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 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€.

Tab.1 – Participants and time schedule

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 florestan.ogheard@cetiat.fr (00 33) (0)4 72 44 59 45		1.9.2020 to 11.9.2020
PTB	Germany	Physikalisch-Technische Bundesanstalt (PTB) Fachbereich 1.5 Flüssigkeiten Bundesallee 100, 38116 Braunschweig	Daniel Schumann daniel.schumann@ptb.de +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

VTT					26.10.2020 to 6.11.2020
CMI	Czech Republic	Czech Metrology Institute Department of Fluids Flow, Flow Velocity and Heat Okruzni 31, 638 00 Brno, Czech Republic	Miroslava Benková mbenkova@cmi.cz 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 oliver.buker@ri.se		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):

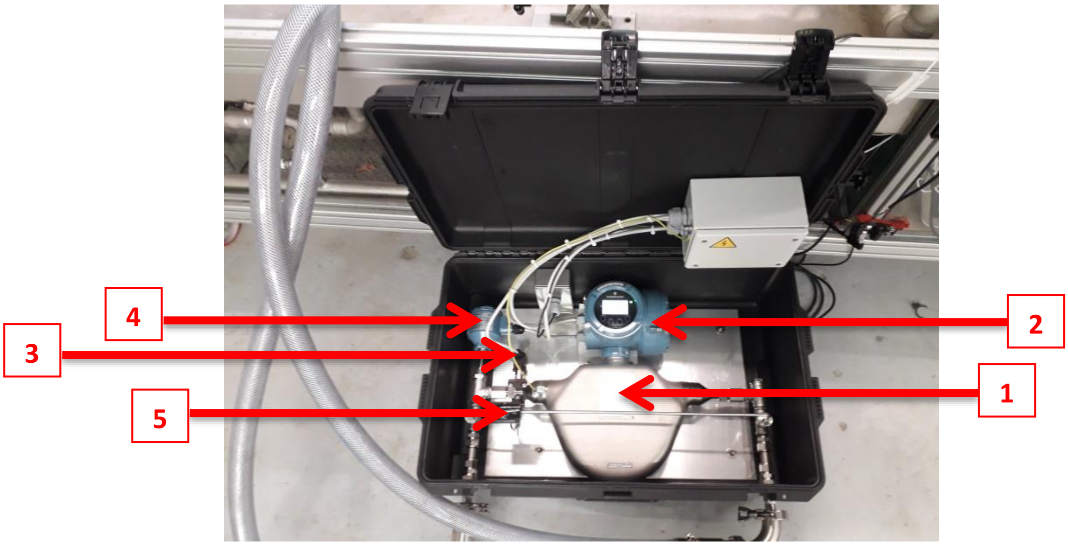


Figure 1: Inner view of the validation module

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

1. 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.

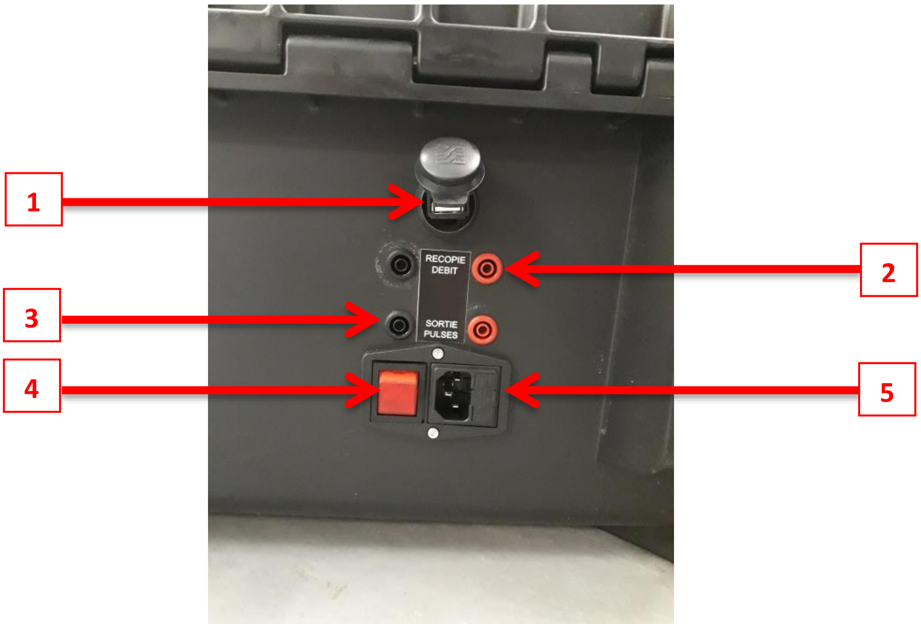
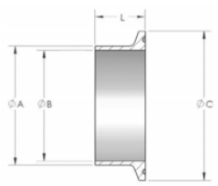


Figure 2: back side of the validation module

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:



Applications : chimie, pharmacie, agro-alimentaire

- Conforme à la norme ISO 1127
- Aucune zone de rétention
- Etat de surface standard : Ra ≤ 0.8 µm
  Electro-polissage sur demande (Ra ≤ 0.38 µm)

Construction : inox 316 L
Autres matériaux : inox spéciaux, Hastelloy®, titane…

Use : food & dairy, pharmaceuticals & chemicals

- *Conformity to ISO 1127 standard*
- *No dead zone*
- *Surface finish : Ra ≤ 0.8 µm*

Electro-polishing on request (Ra ≤ 0.38 µm)

Construction : 316 L
Others : special s. steels, Hastelloy®, titanium...

Type	Micro Clamp		Mini Clamp			Clamp															(*) non standard
Réf.	13001		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	
Ø B (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	
Ø C (mm)	25.4		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									28.0						
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.

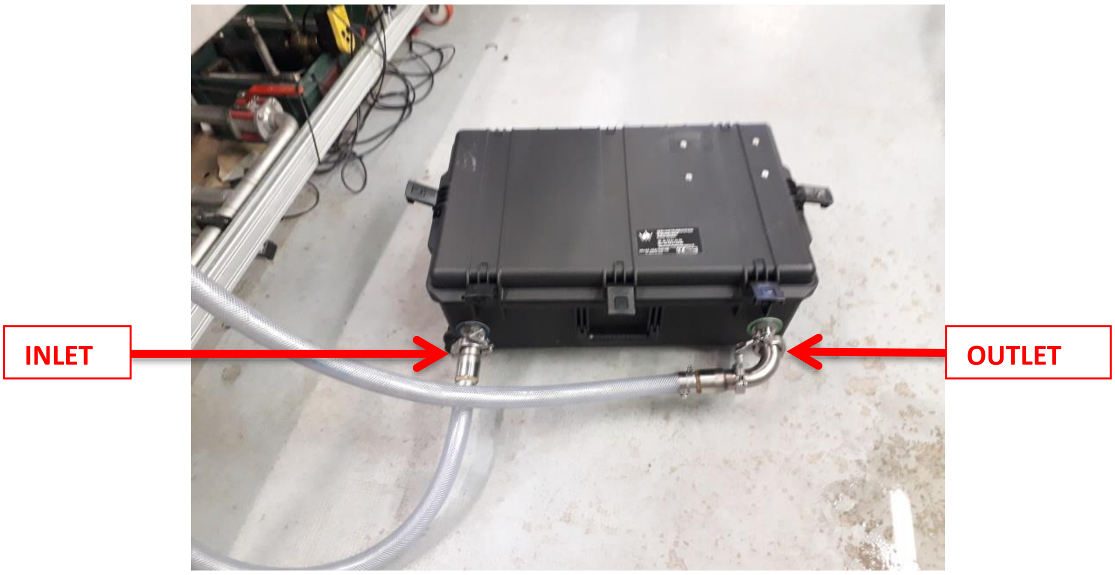


Figure 4: inlet (left side) and outlet (right side) view of the validation module

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

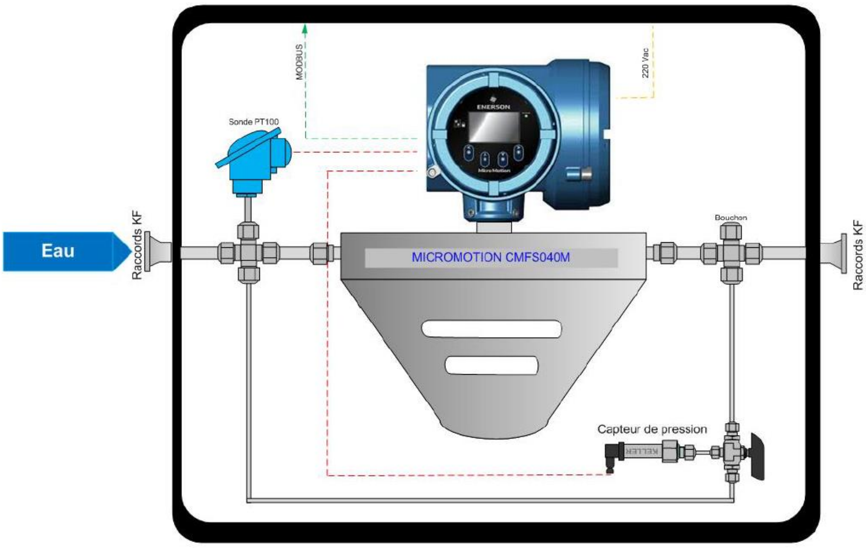


Figure 5: schematic of the validation module

PC time synchronisation:

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

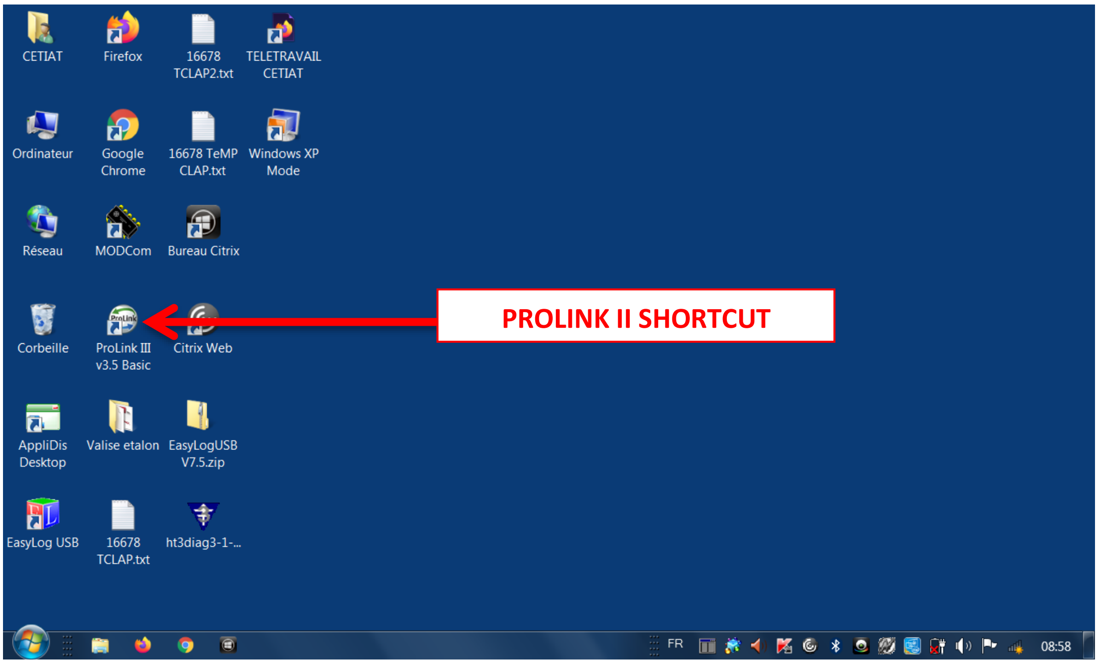
The following link provide a protocol to synchronise to NIST time:

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

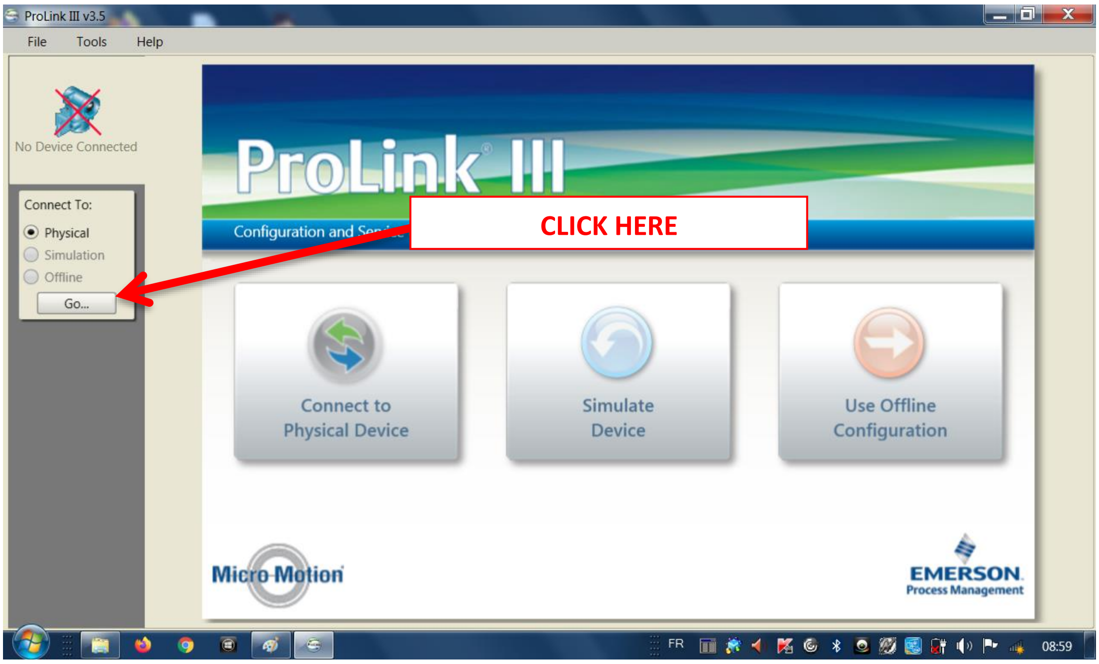
3.1 Zeroing the flow meter

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.

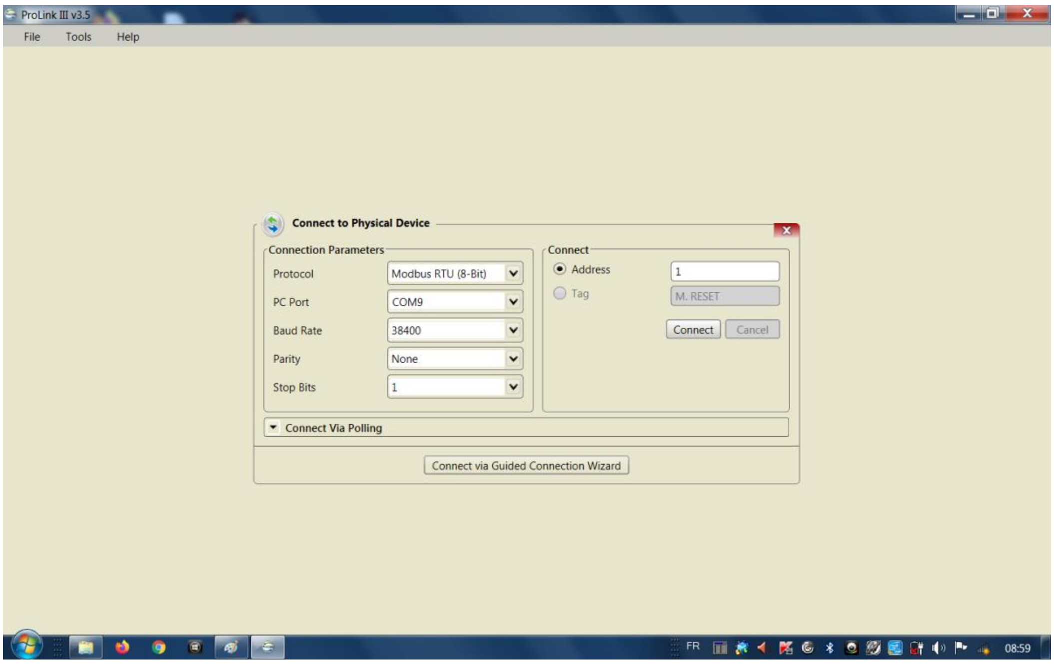
1. Turn on the laptop provided.
2. On the first screen displaying at the laptop startup, enter the code "2042" to unlock the hard-drive.
3. Login by clicking on "CETIAT" user. No password is required.
4. Connect the validation module to the laptop provided using a MALE-MALE USB cable (one is provided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



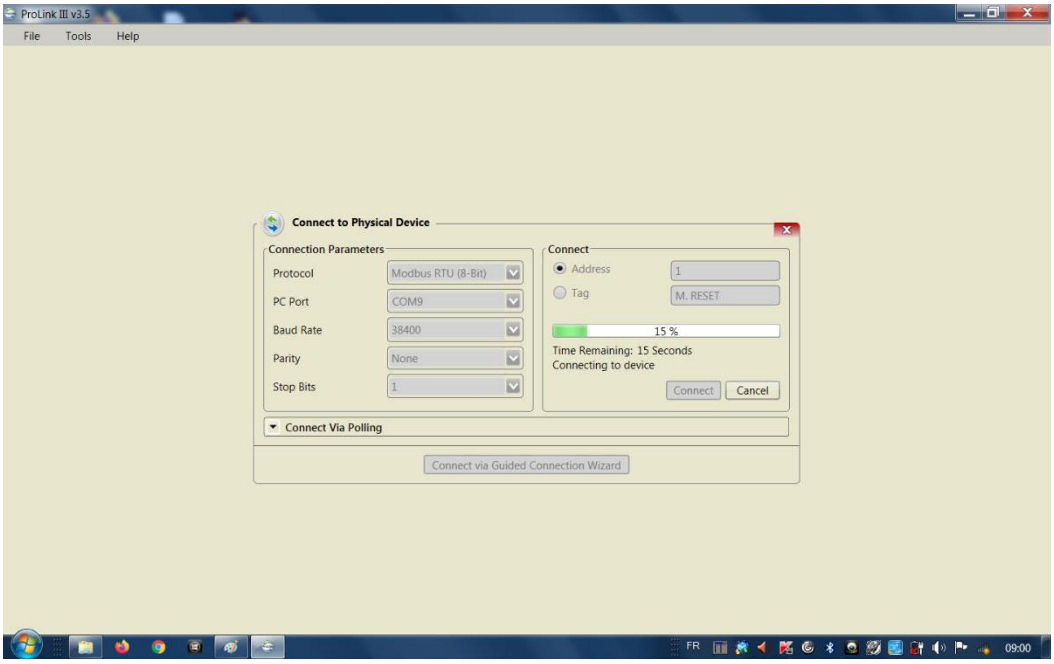
7. Click on "Physical" then click on "Go" to start the connection assistant:



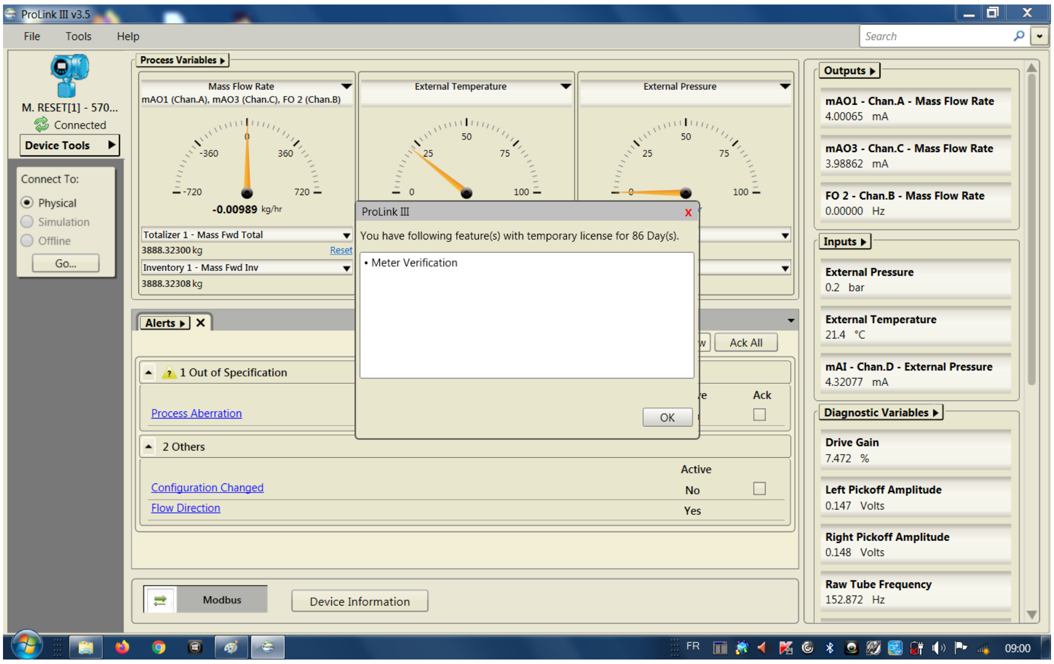
8. Select the parameters as seen below, then click on "Connect". If the connection fails, check that the validation module in powered on and if the USB cable connector's are plugged in. You may also need to change the PC port number (check using the Windows device manager).



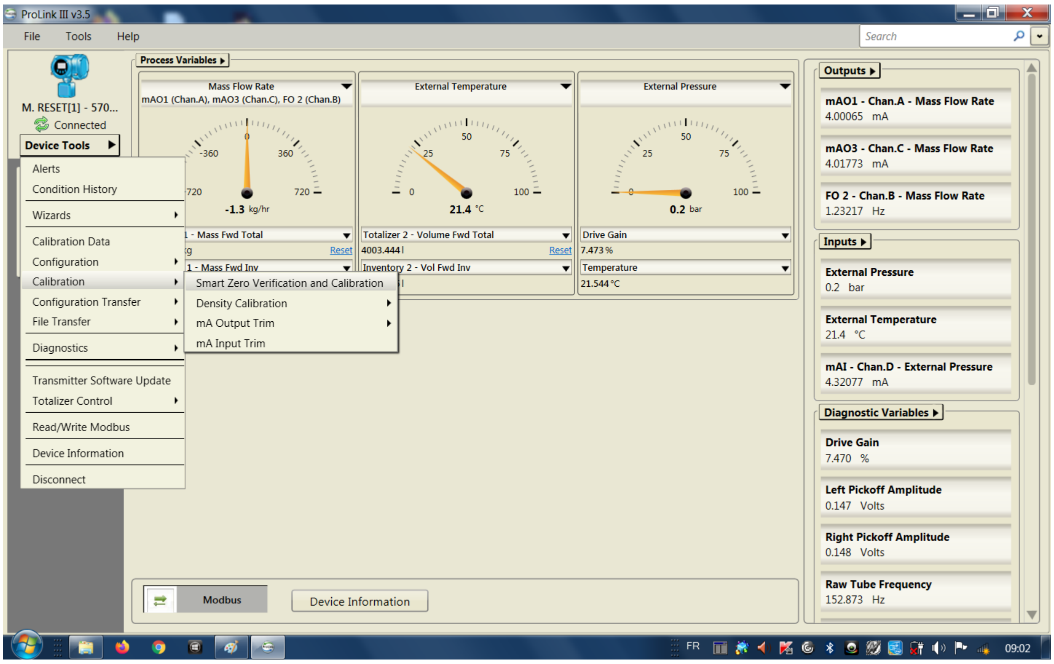
9. A status bar appears as shown below:



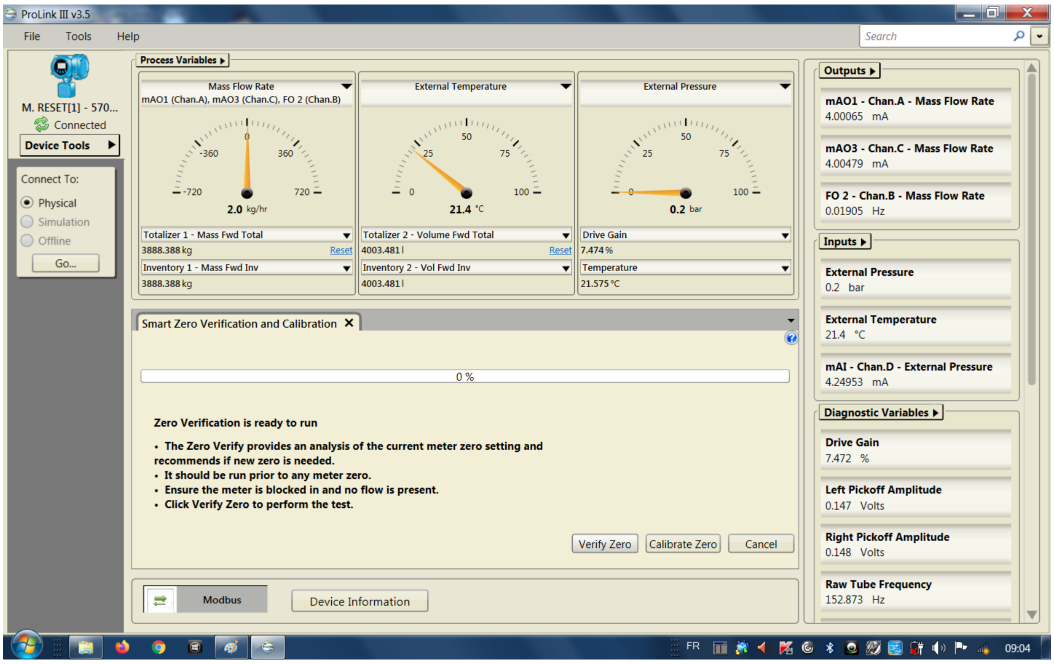
10. The main flow meter window appears, with a smaller "meter verification" window on front. Close the "meter verification" small window by clicking "ok".



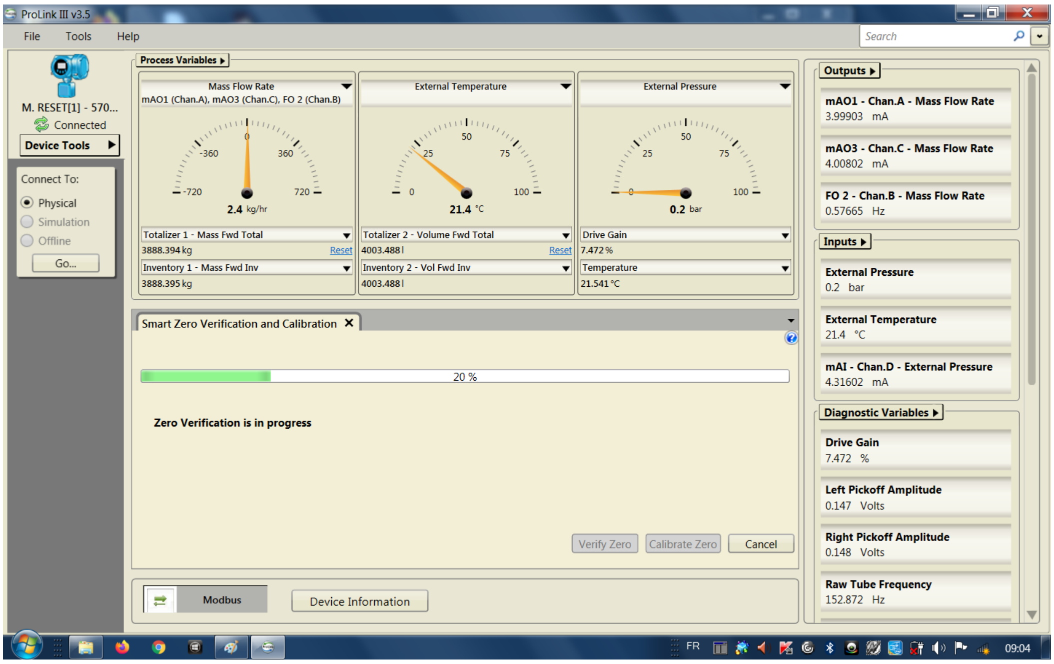
11. Open the "smart zero verification and calibration" tool by clicking on "Device Tools > Calibration > Smart Zero Verification and Calibration" as shown below.



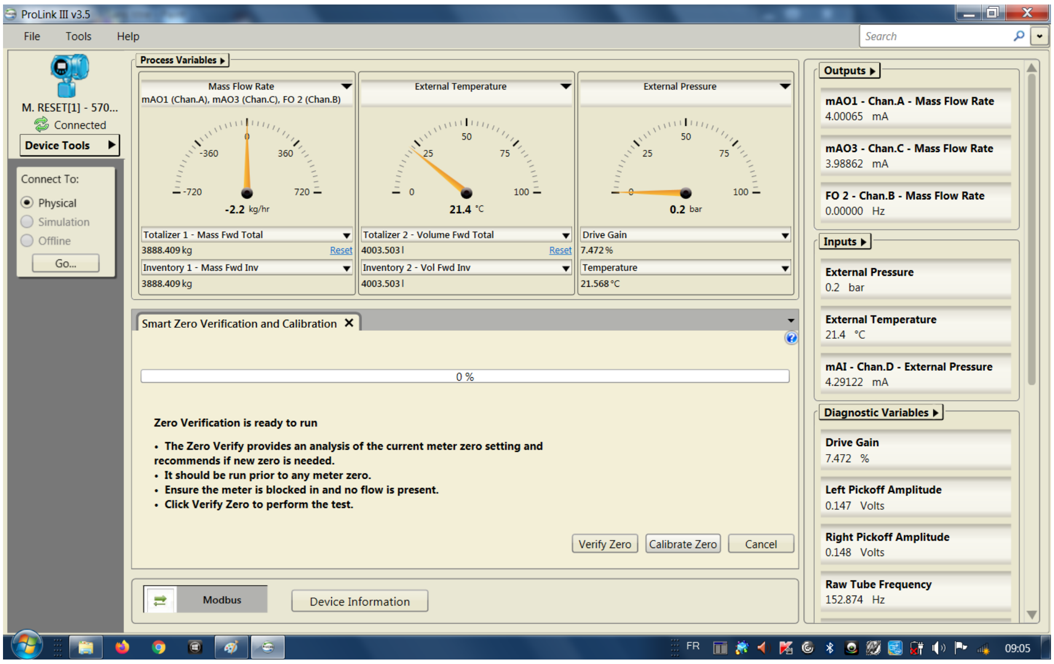
12. Make sure that the meter is filled with water, with no air pockets. Stops the flow inside the meter, ideally by closing any upstream and downstream valves closest to the flowmeter.
13. Click on "Verify Zero" as seen below.



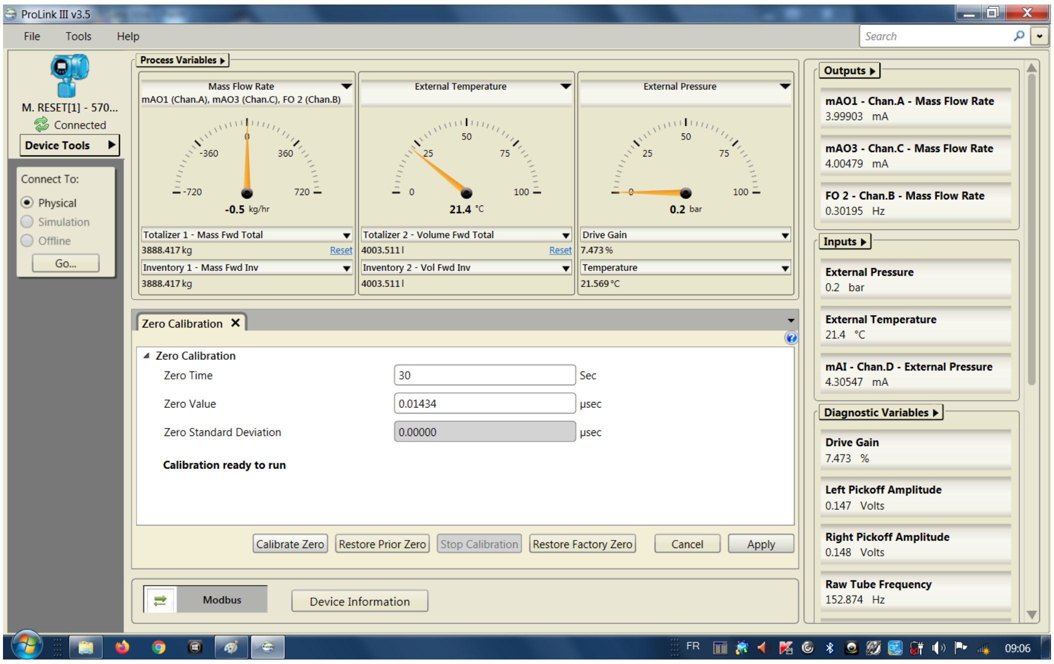
14. A "zero verification in progress" status bar appears as shown below.



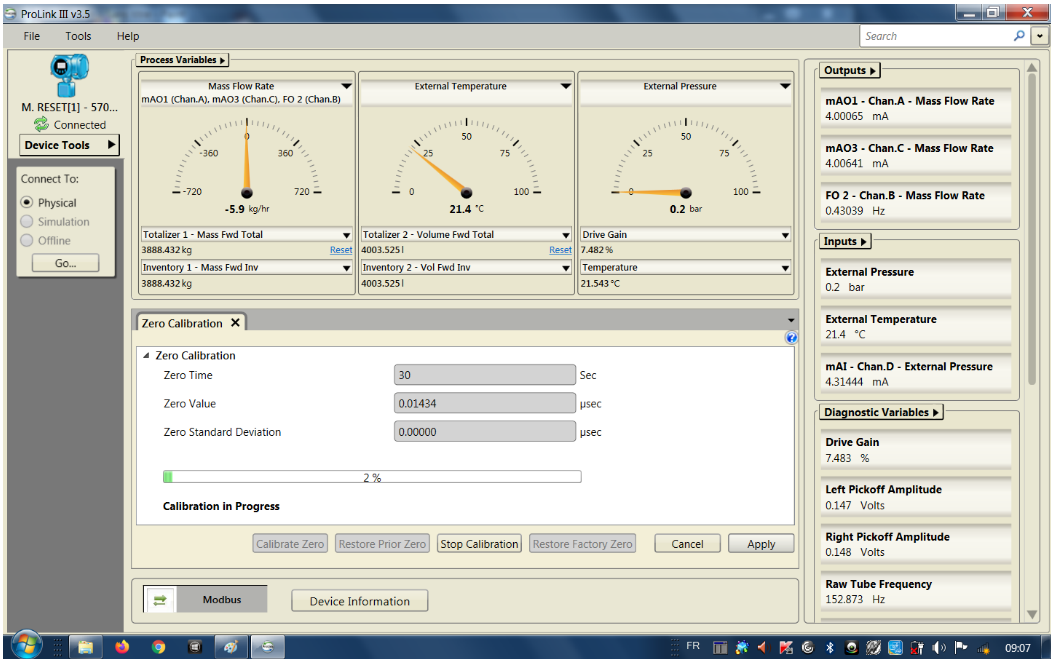
15. Click on "Calibrate Zero" to perform the zeroing of the meter as shown below.



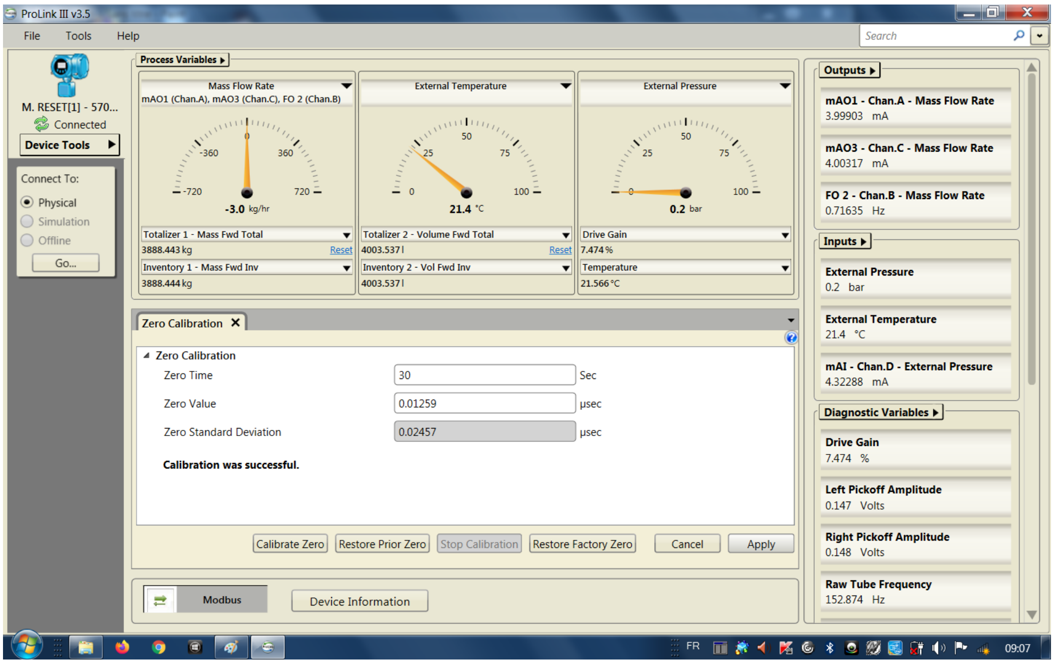
16. Click on "Calibrate Zero" in the new page as shown below.



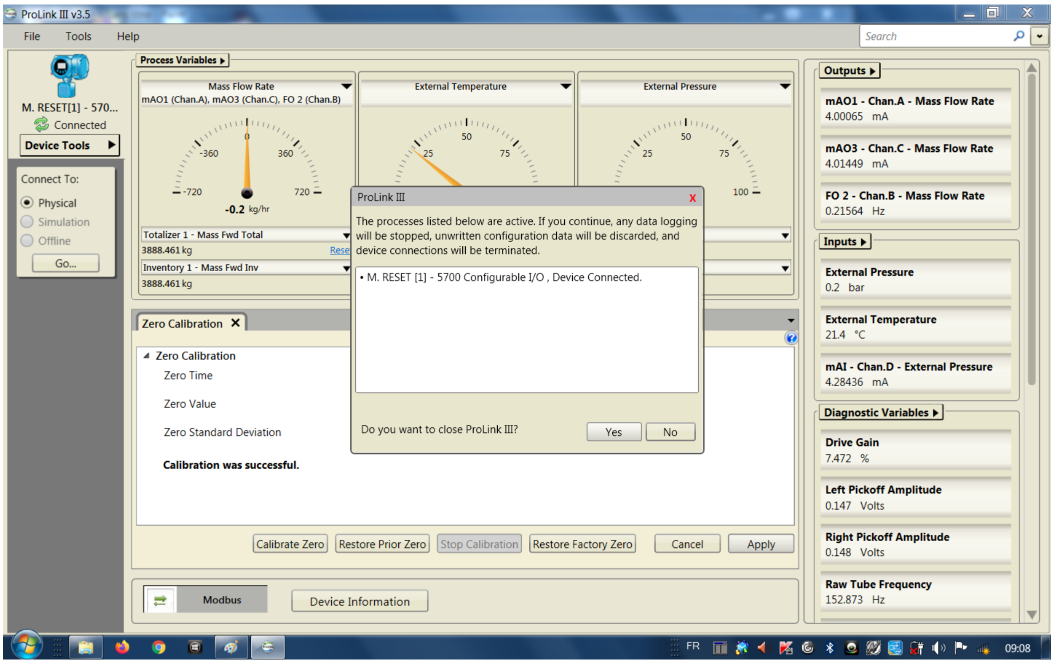
17. A "Calibration in progress" status bar appears as shown below.



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



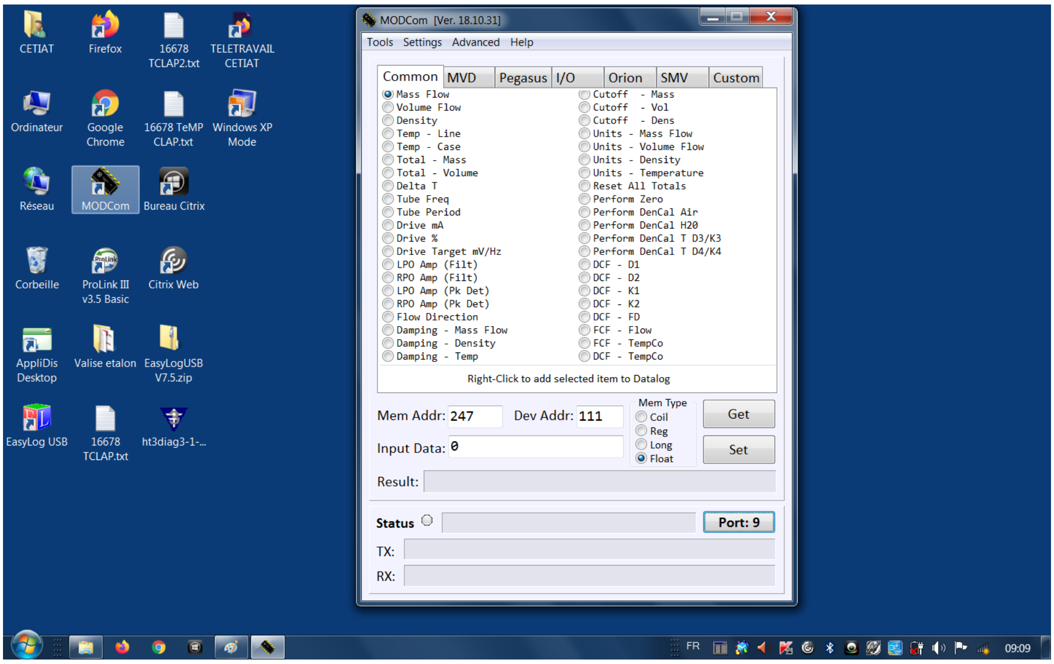
19. Close Prolink III by closing the main window and choose "yes" to confirm the closing as shown below.



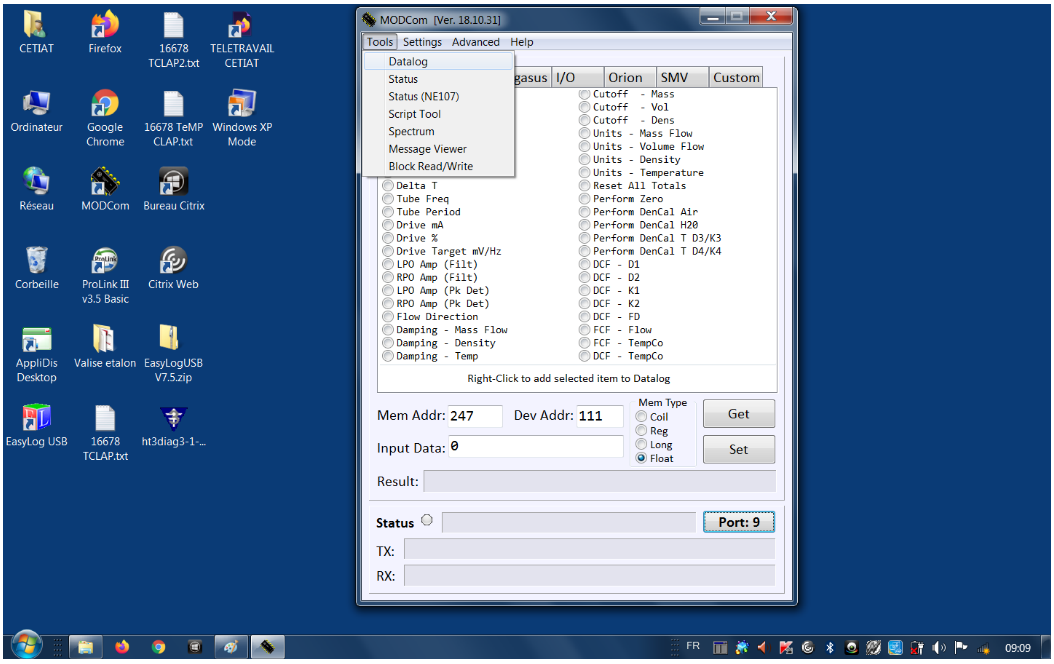
3.2 Recording digital outputs

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.

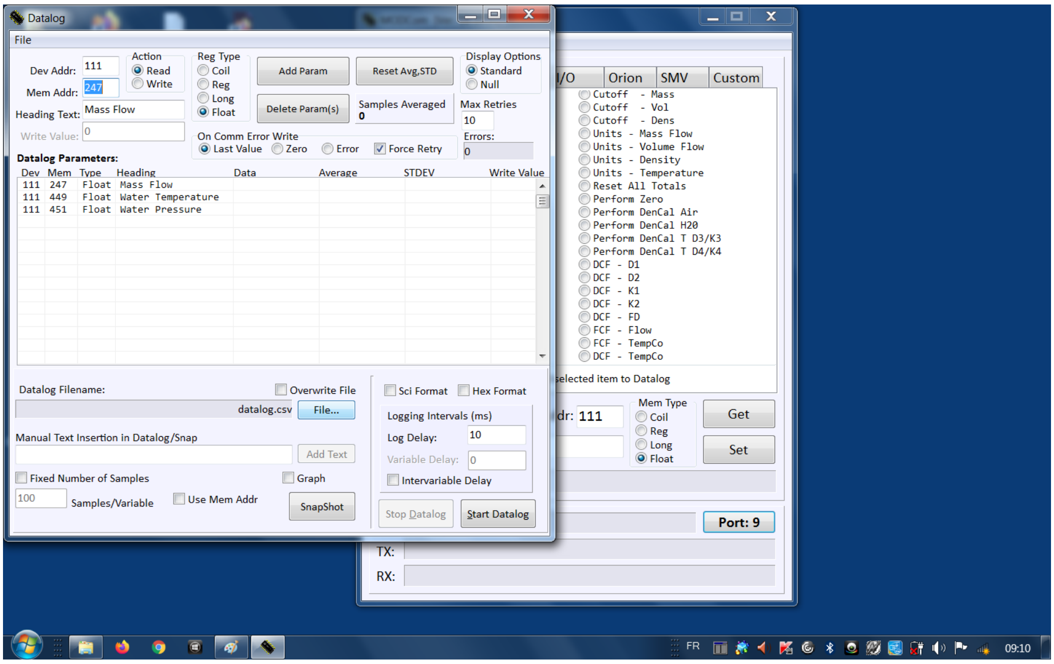
1. Start MODCOM by double-clicking its shotcut on the laptop desktop:



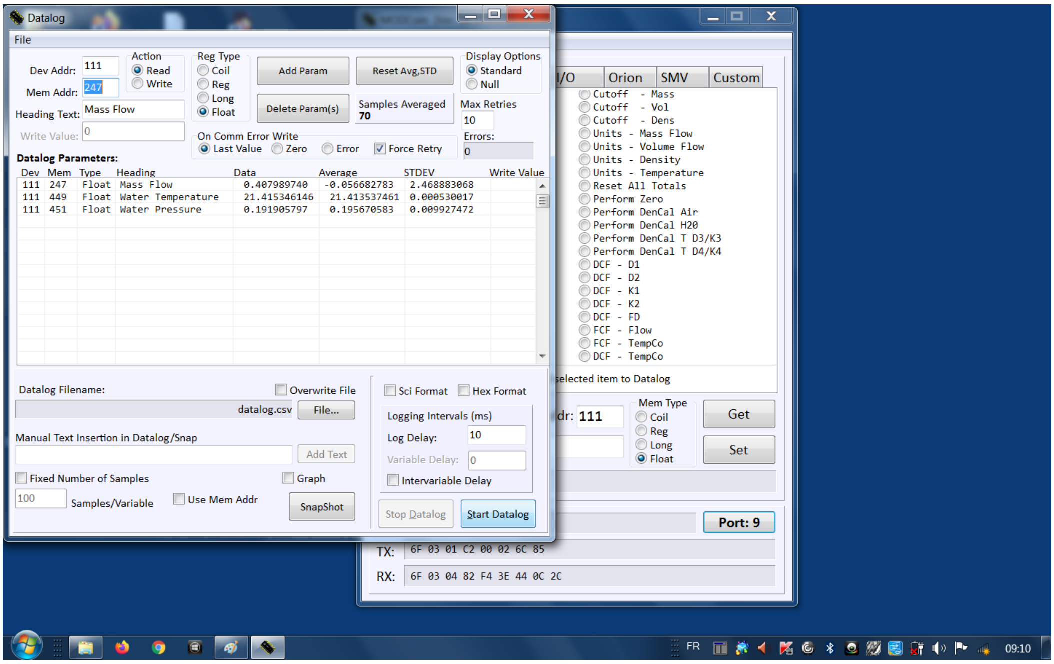
2. Click on "Tools > Datalog" to open the logging window as shown below.



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.



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



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 (florestan.ogheard@cetiat.fr) for each individual measurement (number of lines = 3*N flow profiles):

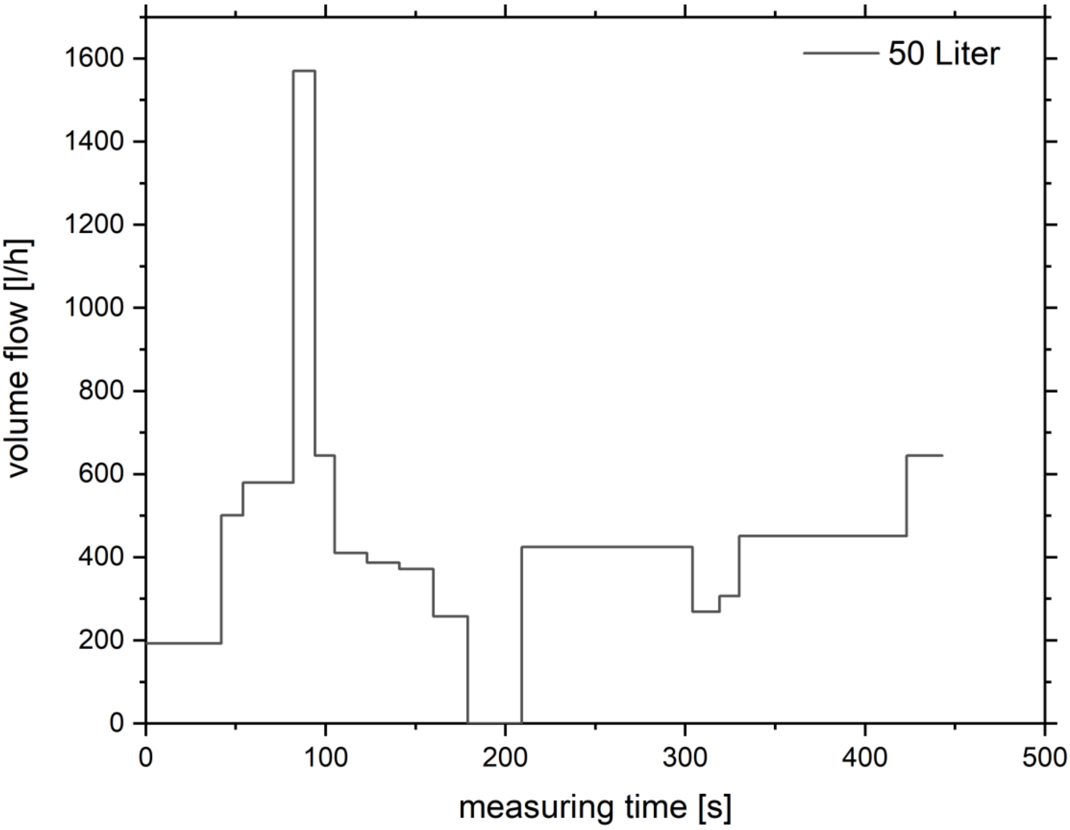
Profile N°	Average Upstream Pressure (bar)	Average Water Temperature (°C)	Average DUT Flow Rate	Average Reference Flow Rate	Average Reference Totalized Volume	Relative Expanded Uncertainty (k=2)
X	X.XX	XX.X	XXX.XXX	XXX.XXX	XX.XXX	X.XX %
…	…	….	…	…		…

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

measuring time [s]	volume flow [l/h]
0	193

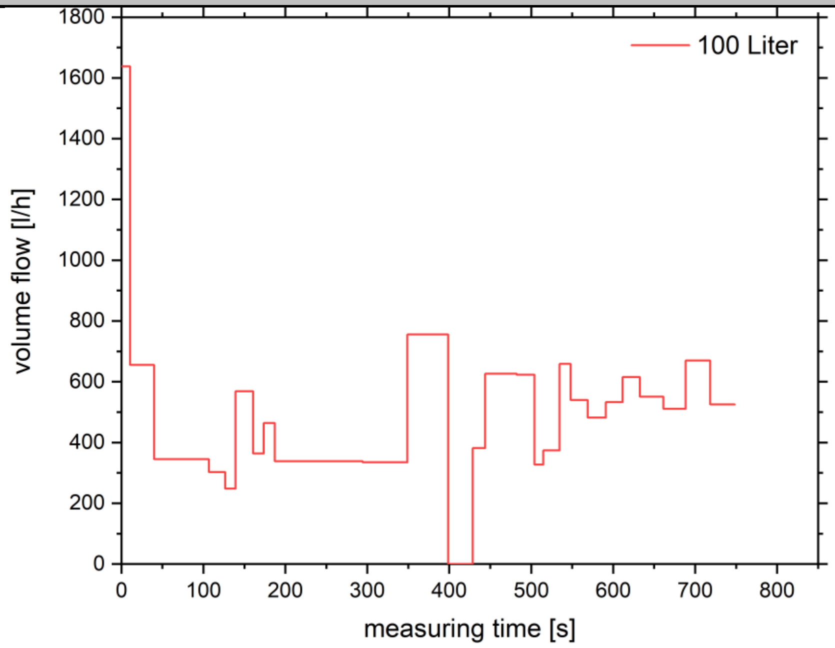
42	501
54	580
82	1570
94	645
105	410
123	387
141	372
160	258
179	0
209	425
304	269
319	307
330	451
423	645
443	645



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

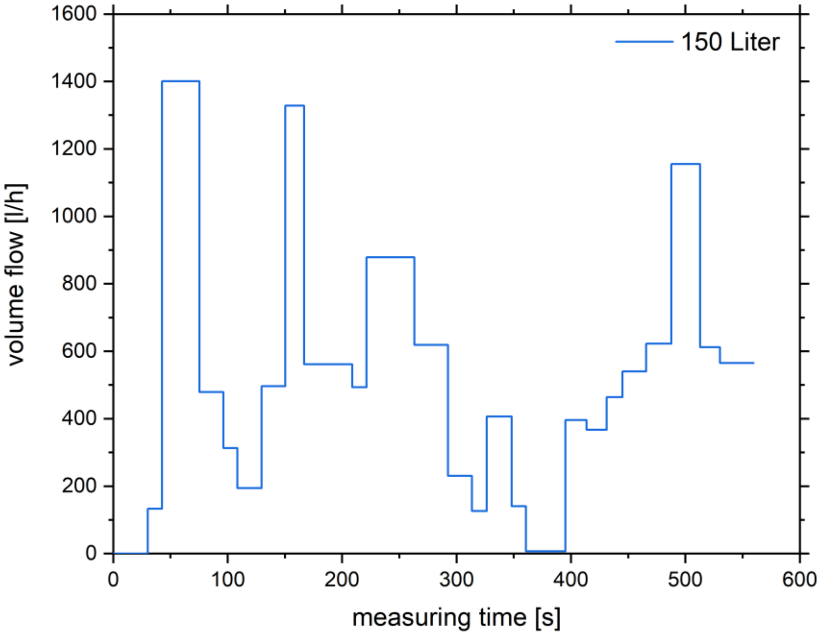
443.699	626.4
482.067	622.8
504.031	327.6
514.688	374.4
534.509	658.8
547.976	540
568.824	482.4
590.919	532.8
611.527	615.6
632.655	550.8
661.237	511.2
688.411	669.6
718.215	525.6
748.333	525.6



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

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