

Sec. 3.37. Mass Flow Meters

A. Application

A.1. Liquids. - This code applies to devices that are designed to dynamically measure the mass, or the mass and density of liquids. It also specifies the relevant examinations and tests that are to be conducted.

(Amended 1997)

A.2. Vapor (Gases). - This code applies to devices that are designed to dynamically measure the mass of hydrocarbon gas in the vapor state. Examples of these products are propane, propylene, butanes, butylenes, ethane, methane, natural gas and any other hydrocarbon gas/air mix.

S. Specifications

S.1. Indicating and Recording Elements.

S.1.1. Indicating Elements. - A measuring assembly shall include an indicating element. Indications shall be clear, definite, accurate, and easily read under normal conditions of operation of the instrument.

S.1.2. Compressed Natural Gas Dispensers. - Except for fleet sales and other price contract sales, a compressed natural gas dispenser used to refuel vehicles shall be of the computing type and shall indicate the quantity, the unit price, and the total price of each delivery. The dispenser shall display the mass measured for each transaction either continuously on an external or internal display accessible during the inspection and test of the dispenser, or display the quantity in mass units by using controls on the device.

(Added 1994)

S.1.3. Units. -

S.1.3.1. Units of Measurement. - Deliveries shall be indicated and recorded in grams, kilograms, metric tons, pounds, tons, and/or liters, gallons, quarts, pints and decimal subdivisions thereof. The indication of a delivery shall be on the basis of apparent mass versus a density of 8.0 g/cm³. The volume indication shall be based on the mass measurement and an automatic means to determine and correct for changes in product density.

(Amended 1993 and 1997)

S.1.3.1.1. Compressed Natural Gas Used as an Engine Fuel. - When compressed natural gas is dispensed as an engine fuel, the delivered quantity shall be indicated in "gasoline liter equivalent (GLE) units" or "gasoline gallon equivalent (GGE) units" (see definitions).

(Added 1994)

S.1.3.2. Numerical Value of Quantity-Value Divisions. - The value of a scale interval shall be equal to:

- 1, 2, or 5, or
- a decimal multiple or submultiple of 1, 2, or 5.

S.1.3.3. Maximum Value of Quantity-Value Divisions.

(a) The maximum value of the quantity-value division for liquids shall be not greater than 0.2 % of the minimum measured quantity.

(b) For dispensers of compressed natural gas used to refuel vehicles, the value of the division for the gasoline liter equivalent shall not exceed 0.01 GLE; the division for gasoline gallon equivalent (GGE) shall not exceed 0.001 GGE. The maximum value of the mass division shall not exceed 0.001 kg or 0.001 lb.

(Amended 1994)

S.1.3.4. Values Defined. - Indicated values shall be adequately defined by a sufficient number of figures, words, symbols, or combinations thereof. A display of "zero" shall be a zero digit for all displayed digits to the right of the decimal mark and at least one to the left.

S.2. Operating Requirements.

S.2.1. Return to Zero. - Except for measuring assemblies in a pipeline:

- (a) One indicator and the primary recording elements, if the device is equipped to record, shall be provided with a means for readily returning the indication to zero either automatically or manually.
- (b) It shall not be possible to return primary indicating elements, or primary recording elements, beyond the correct zero position.

(Amended 1993)

S.2.2. Indicator Reset Mechanism. - The reset mechanism for the indicating element shall not be operable during a delivery. Once the zeroing operation has begun, it shall not be possible to indicate a value other than the latest measurement, or "zeros" when the zeroing operation has been completed.

S.2.3. Nonresettable Indicator. - An instrument may also be equipped with a nonresettable indicator if the indicated values cannot be construed to be the indicated values of the resettable indicator for a delivered quantity.

S.2.4. Provisions for Power Loss.

S.2.4.1. Transaction Information. - In the event of a power loss, the information needed to complete any transaction in progress at the time of the power loss (such as the quantity and unit price, or sales price) shall be determinable for at least 15 minutes at the dispenser or at the console if the console is accessible to the customer.
(Added 1993)

S.2.4.2. User Information. - The device memory shall retain information on the quantity of fuel dispensed and the sales price totals during power loss.
(Added 1993)

S.2.5. Display of Unit Price and Product Identity.

S.2.5.1. Unit Price. - A computing or money-operated device shall be able to display on each face the unit price at which the device is set to compute or to dispense.
(Added 1993)

S.2.5.2. Product Identity. - A device shall be able to conspicuously display on each side the identity of the product being dispensed.
(Added 1993)

S.2.5.3. Selection of Unit Price. - *Except for dispensers used exclusively for fleet sales, other price contract sales, and truck refueling (e.g., truck stop dispensers used only to refuel trucks), when a product or grade is offered for sale at more than one unit price through a computing device, the selection of the unit price shall be made prior to delivery using controls on the device or other customer-activated controls. A system shall not permit a change to the unit price during delivery of a product.*

[Nonretroactive as of January 1, 1998]

(Added 1997)

S.2.5.4. Agreement Between Indications. - *When a quantity value indicated or recorded by an auxiliary element is a derived or computed value based on data received from a retail motor fuel dispenser, the value may differ from the quantity value displayed on the dispenser, provided the following conditions are met:*

- (a) *all total money values for an individual sale that are indicated or recorded by the system agree; and*

(b) *within each element the values indicated or recorded meet the formula (quantity x unit price = total sales price) to the closest cent.*

[Nonretroactive as of January 1, 1998]

(Added 1997)

S.2.6. Money-Value Computations. - A computing device shall compute the total sales price at any single-purchase unit price (i.e., excluding fleet sales, other price contract sales, and truck stop dispensers used only to refuel trucks) for which the product being measured is offered for sale at any delivery possible within either the measurement range of the device or the range of the computing elements, whichever is less.

(Added 1993)

S.2.6.1. Auxiliary Elements. - If a system is equipped with auxiliary indications, all indicated money value and quantity divisions of the auxiliary element shall be identical with those of the primary element.

(Added 1993)

S.2.6.2. Display of Quantity and Total Price. - When a delivery is completed, the total price and quantity for that transaction shall be displayed on the face of the dispenser for at least 5 minutes or until the next transaction is initiated by using controls on the device or other user-activated controls.

(Added 1993)

S.2.7. Recorded Representations, Point-of-Sale Systems. - *The sales information recorded by cash registers when interfaced with a retail motor-fuel dispenser shall contain the following information for products delivered by the dispenser:*

(a) *the total volume of the delivery,*

(b) *the unit price,*

(c) *the total computed price, and*

(d) *the product identity by name, symbol, abbreviation, or code number.*

[Nonretroactive as of January 1, 1986]

(Added 1993)

S.2.8. Indication of Delivery. - *The device shall automatically show on its face the initial zero condition and the quantity delivered (up to the nominal capacity). However, the first 0.03 L (0.009 gal) of a delivery and its associated total sales price need not be indicated.*

[Nonretroactive as of January 1, 1998]

(Added 1997)

S.3. Measuring Elements and Measuring Systems.

S.3.1. Maximum and Minimum Flow-Rates.

(a) The ratio of the maximum to minimum flow-rates specified by the manufacturer for devices measuring liquified gases shall be 5:1 or greater.

(b) The ratio of the maximum to minimum flow-rates specified by the manufacturer for devices measuring other than liquified gases shall be 10:1 or greater.

S.3.2. Adjustment Means. - An assembly shall be provided with means to change the ratio between the indicated quantity and the quantity of liquid measured by the assembly. A bypass on the measuring assembly shall not be used for these means.

S.3.2.1. Discontinuous Adjusting Means. - When the adjusting means changes the ratio between the indicated quantity and the quantity of measured liquid in a discontinuous manner, the consecutive values of the ratio shall not differ by more than 0.1 %.

S.3.3. Vapor Elimination. - A liquid-measuring instrument or measuring system shall be equipped with an effective vapor or air eliminator or other effective means, automatic in operation, to prevent the measurement of vapor and air. Vent lines from the air or vapor eliminator shall be made of metal tubing or some other suitable rigid material. (Amended 1999)

S.3.3.1. Vapor Elimination on Loading Rack Liquid Metering Systems. -

- (a) A loading rack liquid metering system shall be equipped with a vapor or air eliminator or other automatic means to prevent the passage of vapor and air through the meter unless the system is designed or operationally controlled by a method, approved by the weights and measures jurisdiction having statutory authority over the device, such that neither air nor vapor can enter the system.
- (b) Vent lines from the air or vapor eliminator (if present) shall be made of metal tubing or other rigid material.

(Added 1995)

S.3.4. Maintenance of Liquid State. - A liquid-measuring device shall be installed so that the measured product remains in a liquid state during passage through the instrument.

S.3.5. Provision for Sealing. - Adequate provision shall be made for an approved means of security (e.g., data change audit trail) or physically applying security seals in such a manner that no adjustment may be made of:

- (a) any measurement element;
- (b) any adjustable element for controlling delivery rate when such rate tends to affect the accuracy of deliveries;
or
- (c) the zero adjustment mechanism.

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

Audit trails shall use the format set forth in Table S.3.5.

(Amended 1992 and 1995)

S.3.6. Automatic Density Correction.

- (a) An automatic means to determine and correct for changes in product density shall be incorporated in any mass flow metering system that is affected by changes in the density of the product being measured.
- (b) Volume-measuring devices with automatic temperature compensation used to measure natural gas as a motor vehicle engine fuel shall be equipped with an automatic means to determine and correct for changes in product density due to changes in the temperature, pressure, and composition of the product.

(Amended 1994 and 1997)

S.3.7. Pressurizing the Discharge Hose. - The discharge hose for compressed natural gas shall automatically pressurize prior to the device beginning to register the delivery.

(Added 1993)

Table S.3.5. Categories of Device and Methods of Sealing	
Categories of Device	Method of Sealing
<p>Category 1: No remote configuration capability.</p>	<p>Seal by physical seal or two event counters: one for calibration parameters and one for configuration parameters.</p>
<p>Category 2: Remote configuration capability, but access is controlled by physical hardware.</p> <p>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.</p> <p>[Category 2 applies to only devices manufactured prior to January 1, 2005. Devices with remote configuration capability manufactured or in use after that date must meet the sealing requirements outlined in Category 3. Devices without remote configuration capability manufactured after that date will be required to meet the minimum criteria outlined in Category 1].</p>	<p>[The hardware enabling access for remote communication must be on-site. The hardware must be sealed using a physical seal or 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.]*</p> <p>[*Nonretroactive as of January 1, 1996]</p>
<p>Category 3: Remote configuration capability access may be unlimited or controlled through a software switch (e.g., password).</p> <p>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.</p> <p>[Nonretroactive as of January 1, 2001]</p> <p><i>Nonretroactive as of January 1, 2005, all devices with remote configuration capability must comply with the sealing requirements of Category 3.</i></p>	<p>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 through the device or through another on-site device. The event logger shall have a capacity to retain records equal to ten 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.)</p>

Nonretroactive as of January 1, 1995]
 (Table Added 1995) (Amended 1995, 1998, and 1999)

S.3.8. Zero-Set-Back Interlock, Retail Motor-Fuel Devices. - A device shall be constructed so that:

- (a) after a delivery cycle has been completed by moving the starting lever to any position that shuts off the device, an automatic interlock prevents a subsequent delivery until the indicating elements, and recording elements if the device is equipped and activated to record, have been returned to their zero positions;
- (b) the discharge nozzle cannot be returned to its designed hanging position (that is, any position where the tip of the nozzle is placed in its designed receptacle and the lock can be inserted) until the starting lever is in its designed shut-off position and the zero-set-back interlock has been engaged; and
- (c) in a system with more than one dispenser supplied by a single pump, an effective automatic control valve in each dispenser prevents product from being delivered until the indicating elements on that dispenser are in a correct zero position.

(Added 1993)

S.4. Discharge Lines and Valves.

S.4.1. Diversion of Measured Product. - No means shall be provided by which any measured product can be diverted from the measuring instrument. However, two or more delivery outlets may be permanently installed and operated simultaneously, provided that any diversion of flow to other than the intended receiving receptacle cannot be readily accomplished or is readily apparent. Such means include physical barriers, visible valves or indications that make it clear which outlets are in operation, and explanatory signs if deemed necessary.

A manually controlled outlet that may be opened for purging or draining the measuring system, or for recirculating product if recirculation is required in order to maintain the product in a deliverable state shall be permitted.. Effective means shall be provided to prevent the passage of liquid through any such outlet during normal operation of the measuring system and to inhibit meter indications (or advancement of indications) and recorded representations while the outlet is in operation.

(Amended 2002)

S.4.2. Pump-Discharge Unit. - A pump-discharge unit for liquids equipped with a flexible discharge hose shall be of the wet-hose type.

(Added 1993)

S.4.3. Directional Flow Valves. - If a reversal of flow could result in errors that exceed the tolerance for the minimum measured quantity, a valve or valves or other effective means, automatic in operation (and equipped with a pressure limiting device, if necessary) to prevent the reversal of flow shall be properly installed in the system. (See N.1.)

S.4.4. Discharge Valves. - A discharge valve may be installed on a discharge line only if the system is a wet-hose type. Any other shutoff valve on the discharge side of the instrument shall be of the automatic or semiautomatic predetermined-stop type or shall be operable only:

- by means of a tool (but not a pin) entirely separate from the device, or
- by means of a security seal with which the valve is sealed open.

S.4.5. Antidrain Means. - In a wet-hose type device, effective means shall be provided to prevent the drainage of the hose between transactions.

S.4.6. Other Valves. - Check valves and closing mechanisms that are not used to define the measured quantity shall have relief valves (if necessary) to dissipate any abnormally high pressure that may arise in the measuring assembly.

S.5. Markings. - A measuring system shall be legibly and indelibly marked with the following information:

- (a) pattern approval mark (i.e., type approval number);
- (b) name and address of the manufacturer or his trademark and, if required by the weights and measures authority, the manufacturer's identification mark in addition to the trademark;
- (c) model designation or product name selected by the manufacturer;
- (d) nonrepetitive serial number;
- (e) *the accuracy class of the meter as specified by the manufacturer consistent with Table T.2.;**
(Added 1994)
- (f) maximum and minimum flow rates in pounds per unit of time;
- (g) maximum working pressure;
- (h) applicable range of temperature if other than -10 °C to +50 °C;

- (i) minimum measured quantity; and
- (j) product limitations, if applicable.

[*Nonretroactive as of January 1, 1995]

S.5.1. Marking of Gasoline Volume Equivalent Conversion Factor. - A device dispensing compressed natural gas shall have either the statement "1 Gasoline Liter Equivalent (GLE) is Equal to 0.678 kg of Natural Gas" or "1 Gasoline Gallon Equivalent (GGE) is Equal to 5.660 lb of Natural Gas" permanently and conspicuously marked on the face of the dispenser according to the method of sale used.

(Added 1994)

S.6. Printer. - When an assembly is equipped with means for printing the measured quantity, the following conditions apply:

- (a) the scale interval shall be the same as that of the indicator;
- (b) the value of the printed quantity shall be the same value as the indicated quantity;
- (c) a quantity for a delivery (other than an initial reference value) cannot be recorded until the measurement and delivery has been completed;
- (d) the printer is returned to zero when the resettable indicator is returned to zero; and
- (e) the printed values shall meet the requirements applicable to the indicated values.

S.6.1. Printed Receipt. - Any delivered, printed quantity shall include an identification number, the time and date, and the name of the seller. This information may be printed by the device or pre-printed on the ticket.

S.7. Totalizers for Retail Motor-Fuel Devices. - Retail motor-fuel dispensers shall be equipped with a nonresettable totalizer for the quantity delivered through the metering device.

[Nonretroactive as of January 1, 1998]

(Added 1997)

N. Notes

N.1. Minimum Measured Quantity. - The minimum measured quantity shall be specified by the manufacturer.

N.2. Test Medium.

N.2.1. Liquid-Measuring Devices. - The device shall be tested with the liquid that the device is intended to measure or another liquid with the same general physical characteristics.

N.2.2. Vapor-Measuring Devices. - The device shall be tested with air or the product to be measured.

N.3. Test Drafts. - The minimum test shall be one test draft at the maximum flow rate of the installation and one test draft at the minimum flow rate. More tests may be performed at these or other flow rates. (See T.3.)

N.4. Minimum Measured Quantity. - The device shall be tested for a delivery equal to the declared minimum measured quantity when the device is likely to be used to make deliveries on the order of the minimum measured quantity.

N.5. Motor Fuel Dispenser. - When a device is intended for use as a liquid motor-fuel dispenser, the type evaluation test shall include a test for accuracy using five starts and stops during a delivery to simulate the operation of the automatic shut-off nozzle. This test may be conducted as part of the normal inspection and test of the meter.

N.6 Testing Procedures.

N.6.1. Normal Tests. - The normal test of a meter shall be made at the maximum discharge rate developed by the installation. Any additional tests conducted at flow rates down to and including the rated minimum discharge flow rate shall be considered normal tests.

(Added 1999)

N.6.1.1. 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.

(Added 2001)

N.6.2. Special Tests. - Special tests to develop the operating characteristics of a meter and any special elements and accessories attached to or associated with the device, shall be made as circumstances require. Any test except as set forth in N.6.1. shall be considered a special test. Special test of a measuring system shall be made to develop operating characteristics of the measuring systems during a split compartment delivery. (See Table T.2.)

(Added 1999)

T. Tolerances

T.1. Tolerances, General.

(a) The tolerances apply equally to errors of underregistration and errors of overregistration.

(b) The tolerances apply to all products at all temperatures measured at any flow rate within the rated measuring range of the meter.

(Amended 1999)

T.2. Tolerances. - The tolerances for mass flow meters for specific liquids, gases, and applications are listed in Table T.2.

(Amended 1994 and 1999)

Accuracy Class	Application or Commodity Being Measured	Acceptance Tolerance	Maintenance Tolerance	Special Tolerance
0.3	Loading rack meters, vehicle-tank meters, home heating oil, heated products (except asphalt above 50 EC), asphalt 50 EC or below, milk and other food products, large capacity motor-fuel dispensers (maximum discharge flow rates greater than 100 L or 25 gallon per minute), all other liquid applications not shown in the table where the minimum delivery is at least 700 kg (1500 lb)	0.2 %	0.3 %	0.5 %
0.3A	Asphalt above 50 EC	0.3 %	0.3 %	0.5 %
0.5	Small capacity (retail) motor-fuel dispensers, agri-chemical liquids, all other liquid applications not shown in the table	0.3 %	0.5 %	0.5 %
1.0	Anhydrous ammonia, LP Gas (including vehicle tank meters)	0.6 %	1.0 %	1.0 %
2.0	Compressed natural gas as a motor fuel	1.5 %	2.0 %	2.0 %
2.5	Cryogenic liquid meters, liquefied compressed gases other than LP Gas	1.5 %	2.5 %	2.5 %

(Added 1994) (Amended 1999 and 2001)

T.3. 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. See also N.6.1.1.
(Amended 1992, 1994, and 2001)

T.4. Type Evaluation Examinations for Liquid-Measuring Devices. - For type evaluation examinations, the tolerance values shall apply under the following conditions:

- (a) with any one liquid within the range of liquids,
- (b) at any one liquid temperature and pressure within the operating range of the meter, and
- (c) at all flow rates within the range of flow rates.

(Added 1993) (Amended 1994)

UR. User Requirements

UR.1. Selection Requirements.

UR.1.1. Discharge Hose-Length. - *The length of the discharge hose on a retail motor-fuel device shall not exceed 4.6 m (15 ft) unless it can be demonstrated that a longer hose is essential to permit deliveries to be made to receiving vehicles or vessels.*

[Nonretroactive as of January 1, 1998]

(Added 1997)

UR.1.2. Minimum Measured Quantity.

- (a) The minimum measured quantity shall be specified by the manufacturer.
- (b) The minimum measured quantity appropriate for a transaction may be specified by the weights and measures authority. A device may have a minimum measured quantity smaller than that specified by the weights and measures authority; however, the device must perform within the performance requirements for the declared minimum measured quantity.

UR.2. Installation Requirements.

UR.2.1. Manufacturer's Instructions. - A device shall be installed in accordance with the manufacturer's instructions, and the installation shall be sufficiently secure and rigid to maintain this condition.

(Added 1997)

UR.2.2. Discharge Rate. - A device shall be installed so that the actual maximum discharge rate will not exceed the rated maximum discharge rate. Automatic means of flow regulation shall be incorporated in the installation if necessary.

(Added 1997)

UR.2.3. Low-Flow Cut-Off Valve. - If a metering system is equipped with a programmable or adjustable "low-flow cut-off" feature:

- (a) the low-flow cut-off value shall not be set at flow rates lower than the minimum operating flow rate specified by the manufacturer on the meter; and
- (b) the system shall be equipped with flow control valves which prevent the flow of product and stop the indicator from registering product flow whenever the product flow rate is less than the low-flow cut-off value.

(Added 1992)

UR.3. Use of Device.

UR.3.1. Unit Price and Product Identity for Retail Dispensers. - The following information shall be conspicuously displayed or posted on the face of a retail dispenser used in direct sale:

- (a) Except for dispensers used exclusively for fleet sales, other price contract sales, and truck refueling (e.g., truck stop dispensers used only to refuel trucks), all of the unit prices at which the product is offered for sale; and
- (b) in the case of a computing type or money-operated type, the unit price at which the dispenser is set to compute.

(Added 1993)

UR.3.2. Vapor-Return Line. - During any metered delivery of liquefied petroleum gas and other liquids from a supplier's tank to a receiving container, there shall be no vapor-return line from the receiving container to the supplier's tank:

- (a) in the case of any receiving container to which normal deliveries can be made without the use of such vapor-return line, or
- (b) in the case of any new receiving container when the ambient temperature is below 90 °F.

(Added 1993)

UR.3.3. Ticket Printer; Customer Ticket. - *Vehicle-mounted metering systems shall be equipped with a ticket printer which shall be used for all sales where product is delivered through the meter. A copy of the ticket issued by the device shall be left with the customer at the time of delivery or as otherwise specified by the customer. [Nonretroactive as of January 1, 1995] [To become retroactive as of January 1, 1999]*

(Added 1994)

UR.3.4. Printed Ticket. - The total price, the total quantity of the delivery, and the price per unit shall be printed on any ticket issued by a device of the computing type and containing any one of these values.

(Added 1993)

UR.3.5. 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.

(Added 1993)

UR.3.6. Steps After Dispensing. - After delivery to a customer from a retail motor-fuel device:

- (a) the starting lever shall be returned to its shutoff position and the zero-set-back interlock engaged; and
- (b) the discharge nozzle shall be returned to its designed hanging position unless the primary indicating elements, and recording elements, if the device is equipped and activated to record, have been returned to a definite zero indication.

(Added 1993)

UR.3.7. Return of Indicating and Recording Elements to Zero. - The primary indicating elements (visual), and the primary recording elements when these are returnable to zero, shall be returned to zero immediately before each delivery. Exceptions to this requirement are totalizers on key-lock-operated or other self-operated dispensers and the primary recording element if the device is equipped to record.

(Added 1995) (Amended 1997)

UR.3.8. Return of Product to Storage, Retail Compressed Natural Gas Dispensers. - Provisions at the site shall be made for returning product to storage or disposing of the product in a safe and timely manner during or following testing operations. Such provisions may include return lines, or cylinders adequate in size and number to permit this procedure.

(Added 1998)