189	8 - 3.0	4.508	0.603	7.4
15.00	390.24	375.54	8.183	8 - 2.9	4.527	0.605	7.4
15.25	391.78	377.08	8.177	8 - 2.8	4.547	0.608	7.4
15.50	393.32	378.62	8.171	8 - 2.7	4.567	0.611	7.5
15.75	394.87	380.17	8.165	8 - 2.6	4.587	0.613	7.5
16.00	396.42	381.72	8.159	8 - 2.5	4.608	0.616	7.5
16.25	397.98	383.28	8.153	8 - 2.4	4.628	0.619	7.6
16.50	399.54	384.84	8.147	8 - 2.3	4.648	0.621	7.6
16.75	401.10	386.41	8.141	8 - 2.2	4.669	0.624	7.7
17.00	402.67	387.98	8.134	8 - 2.2	4.689	0.627	7.7
17.25	404.25	389.55	8.128	8 - 2.1	4.710	0.630	7.7
17.50	405.82	391.13	8.122	8 - 2.0	4.731	0.632	7.8
17.75	407.41	392.71	8.116	8 - 1.9	4.751	0.635	7.8
18.00	409.00	394.30	8.110	8 - 1.8	4.772	0.638	7.9
18.25	410.59	395.89	8.104	8 - 1.7	4.793	0.641	7.9
18.50	412.19	397.49	8.098	8 - 1.6	4.814	0.644	7.9
18.75	413.79	399.09	8.092	8 - 1.5	4.835	0.646	8.0
19.00	415.39	400.70	8.085	8 - 1.4	4.857	0.649	8.0
19.25	417.00	402.31	8.079	8 - 1.3	4.878	0.652	8.1
19.50	418.62	403.92	8.073	8 - 1.2	4.900	0.655	8.1
19.75	420.24	405.54	8.067	8 - 1.1	4.921	0.658	8.2
20.00	421.86	407.17	8.061	8 - 1.0	4.943	0.661	8.2

N.4.5. Repeatability Tests. – Tests for repeatability should include a minimum of three consecutive test drafts of approximately the same size and be conducted under controlled conditions where variations in factors such as temperature, pressure, and flow rate are reduced to the extent that they will not affect the results obtained. When conducting the tests, the discharge rates shall be within the minimum and maximum discharge rates as marked by the manufacturer. For devices equipped with an automatic temperature or density compensator, results shall be based on tests with either:

(1) all runs conducted with the compensated (net) volume (e.g., with the temperature or density compensator activated); or

(2) all runs conducted with the uncompensated (gross) volume (e.g., with the temperature or density compensator deactivated).

(Amended 2019)

T. Tolerances

T.1. Application.

T.1.1. To Underregistration and to Overregistration. – The tolerances hereinafter prescribed shall be applied to errors of underregistration and errors of overregistration.

T.2. Tolerance Values. – The maintenance and acceptance tolerances for normal and special tests shall be as shown in Table T.2. Accuracy Classes and Tolerances for Carbon Dioxide Liquid-Measuring Devices.

Table T.2.
Accuracy Classes and Tolerances for Carbon Dioxide Liquid-Measuring Devices

Accuracy Class	Application	Acceptance Tolerance	Maintenance Tolerance	Special Test Tolerance
2.5	Liquid carbon dioxide	1.5 %	2.5 %	2.5 %

(Table Added 2003) (Amended 2003)

T.2.1. Repeatability. – When multiple tests are conducted at approximately the same flow rate and draft size, the range of the test results for the flow rate shall not exceed 40 % of the absolute value of the maintenance tolerance and the results of each test shall be within the applicable tolerance. Also see N.4.5. Repeatability Tests. (Added 2002) (Amended 2019)

T.3. On Tests Using Transfer Standards. – To the basic tolerance values that would otherwise be applied, there shall be added an amount equal to two times the standard deviation of the applicable transfer standard when compared to a basic reference standard.

UR. User Requirements

UR.1. Installation Requirements.

UR.1.1. Discharge Rate. – A device shall be so installed that the actual maximum discharge rate will not exceed the rated maximum discharge rate. If necessary, means for flow regulation shall be incorporated in the installation.

UR.1.2. Length of Discharge Hose. – The discharge hose shall be of such a length and design as to keep vaporization of the liquid to a minimum.

UR.1.3. Maintenance of Liquid State. – A device shall be so installed and operated that the product being measured shall remain in the liquid state during passage through the meter.

UR.2. Use Requirements.

UR.2.1. Return of Indicating and Recording Elements to Zero. – The primary indicating elements (visual) and the primary recording elements shall be returned to zero immediately before each delivery.

UR.2.2. Condition of Discharge System. – The discharge hose, up to the valve at the end of the discharge hose, shall be completely filled and pre-cooled to liquid temperatures before a "zero" condition is established and prior to the start of a commercial delivery. Means shall be provided to fill the discharge hose with liquid prior to the start of a delivery.

UR.2.3. Vapor Equalization Line. – A vapor equalization line shall not be used during a metered delivery unless the quantity of vapor displaced from the buyer's tank to the seller's tank is deducted from the metered quantity. The appropriate correction values shall apply as specified in Table N.4.4.

UR.2.4. Temperature or Density Compensation.

UR.2.4.1. Use of Automatic Temperature or Density Compensators. – Devices equipped with an automatic temperature or density compensator shall have the compensator connected, operable, and in use at all times. Such automatic temperature or density compensator may not be removed.

UR.2.4.2. Tickets or Invoices. – Any written invoice or printed ticket based on a reading of a device that is equipped with an automatic temperature or density compensator shall have shown thereon that the quantity delivered has been temperature or density compensated.

UR.2.5. Ticket in Printing Device. – A ticket shall not be inserted into a device equipped with a ticket printer until immediately before a delivery is begun, and in no case shall a ticket be in the device when the vehicle is in motion while on a public street, highway, or thoroughfare.

UR.2.6. Sale by Weight. – All quantity determinations shall be made by means of an approved and sealed weighing or measuring device. All sales shall be stated in kilograms or pounds.

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