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Technical evaluation: ACS and Dräger breath alcohol ignition interlock devices (BAIIDs)

TECHNICAL EVALUATION: ACS AND DRÄGER BREATH ALCOHOL IGNITION INTERLOCK DEVICES (BAIIDS)

1 Introduction

In the framework of the European Alcolock project, coordinated by the Belgian Road Safety Institute (IBSR), and born by a consortium composed by the German Federal Highway Research Institute (Bast), the Dutch Institute for Road Safety Research (SWOV), the Norwegian Institute of Transport Economics (TØI) and the University of Valladolid, the IBSR will start an alcolock trial with 60 drivers.

In this study three types of breath alcohol ignition interlock devices (BAIID) have been investigated: Dräger Interlock XT (Dräger), WR2 and WR3 (ACS). The devices have been evaluated according the Belgian legislation for breath testing devices (KB 538, 18 February 1991) and the results are compared to the technical data sent by the manufacturer. The devices have been tested quantitatively as well as qualitatively. Each test was carried out on three different devices sent by the manufacturer after a complete calibration.

2 Breath alcohol ignition interlock devices

2.1 Definition

A Breath Alcohol Ignition Interlock Device (BAIID) is a breath-testing device connected to the ignition system of a motor vehicle. The purpose of the ignition interlock is to prevent a driver from starting or operating the vehicle when the BAC (blood alcohol concentration), measured by means of a breath test, is above a predetermined threshold level ('fail level').

Once the vehicle has been started, the interlock requires random running re-tests to ensure the driver's BAC (Blood Alcohol Level) does not rise above the threshold value. Failing to provide a valid running re-test within a time allowed will result in a warning and an activation of a horn. Sometimes a restart without a further alcohol breath test is allowed within a fixed time, two minutes for example, after the ignition has been shut off.

The BAIID unit consists of two components. The control module or relay module is fixed to the vehicle and controls the ignition of the engine by interrupting the connection lead between the power supply and the ignition system of the vehicle. This component also records every attempt of tampering or circumvention electronically by monitoring continuously various parameters: accelerometer, tachometer…. A data recorder captures the results of all breath tests for later review. The sample head, which has visual indicators and can produce audible signals is connected to the control unit and measures the alcohol concentration in the breath sample.

Technical standards have been developed in the USA (NHTSA Standard), Canada (Alberta Standard) and in Australia (Australian Standard). These standards are used to set minimum requirements to BAIID.

2.2 Dräger Interlock XT

This device uses an electro-chemical sensor (fuel cell) as measurement technology. The basic advantage of this measuring technology is that the BAIID has a long-term stability compared to semiconductor sensors and that the sensor only reacts with high specificity to alcohol compared to semiconductor sensors.

Figure 1: Sample head (left) and control unit of the new Dräger Interlock XT

The Dräger Interlock XT has an official certificate for the Australian, the Alberta and the NHTSA Standard. Furthermore the device complies with the Directive 95/54/EC (equivalent to ECE Regulation No 10) regarding radio interference.

The device is equipped with different tamper detection features, capable of detecting bogus breath samples, filtered breath samples or breath samples provided by an unauthorized and untrained person. The mouthpiece incorporates an non-return valve. This valve prevents the driver from certain circumvention attempts and provides hygienic benefits. The device can be programmed to suck in the device after providing a valid breath sample to reduce furthermore false samples. Operating the vehicle without passing a valid breath test is recorded even when the handset is disconnected. The BAIID can store more than 30 000 events. No data is stored in the handset and the handset is fully exchangeable (including calibration data). At normal or high temperatures, the Dräger unit is ready for use within 10 seconds and the analysis of the breath sample takes less than 10 seconds.

2.3 WR2 and WR3 Interlock (ACS)

These devices are using an electrochemical cell as well and thus benefit from the long-term stability and the high specificity to alcohol.

The WR2 and WR3 complies with the NHTSA Standard and the WR2 has also an Alberta Standard certificate. Furthermore the WR2 and WR3 complies with the Directive 95/54/EC (equivalent to ECE R10).

Both Interlocks are equipped to detect events of tampering similar to those described previously for the Dräger device. However ACS proposes mouthpieces with or without a non-return valve. The device is programmed to require that the subject hum while taking the breath test. Circumvention and tampering are monitored and recorded by the control box for WR2. Both the control box as the sample head will record every attempt of circumvention and tampering for the WR3. The WR2 has a capacity of 10 000 events while the WR3 has a capacity of 100 000 events.

Figure 2: Sample head (left) and control unit of WR2 Interlock (left) and the new WR3 Interlock (right)

With the WR2, the elapsed time from the initial activation until the device is ready for a test is less than 5 minutes at –40°C and less than 30 seconds at 10°C to 25°C. The ready to test time for the WR3 is approximately 2.5 minutes at –40°C and less than 30 seconds at 10°C to 25°C. The analysis time for both the WR2 as the WR3 is largely function of the breath alcohol level. However even at high alcohol levels, the total time for testing and analysis should not be longer than 15 seconds.

3 Test procedure

3.1 Introduction

The BAIID have been evaluated according to the Belgian legislation for breath testing devices (KB 538, 18 February 1991)[1]. Breath testing devices used by the police are based on the same measurement technology as the common BAIID. KB 538 can thus be used to evaluate the BAIID on their performance as thee are no legal requirements available for BAIID in Belgium. It is the first time that BAIID are tested in Europe for an Alcolock project by an ISO 170025 accredited alochol lab.

The BAIID were evaluated on accuracy, dispersion range, blow resistance, minimum start flow rate, duration of blowing and minimum volume. Furthermore the anti-circumvention

[1] Koninklijk Besluit van 18 februari 1991 betreffende de ademtesttoestellen die het niveau van de alcoholopname in de uitgeademde alveolaire lucht aangeven.

features have been controlled for all BAIID. All devices have also been evaluated for their user-friendliness, solidity, durability and hygiene. All the results can be found in the Appendix.

Three units were tested for each type of BAIID (3 Dräger Interlock XT units; 3 WR2 units; 3 WR3 prototypes). In order to simplify the testing procedure only 1 control box was used for the three Dräger units. The use of 1 control box cannot have any influence on the test procedure, as the measurement and the anti-circumvention sensors for breath samples are located in the handset. All ACS handsets were tested with the corresponding control box although it has been shown during preliminary tests that the use of a different control box didn't have any influences on the measurement.

3.2 Breath ignition interlock devices used for the test procedure

All BAIID have been calibrated before any tests were carried out. The serial numbers of all BAIID are shown in Table 1. The ACS WR3 did not have any serial number and have been identified as mentioned in the table.

In order to facilitate testing it was asked to the manufacturers to disable some of the anti-circumvention features. The hum-tone that is needed while taking the breath test has been disabled in the WR2 and WR3. Furthermore the suck-blow feature that is normally installed on the Dräger Interlock XT has been disabled too. Disabling some anti-circumvention features does not influence the measurements done by the BAIID.

3.3 Measurement accuracy

The accuracy of the Dräger Interlock XT and the ACS devices, WR2 and WR3, were tested for two different test gasses (ethanol concentrations 0.053mg/L and 0.137mg/L). For 10 successive measurements of the test gas, the estimation of the bias, the difference between the mean value of 10 measurements and the known concentration of the test gas was measured. According to the Belgian legislation of breath testing devices (KB 538) the difference between these values cannot exceed 0.03mg/L for breath testing devices, positively or negatively. This requirement is slightly more stringent than the accuracy requirement of the NHTSA or the Alberta standard for unstressed conditions (NHTSA Standard, paragraph 1.1.1.S): "Following a calibration, and when tested at neutral ambient air temperature (10-30°C), all BAIIDs shall lock the vehicle ignition 90% of the time when the true alcohol content of the breath sample is 0.01% w/v BrAC (0.01g ETOH/210 liters air = 0.0476mg/L BrAC = 0.11‰ BAC) or more above the alcohol setpoint."

All the Dräger Interlock XT and WR3 units have an accuracy much better than 0.03mg/L (or 0.07‰ BAC) for the given ethanol concentrations. They display 3 significant digits. The WR2 units show the same results but the accuracy has been rounded up to 2 significant digits as for the display (Table 2).

Testing the accuracy in unstressed conditions according to the NHTSA or Alberta standard requires 20 tests with a test gas 0.0476mg/L higher than the threshold value set in the BAIID. Although these tests have not been carried out, it is thought that the standard would have been met for both the Dräger as well as the WR3 and WR2.

The time drift of the devices has not been tested in this paper and thus no information is available for the accuracy after long periods without a recalibration.

3.4 Dispersion range

For 10 successive measurements of the same test gas, the dispersion range (the difference between the two most extreme values) was measured. The dispersion range should not exceed 0.04mg/L (or 0.09‰ BAC) for breath testing devices according to KB 538. The accuracy requirement of the NHTSA or Alberta standard is equivalent to distributions of test results with a mean equal to the alcohol setpoint and a standard deviation equal to 0.0371mg/L (or 0.084‰ BAC. Both the Dräger as the ACS units succeeded to have a dispersion that remained under both the standard deviation of the NHTSA and Alberta standard as well as the limit specified in KB 538 (Table 3).

It can be concluded that the dispersion ranges of all BAIID are approximately the same and thus there is no clear indication that one device is better than the others.

3.5 Blow resistance

In the tests a flow rate of approximately 280mL/s is injected in the mouthpiece of all BAIID and the backpressure is measured to evaluate the blow resistance. The NHTSA standard doesn't mention any blow resistance and only recommends (Paragraph 3.2.2.S: "Optional Minimum Pressure of Sample") that the minimum pressure needed for providing a valid breath sample should be higher than 2.5hPa in order to screen out filtered breath samples. The Alberta standard doesn't mention any blow resistance or minimum pressure but just requires that the use of a breath filter for providing a breath sample should be rejected by the BAIID. According to KB 538 the blow resistance of the breath testing devices should not exceed 20hPa at a flow rate of 0.1L/s. A higher bolw resistace will make it very hard to provide a valid breath sample.

All the BAIID comply with the optional minimum pressure of the NHTSA standard at a flow rate of 280mL/s (Table 4). Furthermore all the devices succeeded the specifications given by KB 538 as the blow resistance can only increase at higher flow rate (the blow resistance specified in KB 538 is measured at 0.1L/s). The blow resistance of the Dräger units can differ to each other because of the different mouthpieces and the different handsets used. ACS units have a blow resistance approximately twice as high compared to the Dräger units and thus more effort is needed by a person to provide a breath sample in those units. It can be concluded that Dräger offers the device for which a breath sample is the easiest to provide.

3.6 Minimum start flow rate

Each BAIID has been tested for different constant flow rates until the threshold start flow rate was found where the unit rejects the breath sample. Minimum start flow rate and minimum pressure needed for a valid breath sample are closely related as each flow rate corresponds to a certain pressure measured in the BAIID. The NHTSA standard only gives recommendations about the minimum pressure as mentioned previously. The Alberta standard doesn't give any requirements for the minimum start flow rate. According to the Belgian legislation for breath testing devices, the minimum start flow rate has to exceed 100mL/s.

Two flow rates are given for each unit in Table 5. One flow rate (lowest, red color) is below the threshold value of the unit (providing a sample with that flow rate in the device resulted in an error) while the other flow rate (green color) was high enough for a valid breath sample.

The minimum start flow rate is consistent for all the Dräger Interlock XT units and higher than 100mL/s. The dispersion of the minimum start flow rate is higher for the ACS WR2 units but the flow rate remains above 100mL/s. ACS knows the problem and replied that the design and electronics are responsible for this problem but that the WR3 has been designed to solve this problem. According to the test results it can be concluded that the WR3 devices indeed don't show the same trend and have a minimum flow rate higher than 100mL/s. Both the Dräger Interlock XT as well as the WR3 have a consistent minimum start flow rate in comparison to the WR2.

3.7 Duration for providing a valid breath sample

A BAIID only gives a representative alcohol concentration if alveolar air (air which is the last portion of a prolonged, uninterrupted exhalation) is analyzed. NHTSA standard requires at least 1.5L of air before the BAIID samples the alcohol concentration (Paragraph 1.2.T: "Breath Sampling Requirements Tests"). The Alberta standard requires at least 1.5L as well (Paragraph 6.4.1 "Test for Deep Lung Sample"). Breath testing devices require a breath sample of at least 1.2L sample according to KB 538.

The minimum volume can be determined indirectly with the following test. A test gas is introduced at a certain constant flow rate until the unit accepts the breath sample. Two durations, T, have been inserted in the second column of Table 6 corresponding to the case where the unit respectively accepts and rejects the breath sample. The third and fourth column give the duration that is needed for providing respectively a 1.2L and 1.5L breath sample at a constant given flow rate. This can be calculated by dividing the volume (1.2L or 1.5L) by the flow rate given in the first column.

The Dräger units accept at least 1.2L because the threshold duration, T (duration interval between accept and reject), exceeds the "Limit duration 1.2L". However one Dräger unit didn't achieve a minimum volume of 1.5L as written in the NHTSA and Alberta standard (Note: the minimum volume can be set with the software program and the test results are based on the setting that the device had at the moment). The difference is however very small and time measurement inaccuracies and the indirect measurement of the volume can cause these errors.

The ACS devices required a minimum breath sample of at least 1.5L for all the units and comply both with Alberta as well as with the NHTSA standard.

Although it is seen from above that all BAIID succeeded to accept a breath sample of 1.2L when the flow rate is constant, it will be shown later that not all BAIID succeed this test when the flow rate is variable or low. The duration that is needed for providing a valid breath sample is constant for the ACS devices no matter what the flow rate is during the test. Dräger Interlock XT adapts this duration in function of the actual flow rate in order to receive a certain total volume. The two manufacturers are using a different technology for taking a breath sample. Both BAIID have a significantly different method for controlling the deep lung sample: ACS works with a specific time period and Dräger works with a specific volume. The volume that is introduced with the ACS devices is dependent on the flow rate that is used during the blowing, as the time needed for a breath sample is constant. Because the two ACS devices are working in a different way compared to the Dräger units, they have been tested in a different way for the second test as will be described later.

In a second test it is controlled if the minimum volume of 1.2L and 1.5L is still achieved when the flow rate of the breath sample is modified. Therefore two flow rates are used during the injection of a test gas in the mouthpiece. For a period of 1 to 3 seconds a test gas with a certain constant flow rate (flow rate 1) is injected in the mouthpiece. After this period the flow rate is changed to a lower flow rate (flow rate 2, defined as the lowest flow rate that will not result in a rejection of the sample) until the sample is accepted and analyzed. The durations where flow rate 1 and 2 are used are given by T_1 and T_2 in Table 7.

The Dräger Interlock XT devices maintained a minimum volume higher than 1.2L but slightly lower than 1.5L even after changing the conditions during blowing and the minimum flow rate remained higher than 0.1L/s (KB 538) for all the Dräger units. The small differences with 1.5L can again be explained by the indirect measurement of the volume and the error on time measurements.

All ACS units did not succeed this test and it has been seen that it is possible to provide a valid breath sample with a volume significantly lower than 1.2L. If the minimum start flow rate in Table 5 is multiplied with the duration for providing a breath sample (approximately 4 seconds: Table 6), volumes are obtained lower than 1.2L.

Furthermore it has been noticed that after a few seconds the ACS devices did not monitor anymore the flow rate of the sample and thus it is possible to achieve lower volumes that are still accepted. According to the technical data of ACS (Appendix 3 - 4) the minimum volume for WR2 as well as WR3 is however 1.5L. Furthermore a continuous breath sample of 5 seconds is required according to the data given by the manufacturer although breath samples were accepted after only 4 seconds as shown in Table 6.

As the ACS devices have a different method for controlling the deep lung sample, the previous test method for Dräger has not been used and only the minimum flow rate has been evaluated during blowing. Table 8 gives an overview of the different minimum flow rates (flow rate 2) that were recorded. For a few seconds a test gas was blown into the device with a flow rate equal to “flow rate 1”. Afterwards a new and lower “flow rate 2” (the lowest flow rate that will not result in a rejection of the sample) was used in order to provide a valid breath sample. The minimum flow rate remains higher than the minimum flow rate, 0.1L/s, specified for breath testing devices (KB 538). Again it has been noticed that the minimum flow rate of WR2 was not consistent.

Both the ACS devices as the Dräger devices have a minimum flow rate that is different from the minimum start flow rate (see Table 5).

ACS agreed that it was possible to validate a breath sample with a volume lower than 1.2L. This problem however has been solved partially by extending the time needed for blowing and by raising the minimum start flow rate up to approximately 290mL/s. Table 9 gives an overview of the duration for providing a valid breath sample after this firmware update.

The WR3 and WR2 without any firmware update had a blow duration of approximately 4 seconds while the updated WR2 and WR3 have now a blow duration of 4.5 seconds. However the updated device asks the user to blow even after the breath sample is taken. The pressure is thus monitored before and after that the breath sample is analyzed.

The updated ACS devices required a minimum breath sample of at least 1.5L for all the units and comply both with Alberta as well as with the NHTSA standard according to Table 9. However if the minimum start flow rate for each device is multiplied with the duration for providing a breath sample (approximately 4.5 seconds: Table 9), volumes are obtained between 1.2L and 1.5L (except for ACS WR2 N°2 which accepts volumes of 1.18L). The previous WR3 and WR2 model accepted volumes significantly lower than 1.2L and thus the devices have been improved but still accept a breath volume less than 1.5L under some circumstances before analyzing. Furthermore one WR2 device accepted a breath volume less than 1.2L because the minimum start flow rate could not be set properly.

3.8 Circumvention

ACS devices had the same settings as mentioned in paragraph 3.2 and thus the hum-tone protection was not active. During the tests it has been noticed that ACS devices could analyze the breath sample after blowing was stopped for approximately one second before analyzing. As long as the device receives a breath sample the first 4 seconds, blowing could be stopped afterwards and the device could still give a confirmation that a valid breath sample was provided. This means that the device can analyze a different ethanol concentration if someone blows hard in the beginning but stops after a few seconds. The hum-tone protection does not resolve the problem but only makes it more difficult to provide a false valid breath sample as mentioned previously.

Furthermore it has been proven that it was possible to blow into the ACS device for approximately 4 seconds and suck afterwards just before the measurement is done. This means that even ambient air can be sucked into the device and analyzed instead of a human breath sample under certain conditions.

Dräger devices have been tested in the same way but the suck-blow protection has been activated for this test. As the mouthpiece has a non-return valve, it is not possible to suck air through the mouthpiece. However one mouthpiece was damaged in order to allow sucking and the same test was carried out on the Dräger Interlock XT as on the ACS devices. None of the provided breath samples was accepted when blowing was interrupted. The Dräger device prevents successfully the suck-blow circumvention by the user.

The NHTSA standard describes several tampering and circumvention specifications that the BAIID have to meet. Interrupting the power source and starting the vehicle without passing a valid breath test have to be detected. Furthermore it is specified that air delivered from balloons or compressed air container have to be rejected. Human sources of air samples that are altered through filtration or other means must be detected. However the NHTSA standard doesn't mention that the BAIID should reject the breath sample when blowing has been stopped or when air is sucked into the device at the end. Only if the pressure is monitored continuously, this type of circumvention can be excluded and this is only an optional feature specification, written in the standard under "3.2.2.S Optional Minimum Pressure of Sample". The Alberta standard doesn't mention anything either about this type of circumvention.

ACS responded that a software fault was causing this problem and that an update of the device could solve this. The devices with an updated firmware have been tested and don't allow any interruption of the breath sample. The blowing procedure has even been extended after the measurement is done and even after the final beep (which notices that the user can stop blowing). The new update resolves the circumvention problem by monitoring the pressure again after the measurement.

3.9 User-friendliness, robustness, durability and hygiene

During testing the personnel has also evaluated the BAIID according to other criteria: user-friendliness, solidity, durability and hygiene. Both ACS WR2, WR3 as Dräger Interlock XT offer almost the same user-friendliness. Blowing in the device was easy for all the BAIID but the ACS devices needed harder blowing. Even when the anti-circumvention features are turned on for the Dräger devices and ACS devices, blowing is easy.

All setting of the Dräger units can be changed in a special software program without the assitance from Dräger. These setting are password protected and settings cannot be changed by unauthorized persons. The Dräger units can be set up very easily. However people of the service station have the possibility to change parameters in exchange of money from the aclolock owners.

ACS has chosen to setup the devices with an internet connections through a mainframe in order to exclude any abuse in the service stations. Only ACS persons can access or change the settings of the devices on demand.

Some problem has been noticed for the WR3 device, as the display sometimes did not work. After pressing on the graphical liquid crystal display the problem was solved. It is thought that a bad contact with the display caused this problem.

Both the ACS devices as well as the Dräger devices have mouthpieces that can be replaced in order to improve the hygiene. It has however been noted that some mouthpieces fitted too well in the WR2 devices and were very hard to remove for one device. Both Dräger as well as ACS mouthpieces have non-return valves, which not only improves anti-circumvention, but also offer a better hygiene.

Based on the evaluation of the user-friendliness, solidity, durability and hygiene of the BAIID it can be concluded that Dräger obtained better results than ACS.

4 Conclusions

IBSR has tested the following breath alcohol ignition interlock devices (BAIID): Dräger Interlock XT (Dräger), WR2 and WR3 (ACS: Alcohol Countermeasure Systems Corp). Both the Dräger and WR2 devices succeeded the tests according to the Alberta and the NHTSA standard. The WR3 however has only an official certification of compliance with the NHTSA and the Directives 95/54/EC (and ECE No. 10).

The BAIID have been evaluated according to the Belgian legislation for breath testing devices (KB 538, 18 February 1991). KB 538 is used to evaluate the BAIID on their performance. The BAIID were evaluated on accuracy, dispersion range, blow resistance, minimum start flow rate, duration of blowing, minimum volume, circumvention, user-friendliness, solidity, durability and hygiene. Each test was carried out on three different devices sent by the manufacturer after a complete calibration.

The measurement accuracy for all the BAIID was lower than 0.03mg/L (or 0.07‰ BAC). However the time drift was not investigated and thus no conclusions can be made about the accuracy after long periods. Although the accuracy has not been tested to the NHTSA or Alberta standard, it is thought that the ACS and the Dräger BAIID would meet these standards for unstressed condition based on the test results.

The dispersion range is lower than 0.04mg/L (KB 538) for all the tested BAIID. Both the Dräger as the ACS units succeeded to have a dispersion range lower than the standard deviation given in the NHTSA standard.

All the units that were tested had a blow resistance below 20hPa at a flow rate of approximately 280mL/s. The NHTSA standard does not mention any blow resistance but only recommends a minimum pressure higher than 2.5hPa for a valid breath sample. All BAIID met this optional specification. ACS units have a blow resistance approximately twice as high compared to the Dräger units.

The minimum start flow rate has been registered for each device. All BAIID remained higher than 0.1L/s as described by KB 538. Both NHTSA as well as Alberta standard do not mention anything specific about the minimum start flow rate. Both the Dräger units as well as the WR3 have a consistent minimum start flow rate. The WR2 however showed a much larger dispersion between the different devices.

The minimum volume that is needed for a valid breath sample has been investigated for all the BAIID. NHTSA and Alberta require 1.5L before the breath sample is analyzed. The ACS devices accept volumes below 1.2L when the flow rate is variable or low. ACS devices don't meet the requirements set in NHTSA and Alberta standard when for certain flow rates. The Dräger units accept a volume slightly less than 1.5L. The difference is however very small and time inaccuracies and the indirect measurement of the volume can cause these errors for the Dräger units. Dräger and ACS use a significantly different technology for controlling the deep lung sample. ACS uses a specific time period of approximately 4 seconds (technical data given by the manufacturer mentions 5 seconds) while Dräger uses a specific volume of approximately 1450ml before that the breath sample is analyzed.

An update of the firmware can improve the ACS devices. ACS devices with an updated firmware use a specific time period of approximately 4.5 seconds before that a breath sample is taken and analyzed. One WR2 device accepted a breath sample below 1.2L because the minimum start flow rate could not have been set properly. All other devices accepted volumes between 1.2L and 1.5L. The previous WR3 and WR2 model accepted volumes significantly lower than 1.2L and thus the devices have been improved but still accept a breath volume less than 1.5L under some circumstances.

ACS devices without the hum-tone protection allow an interruption of the breath sample before any measurement is done and still accept the breath sample. It was even possible to suck in the mouthpiece before the concentration is displayed. The hum-tone protection does not resolve the problem but only makes it more difficult to provide a false valid breath sample for the user. Neither the NHTSA nor the Alberta standard mention this kind of circumvention. Dräger did succesfully exclude this type of circumvention.

Updated ACS solved the suck-blow circumvention problem by updating the firmware. The devices don't allow an interruption of the breath sample before (and even a small period after) the measurement is done. The pressure of the breath sample is monitored again after the measurement in order to exclude this type of circumvention.

Both Dräger as ACS are user-friendly devices. The Dräger units can be set properly very easily in a special software. ACS uses an internet connection with the mainframe to setup the devices. WR3 experienced some problems related to the display. It is thought that vibrations can loose contacts and result in display problems. Mouthpieces are sometimes difficult to replace with the WR2 devices as they get stuck in the handset. Both Dräger and ACS BAIID offers a good level of hygiene as the mouthpiece have a non-return valve.

5 Bibliography

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Appendix

Table 1: Serial numbers of the BAIID that have been evaluated

	Serial number
Dräger Interlock XT N°1	ARTB-5035
Dräger Interlock XT N°2	ARTB-5038
Dräger Interlock XT N°3	ARTB-5047
ACS WR2 N°1	015718
ACS WR2 N°2	014358
ACS WR2 N°3	012604
ACS WR3 N°1	T1
ACS WR3 N°2	T2
ACS WR3 N°3	T3

Table 2: Accuracy of the BAIID for different test gasses

	Test gas n°1 0,053mg/L	Test gas n°2 0,137mg/L
Dräger Interlock XT N°1	0.004mg/L	-0.000mg/L
Dräger Interlock XT N°2	0.003mg/L	-0.004mg/L
Dräger Interlock XT N°3	0.003mg/L	0.001mg/L
ACS WR2 N°1	-	0.00mg/L
ACS WR2 N°2	-	0.00mg/L
ACS WR2 N°3	-	-
ACS WR3 N°1	-0.004mg/L	-0.010mg/L
ACS WR3 N°2	-0.001mg/L	-0.006mg/L
ACS WR3 N°3	0.001mg/L	-0.004mg/L

Table 3: Dispersion range (definition of KB 538) of the BAIID for different test gasses

	Test gas n°1 0,053mg/L	Test gas n°2 0,137mg/L
Dräger Interlock XT N°1	0.008mg/L	0.008mg/L
Dräger Interlock XT N°2	0.007mg//L	0.005mg/L
Dräger Interlock XT N°3	0.007mg/L	0.015mg/L
ACS WR2 N°1	0.01mg/L	0.01mg/L
ACS WR2 N°2	0.00mg/L	0.00mg/L
ACS WR2 N°3	0.01mg/L	0.01mg/L
ACS WR3 N°1	0.006mg/L	0.011mg/L
ACS WR3 N°2	0.008mg/L	0.005mg/L
ACS WR3 N°3	0.007mg/L	0.007mg/L

Table 4: Blow resistance of the BAIID

	Flow rate (mL/s)	Pressure (hPa)
Dräger Interlock XT N°1	284.1	9.1
Dräger Interlock XT N°2	283.0	5.6
Dräger Interlock XT N°3	283.9	8.8
ACS WR2 N°1	278.6	15.6
ACS WR2 N°2	278.8	15.1
ACS WR2 N°3	279.8	16.7
ACS WR3 N°1	278.5	18.3
ACS WR3 N°2	279.6	17.6
ACS WR3 N°3	280.2	19.1

Table 5: Minimum start flow rate of the BAIID

	Minimum start flow rate (mL/s)	Accept / Reject display message
Dräger Interlock XT N°1	167.3	Reject
	171.9	Accept
Dräger Interlock XT N°2	173.4	Reject
	182.1	Accept
Dräger Interlock XT N°3	162.0	Reject
	172.8	Accept
ACS WR2 N°1	216.7	Reject
	221.3	Accept
ACS WR2 N°2	159.3	Reject
	174.6	Accept
ACS WR2 N°3	180.7	Reject
	189.7	Accept
ACS WR3 N°1	200.5	Reject
	219.7	Accept
ACS WR3 N°2	200.5	Reject
	219.7	Accept
ACS WR3 N°3	211.9	Reject
	220.8	Accept

Table 6: Duration for providing a valid breath sample

	Flow rate (mL/s)	T (s)	Limit duration 1.5L (s)	Limit duration 1.2L (s)	Acceptance of the breath sample
Dräger Interlock XT N°1	251.6	5.60	5.96	4.77	Reject
	249.9	5.82	6.00	4.80	Accept
Dräger Interlock XT N°2	253.5	5.98	5.92	4.73	Reject
	254.8	6.00	5.89	4.71	Accept
Dräger Interlock XT N°3	252.4	7.31	5.94	4.75	Reject
	252.4	7.41	5.94	4.75	Accept
ACS WR2 N°1	486.8	3.85	3.08	2.47	Reject
	488.1	4.01	3.74	2.46	Accept
ACS WR2 N°2	485.3	3.63	3.09	2.47	Reject
	484.4	3.85	3.10	2.48	Accept
ACS WR2 N°3	487.9	3.85	3.07	2.46	Reject
	488.3	4.01	3.07	2.46	Accept
ACS WR3 N°1	486.9	3.85	3.08	2.46	Reject
	488.4	4.01	3.07	2.46	Accept
ACS WR3 N°2	481.9	4.39	3.11	2.49	Reject
	486.3	4.42	3.08	2.47	Accept
ACS WR3 N°3	485.7	4.01	3.09	2.47	Reject
	487.6	4.12	3.08	2.46	Accept

Table 7: Minimum volume and minimum flow rate during a breath sample with a non-constant flow rate

	Flow rate 1 (mL/s)	T_1 (s)	Flow rate 2 (mL/s)	T_2 (s)	Volume (ml)
Dräger Interlock XT N°1	248.2	1.59	132.4	9.50	1442.2
Dräger Interlock XT N°2	243.9	2.25	132.4	9.23	1472.6
Dräger Interlock XT N°3	245.1	2.92	132.4	8.57	1463.4

Table 8: Minimum flow rate for the ACS WR2 and WR3 devices

	Flow rate 1 (mL/s)	Flow rate 2 (mL/s)	Acceptance of the breath sample
ACS WR2 N°1	262.7	203.2	Reject
	279.6	216.2	Accept
ACS WR2 N°2	221.0	163.8	Reject
	224.6	174.3	Accept
ACS WR2 N°3	220.8	169.6	Reject
	234.9	180.4	Accept
ACS WR3 N°1	238.2	180.7	Reject
	262.1	198.9	Accept
ACS WR3 N°2	261.5	199.5	Reject
	285.8	218.1	Accept
ACS WR3 N°3	253.6	190.6	Reject
	267.0	200.6	Accept

Table 9: Duration for providing a valid breath sample for WR2 and WR3 with an updated firmware

	Flow rate (mL/s)	T (s)	Limit duration 1.5L (s)	Limit duration 1.2L (s)	Acceptance of the breath sample
ACS WR2 N°1	480	4.72	3.13	2.50	Reject
	478	4.94	3.14	2.51	Accept
ACS WR2 N°2	478	4.45	3.14	2.51	Reject
	480	4.61	3.13	2.50	Accept
ACS WR3 N°1	478	4.51	3.14	2.51	Reject
	478	4.61	3.14	2.51	Accept
ACS WR3 N°3	478	4.23	3.14	2.51	Reject
	479	4.51	3.13	2.51	Accept