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

Certificate of Approval

NMI 10/2/10

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.

Hoffer Model HO Bulk Cryogenic Flowmetering System

submitted by Hoffer Flow Controls Inc.
107 Kitty Hawk Lane
Elizabeth City
North Carolina 27906
USA

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 R81, *Dynamic Measuring Devices and Systems for Cryogenic Liquids*, dated August 2009.

This approval becomes subject to review on **1/04/18**, and then every 5 years thereafter.

DOCUMENT HISTORY

Rev	Reason/Details	Date
0	Pattern & variant 1 approved – interim certificate issued	6/03/07
1	Pattern & variant 1 approved – certificate issued	13/06/07
2	Pattern amended (pressure gauge) – notification of change issued	24/07/07
3	Variant 2 approved – interim certificate issued	23/06/08
4	Variant 2 approved – certificate issued	7/10/08
5	Pattern & variants 1 & 2 updated & reviewed – certificate issued	8/08/13

CONDITIONS OF APPROVAL

General

Instruments purporting to comply with this approval shall be marked with approval number ‘NMI 10/2/10’ 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.

Auxiliary devices used with this instrument shall comply with the requirements of General Supplementary Certificates No S1/0/A or 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 10/2/10

1. Description of Pattern approved on 6/03/07

A vehicle-mounted bulk flowmetering system incorporating a Hoffer model HO (*) turbine flowmeter (Figure 1 and Table 1) for bulk metering of cryogenic products.

(*) The full model number of the meter is in the form 'HO-1½x1½-8-130-CB-1M-MS-CE'.

1.1 Field of Operation

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

TABLE 1

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, V_{min} 100 kg (#2)
- Maximum flow rate, Q_{max} 500 kg/min
- Minimum flow rate, Q_{min} 100 kg/min
- 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 increments.

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) Measurement Transducer

The measurement transducer is a Hoffer model HO (*) turbine flowmeter (Figure 2) incorporating single signal pick-off with pre-amplifier. The signal is connected to the calculator/indicator, which has provision for monitoring the integrity of the meter pulse output.

The inlet of the meter is connected to a flow straightener pipe with a bore equal to that of the meter and is at least 10 pipe diameters long.

The outlet of the meter is connected to a straight pipe with a bore equal to that of the meter and is at least 5 pipe diameters long. A flow control valve may be fitted downstream of the straight pipe to regulate the flow and used to prevent flashing/cavitation by maintaining the downstream pressure greater than 70 kPa + (1.25 × vapour pressure of the product).

A check valve is fitted downstream of the flow control valve to prevent reverse flow.

(*) The full model number of the meter is in the form 'HO-1½x1½-8-130-CB-1M-MS-CE'.

(iv) Temperature Transducer

The temperature transducer is a Hoffer model PT 101S-1000-2-MSH-CE (1000 ohms, –220°C to +40°C) with a maximum operating pressure of 6.89 MPa. The temperature transducer is fitted downstream of the meter.

(v) Pressure Transducer

Flowmetering systems delivering cryogenic liquid under pressure are fitted with a Hoffer model PT 570-08-A-A-4-X-X pressure transmitter (incorporating an isolation valve) or a pressure gauge, installed downstream of the meter.

(vi) Calculator/Indicator

'advanced cryogenic electronics' model ACE-B-1TP-3-12-X-S-CE calculator/indicator (Figure 3) has a two line 32 character alphanumeric liquid crystal display with LED backlight. The instrument has five buttons labelled Mode, Select, Control, Clear and Print to access/perform functions.

The calculator/indicator operates using Hoffer version (code) AB0618EXX1 software, which is marked on the instrument.

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.

(vii) Printer

For applications where the delivery is carried out without the presence of the customer, an approved printer such as Hoffer model ACE-P5-12-X-3-R-CE 12 VDC printer or equivalent (*) is interfaced to the calculator/indicator.

If a second docket needs to be re-printed the words 'Duplicate ticket' will be printed at the bottom of the ticket.

(*) '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.

(viii) Power Supply

The instrument operates with either a 12 or 24 volt DC battery. The built in time clock, and memory uses a lithium battery to maintain time, date and calculated totals.

(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.

(x) Checking Facilities

The calculator/indicator has the following checking facilities:

- To check the display segments press the Mode switch and when in maintenance menu press the Select switch until display test menu appears, then press Print switch to execute the test.
- Temperature probe checking with faults detected and displayed as either 'Probe open' or 'Probe short' message.
- Turbine meter pick-off coil checking with faults displayed as either 'Coil open' or 'Coil short' message.
- Liquid phase checking with faults displayed as '2 phase warning' message when delivery approaches within 35 kPa of the saturated condition.
- When the liquid is approaching a point where it may contain bubbles (vapour) a warning message 'Two phase warning' will be displayed.

(xi) Set-up Functions

The calculator/indicator set-up functions are accessible by pressing the 'mode'-'select'-'control' switches at the front of the indicator allowing access to the following functions:

- Average k-factor
- Blades: (set to 6 blades)
- Fluid type: LIN, LAR, and LOX
- System of measure (OIML = 15ºC and 101.325 kPa)
- Unit of measure
- k-factor method
- Temperature method
- Pressure method
- Density method
- Default temperature
- Default density
- Linearisation
- and other non-metrological functions

1.3 Verification Provision

Provision is made for the application of a verification mark.

1.4 Sealing Provision

Access to the calibration parameters is via the Mode-Select-Control switches on the calculator/indicator, which can be concealed by a cover fixed by two screws with provision for sealing (Figure 3).

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 10/2/10
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
Minimum measured quantity (M_{min} or MMQ)	….. kg (#1)
Nominal k-factor	….. pulses/litre
Type of the liquid for which the system is verified	….. (#2)
Accuracy class	Class 2.5
Environmental class	Class I

(#1) Optional marking.

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

The minimum measured quantity (V_{min}) and the software version (code) number are clearly visible on the indicating device, e.g. 'Minimum Delivery 100 kg' and 'SC – AB0618EXX1'.

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

2. Description of Variant 1 **approved on 6/03/07**

Using certain other Hoffer HO series cryogenic flowmeters as listed in Table 2.

TABLE 2

Flowmeter Model	Minimum Flow (Q_{min})	Maximum Flow (Q_{max})	Minimum Measured Quantity
HO-¾ x ¾ -2.5-29-B-1M-MS-CE	10 kg/min	50 kg/min	50 kg
HO-2 x 2 -15-225-B-1M-MS-CE	140 kg/min	700 kg/min	200 kg

3. Description of Variant 2 approved on 23/06/08

A bulk cryogenic flowmetering system with the Hoffer Flow Controls 'advanced cryogenic electronics' model ACE-II-1-TP (*) calculator/indicator.

(*) The full model number of the calculator/indicator is in the form 'ACE-II-1-TP-PI-X-X-X-12-H-S-CE'.

The model ACE-II-1TP calculator/indicator (Figure 4) has a 128 × 68 pixel graphic liquid crystal display with LED backlight and adjustable contrast.

The instrument has 3 access/function buttons and 2 scroll buttons. The calculator/indicator operates using version 1.00.6298 software; the version number is displayed during the power-up sequence.

TEST PROCEDURE No 10/2/10

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

Maximum Permissible Errors

For accuracy class 2.5

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

It is forbidden to adjust the calibration of the meter to an error other than as close as practical to zero error.

The meter is required to be verified with the liquid that the meter is metering.

Other applicable maximum permissible errors are:

±1.0% for repeatability of a delivery at a set flow rate;
±1 K for temperature measurement;
±50 kPa for pressure measurement; and
±5 kg/m^3 for density measurement.

Tests

Check the calculator/indicator is marked with the software version (code) number.

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. 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 then 100 scale intervals.

At least one test comprising minimum delivery shall be performed.

Gravimetric method:

The accuracy and calibration of the flowmeter is determined with the indicator set to display the delivered liquid volume measured in litres. The liquid volume (in litres) delivered into a cylinder is then manually converted to mass (in kg) by dividing the volume by 1000 to convert the volume to cubic meters of liquid and then multiplying the result by the density (in kg/m^3) obtained from OIML R81 Tables (Annex C) for the cryogenic liquid. The calculated 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.

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 needs to be measured.

To ensure that the calculator/indicator converts the measured volume (in litres) to volume of gas at 15ºC and 101.325 kPa, for the above accuracy tests convert the calculated mass (for the flowmeter) to volume using the equations below and compare against the volume displayed by the calculator/indicator in cubic meters. Note: This is only possible if the calculator/indicator can provide both the volume in litres and volume in cubic meters for a given delivery.

Alternatively, for a calculator/indicator that is not able to display both liquid volume in litres and the volume in cubic meters of gas for a single delivery, the test can be carried out as follows:

- Having calibrated/adjusted the flowmeter with the calculator/indicator displaying in litres and obtained an average error, switch the calculator/indicator back to its normal display mode (in cubic meters of gas) and repeat the tests. For each delivery use the equation below to convert the mass delivered into a cylinder (as indicated by a certified weighing instrument) into cubic meters of gas at standard conditions and compare against the volume of gas indicated by the calculator/indicator. Calculate the average error and compare against the average error obtained for accuracy test. The difference shall not exceed 0.5%.

The following equations may be used to convert mass (in kg) 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,

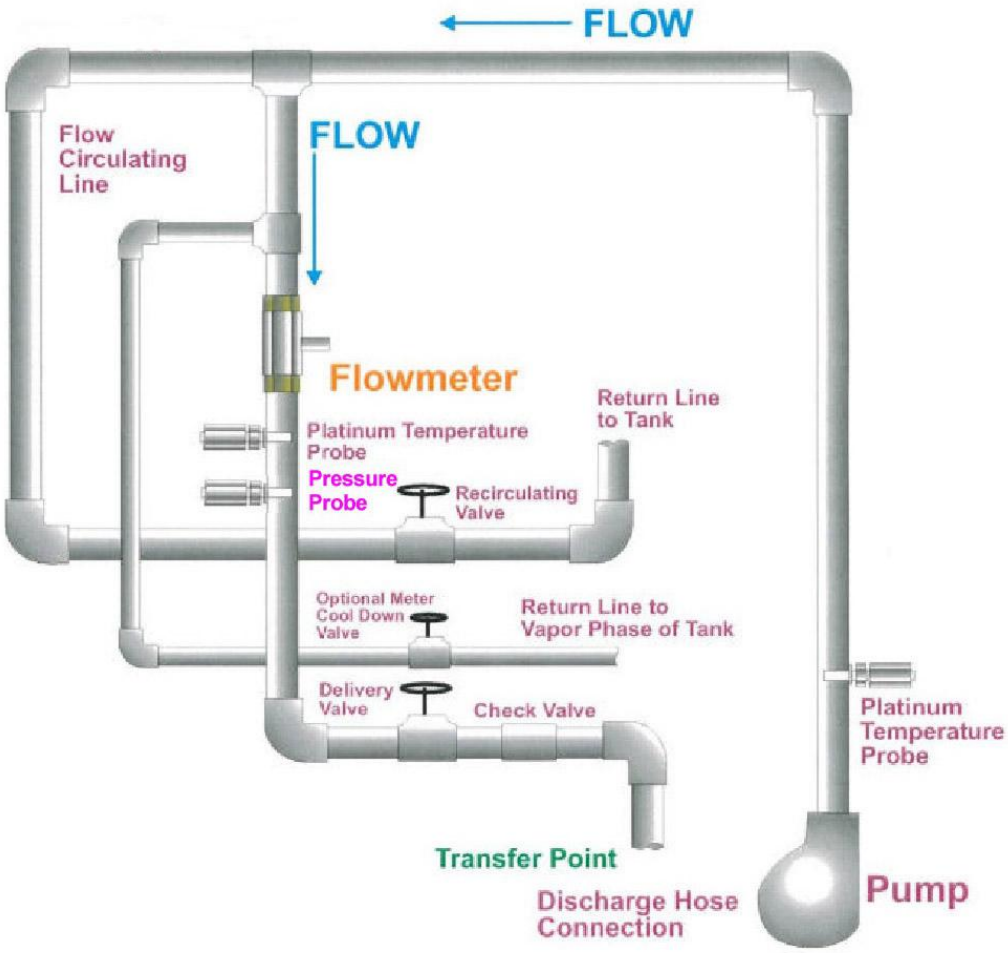
Volume = mass x 0.7389296 m^3 at 15ºC and 101.325 kPa

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 10/2/10 – 1



Hoffer Model HO Bulk Cryogenic Flowmetering System

FIGURE 10/2/10 – 2

Hoffer Model HO* Flowmeter

FIGURE 10/2/10 – 3

Hoffer Flow Controls Model ACE-B-1TP-3-12-X-S-CE Calculator/Indicator

FIGURE 10/2/10 – 4

Hoffer Flow Controls Model ACE-II-1-TP * Calculator/Indicator

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