

EURAMET Project No. 1506 EURAMET Pilot study

Validation of standards for liquid flow rate under dynamic flows

Technical Protocol

Pilot - Coordinator CETIAT/France

May, 2020

Contents

1	Intro	oduction	. 3
2	Part	icipants and planning	. 3
3	Valio	dation Module	. 4
	3.1	Zeroing the flow meter	. 8
	3.2	Recording digital outputs	15
4	The	measurement procedure and calibration protocol	17
	4.1	Conditions during measurements	17
	4.2	Dynamic calibration	17
	4.3	DYNAMIC FLOW PROFILE N°1, 50 L	18
	4.4	DYNAMIC FLOW PROFILE N°2, 100 L	20
	4.5	DYNAMIC FLOW PROFILE N°3, 150 L	21
5	Eval	uation measurement results	23
Re	eferenc	es	23

1 Introduction

The aim of this pilot study is an assessment of the metrological comparability concerning dynamic flow profile capability of the dynamic test rigs developed for the project EMPIR 17IND13 Metrowamet - Metrology for real-world domestic water metering. The validation module consists of a Pelicase including the following main elements: Emerson MicroMotion Elite CMFS040M Coriolis Mass Flow Meter, Emerson 5700 Transmitter, Keller PR23 Pressure Sensor, Rosemount Pt100 Class B HART Temperature Sensor will be used as the transfer standard. The pilot study will be done in test profiles in the range up to 1600 l/h and volumes of 50 L, 80 L and 150 L for dynamic load changes.

These specifications will ensure compatibility between the rigs of the partners where necessary and comparable test rig operation independent of the actual load realisation. As a result it will be possible to determine and evaluate the quality of the profile run.

2 Participants and planning

The participants and planning are shown in Table 1. One is requested to arrange for transport to the next institute. Each laboratory therefore pays for the cost of shipment of the package to the next laboratory. The package has to be sent by road, not by air. It is advised to include in each shipment order an insurance covering the hardware cost of 15000€.

Institute	Country	Shipping address	Contact/mail/phone	remarks	date
CETIAT (PILOT)	France	CETIAT Laboratoire Micro- Débitmètrie Liquide Domaine Scientifique de la Doua 54, boulevard Niels Bohr FR - 69100 Villeurbanne FRANCE	Florestan Ogheard <u>florestan.ogheard@cetiat.fr</u> (00 33) (0)4 72 44 59 45		1.9.2020 to 11.9.2020
РТВ	Germany	Physikalisch- Technische Bundesanstalt (PTB) Fachbereich 1.5 Flüssigkeiten Bundesallee 100, 38116 Braunschweig	Daniel Schumann <u>daniel.schumann@ptb.de</u> +49 531 592 - 1373		14.9.2020 to 25.9.2020
DTI	Denmark	Danish Technological Institute Kongsvang Allé 29 DK - 8000 Aarhus C Denmark	Søren Haack sorh@teknologisk.dk +45 72 20 23 38		29.9.2020 to 9.10.2020
FORCE	Denmark	FORCE Technology Park Allé 345 2605 Brøndby Denmark	Johan Bunde Kondrup jbko@forcetechnology.com Mobile: +45 42 62 76 52		12.10.2020 to 23.9.2020

Tab.1 – Participants and time schedule

VTT				26.10.2020 to 6.11.2020
СМІ	Czech Republic	Czech Metrology Institute Department of Fluids Flow, Flow Velocity and Heat Okruzni 31, 638 00 Brno, Czech Republic	Miroslava Benková <u>mbenkova@cmi.cz</u> mobil: +420 734 877 960	9.11.2020 to 20.11.2020
RISE	Sweden	Division: Safety and Transport Department: Measurement Science and Technology Unit: Volume and Flow Brinellgatan 4, SE-504 62 Borås, Sweden	Oliver Büker <u>oliver.buker@ri.se</u>	23.11.2020 to 4.12.2020
UME TUBITAK	Turkey		Bülent ÜNSAL bulent.unsal@tubitak.gov.tr	7.12.2020 to 18.9.2020
CETIAT (PILOT)	France	CETIAT Laboratoire Micro- Débitmètrie Liquide Domaine Scientifique de la Doua 54, boulevard Niels Bohr FR - 69100 Villeurbanne FRANCE	Florestan Ogheard florestan.ogheard@cetiat.fr	21.12.2020 to 31.12.2020

3 Validation Module

The validation module consists of a Pelicase including the following elements:

- 1. A : Emerson MicroMotion Elite CMFS040M Coriolis Mass Flow Meter
- 2. Emerson 5700 Transmitter
- 3. Keller PR23 Pressure Sensor
- 4. Rosemount Pt100 Class B HART Temperature Sensor
- 5. Three way valve to choose Upstream ("AMONT" in French on the label) or Downstream ("AVAL" in French on the label) pressure measurement. The valve should be positioned so that the measured pressure is the one which is changed by your flow change generator: upstream ('AMONT") if your flow generator is upstream of the validation module, downstream in the contrary.

A DELL Laptop (CETIAT number n°15868) with power supply and 1 meter USB cable to connect to the validation module is also provided.

The following picture presents the validation module (numbers refers to elements above):



Figure 1: Inner view of the validation module

On the back side of the Pelicase, the following inputs and outputs can be found (see next figure):

- USB connector to be connected to the Laptop using a MALE-MALE cable (a one meter USB cable is provided is the laptop suitcase)
- 2. 4-20 mA Output (active, set to 0->4000 kg/h full scale)
- 3. Pulse Output (active, set to 1 g per pulse)
- 4. On/Off switch (single switch for the entire validation module)
- 5. Power supply connector, 220-240V AC.



Figure 2: back side of the validation module

The inlet (left side, blue "ENTRÉE" label) and outlet (right side, "SORTIE" label) are clamp fittings (outer diameter of ferrule = 50.5mm) and can be connected to DN15/20/25/32 clamps as underlined in red in the following table:

φ Α φ Β	- L	6	ØC	Appl • Co • Au • Eta Ele Cons Autre	ication onform icune : at de s ectro-p structio es mat	ns:chir eàlai zoned urface olissag n:ino ériaux:	mie, ph norme e réter standa e sur d c 316 L : inox sp	narmad ISO 11 ntion ard : Ra Ieman Déciaux	cie, ag 27 a ≤ 0.8 de (Ra k, Haste	ro-alime µm ≤ 0.38 elloy®, ti	entaire µm) tane		Use : fo • Com • No d • Surfa Electro Constru Others	od & c formity lead zc ice fini -polishi uction : : speci	lairy, p to ISO one sh : Ra ng on i : 316 L al s. ste	harma 1127 st ≤ 0.8 µ ceques eels, Ha	ceutic andar m t (Ra ≤ stelloy	als & cl d 0.38 µr ®, titan	hemica n) ium	nls
Туре	Micro	Clamp	М	ini Clar	np								Clamp						(*) non s	tandard
Réf.	130	001		13002									13003							
DN	8	10	8	10	15	15	20	25	32	32 (*)	40	50	65	80	100	125	150	200	250	300
Ø A (mm)	13.5	17.2	13.5	17.2	21.3	21.3	26.9	33.7	42.4	42.4	48.3	60.3	76.1	88.9	114.3	139.7	168.3	219.1	273.0	323.9
ØB(mm)	10.3	14.0	10.3	14.0	18.1	18.1	23.7	29.7	39.2	38.4	44.3	56.3	72.9	84.9	110.3	135.7	163.1	213.9	267.8	318.7
ØC (mm)	25	5.4		34.0			50).5		64.0	64.0	77.5	91.0	106.0	130.0	155.0	183.0	233.5	286.1	338.5
L (mm)	21	.5		18.0						21.5							28	3.0		
Poids (kg)	0.	02		0.03		0.08	0.	07	0.10	0.11	0.09	0.12	0.14	0.18	0.25	0.37	0.51	0.66	0.93	1.28

Figure 3: table of clamp fittings

The clamp fittings are threaded and normally screwed to the inlet and outlet. For the shipment, the clamp fittings must be unscrewed and placed inside a bubble bag (provided) inside the Pelicase.



Figure 4: inlet (left side) and outlet (right side) view of the validation module

Finally, the picture below shows a schematic of the validation module:



Figure 5: schematic of the validation module

PC time synchronisation:

If possible, please synchronise the provided laptop time to a NMI time server of you choice.

The following link provide a protocol to synchronise to NIST time:

https://www.guidingtech.com/3119/windows-clock-sync/

3.1 Zeroing the flow meter

Before performing tests with the validation module, is it is necessary to perform a "zero" of the flow meter. The following procedure describes the steps required to perform the "zero" using the laptop provided and Prolink III software.

- 1. Turn on the laptop provided.
- 2. On the first screen displaying at the laptop startup, enter the code "2042" to unlock the harddrive.
- 3. Login by clicking on "CETIAT" user. No password is required.
- 4. Connect the validation module to the laptop provided using a MALE-MALE USB cable (one is provided in the laptop suitcase).
- 5. Turn on the validation module.
- 6. Start Prolink III by double-clicking its shortcut on the desktop:



7. Click on "Physical" then click on "Go" to start the connection assistant:



8. Select the parameters as seen below, then click on "Connect". If the connection fails, check that the validation module in powered on and if the USB cable connector's are plugged in. You may also need to change the PC port number (check using the Windows device manager).

ProLink III v3.5		A REAL PROPERTY AND INC.	
File Tools Help			
r 🔍	Connect to Physical Device		
Co	nnection Parameters	Connect	
Pr	rotocol Modbus RTU (8-Bit)	Address	
P	COM9	Tag M. RESET	
Ba	aud Rate 38400 🗸	Connect Cancel	
Pa	arity None 💌		
St	op Bits		
	Connect Via Polling		_
	Connect via Guided	Connection Wizard	
🎒 🔝 🌢 🧿 🗃 🐼		FR 🔟 💏 ┥ 隆	i 🎯 🗚 🧕 🌌 🧱 📑 🌗 🏲 👍 08:59

9. A status bar appears as shown below:

Connect	to Physical Device	×
Connection Pa	rameters	Connect
Protocol	Modbus RTU (8-Bit)	Address
PC Port	COM9	Tag M. RESET
Baud Rate	38400	15 %
Parity	None	Time Remaining: 15 Seconds Connecting to device
Stop Bits	1	Connect Cancel
Connect Vi	a Polling	
	Connect via Guide	J Connection Wizard

The main flow meter window appears, with a smaller "meter verification" window on front.
 Close the "meter verification" small window by clicking "ok".

le Tools He	łp				Search
O	Process Variables >				Outputs
	Mass Flow Rate mAO1 (Chan.A), mAO3 (Chan.C), FO 2 (Chan.B)	External Temperature 🔹 🔻	External Pre	ssure 🔻	mAO1 - Chan.A - Mass Flow Rate
Connected	ANNI IIIII	un lun,	una.	un,	4.00065 mA
evice Tools 🕨	-360 360	25 75	25 50	75	mAO3 - Chan.C - Mass Flow Rate
nnect To:	and a second sec		111	0.00	3.98862 mA
Physical		- 0 100 -		100 -	FO 2 - Chan.B - Mass Flow Rate
Simulation	Totalizer 1 - Mass Fwd Total	You have following feature(s) with temporary	license for 86 Day(s).		
Go	3888.32300 kg Reset	Meter Verification			
	3888.32308 kg				0.2 bar
					External Temperature
	Alerts > X			w Ack All	21.4 °C
	1 Out of Specification				mAI - Chan.D - External Pressure
				e Ack	4.32077 mA
	Process Aberration		ОК		Diagnostic Variables
	2 Others				Drive Gain
			Act	tive	7.472 %
	Configuration Changed		N	•	Left Pickoff Amplitude 0.147 Volts
			Te	<u> </u>	Dight Diskoff Amplitude
					0.148 Volts
					Raw Tube Frequency
	🔁 Modbus Device Ir	nformation			152.872 Hz

11. Open the "smart zero verification and calibration" tool by clicking on "Device Tools > Calibration > Smart Zero Verification and Calibration" as shown below.

ProLink III v3.5			
File Tools Help			Search 🔎 💌
Process Variables >			Outputs
Mass Flow Rate M. RESET[1] - 570 M. RESET[1] - 570	External Temperature	External Pressure	mAO1 - Chan.A - Mass Flow Rate
Seconected	25 75 75 V	50	mAO3 - Chan.C - Mass Flow Rate
Alerts			4.01773 mA
Wizards , -1.3 kg/hr	- 0 100 - 21.4 °C	- 0 - 100 - 0.2 bar	FO 2 - Chan.B - Mass Flow Rate 1.23217 Hz
Calibration Data L - Mass Fwd Total g Ress	Totalizer 2 - Volume Fwd Total V 4003.4441 Reset	Drive Gain v 7.473 %	Inputs
Configuration 1 - Mass Fwd Inv Calibration Smart Zero Verification and Cali	Inventory 2 - Vol Fwd Inv	Temperature	External Pressure
Configuration Transfer Density Calibration	> >		External Temperature
Diagnostics MA Input Trim			21.4 °C
Transmitter Software Update			MAI - Chan.D - External Pressure 4.32077 mA
Totalizer Control			Diagnostic Variables
Device Information			Drive Gain 7.470 %
Disconnect			Left Pickoff Amplitude
			0.147 Volts
			0.148 Volts
Modbus Device	information		Raw Tube Frequency 152.873 Hz
		🧮 FR 📑 💏 📣 🔀	🌀 🛠 🧕 💯 🛃 🔐 🌗 🏴 👍 09:02

- 12. Make sure that the meter is filled with water, with no air pockets. Stops the flow inside the meter, ideally by closing any upstream and downstream valves closest to the flowmeter.
- 13. Click on "Verify Zero" as seen below.

ProLink III v3.5						x
File Tools Hel	lp				Search	◄ م
M. RESET[1] - 570 Connected Device Tools	Process Variables }	External Temperature	External Pressure	Out mA 4.01 mA 4.01	uputs ▶ Ol - Chan.A - Mass Flow Rate 0065 mA O3 - Chan.C - Mass Flow Rate 9479 mA	
Physical Simulation Offline		0 100 - 21.4 °C Totalizer 2 - Volume Fwd Total volume Fwd Total		FO 0.0	2 - Chan.B - Mass Flow Rate 1905 Hz	
Go	Inventory 1 - Mass Fwd Inv V 3888.388 kg	Inventory 2 - Vol Fwd Inv v 4003.4811	Temperature v 21.575 °C	Ext 0.2	ernal Pressure bar	
	Smart Zero Verification and Calibration ×	0 %		Ext 21.4 mA 4.24	ernal Temperature 4 °C J - Chan.D - External Pressure 4953 mA	
	Zero Verification is ready to run • The Zero Verify provides an analysis of recommends if new zero is needed. • It should be run prior to any meter zero • Ensure the meter is blocked in and no	of the current meter zero setting and ro. flow is present.		Dia Dri 7.4 Lef	gnostic Variables ►) ve Gain 72 % t Pickoff Amplitude	
	Click Verify Zero to perform the test.		Verify Zero Calibrate Zero Cancel	0.14 Rig 0.14 Ray	47 Volts ht Pickoff Amplitude 48 Volts w Tube Frequency	
	Tevice In	formation	🗄 FR 🔟 💏 🕇 隆	152 © *	.873 Hz 	2:04

	Process Variables >			Outputs >
	Mass Flow Rate 🗸 🗸	External Temperature 🔹	External Pressure	
ESET[1] - 570	mAO1 (Chan.A), mAO3 (Chan.C), FO 2 (Chan.B)			mAO1 - Chan.A - Mass Flow Rate
Connected	ANNI THURS	and truthe	, ريينا يېسى	3.99903 mA
ce Tools 🕨	-360 360 III	25 75	50 50 50 50 50 50 50 50 50 50 50 50 50 5	mAO3 - Chan.C - Mass Flow Rate 4.00802 mA
		- 0 100-	- 0 - 100 -	FO 2 - Chan.B - Mass Flow Rate
ysical	2.4 kg/hr	21.4 °C	0.2 bar	0.57665 Hz
line	Totalizer 1 - Mass Fwd Total	Totalizer 2 - Volume Fwd Total	Drive Gain	
ine	3888.394 kg Reset	4003.4881 Reset	7.472 %	
Go	Inventory 1 - Mass Fwd Inv 🔻	Inventory 2 - Vol Fwd Inv 💌	Temperature 🗸	External Pressure
	3888.395 kg	4003.4881	21.541 °C	0.2 bar
		20 %		MAI - Chan.D - External Pressure 4.31602 mA
	Zero Verification is in progress	20 %		mAI - Chan.D - External Pressure 4.31602 mA ☐ Diagnostic Variables ►
	Zero Verification is in progress	20 %		mAI - Chan.D - External Pressure 4.31602 mA Diagnostic Variables ► Drive Gain
	Zero Verification is in progress	20 %		MAI - Chan.D - External Pressure 4.31602 mA Diagnostic Variables • Drive Gain 7.472 %
	Zero Verification is in progress	20 %		mAI - Chan.D - External Pressure 4.31602 mA Diagnostic Variables ► Drive Gain 7.472 % Left Pickoff Amplitude
	Zero Verification is in progress	20 %		MAI - Chan.D - External Pressure 4.31602 mA Diagnostic Variables ► Drive Gain 7.472 % Left Pickoff Amplitude 0.147 Volts
	Zero Verification is in progress	20 %		mAI - Chan. D - External Pressure 4.31602 mA Diagnostic Variables ► Drive Gain 7.472 % Left Pickoff Amplitude 0.147 Volts
	Zero Verification is in progress	20%	Verify Zero Calibrate Zero Cancel	mAI - Chan.D - External Pressure 4.31602 mA Diagnostic Variables ► Drive Gain 7.472 % Left Pickoff Amplitude 0.147 Volts Right Pickoff Amplitude 0.382 Volts
	Zero Verification is in progress	20 %	Verify Zero Calibrate Zero Cancel	mAI - Chan. D - External Pressure 4.31602 mA Diagnostic Variables ► Drive Gain 7.472 % Left Pickoff Amplitude 0.147 Volts Right Pickoff Amplitude 0.148 Volts
	Zero Verification is in progress	20 %	Verify Zero Calibrate Zero Cancel	mAI - Chan.D - External Pressure 4.31602 mA Diagnostic Variables ▶ Drive Gain 7.472 % Leff Pickoff Amplitude 0.147 Volts Right Pickoff Amplitude 0.148 Volts Raw Tube Frequency

14. A "zero verification in progress" status bar appears as shown below.

15. Click on "Calibrate Zero" to perform the zeroing of the meter as shown below.

ProLink III v3.5		_		
File Tools Hel	p			Search 🔎 💌
	Process Variables		[]	Outputs
M RESET[1] - 570	Mass Flow Rate mAO1 (Chan.A), mAO3 (Chan.C), FO 2 (Chan.B)	External Temperature 🔹	External Pressure	mAO1 - Chan.A - Mass Flow Rate
S Connected	NNNNN UNIT	50	50	4.00065 mA
Device Tools	360 360	25 75	25 75	mAO3 - Chan.C - Mass Flow Rate 3.98862 mA
Connect To:	-720 720	- 0 100 -	- 0 100 -	FO 2 - Chan.B - Mass Flow Rate
Simulation	-2.2 kg/hr	21.4 °C	0.2 bar	0.00000 Hz
Offline	Totalizer 1 - Mass Fwd Total	Totalizer 2 - Volume Fwd Total V 4003.503 I Reset	Drive Gain 7.472 %	Inputs >
<u> </u>	Inventory 1 - Mass Fwd Inv 🔻 3888.409 kg	Inventory 2 - Vol Fwd Inv 🔻 4003.503 I	Temperature ▼ 21.568 °C	External Pressure 0.2 bar
)		External Temperature
	Smart Zero Verification and Calibration		•	21.4 °C
		0 %		mAI - Chan.D - External Pressure
	Zero Verification is ready to run			Drive Gain
	 The Zero Verity provides an analysis of recommends if new zero is needed. 	or the current meter zero setting and		7.472 %
	Ensure the meter is blocked in and no Click Verify Zero to perform the test	flow is present.		Left Pickoff Amplitude
				Diska Disks (f Asselfands
		l	Verify Zero Calibrate Zero Cancel	0.148 Volts
				Raw Tube Frequency
	The Modbus Device In	formation		152.8/4 Hz
	o 🛛 🚿 🗢	1000 March 1000	🛛 🕅 🕅 🂏 📣 🌠	🎯 🖇 🧕 🎉 🛃 🔐 🌗 🏲 👍 09:05

TOOIS He	lp			Search
O	Process Variables >			Outputs >
	Mass Flow Rate mAO1 (Chan.A), mAO3 (Chan.C), FO 2 (Chan.B)	External Temperature	External Pressure	mAO1 - Chan.A - Mass Flow Rate
Connected	360 360 E	25 75 E	25 75 15	3.99903 mA mAO3 - Chan.C - Mass Flow Rate 4.00479 mA
hysical	≟ -720	≟ 0 100 ≟ 21.4 °C	<u> </u>	FO 2 - Chan.B - Mass Flow Rate 0.30195 Hz
Offline	Totalizer 1 - Mass Fwd Total 💌 3888.417 kg Reset	Totalizer 2 - Volume Fwd Total v 4003.511 Reset	Drive Gain 7.473 %	Inputs >
Go	Inventory 1 - Mass Fwd Inv 🛛 🔻 3888.417 kg	Inventory 2 - Vol Fwd Inv 4003.5111	Temperature 21.569 °C	External Pressure 0.2 bar
	Zero Calibration ×			External Temperature 21.4 °C
	 Zero Calibration Zero Time 	30	Sec	mAI - Chan.D - External Pressure
	Zero Value	0.01434) µsec	4.30547 mA
	Zero Standard Deviation	0.00000	µsec	Drive Gain
	Calibration ready to run			7.473 %
				Left Pickoff Amplitude 0.147 Volts
	Calibrate Zero) Rest	tore Prior Zero Stop Calibration Restore	Factory Zero Cancel Apply	Right Pickoff Amplitude 0.148 Volts
	Modbus Device In	formation		Raw Tube Frequency

16. Click on "Calibrate Zero" in the new page as shown below.

17. A "Calibration in progress" status bar appears as shown below.

ols He	elp			Search
1	Process Variables >			Outputs b
1 570	Mass Flow Rate mA01 (Chan.A), mA03 (Chan.C), FO 2 (Chan.B)	External Temperature 🔹	External Pressure	mA01 - Chan.A - Mass Flow Rate
ected	NNNN INTING	50	50	4.00065 mA
ls ►	360 360	25 75	25 75	mAO3 - Chan.C - Mass Flow Rate 4.00641 mA
	-720 720 - -5.9 kg/hr	= 0 100 = 21.4 °C	- 0 100 - 100 -	FO 2 - Chan.B - Mass Flow Rate 0.43039 Hz
n	Totalizer 1 - Mass Fwd Total	Totalizer 2 - Volume Fwd Total	Drive Gain 💌	
5 1	3888.432 kg Reset	4003.5251 <u>Reset</u>	7.482%	Inpus P
4	Inventory 1 - Mass Fwd Inv 🔻	Inventory 2 - Vol Fwd Inv	Temperature •	External Pressure
)[
	Zero Calibration ×			External Temperature 21.4 °C
	✓ Zero Calibration			mAL Chan D. External Process
	Zero Time	30	Sec	4.31444 mA
	Zero Value	0.01434) µsec	Diagnostic Variables
	Zero Standard Deviation	0.00000	usec	
			y ·	Drive Gain 7.483 %
		2 %		1.105 7
	Calibration in Progress		_	Left Pickoff Amplitude 0.147 Volts
	Calibrate Zero Res	store Prior Zero Stop Calibration Restore	Factory Zero Cancel Apply	Right Pickoff Amplitude 0.148 Volts
				Bau Tuba Francisco

18. Click on "Apply" and close the "Zero calibration" tab.

ProLink III v3.5				
File Tools Help	p			Search 🔎 👻
	Process Variables >			Outputs >
	Mass Flow Rate mAO1 (Chan.A), mAO3 (Chan.C), FO 2 (Chan.B)	External Temperature 🗸 🔻	External Pressure 💌	mAO1 - Chan.A - Mass Flow Rate
Connected	ANNI UTITI	ANNI United	Samulun _n	3.99903 mA
Device Tools ►	-360 360	25 75	25 75	mAO3 - Chan.C - Mass Flow Rate
Connect To:				4.00517 mA
Physical		- 0 100 - 21.4 °C	0.2 bar	FO 2 - Chan.B - Mass Flow Rate 0.71635 Hz
 Offline 	Totalizer 1 - Mass Fwd Total	Totalizer 2 - Volume Fwd Total	Drive Gain 💌	Inputs >
G0	3888.443 kg Reset	4003.5371 Reset	7.474 %	
	3888 444 kg	4003 5371	21 566 °C	External Pressure
				0.2 bar
	Zero Calibration ×		•	External Temperature 21.4 °C
	A Zero Calibration			
	Zero Time	30	Sec	mAI - Chan.D - External Pressure
				4.32288 mA
	Zero Value	0.01259	µsec	Diagnostic Variables
	Zero Standard Deviation	0.02457	µsec	
				Drive Gain
	Calibration was successful.			7.474 70
				Left Pickoff Amplitude
				0.147 Volts
	Calibrato Zoro	toro Drior Zoro Stop Calibration Postoro D	actony Zoro Cancol Apply	Right Pickoff Amplitude
	Calibrate Zeroj (ites	tore mor zero [otop Calibration] [Restore i	concer Apply	0.148 Volts
ſ				Raw Tube Frequency
	🚔 Modbus Device In	formation		152.874 Hz
- 🥂 👘 👘 🔥				🙆 🔹 🛜 🥨 😨 🕞 📣 🕨 🖉 00-07

19. Close Prolink III by closing the main window and choose "yes" to confirm the closing as shown below.

	(
e))	Process Variables >]	Outputs >
	Mass Flow Rate mAO1 (Chan.A), mAO3 (Chan.C), FO 2 (Chan.B)	External Temperature 🗸	External Press	sure 🔻	mAO1 - Chan.A - Mass Flow Rate
Connected	ANNI DIG	ANNI UUU	unun a	un,	4.00065 mA
e Tools 🕨	360 360	25 75	25	75	mAO3 - Chan.C - Mass Flow Rate 4.01449 mA
ect To:	-720 720	ProLink III	<u> </u>	100 -	FO 2 - Chan.B - Mass Flow Rate
nulation	-0.2 kg/hr	The processes listed below are active. If you c	ontinue, any data logging		0.21564 Hz
fline	Totalizer 1 - Mass Fwd Total	will be stopped, unwritten configuration data device connections will be terminated.	will be discarded, and		Inputs ►
Go	Inventory 1 - Mass Fwd Inv	• M. RESET [1] - 5700 Configurable I/O , Devi	ce Connected.		External Pressure
					0.2 bar
	Zero Calibration ×			•	External Temperature 21.4 °C
	✓ Zero Calibration				mAI - Chan.D - External Pressure
	Zero Time				4.28436 mA
	Zero value	Do you want to close Drol ink III?			Diagnostic Variables
	Zero Standard Deviation	Do you want to close ProLink III?	Yes No		Drive Gain
	Calibration was successful.				1.412 70
					Left Pickoff Amplitude 0.147 Volts
	Calibrate Zero	store Prior Zero Stop Calibration Pertore I	Eactory Zero	Apply	Right Pickoff Amplitude
	Calibrate Zero	store mor zeroj (stop Calibration) (Restore h	Calice	Apply	0.148 Volts
					Raw Tube Frequency

3.2 Recording digital outputs

Digital flow, pressure and temperature values can be recorded at 20 Hz sampling frequency by using the MODCOM software. Follows the steps below to record the digital outputs.

1. Start MODCOM by double-clicking its shotcut on the laptop desktop:

	#			💊 MODCom [Ver. 18:10:31]
CETIAT	Firefox	16678	TELETRAVAIL	Tools Settings Advanced Help
		TCLAP2.txt	CETIAT	Common MVD Pegasus I/O Orion SMV Custom
Qrdinateur	Google	16678 TeMP	Windows XP	Mass Flow Cutoff - Mass Volume Flow Cutoff - Vol Density Cutoff - Dens Temp - Line Units - Mass Flow
🚯 Réseau	MODCom	Bureau Citrix		Total - Mass Units - Volume Flow Total - Mass Units - Density Total - Volume Units - Temperature Delta T Reset All Totals Tube Freq Perform Zero Tube Period Perform DenGal Air Drube wa Perform DenGal H20
Corbeille	ProLink III v3.5 Basic	Citrix Web		Drive % Perform Dencal T D3/K3 Orive Target mVHz Perform Dencal T D3/K3 Pr0 Amp (Filt) DCF - D1 PR0 Amp (Filt) DCF - D2 Pr0 Amp (Pk Det) DCF - K1 PR0 Amp (Pk Det) DCF - K1
AppliDis Desktop	Valise etalon	EasyLogUSB V7.5.zip		Damping - Temp OCF - Flow Damping - Density FCF - Flow Damping - Density FCF - TempCo Damping - Temp OCF - TempCo Right-Click to add selected item to Datalog
FasyLog USB	16678 TCLAP byt	tt3diag3-1		Mem Addr: 247 Dev Addr: 111 Coil Reg Input Data: 0 Set
				Result:
				Status Port: 9 TX:
🤣 🗉	(1)	()	🧳 💊	FR 🔟 🎋 ┥ 🌠 🎯 🕸 🧕 🕼 🌗 🏲 🐗 09:09

2. Click on "Tools > Datalog" to open the logging window as shown below.

			- -	Section [Ver. 18.10.31]				l		~		
CETIAT	Firefox	16678	TELETRAVAII	Tools Settings Advanced	Help							
		TCLAP2.txt	CETIAT	Datalog								
				Status	gasus	1/0	Orion	SMV	Custom			
	5			Status (NE107)			utoff -	Mass				
~~				Script Tool		Öč	utoff -	Dens				
linateur	Google	CLAP tyt	Windows XP Mode	Spectrum		ω	nits - Ma	ss Flow				
	chiome	CD II ION	mode	Message Viewer			nits - Vo nits - De	lume ⊦low	1			
A	<i>6</i> .			Block Read/Write		ÖŬ	nits - Te	mperature	2			
4		2		O Delta T		R	eset All	Totals				
éseau	MODCom	Bureau Citrix		Tube Period		O P	erform Ze erform De	nCal Air				
				Drive mA		0 P	erform De	nCal H20				
	_			Drive %		P	erform De erform De	nCal T D3	3/K3			
3	ProLink	لاک ا		CLPO Amp (Filt)		ÖÞ	CF - D1	incur i ba	() K .			
orbeille	ProLink III	Citrix Web		RPO Amp (Filt)		O	CF - D2					
	v3.5 Basic			RPO Amp (Pk Det)		ÖD	CF - K1 CF - K2					
	_	_		Flow Direction		<u></u>	CF - FD					
				Damping - Mass Flow	4	F	CF - Flow CF - Temp	6				
aliDia	Valica atalaa	Facul col ICD		Damping - Temp		ÖÞ	CF - Temp	Co				
esktop	valise etaion	V7.5.zip		Right-C	lick to add	selected i	tem to Dat	alog				
**	-	-		Mom Addr: 247	Day Ac	lde: 111	Me	em Type	Get	7		
7				Well Adul. 247	Dev At	iai. 111	. 8	Reg	Oct			
.og USB	16678 TCLAP.txt	ht3diag3-1		Input Data: 0				Long Float	Set			
				Result:								
				Status 🔍					Port: 9			
				TX:								
				DV								
				nx:								

3. All parameters (mass flow, water temperature, water pressure) are already configured. Select the file path and file name you want by clicking on "File..." as shown below.

S Datalog			Station in	_ D X	
File	Dee Tree			Disalar Ostiana	
Dev Addr: 111 Rea	d Coil	Add Param	Reset Avg,STD	Standard	I/O Orion SMV Custom
Mem Addr: 247	Long	Delete Param(s)	Samples Averaged	Max Retries	Cutoff - Mass
Heading Text: Mass Flow	Float	Delete Paralit(s)	0	10	© Cutoff - Dens
Write Value:	On Comm Err	ror Write	rear 🔽 Carea Datas	Errors:	Ounits - Mass Flow
Datalog Parameters:	Cast Value		Tor Porce Kerry	0	Units - Density
Dev Mem Type Heading	Data	Avera	age STDEV	Write Value	O Units - Temperature
111 247 Float Mass Fl	W			*	Reset All Totals
111 449 Float Water T	mperature			E	O Perform Zero
111 451 Float water P	essure				Perform DenCal Air
					Perform Dencal H20
					Perform DenCal T D3/K3
					DCF - D1
					O DCF - D2
					O DCF - K1
					O DCF - K2
					OCF - FD
					FCF - Flow
					FCF - TempCo
				Ŧ	ODCF - TempCo
Datalog Filename:		Overwrite F	ile Sci Format	Hex Format	elected item to Datalog
	data	log.csv File			Mem Type
			Logging Inter	vals (ms)	dr: 111 Coil Get
Manual Text Insertion in Datalo	g/Snap		Log Delay:	10	logr logr
		Add Tex	t Variable Dela	ay: 0	Cong Set
Fixed Number of Samples		C Graph	🔲 Intervaria	ble Delay	
100 Samples/Variable	📃 Use Mem Addr	SnanShot			
		onaponoc	Stop Datalog	Start Datalog	Port: 9
			TX:		
			DV.		
			RA:		
		4			🗄 FR 📷 🔅 📣 🔀 🚳 🛠 🗿 🌌 💷 🕼 🕪 📣 09-10

4. Start the recording by clicking "Start Datalog" on the bottom right corner of the Datalog window.

Dev Addr: 111 Mem Addr: 249 teading Text: Mass Write Value: 0 Dotalog Parameter 111 247 Float 111 459 Float	Action Action Read Write Flow Heading Mass Flow Water Tenpe Water Pressi	Reg Type Coil Reg Iong Float On Comm Last Val Calanta Calanta Reg Last Val Calanta Calanta Reg Reg Reg Type Reg Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Last Calanta Reg S Reg S Calanta Calanta Reg S Calanta Reg S Calanta Reg S Calanta Calanta Reg S Calanta Reg S Calanta Reg S Calanta Cala	Add Para Delete Para Error Write lue 2 Zero 4.407989740 1.415346146 .191905797	m Reset Samples 70 € Error ♥ Fo Average -0.956682783 21.413537461 0.195670583	Avg,STD Averaged Averaged Max 1 10 10 10 10 10 10 10 10 10 1	lay Options tandard ull Retries S: Write Value	VO Orion SMV Custom Cutoff - Mass Cutoff - Vol. Cutoff - Dens Outrost - Dens Units - Nass - Nass - Dens Units - Volume Flow - Outrost - Dens Units - Density - Outrost - Density Units - Temperature - Reset All Totals - Perform Dencal Air Perform Dencal I D3/K3 - Perform Dencal I D4/K4 - DCF - D1 DCF - D1 - DCG - D2 - DCF - D2 DCF - D2 - DCF - D2 - DCF - D2 DCF - D2 - DCF - D2 - DCF - D2 DCF - D2 - DCF - D2 - DCF - D2 DCF - D2 - DCF - D2 - DCF - D2
Datalog Filename: Manual Text Insertio Fixed Number of 100 Samples	n in Datalog/Sn Samples (Variable	da ap Use Mem Ad	Cverw atalog.csv F Ad Grap Idr Sna	vrite File Log Log Id Text Va pShot Sto	Sci Format He gging Intervals (me g Delay: 10 riable Delay: 0 Intervariable Dela p Datalog	x Format ;) y	DCF - TempCo elected item to Datalog dr: 111 Coil Reg Dog Float Port: 9
				TX: RX:	6F 03 01 C2 0	0 02 6C 85 4 3E 44 0C	20

5. Stop the recording when desired by clicking on "Stop Datalog" on the bottom right corner of the Datalog window. You recording is automatically saved in a csv file.

4 The measurement procedure and calibration protocol

4.1 Conditions during measurements

Participating laboratory ensures the following conditions during the measurements:

- working fluid temperature: 20 ± 5 °C;
- ambient temperature: 20 ± 5 °C;
- ambient humidity: from 30 to 80 %;
- atmosphere pressure: from 86 to 106 kPa;
- absence in the measuring line of the standard of free air.

Before starting work, it is necessary to withstand at least 8 hours in the laboratory room.

4.2 Dynamic calibration

Perform a dynamic calibration in accordance with your internal calibration procedure, and respecting the following requirements:

• Install, purge and warm-up the validation module using your internal procedures. The package must be laying horizontally as shown in Figure 1.

- Perform a "zero" of the validation module using the protocol provided in section 3.1. Note the zero value displayed after zero calibration.
- Connect the desired output (4-20 mA, Pulses, or both) to your test rig's acquisition system.
- Record all calibrations measurements using MODCOM, following the protocol provided in section 3.2. At the same time, record all calibration measurements (from the validation meter analog/pulse output(s) and all relevant parameters (i.e. water pressure and temperature) using your test rig's acquisition system.
- Perform a dynamic calibration with water at room temperature for the at least one of the following flow profiles (depending on your volume capacity), each flow profile being repeated 3 times. The flow profiles are provided in the annex of this document and available on the METROWAMET OwnCloud server in WP1_Dynamic Load Changes / 4_Reports / A1.1.1 / Final Profiles:

https://ocloud.ptb.de/s/LRKPmz7NAxkYFYj?path=%2FWP1_Dynamic%20Load%20Changes% 2F4_Reports%2FA1.1.1%2FFinal%20Profiles

- Profile 1, 50 L, 2020-02-27_50_liter_Flow_Profile.csv
- Profile 2, 100 L, 2020-02-27_100_liter_Flow_Profile.csv
- Profile 3, 150 L, 2020-02-27_150_liter_Flow_Profile.csv
- Provide the MODCOM recordings and the following calibration data to the pilot (<u>florestan.ogheard@cetiat.fr</u>) for each individual measurement (number of lines = 3*N flow profiles):

Profile N°	Average Upstream Pressure (bar)	Average Water Temperature (°C)	Average DUT Flow Rate	Average Reference Flow Rate	Average Reference Totalized Volume	Relative Expanded Ucertainty (k=2)
Х	X.XX	XX.X	XXX.XXX	XXX.XXX	XX.XXX	X.XX %

NOTE: this table shows the minimum required data for the comparison, but you can provide any complementary data that you will see fit (pulse mass/volume, etc.).

4.3 DYNAMIC FLOW PROFILE N°1, 50 L



42	501
54	580
82	1570
94	645
105	410
123	387
141	372
160	258
179	0
209	425
304	269
319	307
330	451
423	645
443	645



4.4 DYNAMIC FLOW PROFILE N°2, 100 L

measuring time [s]	volume flow [l/h]
0	1638
10.481	655.2
39.662	345.6
106.584	302.4
126.459	248.4
138.97	568.8
160.698	363.6
173.542	464.4
187.18	338.4
294.21	334.8
348.642	756
398.457	0
428.457	381.6



4.5 DYNAMIC FLOW PROFILE N°3, 150 L

measuring time [s]	volume flow [l/h]
0	0
30	133.2

42.673	1400.4
75.298	478.8
96.197	313.2
108.364	194.4
129.474	496.8
150.319	1328.4
166.648	561.6
208.84	493.2
221.344	878.4
263.201	619.2
292.573	230.4
313.311	126
326.245	406.8
348.129	140.4
360.654	7.2
395.113	396
413.505	367.2
431.225	464.4
444.863	540
465.711	622.8
487.675	1155.6
512.853	612
530.147	565.2
559.52	565.2



5 Evaluation measurement results

The reference value will be determined for all individual flow points and will be determined on the (uncertainty) weighted average from all individual labs. All results will then be compared against this reference value. The chi-squared test will be used to identify outliers. The procedure according to **Fehler! Verweisquelle konnte nicht gefunden werden.** will be used.

References

 WGFF, WGFF Guidelines for CMC Uncertainty and Calibration Report Uncertainty, technical report, October 2013, available online at <u>http://www.bipm.org/utils/en/pdf/ccm-wgff-guidelines.pdf</u>