Australian Government
National Measurement Institute
Bradfield Road, West Lindfield NSW 2070

Certificate of Approval

NMI 10/2/15

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 instruments herein described.

Flow Instruments Model Flowcom 3000 Bulk Cryogenic Flowmetering System

submitted by Flow Instruments
Heiligenstock 34 c-f
Solingen, Nordrhein-Westfalen 42697
GERMANY

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 NMI R NMI R81, *Dynamic Measuring Devices and Systems for Cryogenic Liquids*, dated August 2009, and with reference to document 117-1, *Measuring for Liquids Other Than Water*, dated June 2011.

This approval becomes subject to review on 1/07/18, and then every 5 years thereafter.

DOCUMENT HISTORY

Rev	**Reason/Details**	**Date**
0	Pattern & variant 1 provisionally approved – interim certificate issued	18/06/13
1	Pattern & variant 1 approved – interim certificate issued	7/02/14
2	Pattern & variant 1 approved – certificate issued	29/04/14

CONDITIONS OF APPROVAL

General

Instruments purporting to comply with this approval shall be marked with pattern approval number ‘NMI 10/2/15’ and only by persons authorised by the submittor.

Instruments purporting to comply with this approval and currently marked ‘NMI P10/2/15’ may be re-marked ‘NMI 10/2/15’ but 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.

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

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

Dr A Rawlinson

TECHNICAL SCHEDULE No 10/2/15

1. Description of Pattern **provisionally approved on 18/06/13**

approved 7/02/14

A Flow Instruments model Flowcom 3000 vehicle-mounted bulk flowmetering system (Figure 1 and Tables 1 & 3) 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:

TABLE 1 – For Cryogenic products

Product (#1)	Temperature Range (K)	Pressure Range (MPa rel.)	Density Range (kg/m³)
Liquid argon (LAR)	84 to 134	0.1 to 3.0	1407.8 to 1241.2
Liquid nitrogen (LIN)	77 to 116	0.1 to 3.0	819.3 to 701.6
Liquid oxygen (LOX)	81 to136	0.1 to 3.0	1142.0 to 1012.1
Liquified natural gas (LNG)	103 to 173	0.1 to 27.0	301 to 478

- Minimum measured quantity, V*min* 500 kg (#2)
- Maximum flow rate, Q*max* 683 kg/min (#3)
- Ambient temperature range –25°C to 55°C
- Accuracy class Class 2.5

(#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 volume at least in 1 L, 1 kg or 1 m³ increments.

(#3) Flow rates depend on the meter model and size, and the type of product.

1.2 Components of the Measuring System (Figure 1)

(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.

(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) Power Supply

The instrument operates with a 9 to 36 V DC power supply. The built-in time clock and memory use a lithium battery to maintain time, date and calculated totals.

(iv) Measurement Transducer

The measurement transducer is a Metering Section model CFI40-00-40SS flowmeter (Figure 2). A differential pressure is created in the metering section as a result of mass flow, and a differential pressure measurement converter changes the differential pressure into a 4-20 mA signal, which is changed into a digital signal by the calculator/indicator.

(v) Differential Pressure Transducer

A Rosemount model 3051 Smart (Figure 3) differential pressure transducer is used to measure the differential pressure at the restriction in the metering section of the flowmeter. The differential pressure data is sent to the Flowcom 3000 calculator/indicator as a 4 to 20 mA signal. The level of maximum pressure differential depends on factors including the maximum flow rate, flowmeter diameter and pump pressure.

(vi) Temperature Transducer

The temperature transducer is a PT100-Thermometer (100 ohms @ 0°C, –200°C to +600°C) connected as 4-wire. Alternatively, a temperature transducer with a 4 to 20 mA output may be used. The temperature transducer is fitted upstream of the flowmeter.

(vii) Calculator/Indicator

A Flow Instruments model Flowcom 3000 (FC3000) calculator/indicator is used (Figures 4 and 5).

(a) The field of operation of the calculator/indicator is determined by the following characteristics:

- Input voltage ranges:
  - for the calculator/indicator — 9 V DC to 36 V DC
  - for the printer — 24 V DC (*)
- Liquid temperature range — –273ºC to 146ºC
- Pressure range — 200 kPa to 5100 kPa
- Environment temperature range — –25ºC to 55ºC
- Accuracy class — Class 1.5 or 2.5, depending on the product

(*) Generated from a 9-36 V DC power supply by a dedicated DC/DC converter located inside the printer enclosure.)

The model Flowcom 3000 calculator/indicator has a colour graphic liquid crystal display with LED backlight. The instrument has four function buttons (which may be labelled Delivery, Service, Loading, Language, etc.), alphanumeric function buttons and an ON/OFF button.

(b) Software

The program versions are displayed for several seconds after the device is switched on (see below). By briefly pressing the right function button, the display duration can be extended as required in which the start procedure is interrupted.

Anzeige Softwareversion und Prüfsummen

Checksum in HEX

Software version for CPU#A

Software version for CPU#B

Function key to interrupt the 'boot' process

Green 'tick' shows no checksum error – X shows an error

Authorised software versions:

	Version	Checksum
CPU#A	1.00.3	0x5142
	1.00.4	0x2bdd
	1.01.0	- - -
CPU#B	1.00.2	0x25c8
	1.01.0	0x139d
	1.01.8	- - -

Integrated equipment and functions not covered by this approval

- Issue of all measurement and computer values on a delivery note printer.
- Control and display functions, which cannot be realised in the microcontroller (CPU#C) not relevant to metering.
- Software update or download of software for CPU#C

The liquid volume measured by the flowmeter is converted to mass 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. The mass is then converted to volume of gas in cubic metres at 15ºC and 101.325 kPa, based on constants given in the Test Procedure.

For the purpose of meter verification the calculator/indicator has provision for displaying the delivery of liquid in litres.

(viii) Printer

For applications where the delivery is carried out without the presence of the customer, an Epson model TM-295 printer (Figure 6) or equivalent (*) is interfaced to the calculator/indicator. If a ticket needs to be reprinted, the words 'Duplicate ticket' will be printed at the top.

(*) 'Equivalent' is defined to mean other proprietary equipment of the same or better specifications requiring no changes to software for satisfactory operation of the complete system.

(ix) 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.

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 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 10/2/15	
Manufacturer's identification mark or trade mark	…..	
Meter model	…..	
Serial number of the instrument	…..	
Year of manufacture	….	
Maximum flow rate, *Qmax*	….. kg/min	
Minimum flow rate, *Qmin*	….. kg/min	
Maximum pressure of the liquid, *Pmax*	….. kPa	
Minimum measured quantity (*Mmin* or MMQ)	….. kg	(#1)
Calibration factor alpha high	…..	
Calibration factor alpha low	…..	
Type of the liquid for which the system is verified	…..	(#2)
Accuracy class	Class …..	(#3)
Environmental class	Class I	

(#1) Optional marking

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

(#3) The pattern accuracy class 2.5 while variant 2 (CO_2/N_2O) is class 1.5

The minimum measured quantity is clearly visible on the indicating device, e.g. 'Minimum Delivery 500 kg'.

A notice in the vicinity of the meter and pipework states the sequence procedure of operation/delivery.

1.4 Verification Provision

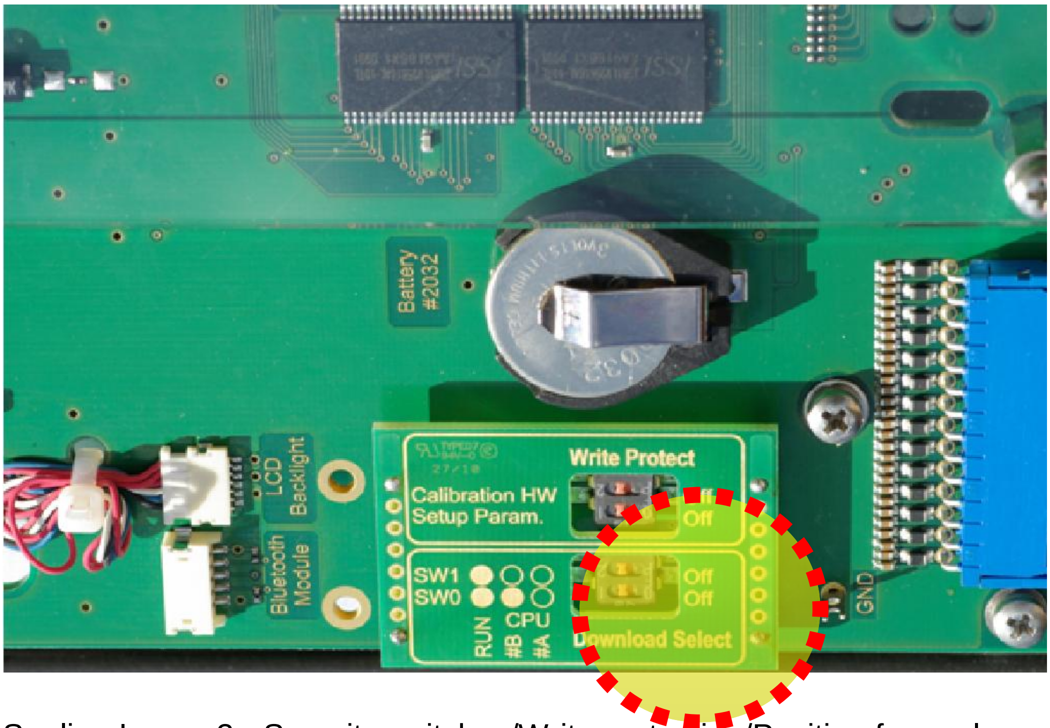
Provision is made for the application of a verification mark.

1.5 Sealing Provision

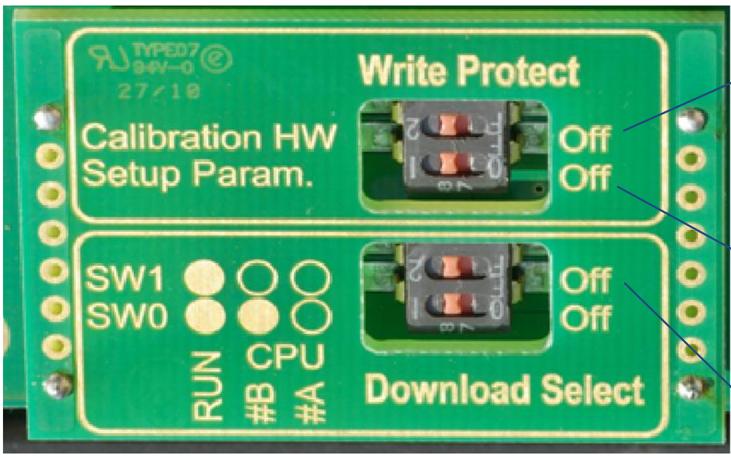
Access to the calibration parameters is via switches in the calculator/indicator, which have provision for sealing (see below and Figure 5).

Calibration protected parameters (parameters which influence the measurement accuracy), the calibration data of the hardware and the calibration relevant software, or software requiring approval (CPU#A and CPU#B), must be protected against unintentional or intentional changes with the help of two safety switches (write protection). These switches are switched on after calibration and are secured using calibration marks. The switches are found on the display board. A labelling template offers sufficient space for self-adhesive security marks.

Sealing Image 1 – Security switches/Write protection/Position for seal



Sealing Image 2 – Security switches/Write protection/Position for seal



Write protection for:

- Hardware calibration data (sensor inputs)
- Software requiring approval (CPU#A and CPU#B) via program interfaces

Write protection for settings:

- Configuration of meter system
- Calibration of meter system

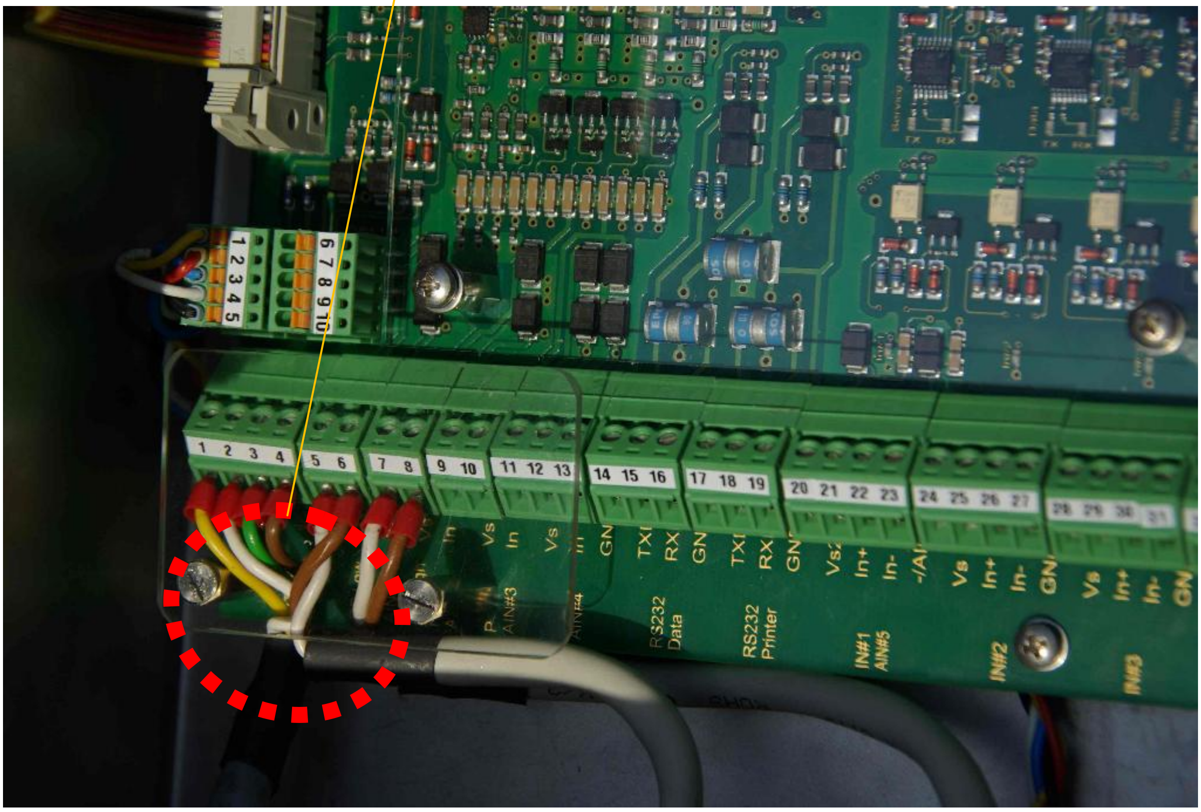
Write protection for:

- Software requiring approval (CPU#A and CPU#B) via service interface

Note: write protection is activated when all four switches are in the left position - see above.

Sealing Image 3 – Protection of the connection cables

Protection of the connection cables of sensors against unauthorised manipulations



The measurement transducer, differential pressure transducer, and temperature transducer are typically sealed as shown in Figures 7 to 9.

1.6 Audit Trail

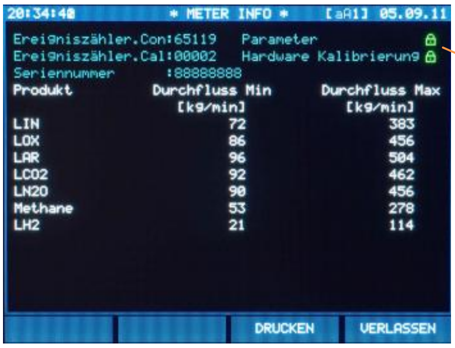
An audit trail offers a variety of information on the meter system, including:

- Meter ranges for the different products based on the current configuration
- The serial numbers of the flow computer Flowcom3000 (not the meter system)
- Incident counter for setting with respect to configuration of the meter system
- Incident counter for setting with respect to calibration of the meter system
- Status of the security switches (write protection) for settings/parameters and hardware calibration

Access the functions as follows - SERVICE ⇒ Settings ⇒ Audit Trail

Audit Trail Image 1 – Security switch protection status

Secured



Flow Meter Info (security switches ON)

Closed locks signalise at a glance that the security switches (write protection) are switched ON

2. Description of Variant 1 **provisionally approved on 18/06/13 approved 7/02/14**

For use with certain other Metering Section model flowmeters as listed below (Figure and Table 3):

- SWM48,3x2-22,7-2626-10-EGN,
- SWM48,3x2,9-15-1246-10-EGN,
- SWM48,3x2,9-17,5-1696-10-EGN; or
- SWM48,3x2,9-26-3743-10-EGN; or
- SWM60,3x2,9-27-2454-10-EGN (Figure 10).

3. Description of Variant 2 **provisionally approved on 18/06/13 approved 7/02/14**

A Flow Instruments model Flowcom 3000 vehicle-mounted bulk flowmetering system for bulk metering of liquefied carbon dioxide and liquid nitrous oxide (Figures 1 & 11 and Tables 2 & 3).

Figure 11 shows a CO2/N2O system with an optional vapour recovery system.

Flowmetering systems delivering carbon dioxide (CO_2) may be fitted with an Endress & Hauser model PMC131 pressure transmitter to calculate the amount of vapour return gas. The maximum operating pressure is 2.5 MPa. The pressure transducer is connected to a 3/2-way valve to monitor the pressure of the supply tank and the customer's receiving tank.

3.1 Field of Operation

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

TABLE 2 – For Non-cryogenic Products

Product (#1)	Temperature Range (K)	Pressure Range (MPa rel.)	Density Range (kg/m³)
Carbon Dioxide (CO_2)	218 to 268	0.1 to 25.0	957.5 to 1174
Nitrous Oxide (N_2O)	213 to 268	0.1 to 25.0	957.5 to 1172.7

- Minimum measured quantity, V*min* 500 kg (#2)
- Maximum flow rate, Q*max* 600 kg/min (#3)
- Ambient temperature range –25°C to 55°C
- Accuracy class Class 1.5

(#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 volume at least in 1 L or kg increments.

(#3) Flow rates depend on the meter model and size

NOTE:

The maximum flow rates specified in Table 3 (Nominal Operating Conditions) represent normal expected operating conditions, depending at the expected pump performance.

The flow rate can be vary. The maximum flow rate Qmax may be lower or higher depending by the pump performance, the calibration factor and the actual density of the measured liquid. The minimum flow rate is always referenced to the actual figure of Qmax and is always 20% of it.

TABLE 3 (Part A) – Flow Rates

Model: CFI40-00-40SS, S: 13 (m: 0,4265) – The Pattern

Medium	Bore Size (inner diameter)	Flowrate Min kg/min	Flowrate Max kg/min	@ Density kg/m³
LIN	38,1	83	417	781
LOX	38,1	100	500	1100
LAR	38,1	110	550	1323
LNG	38,1	61	308	420
CO2	38,1	98	492	1067
N2O	38,1	94	473	1013

Model: SWM48,3x2-22,7-2626-10-EGN

Medium	Bore Size (inner diameter)	Flowrate Min kg/min	Flowrate Max kg/min	@ Density kg/m³
LIN	44,3	81	408	781
LOX	44,3	96	483	1100
LAR	44,3	106	533	1323
LNG	44,3	59	298	420
CO2	44,3	95	477	1067
N2O	44,3	92	463	1013

Model: SWM48,3x2,9-15-1246-10-EGN

Medium	Bore Size (inner diameter)	Flowrate Min kg/min	Flowrate Max kg/min	@ Density kg/m³
LIN	42,5	33	166	781
LOX	42,5	39,6	198	1100
LAR	42,5	43	217	1323
LNG	42,5	25	123	420
CO2	42,5	39	197	1067
N2O	42,5	38	192	1013

NOTE:

The maximum flow rates specified in Table 3 (Nominal Operating Conditions) represent normal expected operating conditions, depending at the expected pump performance.

The flow rate can be vary. The maximum flow rate Qmax may be lower or higher depending by the pump performance, the calibration factor and the actual density of the measured liquid. The minimum flow rate is always referenced to the actual figure of Qmax and is always 20% of it.

TABLE 3 (Part B) – Flow Rates

Model: SWM48,3x2,9-17,5-1696-10-EGN

Medium	Bore Size (inner diameter)	Flowrate Min kg/min	Flowrate Max kg/min	@ Density kg/m³
LIN	42,5	49	245	781
LOX	42,5	58,4	292	1100
LAR	42,5	64	320	1323
LNG	42,5	36	180	420
CO2	42,5	57	287	1067
N2O	42,5	56	280	1013

Model: SWM48,3x2,9-26-3743-10-EGN

Medium	Bore Size (inner diameter)	Flowrate Min kg/min	Flowrate Max kg/min	@ Density kg/m³
LIN	42,5	107	533	781
LOX	42,5	127	633	1100
LAR	42,5	139	695	1323
LNG	42,5	78,4	392	420
CO2	42,5	125	625	1067
N2O	42,5	122	608	1013

Model: SWM60,3x2,9-27-2454-10-EGN

Medium	Bore Size (inner diameter)	Flowrate Min kg/min	Flowrate Max kg/min	@ Density kg/m³
LIN	54,5	107	533	781
LOX	54,5	127	633	1100
LAR	54,5	139	695	1323
LNG	54,5	77	384	420
CO2	54,5	120	600	1067
N2O	54,5	117	588	1013

TEST PROCEDURE No 10/2/15

Instruments shall be tested in accordance with any relevant tests specified in the National Instrument Test Procedures.

The instrument shall not be adjusted to anything other than as close as practical to zero error, even when these values are within the maximum permissible errors.

Maximum Permissible Errors

The maximum permissible errors are specified in Schedule 1 of the *National Trade Measurement Regulations 2009*.

Tests

Check the calculator/indicator is marked with the software version numbers when the instrument is powered up.

Calibration Procedure

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

The accuracy of the flowmeter is checked by setting the flowmetering system to indicate volume in litres or the mass in kg.

The accuracy of the conversion device is checked by comparing the average error for the flowmetering system indicating volume of gas against the average error for the flowmetering system indicating the volume in litres and manually converted to volume of gas. The difference shall not exceed 0.5%.

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 than 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 Argon,

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

For Liquid Nitrogen,

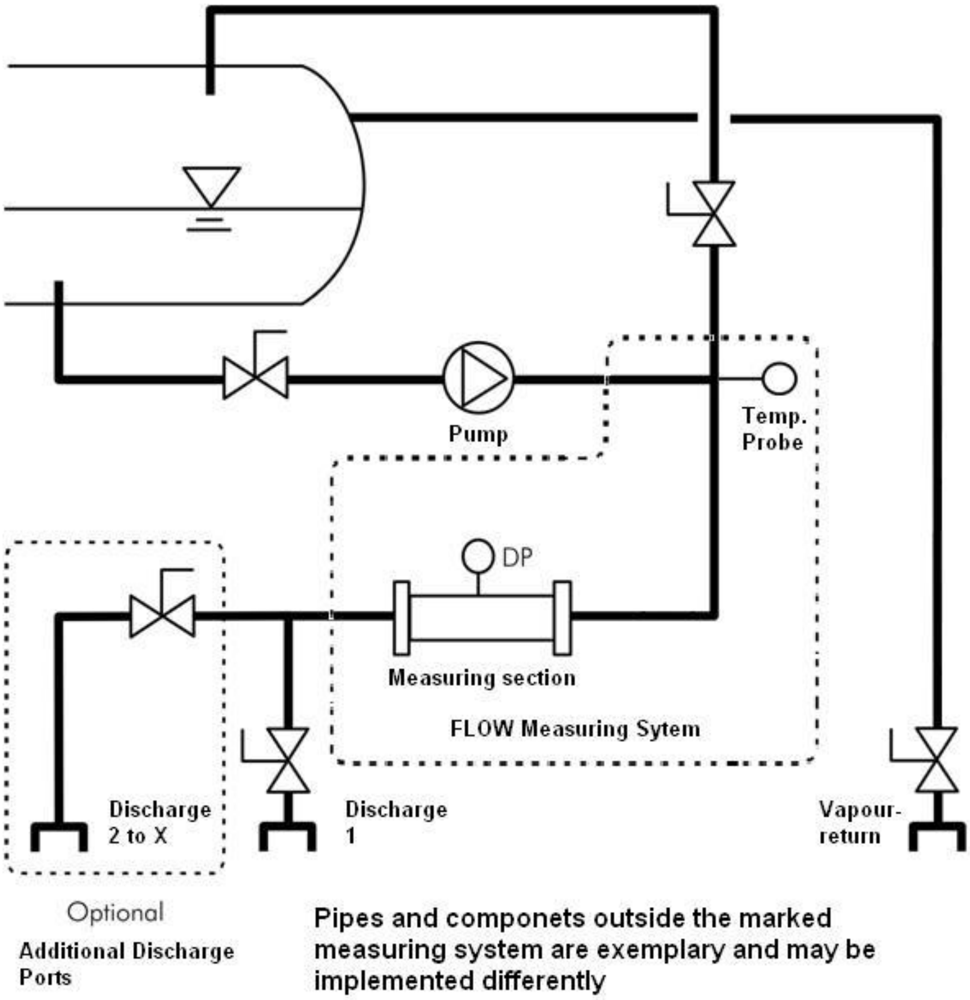
Volume = mass × 0.8440529 m^3 at 15ºC and 101.325 kPa

For Liquid Oxygen,

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

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

FIGURE 10/2/15 – 1



Flow Instruments Model Flowcom 3000 Bulk Flowmetering System
(All Products – Pattern and Variants)

FIGURE 10/2/15 – 2

Metering Section Model CFI40-00-40SS Flowmeter

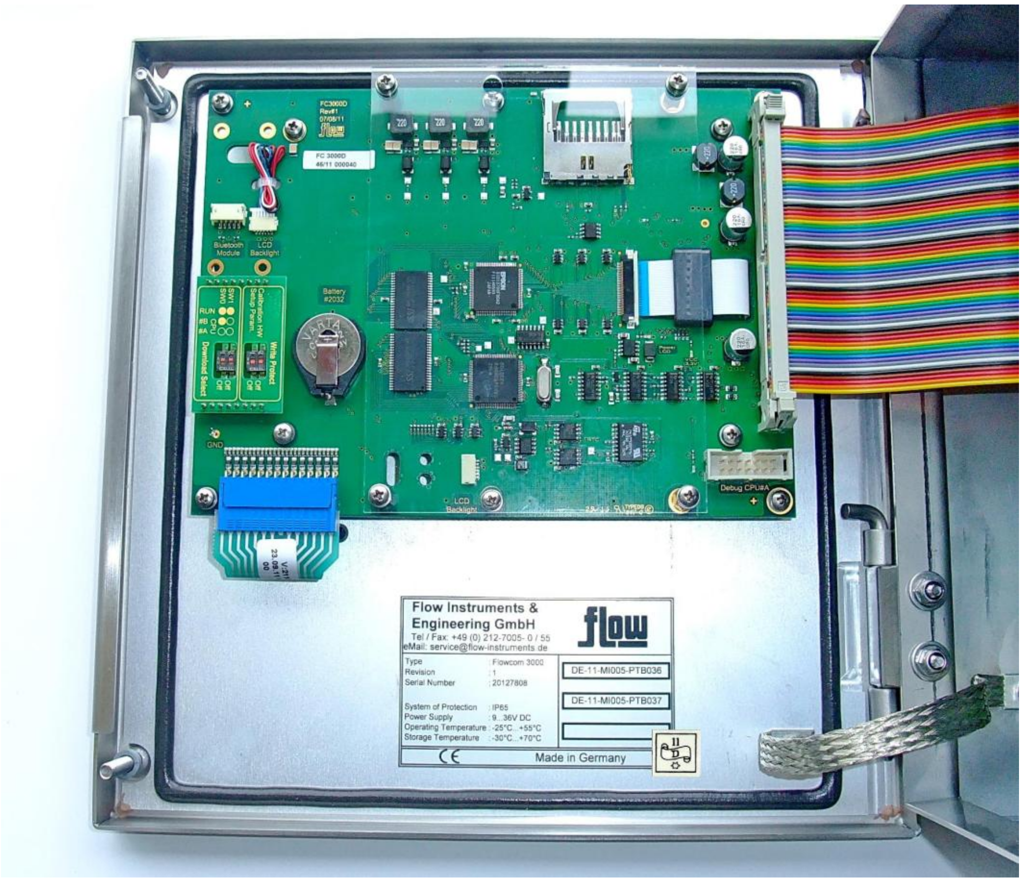
FIGURE 10/2/15 – 3

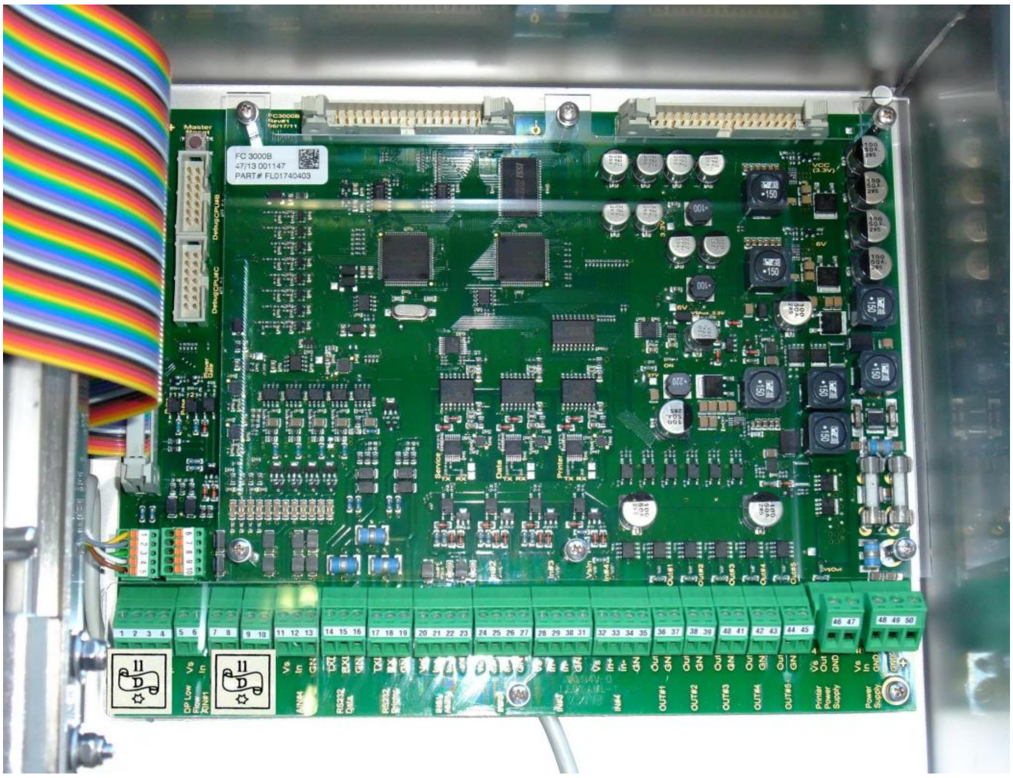
Rosemount Model 3051 Smart Differential Pressure Transducer

FIGURE 10/2/15 – 4

Flow Instruments Model Flowcom 3000 (FC3000) Calculator/Indicator

FIGURE 10/2/15 – 5



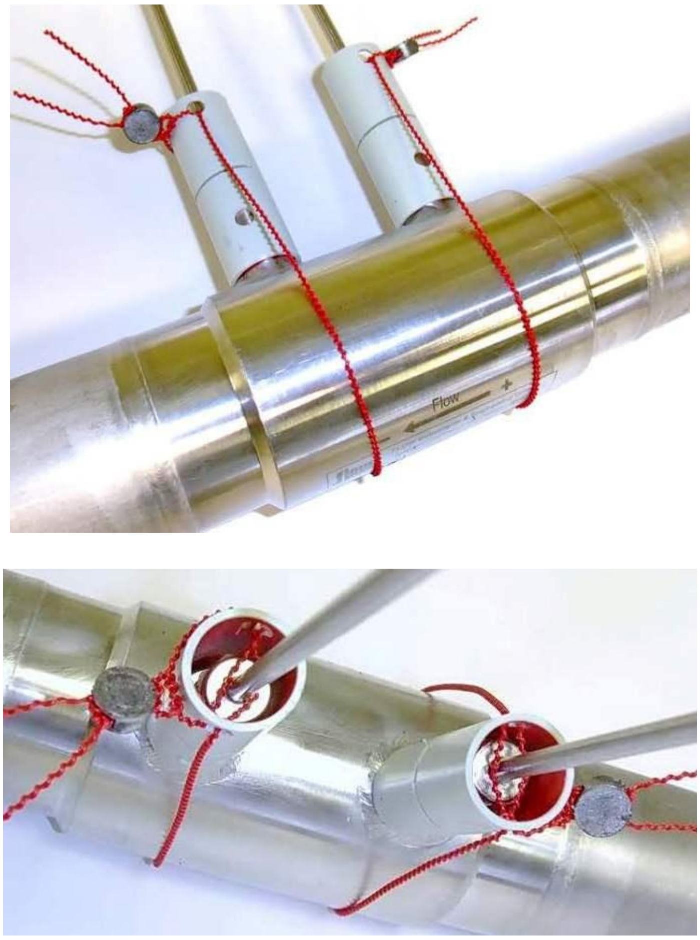


Internal Views of Model Flowcom 3000 (FC3000) Calculator/Indicator

FIGURE 10/2/15 – 6

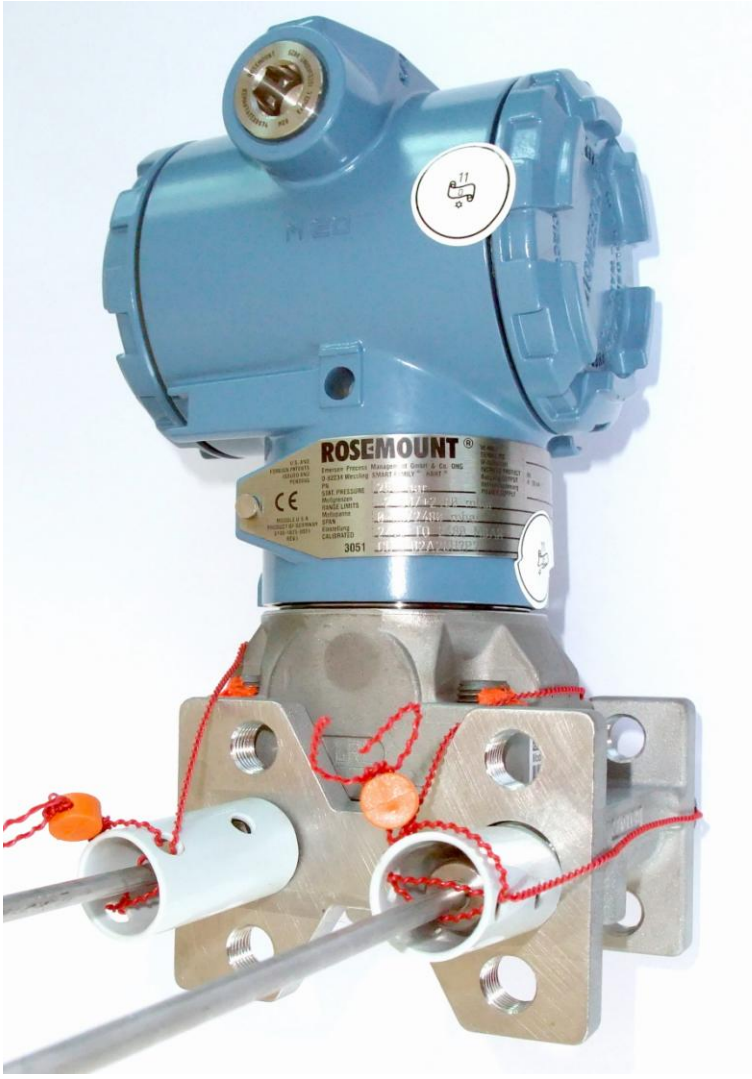
Epson Model TM-295 Printer

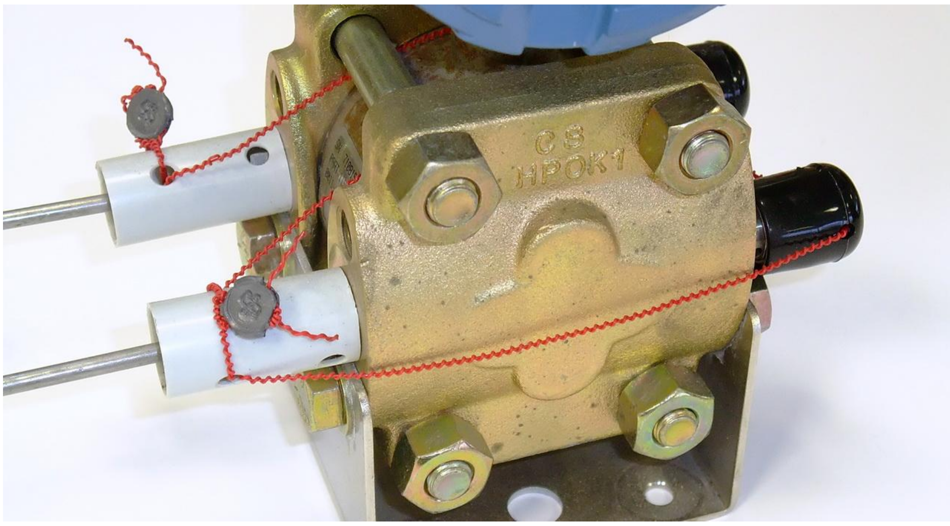
FIGURE 10/2/15 – 7



Typical Sealing of Metering Section Measurement Transducer

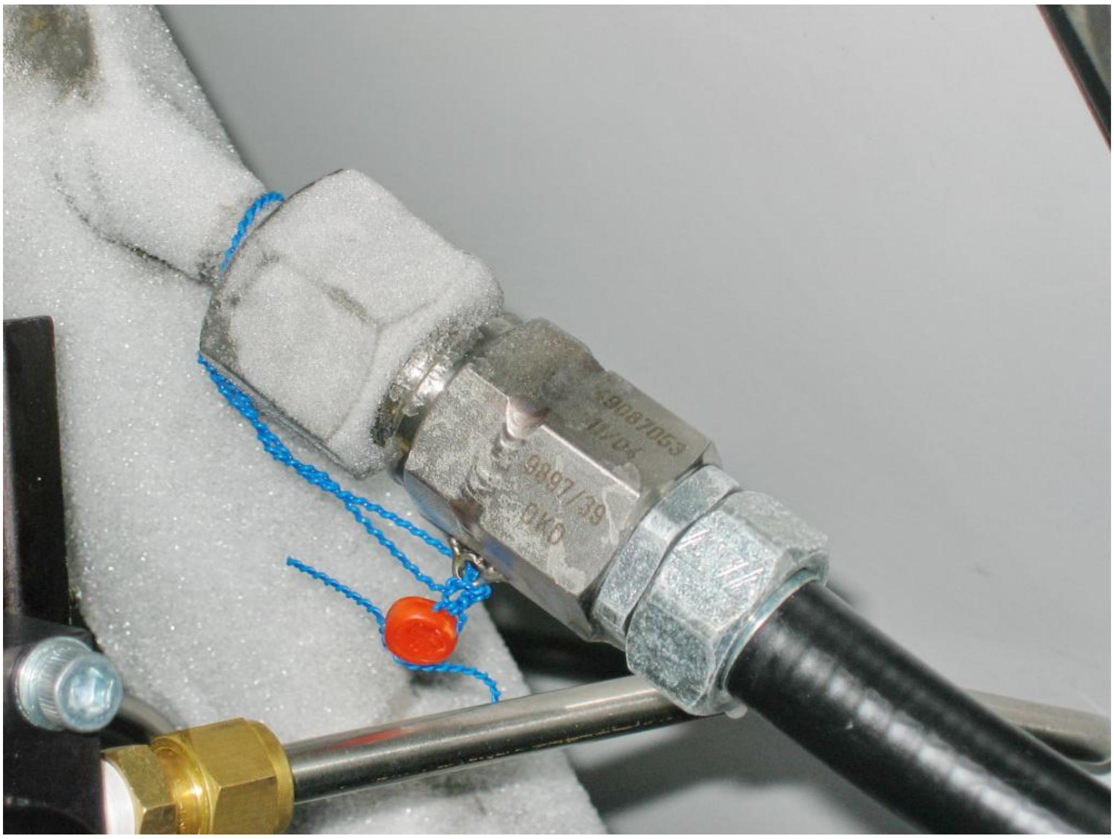
FIGURE 10/2/15 – 8





Typical Sealing of Differential Pressure Transducer

FIGURE 10/2/15 – 9

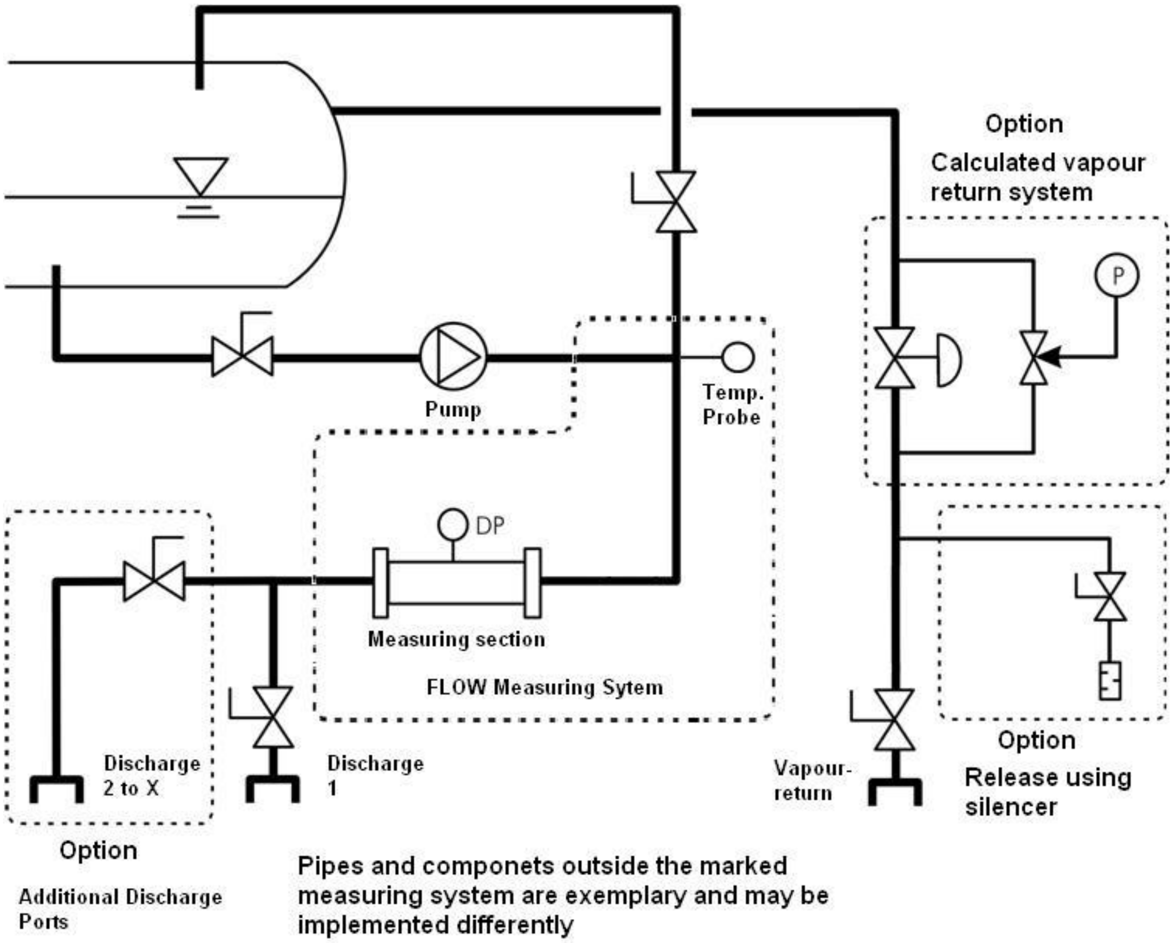


Typical Sealing of Temperature Transducer

FIGURE 10/2/15 – 10

Metering Section Model SWM60,3-27-2454-10-ENG Flowmeter

FIGURE 10/2/15 – 11



Measuring System for CO_2/N_2O With Vapour Recovery System (Variant 2)

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