

Flow calibration

ABB facilities overview



Measurement made easy

Flow calibration certification

Introduction

ABB is dedicated to maintaining the best possible standards in flow calibration and, as such, maintains a staff of three people tasked with this responsibility:

- Laboratory Head
- Laboratory Technical Manager
- Laboratory Quality Manager

ABB Stonehouse's Flow Calibration Facility comprises one large and one small flow laboratory.

ABB has United Kingdom Accreditation Service (UKAS) accreditation for flowrates from 0.1 to 2800 l/s (0.03 to 740 US gal/s). This reinforces customer confidence and ensures that claims of uncertainty, made by ABB, are confirmed by UKAS; which by its membership of ILAC* (International Laboratory Accreditation Cooperation) is recognized globally by all other similar organizations in the various countries of the world.

Calibrations carried out at the Stonehouse Flow Facility are to ISO17025 standards. Three methods of calibration are used, depending on the requirement:

- gravimetric (using weigh scales)
- volumetric (using the meter prover)
- comparison (using reference meters)

Additionally, ABB's laboratories are checked against each other and against external accredited laboratories using transfer standard meters.

*ILAC is the international cooperation between the various laboratory accreditation schemes operated throughout the world. ILAC was formalized as a cooperation in 1996 when 44 national bodies signed a Memorandum of Understanding (MOU). This MOU provided the basis for the further development of the cooperation and the establishment of the multilateral recognition arrangement that was signed by 36 member accreditation bodies in 2000. The arrangement facilitates the international acceptance of test data and the elimination of technical barriers to trade.

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1 Calibration Methods

1.1 Gravimetric

The flowmeter to be calibrated is installed in a pipeline through which water is pumped from a sump. A diverter valve down-stream of the meter enables the flow from the meter to be directed either back to the sump or diverted to a tank of sufficient water collecting capacity attached to a very accurate weighing system.

At the commencement of a calibration run, the flow from the meter is directed back to the sump. When the flow from the meter has stabilized, the diverter is activated to direct the water into the tank. As the diverter is activated, a timer is started, the flow rate output from the flowmeter is monitored and the water temperature is measured.

When the weight of water in the tank reaches a pre-determined level, the diverter is activated again, causing the water to return to the sump. Simultaneously, the timer is stopped and the average output from the flowmeter is calculated.

The following data is now available:

- Weight of water collected
- Time to collect the water
- Water temperature
- Average flowrate output from the flowmeter in calibration.

Using this data, the volume of water collected can be ascertained by calculating its density from the temperature and using this to convert its weight to volume. The volume, together with the collection time, gives the average flowrate from the meter during the calibration run. This figure is then compared with the average flowrate indication from the flowmeter. Any difference is the error.

1.2 Volumetric

1.2.1 Fixed volume volumetric tank

This method is similar to the gravimetric method (see section 1.1, page 3) except that the flow from the meter is diverted into a tank of known volumetric capacity. This negates the need for both a weighing system and the requirement to calculate the volume of the water from its weight.

1.2.2 Fixed volume ball meter prover

The diverter valve down-stream of the flowmeter in calibration enables the flow from the meter to be diverted into a meter prover. The prover is an accurately manufactured section of pipe containing a sphere that is 3 % larger in diameter than the pipe. The pipe is fitted with two detector switches a fixed distance apart and the volume of water that is contained in the pipe between the switches is known as the Calibrated Volume.

When the flow through the flowmeter is stable, the diverter valve is activated to direct the water through the prover tube. The sphere is introduced or 'launched' into this flow. As the sphere passes and activates the first switch, a timer is started and monitoring of the flowmeter output, water temperature and pressure is initiated. When the sphere passes and activates the second switch, the timer is stopped and the average output of the flowmeter is calculated. The flow through the prover is then reversed and the whole cycle is repeated.

The following data is now available:

- Volume of water passed through the prover
- Time taken for this to happen
- Pressure upstream and downstream of the ball
- Water temperature in the meter and in the prover
- Average flowrate output from the flowmeter in calibration.

From this, the total volume of water passed through the prover can be calculated and compared with the volume of water measured by the meter. Any difference is the error.

1.3 Comparison

The flowmeter to be calibrated is installed in a pipeline upstream of a reference (or master) flowmeter. When the flow of water through the flowmeters is stable, a timer is started and, simultaneously, the outputs of both the flowmeter in calibration and the reference meter are monitored. The water temperature is also measured. When sufficient time has passed, the timer is stopped, simultaneously stopping the monitoring of the outputs of both flowmeters.

The following data is now available.

- Average flowrate indication from the flowmeter in calibration
- Average flowrate indication from the reference or master flowmeter
- Time of the run
- Water temperature

From this data, the average flowrate indication from the flowmeter in calibration can be compared with the average flowrate indication from the reference (or master). Any difference is the error.

2 Calibration methods compared

There is no best method; all reputable laboratories use the method best suited to achieving the most accurate result and this depends on circumstances. The gravimetric calibration method is often perceived to be the best but, as most flowmeters are volumetric, mass measurement must be converted into volume allowing errors to be introduced.

At Stonehouse, ABB manufacture and calibrate a range of flowmeters with bores ranging in size from 15 to 2200 mm (0.6 to 86.6 in.). The diversity of such a large range of sizes means that different calibration methods must be used.

ABB use the gravimetric, volumetric (ball prover) and comparison methods. Having this range of methods available means that the most applicable methodology can be chosen to suit the best interests of ABB's customers.

	Gravimetric	Volumetric	Comparison
Maximum run time	Limited by size of tank/scale	Limited by size of tank	Unlimited
Minimum run time	Fixed by size of tank/scale	Fixed by size of tank	Unlimited
Uncertainty	Depends on scale uncertainty, density uncertainty, buoyancy uncertainty and temperature uncertainty.	Depends on volumetric tank calibration uncertainty, temperature uncertainty and timing uncertainty.	Depends only on the reference meter uncertainty
Limits on run time	Run time at maximum flowrates is governed by the time taken to fill the tank. Run time at minimum flowrates is governed by the amount of water required to be put into the tank to ensure that the weight can be measured with an acceptable uncertainty (normally around 25% of its capacity).	Run time at maximum flowrates is governed by the time taken to fill the tank. Run time at minimum flowrates is governed by the amount of water required to be put into the tank to ensure that the volume can be measured with an acceptable uncertainty (normally 100% of its capacity).	Unlimited
Effects of run times at low flowrates	Can make run times very long, introducing uncertainties (for example, evaporation).	Can make run times very long, introducing uncertainties (for example, evaporation).	No effect
Effects of run times at high flowrates	Tank capacity can make run times very short – they must be ≥ 30 seconds.	Tank capacity can make run times very short – they must be ≥ 30 seconds.	No effect

Table 2.1 Flow calibration method comparison

3 Laboratory accreditation

In the United Kingdom, the laboratory accreditation body is the 'United Kingdom Calibration Service' (UKAS). UKAS is the sole national accreditation body recognized by government to assess, against internationally agreed standards, organizations that provide certification, testing, inspection and calibration services.

Accreditation by UKAS demonstrates the competence, impartiality and performance capability of these evaluators.

Customers can be confident that a UKAS-accredited laboratory will carry out the calibration correctly, in accordance with laid down and UKAS approved procedures that will provide results within the uncertainty budgets published in the accreditation documentation.

ABB's UK laboratory at Stonehouse is accredited by UKAS¹ as laboratory 0255.

ABB's Australian Laboratory in Sydney is accredited by the 'National Association of Testing Authorities' (NATA²). NATA uses ABB's flow laboratory as the Australian Standard.

ABB's USA Laboratory at Warminster is accredited by the 'National Institute of Standards and Technology' (NIST³).

ABB's German Laboratory is accredited by the 'Physikalisch-Technische Bundesanstalt' (PTB⁴).

ABB's Chinese Laboratory is accredited by the 'Shanghai Institute of Measurement and Testing Technology' (SIMT⁵).

ABB's Indian Laboratory will be accredited by the 'National Accreditation Board for Testing and Calibration Laboratories (NABL⁶).

All the above laboratories are linked by means of the 'International Laboratory Accreditation Cooperation' (ILAC⁷), ensuring that, irrespective of where in the world a meter is calibrated, provided that it is calibrated at a nationally accredited laboratory, the calibration will be within the published uncertainty for that laboratory.

4 UKAS-Accredited 0255 calibration laboratory schedule of accreditation

ABB's flow laboratory is qualified to perform UKAS calibrations on external customer devices to accuracies better than 0.2%, dependant on meter size and rig selection.

The latest copy of the flow accreditation schedule can be downloaded from the UKAS web site by clicking on the following link or by copying and pasting the URL into the address bar of a web browser:

<http://www.ukas.org/calibration/schedules/actual/0255Calibration%20Single.pdf>

1. For more information contact www.UKAS.com
2. www.nata.asn.au
3. www.nist.gov
4. www.ptb.de
5. <http://app.shzj.gov.cn:8080/english/organization/simt.jsp>
6. www.nabl-india.org
7. www.ilac.org

5 Large flow laboratory

5.1 Rig 9 – large flow facility

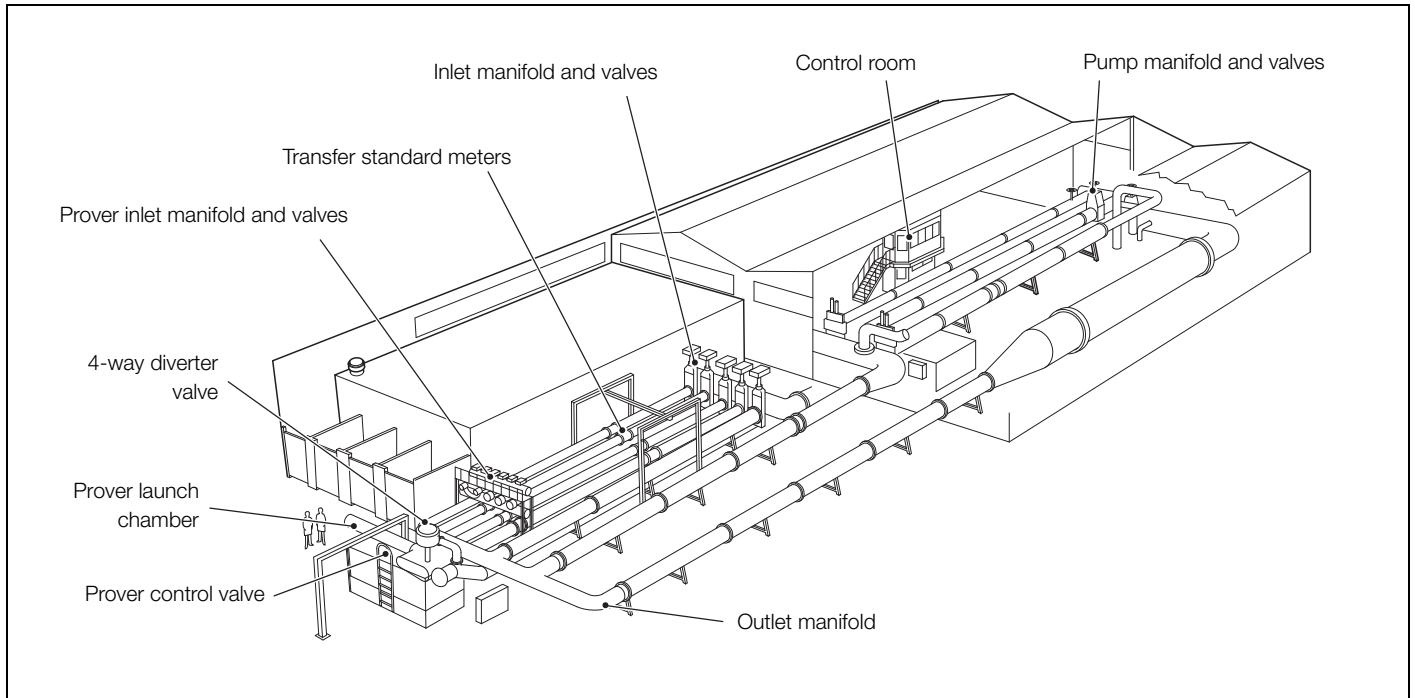


Fig. 5.1 The world's largest continuous flow laboratory

- Flowrate capacity 34 to 2700 l/s (9 to 713 US gal/s)
- Accredited to UKAS and International Flow Standards
- The keystone of ABB's Global Flow Calibration Ability

5.2 Overview

The large flow laboratory contains 3 work centers, designated lines 1, 2 and 3. Each has a choice of up to 4 transfer reference standards, depending on velocity. These reference standards require calibration and functional checking every 2 months.



5.3 Capacity

The Large Flow Laboratory is UKAS-accredited (Laboratory no. 0255), to a maximum flow of 2700 l/s (713 US gal/s). The laboratory is served by two large 909 l/s (240 US gal/s) and two small 454 l/s (120 US gal/s) pumps for parallel operation, providing a maximum throughput of 2700 l/s (713 US gal/s) at 2 bar (29 psi) pressure. The combined power consumption at 2000 l/s (528 US gal/s) is 1032 kW.

The water is circulated continuously from a main sump holding approximately 1,000,000 litres (264,000 US gallons). The sump is equipped with de-aeration chambers to remove entrained air from the water.

5.4 Summary of operation

5.4.1 In-line proving

The primary measurement device used is a 762 mm (30 in.) meter prover loop, calibrated to BS EN ISO 7278-2 1996. This prover loop is used to calibrate the 4 Transfer Standard streams consisting of 150, 350, 400 and 450 mm (6, 14, 16 and 18 in.) MagMaster flowmetering systems.

The prover loop is a volumetric calibration device comprising a pipe section of a known volume of 32,227.250 litres (8,513.54 US gallons) containing a polyurethane proving sphere. The sphere is approximately 3 % larger than the pipe section, providing a good interference fit to eliminate leakage past the sphere.

The sphere is introduced or 'launched' into the flow of water from the meter in calibration and propelled through the prover pipe by the differential pressure across the sphere. Detector switches mounted on the prover pipe walls, a fixed distance apart, enable the sphere travel time to be measured. The volume of water passed between the switches is known. The process is repeated at different flow rates, in both forward and reverse directions, across the range of each individual stream, thus setting the primary measurement that the transfer meters are adjusted to, if required. The uncertainty of measurement for the transfer standard meters must be less than 0.1 % of actual measurement. The calibration repeatability of the prover is achieved by performing 2 or more consecutive runs within <0.02 % of the average base volume. A third run (or more if necessary) is carried out at varying flowrates to verify the absence of a consistent leak.

PROVER LOOP CALIBRATION REPORT

CLIENT
LOCATION
CALIBRATION DATE
CALIBRATION TIME

ABB Ltd.
Stonehouse
16-04-2013
1110-1455 Hrs

PROVER LOOP SERIAL NO.
MASTER METER SERIAL NO.
PROVER TANK SERIAL NO.
CALIBRATION FLOWRATE

KEN 2500
XX56232-3/17DC
MBRMPT 17
970 LPM

RUN No. & DIRECTION	MASTER METER		TEMPERATURE MEASUREMENTS °F.		PRESSURE MEASUREMENTS Psi g		CORRECTION FACTORS					PROVER LOOP VOLUME
							PROVER			MASTER METER		
	METER PULSES	METER FACTOR	Tp	Tm	Pp	Pm	Ctsp	Cpdp	Cplp	Ctdw	Cplm	
1 Fwd.	3531200	1.02710	67.6	67.4	42.5	26.0	1.000160	1.000111	1.000136	1.000023	1.000083	16114.688
1 Rev.	3532071	1.02710	67.8	67.6	42.5	26.0	1.000164	1.000111	1.000136	1.000023	1.000083	16118.598
1 R.Trip												32233.286
2 Fwd.	3531838	1.02710	67.9	67.8	42.5	26.0	1.000166	1.000111	1.000136	1.000011	1.000083	16117.299
2 Rev.	3531515	1.02710	68.0	67.9	42.5	26.0	1.000167	1.000111	1.000136	1.000011	1.000083	16115.808
2 R.Trip												32233.107
3 Fwd.	3531494	1.02710	68.0	67.9	42.5	26.0	1.000167	1.000111	1.000136	1.000011	1.000083	16115.713
3 Rev.	3531635	1.02710	68.1	68.0	42.5	26.0	1.000169	1.000111	1.000136	1.000012	1.000083	16116.340
3 R.Trip												32232.053
4 Fwd.	3531984	1.02710	68.2	68.1	42.5	26.0	1.000171	1.000111	1.000136	1.000012	1.000083	16117.900
4 Rev.	3531834	1.02710	68.1	68.0	42.5	26.0	1.000169	1.000111	1.000136	1.000012	1.000083	16117.248
4 R.Trip												32235.148
5 Fwd.	3531698	1.02710	68.1	68.0	42.5	26.0	1.000169	1.000111	1.000136	1.000012	1.000083	16116.627
5 Rev.	3531535	1.02710	68.2	68.1	42.5	26.0	1.000171	1.000111	1.000136	1.000012	1.000083	16115.851
5 R.Trip												32232.478
For and on behalf of SGS.							AVERAGE ROUND TRIP VOLUME					32233.214
							(Litres @15deg.C & Atmos.Press.)					
							Repeatability(%)					0.010

Document No. METPLP006

Revision No. 01

Dated 04/10/07

Fig. 5.2 ABB prover loop calibration report with a repeatability of 0.01 %

5.4.2 Comparison testing method

Each meter is fitted into the appropriate meter-on-test section depending on size (400, 1000 or 1200 mm [16, 39 or 47 in.] inlet /outlet). Each test runs for 5 minutes and takes the average output from the meter on test and the average combined outputs from the master transfer meters or the prover. The readings are compared and adjusted (calibrated) so that the resulting error is less than ± 0.15 % of reading.

5.4.3 Size and flow range

The size of meters calibrated on the facility range from 350 to 2200 mm (14 to 87 in.), consisting of a rangeable flowrate from 7 to 2700 l/s or 122 to 9,720 m³/h (8.97 to 713 US gal/s or 4315.2 to 343,043 ft³/h).

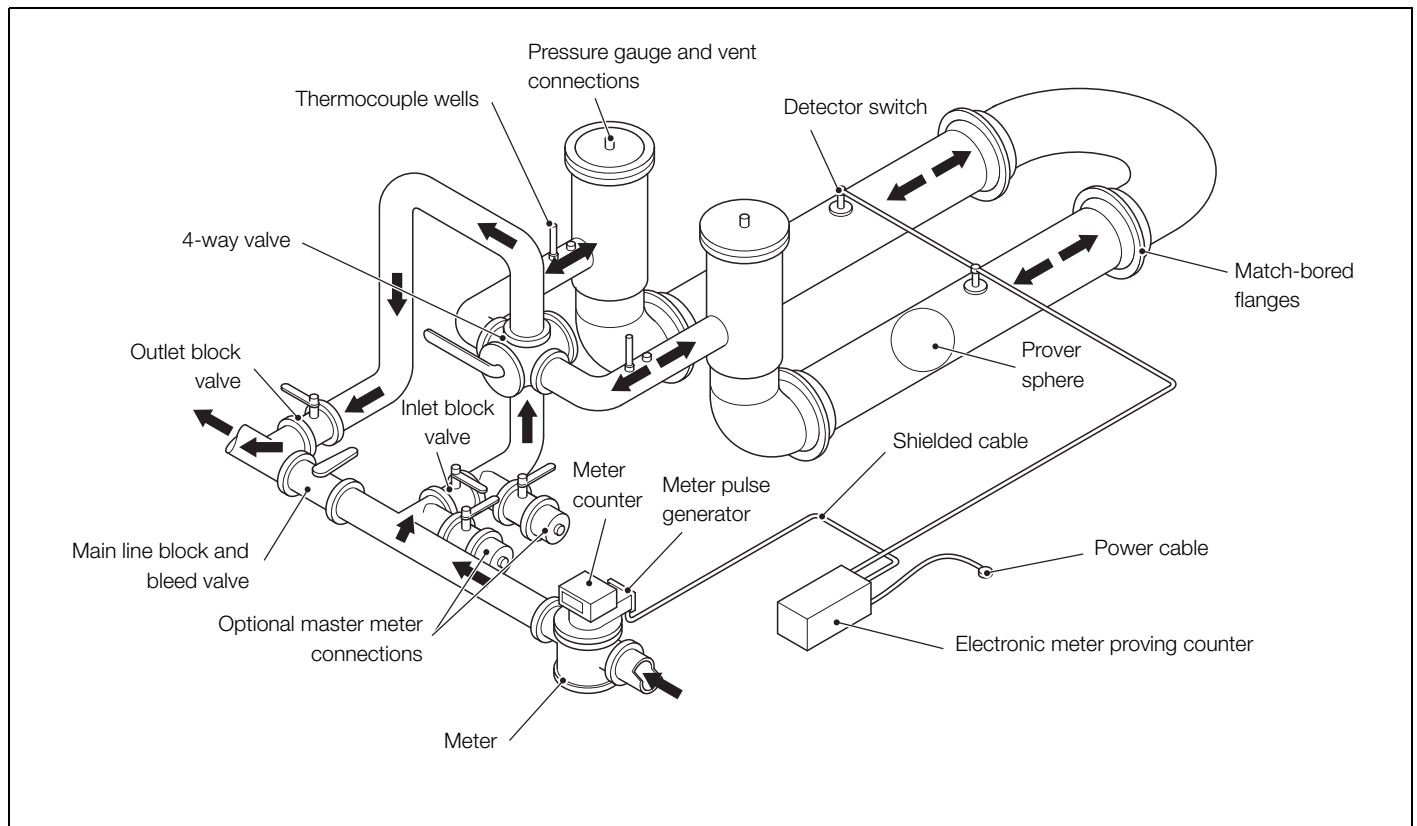


Fig. 5.3 General arrangement of the ABB Stonehouse calibration facility prover system

6 Small flow laboratory

6.1 Overview

The small flow laboratory contains 6 work centers, designated Rigs 1, 2, 3, 4, 7 and 10. Each has 2 or more transfer reference standards with gravimetric options. The reference standards require calibration and functional checking every 2 months.



6.2 Work center Rig 1 650A

This rig is a manual or automatic rig capable of calibrating up to 2 meters against reference meters.

Calibration Capacity	0.9 to 432 m ³ /h (31.78 to 15,255.94 ft ³ /h)
Size range	150 to 300 mm (6 to 12 in.)
Product range	AquaMaster, MagMaster LoFlo, MagMaster Full Bore, WaterMaster
Reference meters operating range:	
150 mm (6 in.)	5.3 to 120.00 l/s (1.4 to 31.7 US gal/s)
50 mm (2 in.)	0.25 to 41.66 l/s (0.07 to 11.0 US gal/s)

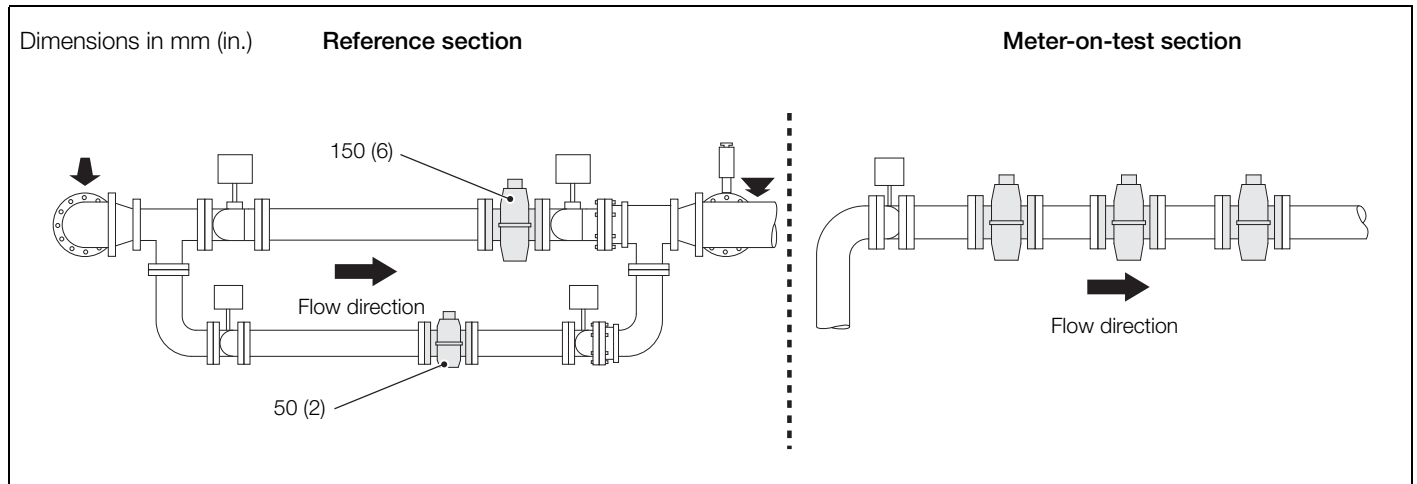


Fig. 6.1 Work center Rig 1 schematic

6.3 Work center Rig 2 150

This rig is a manual or automatic rig capable of calibrating up to 3 meters against reference meters.

Calibration Capacity 0.011 to 144 m³/h (0.39 to 5,085.31 ft³/h)

Size range 80 to 150 mm (3 to 6 in.)

Product range AquaMaster, MagMaster LoFlo, MagMaster Full Bore, WaterMaster

Reference meters operating range:

100 mm (4 in.) 2.5 to 40.00 l/s (0.66 to 10.57 US gal/s)

50 mm (2 in.) 0.0667 to 8.5 l/s (0.02 to 2.25 US gal/s)

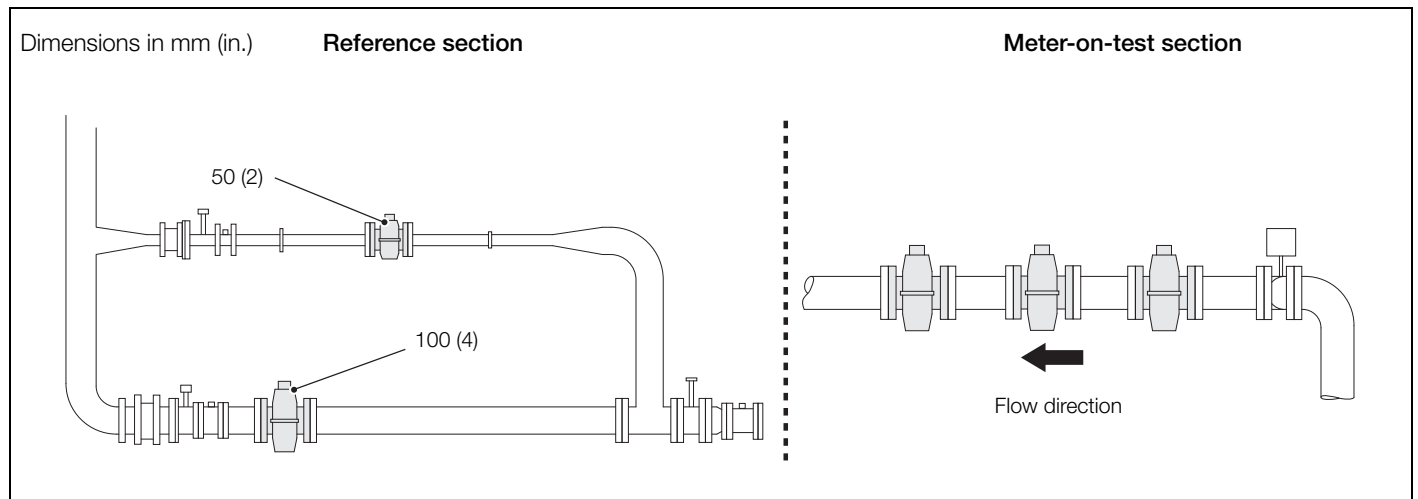


Fig. 6.2 Work center Rig 2 schematic

6.4 Work center Rig 3 70A

This rig is a manual or automatic rig capable of calibrating up to 3 meters against reference meters.

Calibration capacity	0.011 to 55 m ³ /h (0.39 to 1,942.31 ft ³ /h)
Size range	40 to 80 mm (2 to 6 in.)
Product range	AquaMaster, MagMaster LoFlo, MagMaster Full Bore, WaterMaster
Reference meters operating range:	
50 mm (2 in.)	1.00 to 14.00 l/s (0.26 to 3.7 US gal/s)
15 mm (0.6 in.)	0.003 to 1.4 l/s (0.0008 to 0.37 US gal/s)

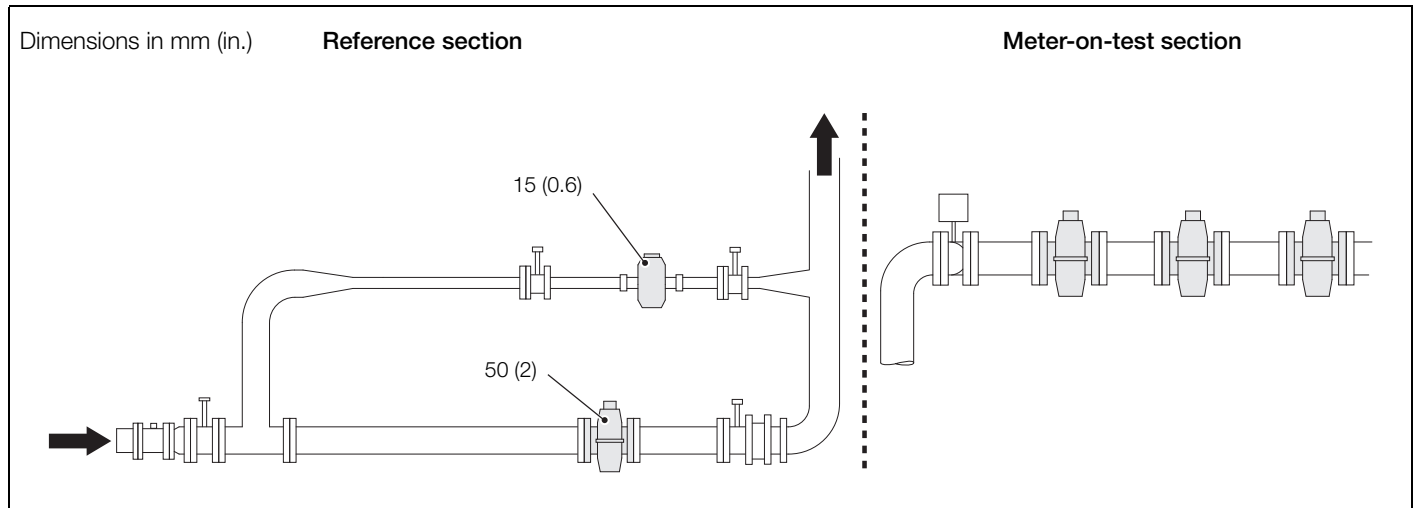


Fig. 6.3 Work center Rig 3 schematic

6.5 Work center Rig 4 70B

This rig is a manual or automatic rig capable of calibrating up to 3 meters against reference meters.

Calibration capacity 0.022 to 79.2 m³/h (0.78 to 2,796.92 ft³/h)

Size range 65 to 100 mm (2.5 to 4 in.)

Product range AquaMaster, MagMaster LoFlo, MagMaster Full Bore

Reference meters operating range:

80 mm (3 in.) 2.00 to 20.00 l/s (0.53 to 5.3 US gal/s)

25 mm (1 in.) 0.006 to 2.5 l/s (0.002 to 0.66 US gal/s)

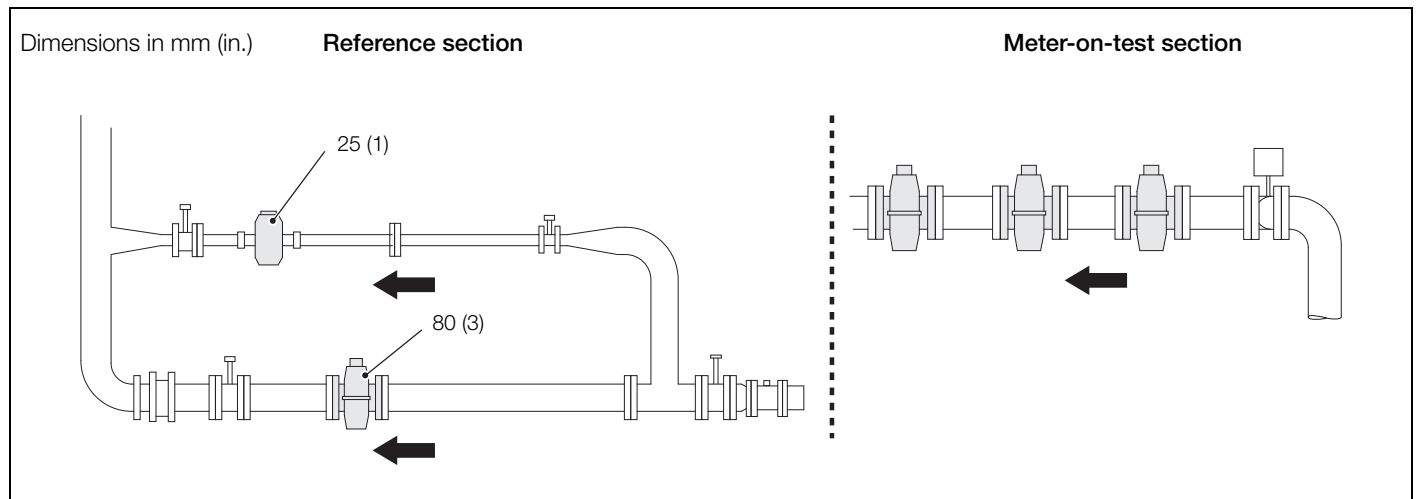


Fig. 6.4 Work center Rig 4 schematic

6.6 Work center Rig 7 650B

This rig is a manual or automatic rig capable of calibrating up to 2 meters against reference meters

Calibration capacity 0.09 to 432 m³/h (3.18 to 15.255.94 ft³/h)

Size range 150 to 300 mm (6 to 12 in.)

Product range AquaMaster, MagMaster LoFlo, MagMaster Full Bore, WaterMaster

Reference meters operating range:

50 mm (2 in.) 0.25 to 8.33 l/s (0.066 to 2.2 US gal/s)

100 mm (4 in.) 2.00 to 55.00 l/s (0.53 to 14.53 US gal/s)

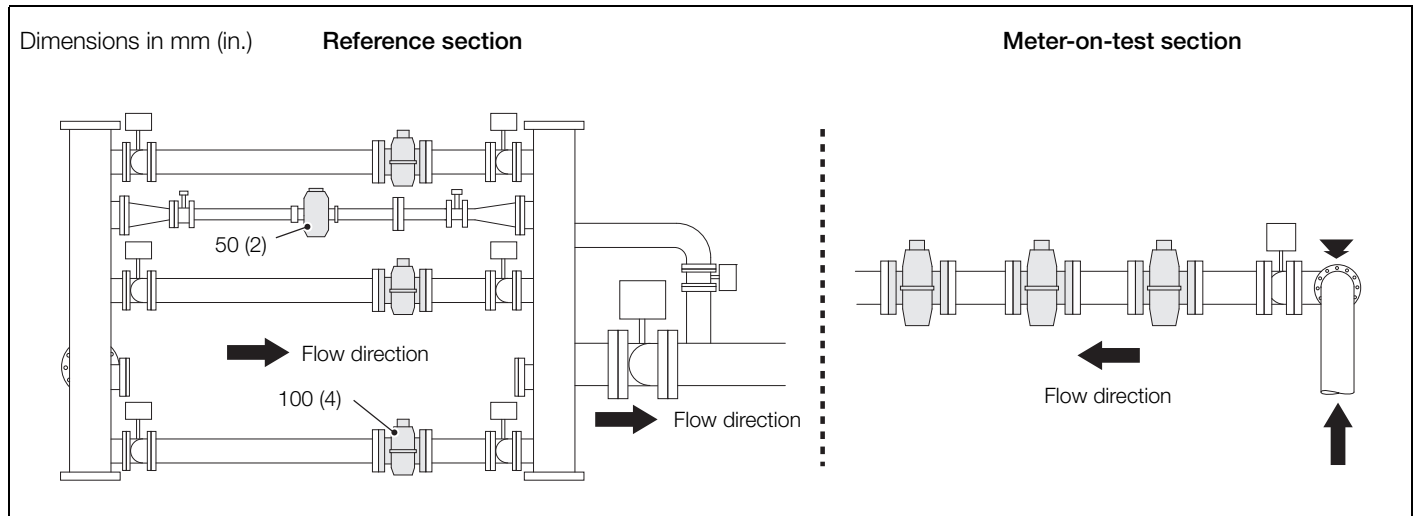


Fig. 6.5 Work center Rig 7 schematic

6.7 Work center Rig 10

This rig is a fully automatic gravimetric rig capable of calibrating 3 meters simultaneously, either against the reference meters or directly against the weigh scale.

Calibration capacity	0.01 to 144 m ³ /h (0.35 to 5,085.31 ft ³ /h)
Size range	100 and 150 mm (4 and 6 in.)
Product range	AquaMaster, MagMaster LoFlo, MagMaster Full Bore, WaterMaster
Reference meters operating range:	
50 mm (2 in.)	0.25 to 8.33 l/s (0.066 to 2.2 US gal/s)
100 mm (4 in.)	2.00 to 55.00 l/s (0.53 to 14.53 US gal/s)
Weigh scale capacity	3,000 kg (6,614 lbs)
Uncertainty	±0.102 kg (±0.225 lbs)

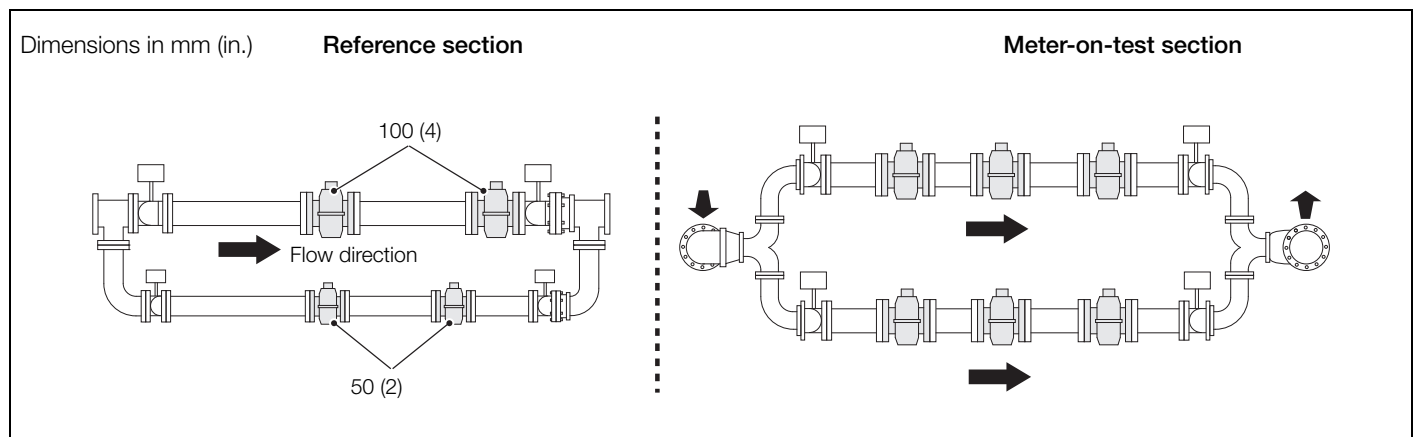


Fig. 6.6 Work center Rig 10 schematic

7 Flowmeter calibration software

All ABB flowmeter calibration laboratories use bespoke software, written by ABB, exclusively for its own use. This approach enables ABB, in conjunction with UKAS, the freedom to develop and introduce improvements at any time.

The software is written in LabView as this has proved to be the most effective platform for calibration excellence.

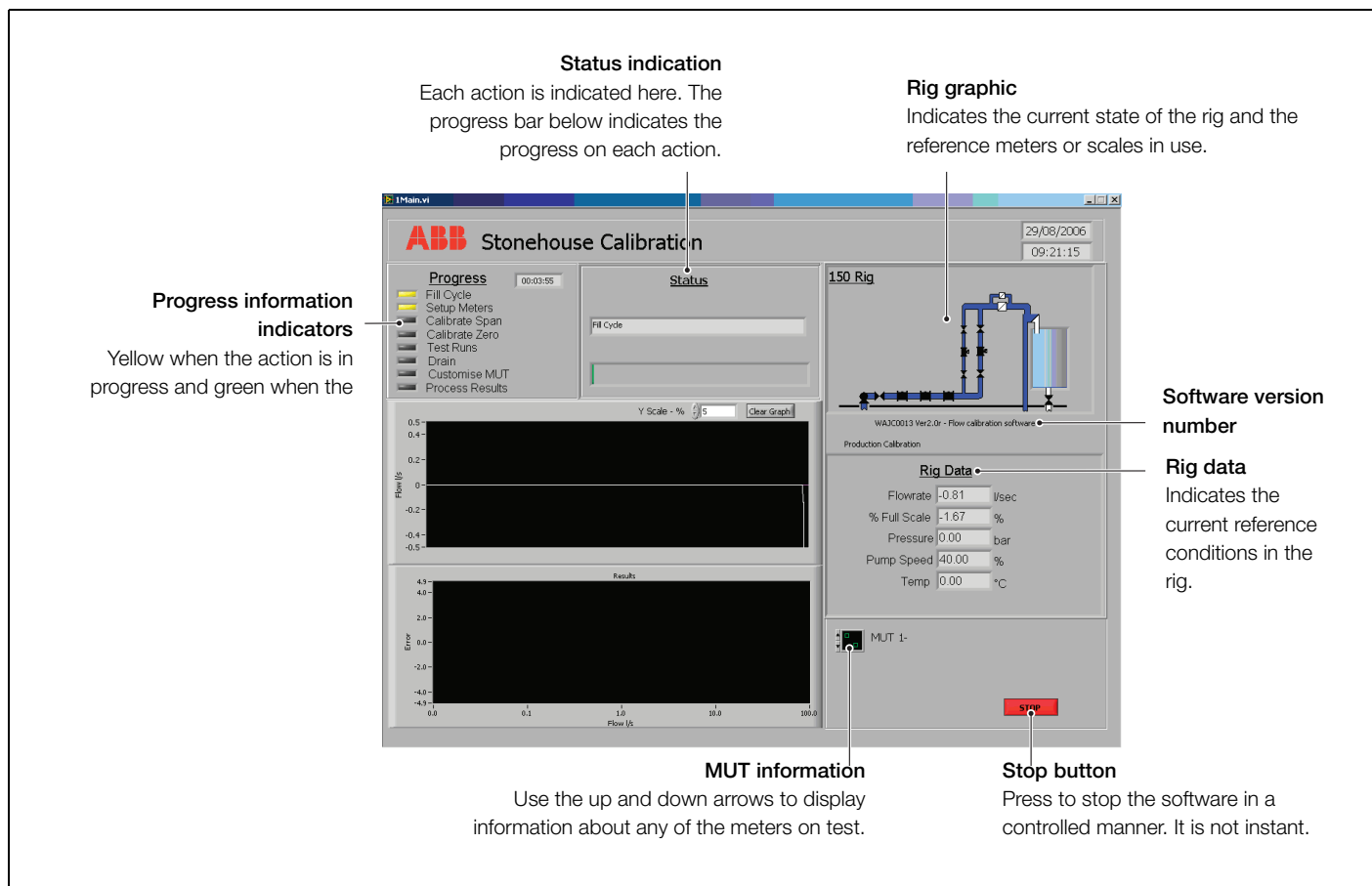


Fig. 7.1 Calibration software main screen

CERTIFICATE OF CALIBRATION

QJSTA 0061 Issue 3



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ABB Automation GmbH
Oranienfelder Str.2
D-37079 Göttingen GERMANY
Tel: +49 (0) 551 9050
Fax: +49 (0) 551 905711

Certificate number : 09/31855

Date of calibration : 23 Jan 2009

Test plant : Rig 7 650m³/h

Sensor Tag No.:

Sensor ID : 121938

Special Meter

Calibration output: Digital

Qn full scale : 600.00 m³/h

Calibration range: 138.88 1/s

Meter Bore : 300 mm

Customer name: ABB LIMITED (TWABB)

Customer ref.: 3139262

Serial number : P/75396/8/8

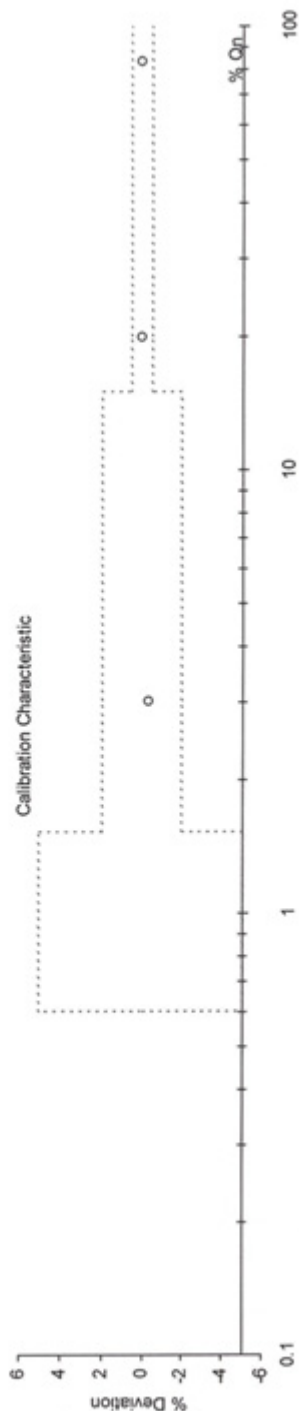
Order reference : EYD/P/75706/NYM

Motor function: Arms Master Pay

Reference

Meter Under Test

Test Run number	Run Time sec	Water Temp °C		Stream 1 l/s	Stream 2 l/s	Stream 3 l/s	Stream 4 l/s	Stream 5 l/s	Total Flow l/s	Flowrate l/s	% Cal. range	% Error
		Int	Ext									
1	100	21.4	-	56.551	0	51.505	31.264	0	139.319	139.341	100.3	0.02
2	100	21.4	-	17.548	0	15.662	0	0	33.21	33.227	23.9	0.05
3	300	21.4	-	0	5.0556	0	0	0	5.0556	5.0388	3.6	-0.33



Calibrator	A. D	Approved by
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Witnessed by

Page 1 of 1



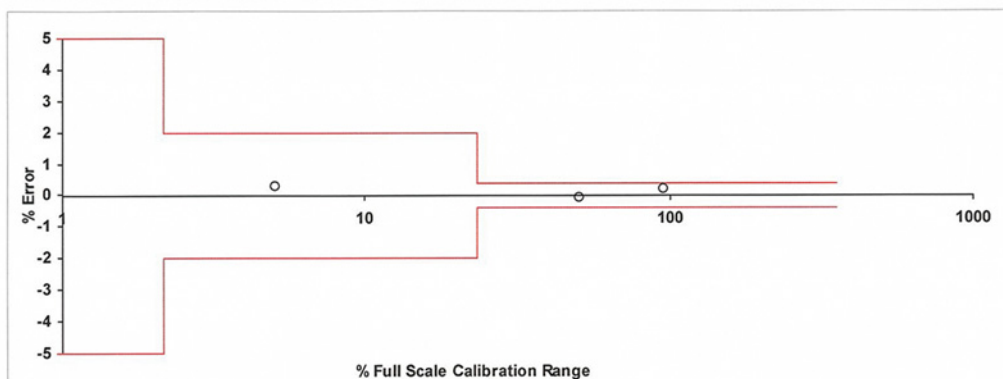
CERTIFICATE OF CALIBRATION

Customer Name:	ABB MALAYSIA SDN BHD (MYMAS)	Certificate Number:	09/1/7/208152
Customer Ref:	3160011178	Accreditation Number:	
Tag Number:		Calibration Date:	08 Jan 2009
Serial No:	PI77527/1/1	Calibration Location:	ABB Stonehouse U.K.
ABB Order Ref:	EXP/PI77527/JLM	Test Rig:	650B
Meter Type:	WaterMaster	Fluid:	Water
Meter Code:	FEF121250K1S1S2B1A1A2A3A2	Calibration Range:	127.0 l/s
Meter Bore:	250.00 mm	Calibration Type:	HART
	OIML Class 2	Sensor Factor Ss:	130.9405
		Sensor Factor Ss(b):	0
		Sensor Factor Sz:	0.5131 Sz(b) 0
		Accuracy Specification:	OIML R49 ISO4064

Reference

Meter Under Test

Test Run number	Run Time sec	Water Temp °C	Ref-Lab Flow l/s	Test Meter Flowrate l/s	% Cal. Range	% Error
1	181.504	21.1	6.341	6.36	5	0.31
2	63.596	22.5	63.55	63.509	50	-0.06
3	51.594	20.2	120.634	120.859	95.2	0.19


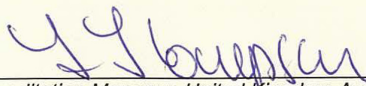


This flowmeter has been wet calibrated at ABB Stonehouse Calibration Facility and is traceable to some/all of the International Standards detailed below
ISO 4185, ISO 7278 Part 2, ISO 8316 and ISO 17025

Note, these are the main calibration standards, but due to the complex nature of fluid flow calibration, other standards will apply to parts of the system

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9 Accreditation certificate

United Kingdom Accreditation Service			
ACCREDITATION CERTIFICATE			
			
CALIBRATION LABORATORY No. 0255			
ABB Ltd			
<p>is accredited in accordance with the recognised International Standard ISO/IEC 17025:2005 General Requirements for the competence of testing and calibration laboratories.</p> <p>This accreditation demonstrates technical competence for a defined scope as detailed in and at the locations specified in the schedule to this certificate, and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF Communiqué dated January 2009).</p> <p>The schedule to this certificate is an essential accreditation document and from time to time may be revised and reissued by the United Kingdom Accreditation Service. The most recent issue of the schedule of accreditation, which bears the same accreditation number as this certificate, is available from the UKAS website www.ukas.com.</p> <p>This accreditation is subject to continuing conformity with United Kingdom Accreditation Service requirements. The absence of a schedule on the UKAS website indicates that the accreditation is no longer in force.</p> <div> _____ <i>Accreditation Manager, United Kingdom Accreditation Service</i></div> <table><tr><td>Initial Accreditation date 24 October 1988</td><td>This certificate issued on 25 June 2012</td></tr></table> <p>UKAS is appointed as the sole national accreditation body for the UK by The Accreditation Regulations 2009 (SI No 3155/2009) and operates under a Memorandum of Understanding (MoU) with the Department for Business, Innovation and Skills (BIS).</p>		Initial Accreditation date 24 October 1988	This certificate issued on 25 June 2012
Initial Accreditation date 24 October 1988	This certificate issued on 25 June 2012		

10 External calibrations

ABB can perform water-based flowmeter calibrations or special calibration work using its extensive UKAS-accredited facilities at Stonehouse in the UK.

ABB's laboratories, backed by many years of experience, offer continuous flowrates from 0.1 to 2700 l/s (0.03 to 713 US gal/s), enabling us to calibrate flowmeters ranging in size from 15 to 2200 mm (0.6 to 87 in.). In addition, ABB's experienced staff are able to undertake specialist investigation work for, and in conjunction with, customers; ranging from water company consultants to universities.

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Appendix A – extrapolation of flowrates within the calibration certificates

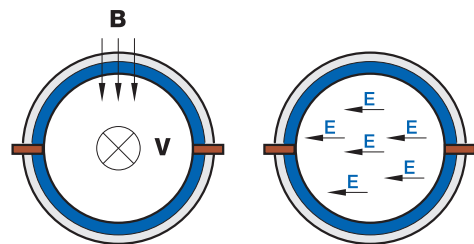
Extrapolation is defined as the relationship between the maximum flow of which an electromagnetic flowmeter is capable, compared to the maximum flowrate at which it is calibrated.

Electromagnetic flowmeters are capable of maximum flowrates of around 10 m/s (32.8 ft/s). However, because the maximum flowrate in most applications in which they are used is approximately 2 to 3 m/s (6.7 to 9.8 ft/s), manufacturers calibrate electromagnetic flowmeters with a maximum flowrate equivalent to 2 to 3 m/s (6.7 to 9.8 ft/s).

However, a customer may occasionally need to use an electromagnetic flowmeter at, or close to, its maximum flowrate. In this instance, the difference between the flowrate at which it was calibrated and the flowrate at which it is used causes the customer to question whether or not it is accurate at the higher flowrate.

All electromagnetic flow meters operate according to Faraday's Law of Induction:

$$E = V \times L \times B$$



This law states that the electromotive force (EMF) generated across the electrodes is directly proportional to the distance between the electrodes, the strength of the magnetic field and the velocity of the fluid passing through the meter. In the case of an electromagnetic flowmeter, the magnetic field and the distance between the electrodes are fixed, therefore the EMF (or output) is directly proportional to the velocity; making this a linear relationship.

Because of this linear relationship, it is generally accepted that an electromagnetic flowmeter does not increase its uncertainty significantly when used at flowrates up to 4 times the maximum flowrate at which it was calibrated – for example:

Calibration maximum flowrate = 100 l/s (26.42 US gal/s)

Maximum flowrate at which the electromagnetic flowmeter can be used with little or no increase in uncertainty = 400 l/s (105.67 US gal/s)

Therefore, the extrapolation factor = 400/100 = 4

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