Australian Government
National Measurement Institute

Bradfield Road, West Lindfield NSW 2070

Certificate of Approval

No 10/2/11

Issued by the Chief Metrologist under Regulation 60
of the
National Measurement Regulations 1999

This is to certify that an approval for use for trade has been granted in respect of the

Micro Motion Model CMF 200 Bulk Cryogenic Mass Flowmetering System

submitted by Emerson Process Management Australia Pty Ltd
471 Mountain Highway
Bayswater VIC 3153.

NOTE: This Certificate relates to the suitability of the pattern of the instrument for use for trade only in respect of its metrological characteristics. This Certificate does not constitute or imply any guarantee of compliance by the manufacturer or any other person with any requirements regarding safety.

This approval has been granted with reference to document OIML R81, *Dynamic Measuring Devices and Systems for Cryogenic Liquids*, dated 1998.

CONDITIONS OF APPROVAL

This approval becomes subject to review on 1 March 2013, and then every 5 years thereafter.

Instruments purporting to comply with this approval shall be marked with approval number 'NMI 10/2/11' and only by persons authorised by the submittor.

It is the submittor's responsibility to ensure that all instruments marked with this approval number are constructed as described in the documentation lodged with the National Measurement Institute (NMI) and with the relevant Certificate of Approval and Technical Schedule. Failure to comply with this Condition may attract penalties under Section 19B of the National Measurement Act and may result in cancellation or withdrawal of the approval, in accordance with document NMI P 106.

The National Measurement Institute reserves the right to examine any instrument or component of an instrument purporting to comply with this approval.

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Auxiliary devices used with this instrument shall comply with the requirements of General Supplementary Certificate No S1/0/A.

DESCRIPTIVE ADVICE

Pattern: approved 4 February 2008

- A Micro Motion model CMF 200 mass flowmetering system for bulk metering of cryogenic products.

Variants: approved 4 February 2008

1. Using certain Micro Motion flowmeters as listed in Table 1.
2. For use with liquid natural gas (LNG).

Variants: approved 8 July 2010

3. With a Micro Motion model 800 core processor.
4. With Micro Motion models 1700, 2500, 3500 or 3700 flow transmitters.
5. With Micro Motion model 510 dual pulse convertor.
6. With a MODbus output.

Technical Schedule No 10/2/11 describes the pattern and variants 1 to 6.

FILING ADVICE

Certificate of Approval No 10/2/11 and its Technical Schedule both dated 12 March 2008 (including Figures 1 to 4) are all superseded by this Certificate, Technical Schedule and Figures 1 to 5 included herein, and may be destroyed. The documentation for this approval now comprises:

Certificate of Approval No 10/2/11 dated 9 July 2010
Technical Schedule No 10/2/11 dated 9 July 2010 (incl. Table 1 and Test Procedure)
Figures 1 to 5 dated 9 July 2010

Signed by a person authorised by the Chief Metrologist to exercise his powers under Regulation 60 of the *National Measurement Regulations 1999*.

TECHNICAL SCHEDULE No 10/2/11

Pattern: Micro Motion Model CMF 200 Bulk Cryogenic Mass Flowmetering System

Submittor: Emerson Process Management Australia Pty Ltd
471 Mountain Highway
Bayswater VIC 3153

1. Description of Pattern

A bulk flowmetering system incorporating a Micro Motion model CMF 200 mass flowmeter (Figure 1 and Table 1) for bulk metering of cryogenic products.

1.1 Field of Operation

The field of operation of the measuring system is determined by the following characteristics:

Product (#1)	Temperature Range (K)	Pressure Range (MPa abs.)	Density Range (kg/m³)
Liquid nitrogen (LIN)	75 to 125	0.1 to 3.0	819.3 to 701.6
Liquid argon (LAR)	90 to 130	0.1 to 3.0	1407.8 to 1241.2
Liquid oxygen (LOX)	85 to125	0.1 to 3.0	1142.0 to 1012.1

- Minimum measured quantity, M_{min} 20 kg (#2)
- Maximum flow rate, Q_{max} 1450 kg/min
- Minimum flow rate, Q_{min} 18 kg/min
- Ambient temperature range -25°C to 55°C
- Liquid temperature range -200°C to 200°C
- Accuracy class Class 2.5
- Power supply (nominal) 24 V DC/240 V AC
- Applications static, pipeline or mobile

(#1) The flowmeter is adjusted to be correct for the liquid for which it is to be verified as marked on the data plate.

(#2) The calculator/indicator indicates the mass at least in 0.1 kg increments.

1.2 Components of the Measuring System (Figure 1a)

(i) Supply Tank

The supply tank is designed to maintain the cryogenic liquid within the temperature range specified for the product in its liquid state. An outlet is provided at the bottom of the tank leading to the inlet of the pump via an isolation valve. The supply tank incorporates a low liquid level device to ensure that vapour does not enter the pipework.

(ii) Pump

Either a positive displacement or centrifugal pump with integral or external pump by-pass valve is positioned as close as possible to the outlet of the supply tank with sufficient flow capacity to maintain the delivery within the flow rate range specified for the flowmeter. The pipe from the supply tank has a continuous fall to the pump inlet and has a diameter not smaller than that of the pump outlet pipe. Provision is made between the pump and the meter for a by-pass line to allow liquid to flood the pump and the meter before measurements begin.

(iii) Measurement Transducer

The measurement transducer is a Micro Motion MVD flowmetering system consisting of a Micro Motion model CMF200 (#) flow sensor (Figure 1b) interfaced to a Micro Motion model 700 (#) core processor (Figure 2a) that in turn is interfaced to a Micro Motion model 2700 (#) flow transmitter (Figure 2b) to convert digital data received into various signal formats. The model 700 core processor may be mounted integral to the flow transmitter, or separate from the mass flow sensor and transmitter.

(#) The numbers listed are basic model numbers only – the full model number may have a variety of additional alphanumeric characters, which designate non-metrological features.

The flow transmitter model is identified by a series of alphanumeric codes which represent various applications options, with option code ‘W’ or ‘D” required for custody transfer applications under this approval.

The model 2700 flow transmitter provides a dual pulse output to the calculator/indicator, the digital communication interface to the model 700 core processor, and power to the core processor and flow sensor. The flow transmitter also displays process data, alarm status and internal totalisers (inventory/control), and has additional non-metrological features.

The model 700 core processor provides a drive frequency to the flow sensor to vibrate the measurement tubes, and monitors the pick-off frequencies as the measurement tubes resonate. This in turn is used to determine the mass flow rate (by the time shift between the two pick-off signals), the density of the flowing medium (by the resonant frequency of the vibrating tubes), and the volume flow rate at flowing conditions (by the ratio of the measured mass and measured density).

Additionally, the model 700 core processor provides the following functions:

- Read/write digital communication interface to the flow transmitter and interface to the flow sensor;
- Storage of the Flow Cal Factor (FCF), density calibration factors, damping factors, slug flow limits/duration, and units of measurement; and
- Automatic correction for temperature effects on sensor tubes, and determination of sensor constants at zero flow.

(iv) Software Versions

Approved software versions are:

- Model 700 core processor – 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 3.0 and 3.1.
- Model 2700 flow transmitter – 3.2, 3.3, 3.4, 3.4.1, 3.5.3, 3.6, 3.7, 4.1, 4.2, 5.00/1.0, 5.12/1.0, 5.20/1.0, 6.0/1.1 and 6.1/1.2.

Software version numbers may be displayed on the 2700 display by performing the following:

- Press SCROLL and SELECT simultaneously for approximately 4 seconds.
- Scroll until 'OFF-LINE MAINT' is displayed, then press SELECT.
- Scroll until 'VER' is displayed, then press SELECT.
- View transmitter version information.
- Scroll to 'EXIT'.
- Press SELECT to exit menu display.

(v) Controller/Indicator

An Enraf Contrec model Trac-40 controller/indicator as described in the documentation of approval NMI S367A, or any other compatible (#) approved controller/indicator.

The mass measured by the flowmeter is converted to volume based on tables given in Annex C of OIML R81, *Dynamic Measuring Devices and Systems for Cryogenic Liquids*, dated 1998, namely Table 1-b for Argon, Table 4-b for Nitrogen and Table 5-b for Oxygen.

(#) 'Compatible' is defined to mean that no additions/changes to hardware/software are required for satisfactory operation of the complete system including all checking facilities.

(vi) Transfer Device

The measuring system incorporates a transfer device, located downstream of the meter, in the form of a valve (which may also be used to control the flow rate) that defines the start and stop of the measurement. Alternatively, the transfer device may be in the form of a dry break coupling which connects to the delivery tank.

The piping and discharge hose after the transfer device shall be of empty-hose type.

The quantity between the transfer device and the connection to the delivery tank, defined by the length of the hose, is reconciled by subtracting from the metered delivery the priming quantity of the delivery hose.

1.3 Verification Provision

Provision is made for the application of a verification mark.

1.4 Sealing Provision

Provision is made for the access to the calibration adjustments to be sealed as described in the approval documentation for the controller/indicator used.

Provision is made for electronically 'pairing' the model 2700 flow transmitter to the model 700 core processor, securing access to the 'pairing' functionality and other factors/settings held in software, and sealing the cover of the transmitter which contains the calibration functions of the instrument.

Calibration and sealing procedures for the flow transmitters are described in the Emerson Process Management document *Configuration and Use Manual*, for the Micro Motion Series 1000 and 2000 Transmitters. After calibration (using the 'service port'), the flow transmitter is mechanically sealed using either the cover lock provided (models 1700/2700) or by sealing the housing into which the model 2500 transmitter is fitted.

1.5 Descriptive Markings and Notices

Each measuring system shall bear the following information, placed together either on the indicating device or on a data plate:

Pattern approval mark	NMI 10/2/11
Manufacturer's identification mark or trade mark	…..
Meter model	…..
Serial number of the instrument	…..
Year of manufacture	…..
Maximum flow rate, Q_{max}	….. kg/min
Minimum flow rate, Q_{min}	….. kg/min
Maximum pressure of the liquid, P_{max}	….. kPa
Type of the liquid for which the system is verified	….. (#)
Accuracy class	Class 2.5
Environmental class	Class I

(#) This may be located separately, e.g. on a metal tag sealed to the instrument.

The minimum measured quantity (M_{min}) is to be clearly visible in the vicinity of the indicating device, e.g. "Minimum Delivery 20 kg", or alternatively or the calculator/indicator is programmed for deliveries equal to or greater than the stated minimum delivery.

2. Description of Variants

2.1 Variant 1

Using certain other Micro Motion CMF series cryogenic mass flowmeters as listed in Table 1 and some of which are shown in Figure 3.

Flowmeter Model (#1)	Size (mm)	Mass Flow Rate $(Q_{min} – Q_{max})$ kg/min	Minimum Delivery (M_{min}) (kg) (#2)	Density Range (kg/m³)	Liquid Temperature Range (°C) (#6)
CMF025	6	0.23 – 36	0.5	350 – 2000	-200 – 200
CMF050	12	1.36 – 110	5	350 – 2000	-200 – 200
CMF100 (#4)	25	5.7 – 450	10	350 – 2000	-200 – 200
CMF200 (#3)(#4)	50	18 – 1450	20	350 – 2000	-200 – 200
CMF 300 (#4)	80	57 – 4500	200	350 – 2000	-200 – 200
CMF 400 (#4)	100	340 – 6800	500	350 – 2000	-200 – 200
CMFHC2 (#4)(#5)	150	500 –12 600	1000	350 – 2000	-200 – 200
CMFHC3 (#4)(#5)	200	1134 –22 000	1000	350 – 2000	-200 – 200
DS600S (#4)	150	570 –10 800	1000	350 – 2000	-200 – 200

(#1) The number listed above is the basic model number only – the full model number may have a variety of additional alphanumeric characters, which designate non-metrological features.

(#2) For minimum deliveries (minimum measured quantities) *(Mmin*) less than 200 kg, the scale interval of the calculator/indicator is 0.1 kg; for deliveries greater than 200 kg the scale graduation is 1 kg.

(#3) The model CMF200 sensor is described for the pattern.

(#4) Pressure compensation is required when the pressure effect on mass flow is more than 1/10 of the Maximum Permissible Error (Class 2.5) due to nominal pressure at flowing conditions differing from calibration pressure and/or a varying pressure from nominal at flowing conditions. Compensation may be static (configured in electronics) or dynamic (external pressure transmitter) based on manufacturer's published pressure effect factor. Pressure compensation is required for the model DS600.

(#5) Requires a model 800 core processor (variant 3). The model CMFHC2 requires 800 ECP Software Version 3.60; the model CMFHC3 requires 800 ECP Software Version 3.42 or higher.

(#6) For fluid temperatures below -100ºC or higher than +100ºC, the meter factor is to be verified at flowing conditions; alternately, the Density Temperature coefficient (DT) factor and the Flow Temperature coefficient (FT) factor can be determined in the factory (ETOITEMDX 14406) which enables the meter to be verified at other than flowing conditions

Note: When used with the model 700 (the pattern) or model 800 (variant 3) core processors, and the model 2700 (the pattern) or models 1700, 2500, 3500 or 3700 (variant 4) flow transmitters or model 510 dual pulse convertor (variant 5) then the pattern and variants are suitable for accuracy pipeline applications.

2.2 Variant 2

For use with liquid natural gas (LNG) and where the field of operation of the measuring system is determined by the following characteristics:

Product	Temperature Range (K)	Pressure Range (MPa abs.)	Density Range (kg/m^3)
Liquid natural gas (LNG)	90 – 170	0.1 – 3.0	350 – 550

The flowmetering system consists of a Micro Motion model CMF 200 mass meter or other meter as approved herein. A flowmetering system with a vapour return line from the delivery tank (Figure 4a) shall have a differential pressure switch or other suitable device will detect a change from vapour flow to liquid flow. Should LNG enter the return line, the system will discontinue delivery of LNG to the delivery tank, and in such cases, the quantity of LNG between the delivery tank and the detection device is to be reconciled by subtracting the quantity in the line from the metered delivery quantity.

For alternative flowmetering systems (e.g. LNG dispenser systems – Figure 4b), the system should have provision for pre-conditioning the system for thermal stabilisation prior to the delivery. Flow is to be circulated through the meter prior to initiating delivery to the transfer device to ensure that the system is at delivery temperature, fluid in the meter and associated piping is in a liquid state, and any residual vapour is removed. When required, provision should also be made to allow pressure equalisation between the metering system and the receiving vessel prior to delivery.

The controller/indicator is to display the delivery of liquid in kilograms.

2.3 Variant 3

With a Micro Motion model 800 core processor in place of a model 700 core processor. The model 800 has the same functionality as the model 700 except that 800 core processors with software Revision 3.6 include Smart Meter Verification functionality for meter verification while the meter is still sealed. (The Software revisions 3.5 and earlier of the 800 core processor require meter verification to occur only when the meter is unsealed). Approved versions of the 800 core processor software are 3.21, 3.30, 3.40, 3.42, 3.50, 3.52, 3.60 and 3.7.

2.4 Variant 4

With Micro Motion models 1700, 2500, 3500 or 3700 flow transmitters (Figures 2 and 5) in place of the model 2700 flow transmitter. The models 1700, 2500, 3500, and 3700 flow transmitters provide the same basic functionality as the 2700 with the following features:

- Model 1700 flow transmitter is identical to the model 2700 (Figure 2b) with some non-metrological features omitted;
- Model 2500 flow transmitter (Figure 2c) 24 V DC (nominal), DIN rail mounted (no display);
- Model 3500 flow transmitter/indicator/controller, rack or panel-mounted; and
- Model 3700 flow transmitter/indicator/controller, field-mounted (Figure 5).

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Approved software versions for this variant are:

- Model 1700 – refer to model 2700 software versions listed above;
- Model 2500 – 4.0, 4.1, 4.2, 5.00/1.0, 5.12/1.0, 5.20/1.0, 6.0/1.1 and 6.1/1.2; and
- Models 3500/3700 – 7.0/1.1, 7.1/1.1, 7.2/1.1 and 8.0/1.2.

The models 1700, 2500, 3500 and 3700 flow transmitters are identified by a series of alphanumeric codes which represent various configuration options, with option code 'W' or 'D' required for custody transfer applications.

The models 2700, 3500 and 3700 flow transmitters are NMI-approved calculator/indicators when used with the Micro Motion MVD flowmetering system.

Refer to the manufacturer's instructions for sealing requirement for the model 2500, 3500, and 3700 flow transmitters.

2.5 Variant 5

With a Micro Motion model 510 dual pulse convertor for use with the model 2500 or model 2700 flow transmitter, to convert the two 90º-shifted output pulses of the flow transmitters to two 180º-shifted output pulses with the same frequency. The pulse width is adjustable. The pulse convertor is used to provide pulse outputs that mimic the pulse shape of a magnetic pulser on a mechanical flowmeter.

2.6 Variant 6

With a MODbus output either:

(a) directly from the core processor (via an MVD Direct Connect power supply/intrinsic-safely barrier) to a compatible approved controller/ calculator/indicator ('flow computer'). The controller/calculator/indicator must provide functionality for electronically 'pairing' it to the core processor and securing access to the core processor as provided by the 2700 flow transmitter (Clause 2.4 Variant 4); or

(b) from a model 1700, 2700, 3500, or 3700 flow transmitter. When in secure mode, the MODbus connection is read only except that process totalisers may be reset at no flow.

TEST PROCEDURE

Instruments should be tested in accordance any relevant tests specified in the Uniform Test Procedures. Tests should be conducted in conjunction with any tests specified in the approval documentation for any controller/indicator and/or any conversion device, etc. used.

Maximum Permissible Errors

The maximum permissible errors are specified in Schedule 12 of the *National Measurement Regulations 1999*.

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Calibration Procedure

To ensure that the complete mass metering system is measuring correctly, the accuracy of the flowmeter and the accuracy of the conversion device shall be checked separately.

The calibration of the meter may be carried out volumetrically or gravimetrically by testing the flowmeter at least at the minimum, maximum and at the intermediate flow rate specified for the flowmetering system.

At least three deliveries at each flow rate are required to determine the repeatability of the flowmeter.

A delivery of at least 5 times the specified minimum delivery is recommended when determining the calibration of the meter. The minimum delivery for a flowmetering system shall not be less then 100 scale intervals.

At least one test comprising minimum delivery shall be performed.

Gravimetric method:

The measured mass (in kg) can then be compared against the mass indicated by a certified weighing instrument used to weight the cryogenic liquid delivered into a cylinder. All results shall be within 1.5%, and for tests carried out at the same conditions the results shall be within 1%. Also calculate the relative average error for the accuracy test.

Volumetric method: (not applicable for LNG systems)

Alternatively, the mass flowmeter may be verified volumetrically by manually converting the indicated mass (in kg) to volume (in litres) – this is achieved by dividing the mass by the density (in kg/m^3) obtained from OIML R81 Tables (Annex C) for the cryogenic liquid, and then multiplying the result by 1000 to convert the volume from cubic meters to litres.

Note: The density in the OIML R81 Tables is given as a function of the measured temperature (in Kelvin) and absolute pressure (in MPa). To obtain the correct density of the cryogenic liquid at the flowmeter, temperature and pressure at the flowmeter need to be measured.

The following equations may be used to convert mass (in kilograms) to volume of gas (in cubic metres):

For Liquid Nitrogen,

Volume = mass x 0.8440529 m^3 at 15ºC and 101.325 kPa

For Liquid Oxygen,

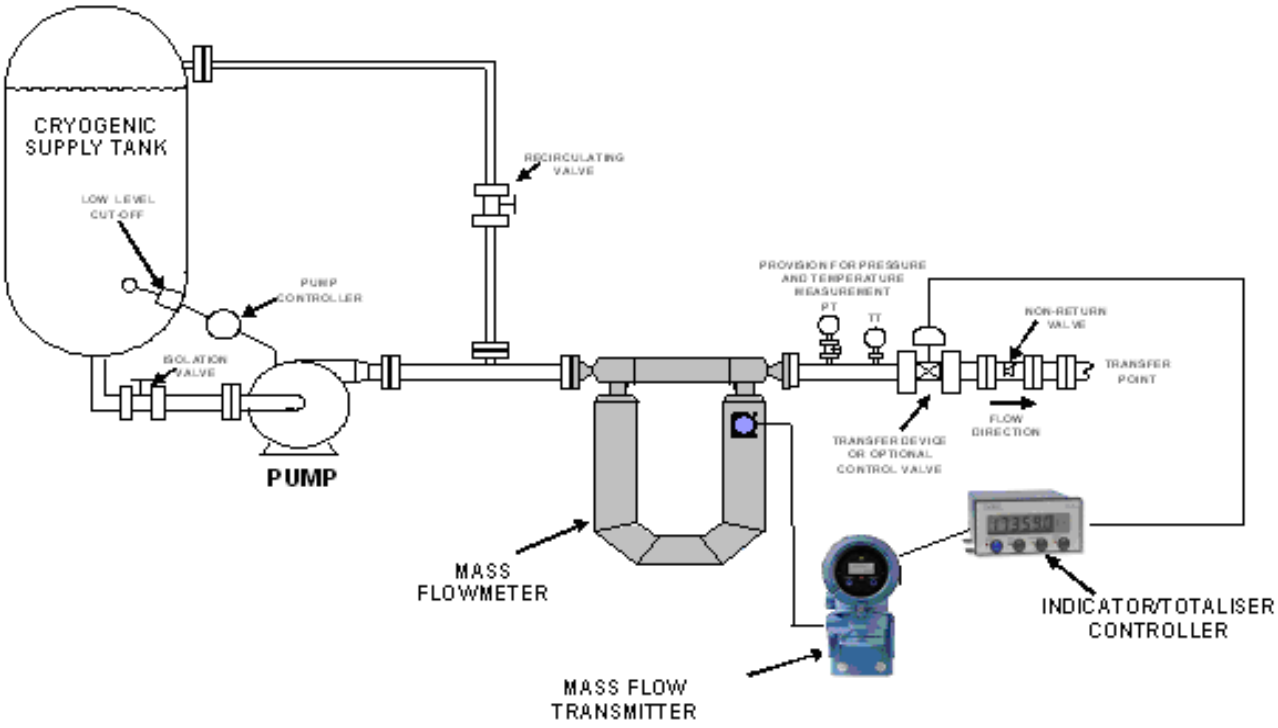
Volume = mass x 0.7389296 m^3 at 15ºC and 101.325 kPa

For Liquid Argon,

Volume = mass x 0.59189096 m^3 at 15ºC and 101.325 kPa

The volume thus calculated may then by rounded to the appropriate number of decimal places.

FIGURE 10/2/11 – 1



(a) Micro Motion Model CMF 200 Mass Cryogenic Flowmetering System

(b) Micro Motion Model CMF200 Flow Sensor

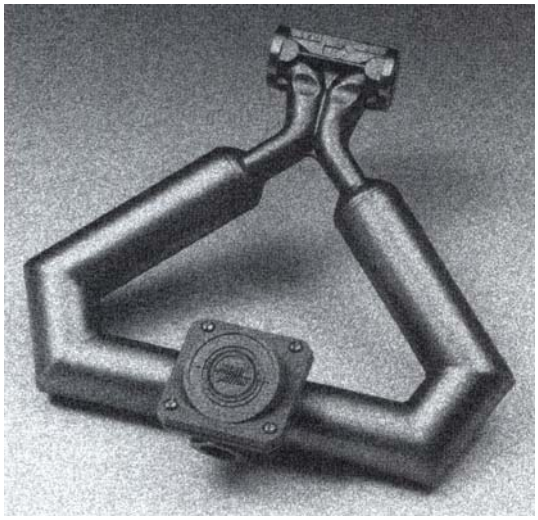
FIGURE 10/2/11 – 2

(a) Model 700 Core Processor

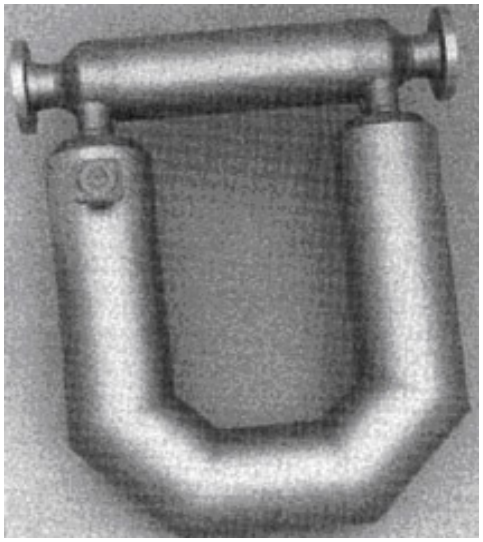
(b) Models 1700/2700 Flow Transmitters

(c) Model 2500 Flow Transmitter

FIGURE 10/2/11 – 3



(a) Model CMF050 Flow Sensor

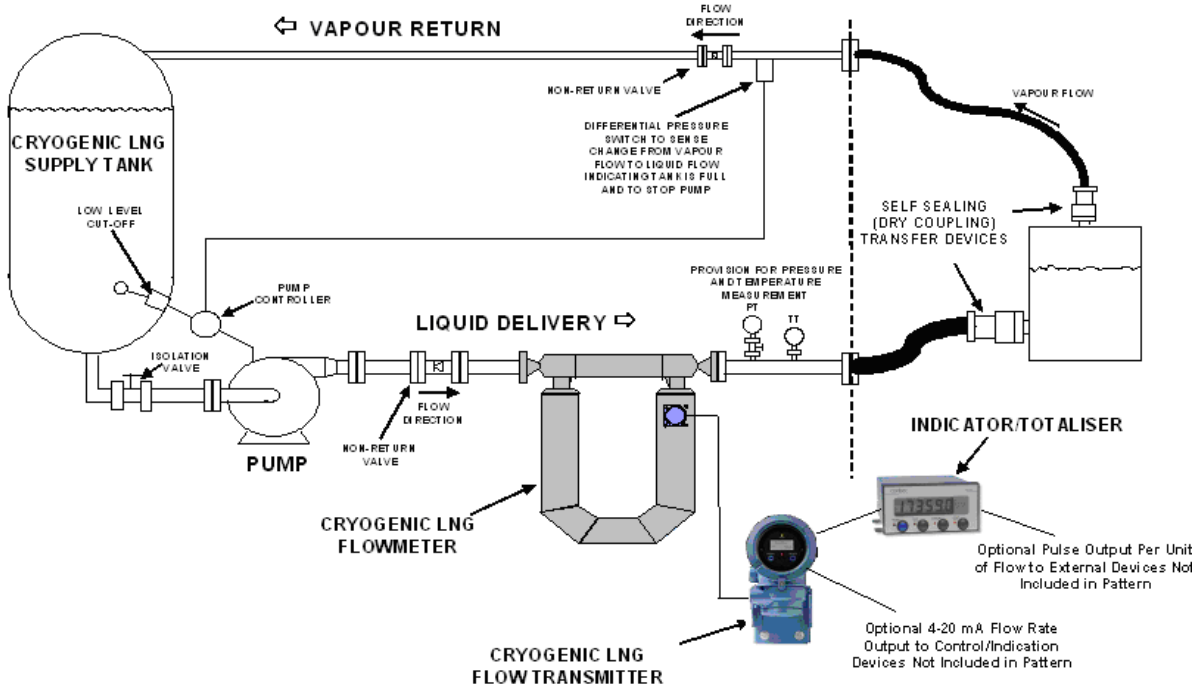


(b) Model CMF 300 Flow Sensor

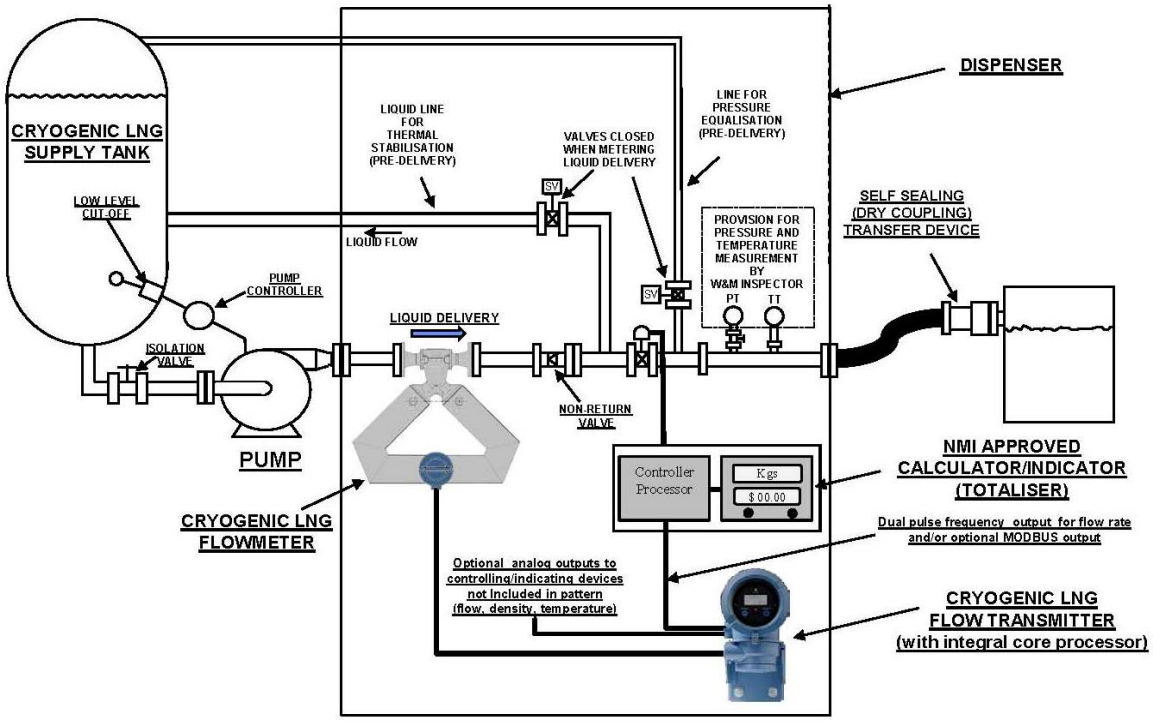
(c) Model CMF 400 Flow Sensor

(d) Model CMFHC3 Flow Sensor

FIGURE 10/2/11 – 4



(a) LNG System (With Vapour Return Line)



(b) LNG Dispenser System

Alternative Micro Motion Mass Cryogenic (LNG) Flowmetering Systems

FIGURE 10/2/11 – 5

Micro Motion Flow Transmitters – Top to bottom: model 3500 rack mount, model 3700 field mount, and model 3500 panel mount