Test Protocol

Dylan Patterson
Jonna Jämte
Karl Asklund
Lucas Sevelin
Martin Ling
Theodor Vallgren

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Project Identity

Group E-mail: tsrt10-evap@groups.liu.se

Homepage: https://tsrt10.gitlab-pages.liu.se/2023/aurobay

Orderer: Lars Eriksson, Linköpings universitet
Phone: +46 (0)13-28 44 09
E-mail: lars.eriksson@liu.se

Customer: Fredrik Wemmert, Aurobay
Phone: N/A
E-mail: fredrik.wemmert@aurobay.com

Supervisor: Oskar Lind Jonsson
Phone: N/A
E-mail: oskar.lind.jonsson@liu.se

Course Responsible: Daniel Axehill
Phone: +46 (0)13-28 40 42
E-mail: daniel.axehill@liu.se

Participants of the group

Name	**Responsible**	**E-mail**
Dylan Patterson	Responsible for the quality (QS)	dylpa851@student.liu.se
Jonna Jämte	Responsible for the testing (TST)	jonja121@student.liu.se
Karl Asklund	Responsible for the Documentation (DOC)	karas744@student.liu.se
Lucas Sevelin	Responsible for software (SWR)	lucse807@student.liu.se
Martin Ling	Project leader (PL)	marli498@student.liu.se
Theodor Vallgren	Responsible for the design (DES)	theva365@student.liu.se

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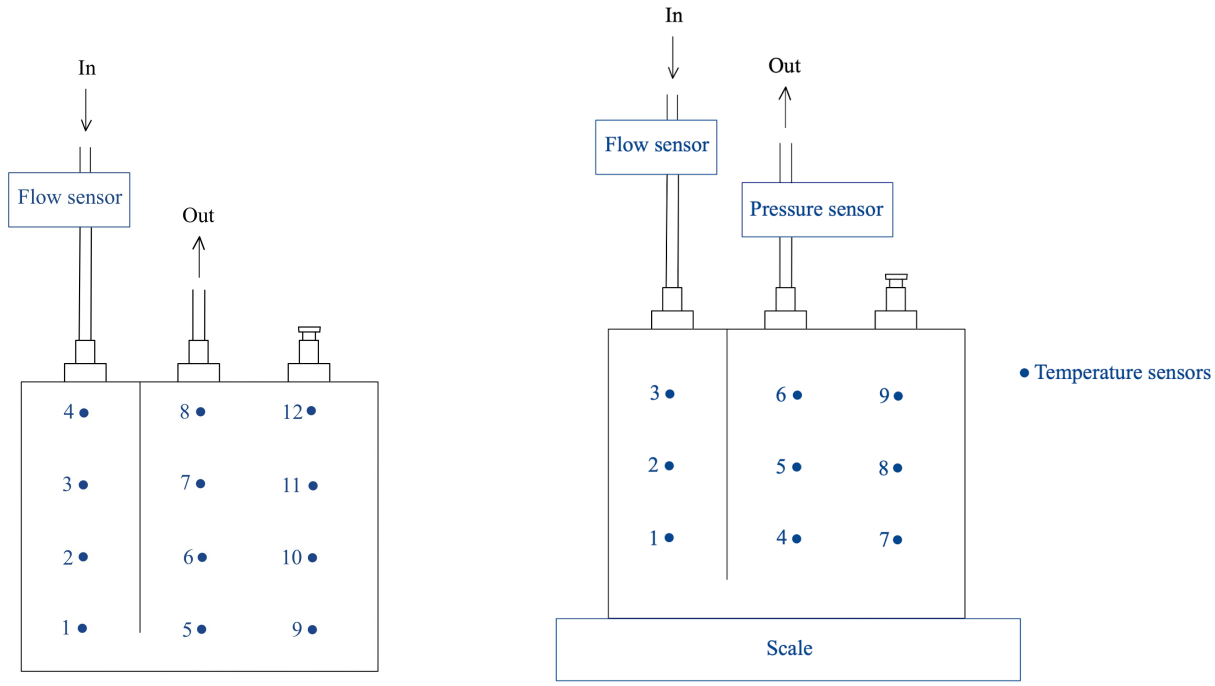
DOCUMENT HISTORY

Version	Date	Changes made	Sign	Reviewer
0.1	2023-09-15	First draft.	Martin Ling	Jonna Jämte
1.0	2023-11-30	Final revision	Martin Ling	Jonna Jämte

1 INTRODUCTION

This test protocol will document the experiment conducted on the carbon canister in order for the tests to be replicated in the future. All tests have a description where the intentions of the specific test are described, a procedure field where the procedure will be documented, and a written goal for each test. In the first version of this document, only a few initial tests are planned. As the project progresses, and knowledge is obtained, more tests will be planned and included in this document.

Two standard test setups will be used where the sensors are placed according to figure 1. Besides these sensors, a scale will be utilized to continuously weigh the canister during the experiments.



(a) Flow sensor and 12 temperature sensors.

(b) Flow sensor, pressure sensor, scale and 9 temperature sensors.

Figure 1: Two different sensor layout for the canister during experiments.

2 EXPERIMENTS

Exp. Nr	Planned Week	Description	Procedure	Goal	Responsibility
1	40	**Test of sensor communication:** To verify the functionality of the sensors a test was conducted using an empty carbon canister with temperature and flow sensors.	**1:** Connect sensors (layout 1b): (1,2,3,4,5,6,7,8) & the flow sensor to the test rig. **2:** Start the test rig and measure the sensor outputs.	Ensure that the sensors can measure correctly and that the data can be stored.	Lucas
2	40	**Understanding of canister behavior during purge:** To see how the temperature and flow are changed during the purge a test with a lot of sensors is made on a full canister. Canister number 1 was used.	**1:** Connect sensors (layout 1b): (1,2,3,4,5,6,7,8) & the flow sensor. **2:** Run the test rig at a flow of 10 [L/min] for 20 minutes.	Get a better understanding of how the temperature and flow change during purge.	Jonna
3	42	**Test scaling of sensor outputs:** The result from test 2 was not as expected, therefore the sensor scaling will be tested to ensure correct measurements.	**1:** Measure temperature sensors at room temperature and compare them with conventional thermometers. **2:** Put sensors in a controlled environment (freezer) and compare the output with a thermometer.	Establish the correct temperature measurements.	Theodor
4	44	**Establish weight measurements:** To make sure that the weight measurements of the carbon canister are working correctly a test of the scale used will be conducted.	**1:** Ensure that the digital measurements work and that the data can be saved. Also, use a known weight to calibrate the scale correctly.	Ensure that the scale can be read digitally and that the measurements are correct.	Theodor

Exp. Nr	Planned Week	Description	Procedure	Goal	Responsibility
5	43	**Measure mass difference during purge:** Run the purge cycle and measure the mass of the canister during purge. Canister number 2 was used.	**1:** Connect canister to test rig & place it on the scale. **2:** Run the test rig with a flow of 20 [L/min] for 40 minutes. **3:** Take measurements of the mass every 10 seconds during the purge.	Establish how the mass changes during purge.	Karl
6	43	**Validate canister temperature during purge:** The same experiment as number 2 but using 12 temperature sensors. This experiment is made in order to validate the results from earlier and get an even better resolution of the temperature differences in the canister. Canister number 3 was used.	**1:** Connect sensors (layout 1a): (1,2,3,4,5,6,7,8,9, 10,11,12) & the flow sensor to the test rig. Weigh the full canister. **2:** Run the test rig with a flow of 30 [L/min] for 40 minutes. **3:** Weigh the empty canister.	Establish how the temperature changes during purge and fully empty the canister during one purge.	Martin
7	44	**Further canister testing:** Run a full cycle of the FTP75 drive cycle with 9 temperature sensors and a flow sensor. This experiment is made in order to see how the canister operates during a normal drive cycle, in this case using the FTP75 standard drive cycle. The weight will be measured. Canister number 4 was used.	**1:** Connect sensors (layout 1b): (1,2,3,4,5,6,7,8,9) & the flow sensor to the test rig. Weigh the full canister. **2:** Run the test rig with the purge flow from FTP75 and document the canister weight every 10 seconds.	Better understand how the canister empties during a normal drive cycle	Lucas

Exp. Nr	Planned Week	Description	Procedure	Goal	Responsibility
8	44	**Verify functionality of pressure sensor and scale:** Run a purge cycle with 9 temperature sensors, a flow sensor, and a pressure sensor. The point of this experiment is primarily to verify the functionality of the pressure sensor and the new scale and data are collected as desired. The secondary purpose is to collect further temperature and flow data. If everything works as desired, all data can be further utilized.	**1:** Connect sensors (layout 1b): (1,2,3,4,5,6,7,8,9), the pressure sensor & the flow sensor to the test rig. Weigh the empty canister. **2:** Run the test rig with a flow of 30 [L/min] for 40 minutes. Utilize the scale to weigh the canister continuously.	Verify that the pressure sensor and the scale works as desired and data is obtained from both sensors.	Jonna
9	45	**Test with sudden start and stop of the purge:** Run a purge cycle with 9 temperature sensors, a flow sensor, and a pressure sensor. The point of this experiment is primarily to collect data on sudden starts and stops of the purge procedure, as per Aurobay's request. The secondary purpose is to collect further temperature and flow data. If everything works as desired, all data can be further utilized. Canister number 5 was used.	**1:** Connect sensors (layout 1b): (1,2,3,4,5,6,7,8,9), the pressure sensor & the flow sensor to the test rig. Weigh the full canister. **2:** Run the test rig with different flows in 5 minutes followed by a 15-minute pause and so on. The sequence is 10 [L/min], pause, 20 [L/min], pause, 30 [L/min] pause 40 [L/min].	Discovery of some anomalies as per Aurobay's request	Karl
10	45	**Empty a canister fully with all sensors connected:** Run a purge cycle with 9 temperature sensors, a flow sensor, a scale and a pressure sensor. The point of this experiment was to try to extract the expected mass from the canister. The weight was documented by Aurobay before and after filling. The secondary purpose was to provide data for the model. Canister number 6 was used.	**1:** Connect sensors (layout 1b): (1,2,3,4,5,6,7,8,9), the pressure sensor & the flow sensor to the test rig. Weigh the full canister. **2:** Run the test rig with a flow of 40 [L/min] for 50 minutes. Utilize the scale to weigh the canister continuously.	Evaluate the time span for the emptying of a filled canister.	Theodor

Exp. Nr	Planned Week	Description	Procedure	Goal	Responsibility
11	46	**Test for stable data towards the model:** Run a purge cycle at constant flow for 4000 seconds. The point is to get good readings for the mass of the canister during the purge. Canister number 7 was used.	**1:** Connect sensors (layout 1b): (1,2,5) & the flow sensor. **2:** Run the test rig at a flow of 30 [L/min] for 4000 seconds.	Achieve good and stable data for the model to refine it.	Dylan
12	47	**Test for stable data towards the model:** Run a purge cycle at constant flow for 4000 seconds. The point is to get good readings for the mass and temperature of the canister during the purge. Canister number 8 was used.	**1:** Connect sensors 3 and 5 (layout 1b). **2:** Run the test rig at a flow of 40 [L/min] for 4000 seconds.	Gather further data to use for the model to refine it.	Jonna
13	47	**Test on a US-regulation canister:** Run a purge cycle at constant flow for 3600 seconds. The point of the test was to get information about different sizes of canisters. This could also verify or differentiate the model. Canister number 9 was used.	**1:**Connect sensors (layout 1a): (1,2,3,4,5,6,7,8) and put the canister on the scale. **2:** Run the test rig at a flow of 40[L/min] for 3600 seconds.	Data for checking the performance of the model.	Karl

Table 1: Experiments

3 TEST CHECKLIST

This section is a protocol and checklist that all of the tests listed in the **"Test Plan"** are done and therefore the requirements are met.

Test Nr	Checkbox
1	**X**
2	**X**
3	**X**
4	**X**
5	**X**
6	**X**
7	**X**
8	**X**
9	**X**
10	**X**
11	**X**
12	**X**
13	**X**
14	**X**
15	**X**
16	**X**
17	**X**
18	**X**
19	**X**
20	**X**
21	**X**

Table 2: Test Checklist

3.1 Checklist for the complementary requirements

Req. Nr	Checkbox
40	**X**
41	**X**
42	**X**
43	**X**
44	**X**
45	**X**
46	**X**
47	**X**
48	**X**
49	**X**
50	**X**
51	**X**
52	**X**
53	**X**
54	**X**
55	**X**
56	**X**
57	**X**
58	**X**
59	**X**

Table 3: Complementary Requirements Checklist