DRIVESAFE™

BREATH ALCOHOL TESTER

Technical manual

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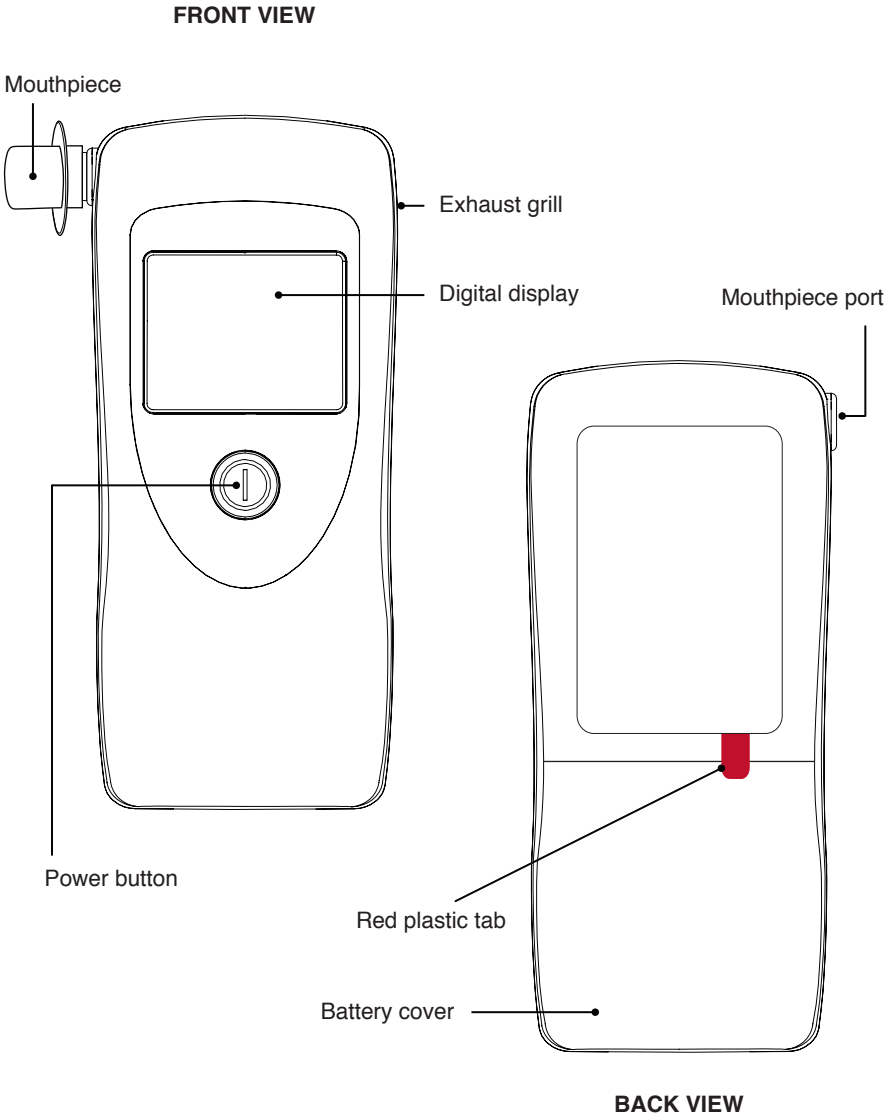
DRIVESAFE HANDSET COMPONENTS



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IMPORTANT SAFETY AND OPERATING INFORMATION

To avoid injury, read all safety information and operating instructions before operating the DRIVESAFE breath alcohol tester, ALCOSIM breath alcohol simulator, or alcohol gas standard canister (for gas standard calibration).

For detailed instructions on the use and calibration of the DRIVESAFE tester, read Chapters 1 to 4.

For detailed information on the effects of alcohol on the body, read Chapter 11.

ASSISTANCE

Contact your local authorized service provider or visit acs-corp.com.

WARNING: Failure to comply with warnings and precautions in this manual may cause personal injury, product damage, voiding of product warranty or a failed calibration.

DISCLAIMER

Sale of the DRIVESAFE breath alcohol tester is on the express condition that neither the manufacturer nor the vendor of the device shall be held responsible for the accuracy of any breath alcohol test reading obtained from the device, nor liable for any loss, damage, injury or other consequence resulting, directly or indirectly, from the use thereof.

BREATH TEST READINGS

Breath test results may be displayed on the DRIVESAFE tester in units of breath alcohol concentration (BrAC) or blood alcohol concentration (BAC). BrAC is directly proportional to BAC. Refer to Chapter 7 for a list of BrAC-BAC conversions.

CAUTION: Be aware of how the legal driving limit is expressed where you live and take special care not to confuse BrAC with BAC results.

EFFECTS OF ALCOHOL ON TEST RESULTS

Each person reacts uniquely to the consumption of alcohol and may become impaired at a point below the legal limit.

BrAC / BAC may continue to rise for up to 2 hours after alcohol was last consumed.

Take special care if a borderline result or a result close to the legal BrAC / BAC limit is indicated.

It may take 10 hours or more for an individual's BrAC / BAC level to return to 0 after a high BrAC / BAC level has been reached. In this case, a further test should be carried out later in the day or on the following morning.

CONTAMINATION AND INTERFERENCE WITH BREATH TESTS

Be aware that alcohol is present in many products such as breath spray, mouthwash and medicine, as well as in certain foods and beverages, which may distort breath test results.

- Before testing – Wait 20 minutes after drinking or eating and 3 minutes after smoking
- Swish and swallow fresh water to remove contaminants from the mouth
- Keep magnets or mobile devices away from tester to minimize the potential of electromagnetic interference

GENERAL SAFETY AND PRECAUTIONS

- Use products for intended purpose only
- Use parts specified by ACS only
- Do not disassemble products
- Do not attempt to repair products; you must contact authorized service provider

DRIVESAFE TESTER

- This tester uses AA alkaline batteries only
- Turn the tester off before removing batteries
- Do not store the tester in extreme heat or extreme cold temperatures
- Use the tester within ambient temperature range of 0 to 50 °C
- Do not blow into the tester without using a mouthpiece
- Always use a new mouthpiece when blowing into the tester
- Do not blow smoke or fluids into the mouthpiece; doing so may damage the sensor
- Make certain that the exhaust grill of the tester is not covered in any way when performing a breath test

CLEANING AND MAINTENANCE

During field use, handle the DRIVESAFE tester with care and keep it clean and dry at all times. Clean the handset with a damp cloth and mild soap. Do not use abrasive cleaners or solvents.

CALIBRATION

To maintain accuracy, the DRIVESAFE tester requires a calibration each year from the first date of use.

When a calibration is due, **CAL** is displayed on the DRIVESAFE tester screen.

BATTERY POWER

The DRIVESAFE tester requires 2 AA alkaline batteries for operation (batteries are included).

In production, a plastic tab is inserted between the battery and the electrical connection to conserve battery power during shipment and storage.

To operate the tester for the first time, pull the plastic tab from the battery compartment, which is accessible at the back of the tester.

The tester can perform over 1,000 tests with a set of new batteries.

BATTERY STRENGTH INDICATOR

When the DRIVESAFE tester is powered on, a battery strength indicator is displayed on the bottom right of the screen. When the battery strength indicator begins to flash, the batteries require changing.

If the **E01** error message is displayed, there is insufficient power to continue operation of the tester.

To install new batteries, power the tester off (press the power button twice in quick succession); remove the back battery cover by pressing down on the indent and slide the cover back.

ALCOHOL GAS STANDARD CANISTER, REGULATOR VALVE AND DELIVERY TUBE

Calibration of the DRIVESAFE tester using the gas standard method should be performed indoors, in a service facility, where the gas-standard cylinder can be properly stored.

WARNING: Damaged or broken regulator valves can turn a canister into an unguided missile.

CAUTION:

- The transportation and storage of compressed gases in vehicles is dangerous and should be avoided
- Never remove or alter canister labels
- Before use, examine the canister and valve for any damage
- Observe all cautions and safety warnings found on the canister; pay attention to the expiration date on the label
- Attach the regulator valve in a safe location
- Never modify the delivery tube in any way
- Always remove the valve and install protective caps on cylinders when not in use
- Store canisters in cool, well-ventilated areas, away from sources of heat

ALCOSIM BREATH ALCOHOL SIMULATOR

- Before use, check that the product power supply rating (24Vdc, 2.5A) conforms to local supply rating
- Before use, inspect all components for visible cracks or damage
- When assembling, disassembling or preparing the simulator for use, ensure that it is not plugged into an electrical outlet
- Avoid contact with the heating element; the surface is hot
- Place the simulator on a flat surface, free from obstruction
- Do not expose the simulator to direct sunlight for extended periods of time
- Do not use the simulator with any toxic or flammable liquids, or in explosive atmospheres
- It is recommended to use the simulator within room temperature environments (23 °C ± 2 °C and approx. 50% RH)
- The solution container, tubing and mouthpieces must be completely dry; even slight condensation may disrupt calibration
- Fit tubing or mouthpieces on an aquarium air pump or a similar setup for drying
- Never connect the simulator to an electrical outlet without first adding solution and attaching the top housing
- The simulator requires 500 mL of solution; the 500 mL fill line is marked on the solution container
- Do not under fill or over fill the solution container
- Do not over tighten the top housing
- Connect the simulator cables neatly to ensure simple disconnection after use of the simulator
- Do not force a misaligned cable connector into place
- Once the solution reaches 34 °C, wait an additional 20 minutes before calibrating a tester; this allows the solution to reach correct conditions and concentration
- If solution overheats considerably beyond 34 °C, disconnect the simulator power immediately
- Disconnect the simulator power after use
- After disconnecting the simulator power, allow 10 to 15 minutes for the heating element to cool off before detaching the top housing
- Empty out solution containers at the end of a work day
- Store the simulator in an environment of 5 to 40 °C and 10 to 85% RH

CLEANING

- Disconnect the simulator power before cleaning
- After disconnecting the simulator power, allow 10 to 15 minutes for the heating element to cool off before detaching the top housing
- Do not submerge the top housing in water

- Clean the top housing by wiping it with a water dampened cloth
- Wash the solution container with plain water and dry with paper towel

CALIBRATION

As a certification requirement, the ALCOSIM simulator must be calibrated by an authorized service provider once a year.

Upon purchase of the simulator, a “Next calibration due” label is placed on the device’s top-housing, indicating the month and year of the next calibration. Calibration is due at the end of the month indicated on the calibration label. The label is replaced after every calibration.

ALCOHOL REFERENCE SOLUTION

- For the calibration of the DRIVESAFE tester, use 0.48 mg/L (100 mg/dL) solution concentration only
- Replace solution every 5 days or 20 tests
- Solution use over time affects alcohol concentration
- Do not use solution bottles with broken seals, or expired solution bottles
- Never use artificial methods (such as a refrigerator or a microwave) to reheat or cool solution or the solution container
- Keep solution at room temperature
- Do not freeze or refrigerate solution
- Do not ingest solution
- If solution is ingested, do not induce vomiting; contact your local poison control centre
- Keep solution away from eyes
- If solution comes in contact with eyes, flush eyes with water; if irritation continues, contact your local poison control centre
- Refer to local environmental regulations for more information about safe solution-disposal amounts
- Dispose of solution down drain

ORDERING PARTS

Contact your authorized service provider or visit shopacs.com. Order additional parts using the ACS part numbers supplied in this manual.

Disposables:

- Round mouthpiece (bag of 25 individually wrapped pieces): 95-000250
- Alcohol reference solution 0.48 mg/L (100 mg/dL); (500 mL bottle): 95-000310
- Alcohol gas standard 0.24 mg/L (50 mg/dL); (105 L, 70 F cylinder): 95-000426

LIMITED WARRANTY

All ACS products are warranted to be free of defects in workmanship and materials for a period of 1 year from the date of shipment. ACS agrees to replace or repair any defective device, provided the defect was not caused by misuse or mishandling.

RETURN INSTRUCTIONS

Any product being returned for warranty repairs must be properly packaged and shipped (prepaid) to an authorized service provider.

CERTIFICATION

The DRIVESAFE breath alcohol tester and other breath alcohol testing products of Alcohol Countermeasure Systems comply with international standards for function and safety.

CHAPTER 1: THE DRIVESAFE BREATH ALCOHOL TESTER

This chapter provides detailed operating information on the use of the DRIVESAFE tester. Information includes product profile, taking a breath test, interpreting test results and changing device settings.

DRIVESAFE TESTER – PRODUCT PROFILE

The DRIVESAFE tester uses an electrochemical sensor (fuel cell) that is specific to alcohol to measure breath alcohol concentration (BrAC).

Navigation and control

Indicators on the LCD screen guide the operator through the test sequence, along the way outlining any errors or missteps. All functions are controlled with a single button.

Getting ready

The DRIVESAFE tester automatically indicates that it is ready to take a breath sample. **READY** will display on the LCD screen. Insert a fresh mouthpiece into the device.

Taking a test

Provide a moderate and continuous breath sample. A tone sounds to indicate proper breath flow. The tone stops after 5 seconds of continuous flow to indicate that a proper sample was received. The result of the analysis is displayed in a few seconds.

View results

Breath alcohol test measurements are shown on a 3-digit LCD screen, along with a graphical intensity meter and a tri-colour backlight.

Calibration

While the sensor provides accurate results over years of use, calibration is required once a year from the date of first use. Calibration is maintained with ACS breath alcohol simulators and alcohol reference solution, or with alcohol gas standard cylinders.

PARTS INCLUDED

Each DRIVESAFE tester comes fully equipped with:

- 2 AA alkaline batteries
- Instruction manual
- Protective carry case
- 5 individually wrapped mouthpieces

ACTIVATE A NEW TESTER (FIRST USE)

Pull out the red plastic tab at the back of the handset (see Figure 1). This tab is inserted between the battery and the electrical connection.

TAKE A BREATH TEST

1. To turn the tester on, press the power button once.

2. **WAIT** is displayed briefly followed by **READY** and a green backlight.

3. Insert a new mouthpiece.

4. Blow moderately and continuously into the mouthpiece.

   A tone sounds to indicate proper breath flow.

5. Stop blowing when the tone ends and the tester clicks.

   If the breath sample is interrupted, too hard or too soft, several beeps sound and **ABORT** is displayed. Wait for **READY** to be displayed and test again.

   If blowing repeatedly in a cold environment (below 10 °C), condensation droplets may form inside the blow channel. Tilt the tester to avoid build-up of condensation.

Figure 1.Tilting tester in cold temperatures

When a breath sample is accepted, the screen displays the result within a few seconds by:

- Digital BrAC / BAC reading
- Bar graph
- Colour backlight (pass = green; warn = amber; fail = red)

The test result is displayed for approximately 30 seconds. During this time, **WAIT** flashes at the bottom of the screen.

When **READY** appears, you may take another breath test.

TURN OFF / TURN ON THE TESTER

The DRIVESAFE tester will automatically turn off after a period of inactivity.

To turn off the tester manually, press the power button twice in quick succession.

To turn on the tester again, press the power button once.

INTERPRET TEST RESULTS

The results of breath analysis are presented digitally and may be interpreted as follows.

NOTE: Refer to Chapter 7 for a list of BrAC-BAC conversions.

CAUTION: Be aware of how the legal driving limit is expressed where you live and take special care not to confuse BrAC with BAC results.

BRAC (mg/L)	SIGNIFICANCE SUMMARY
0.05	Not associated with a positive measure of alcohol
0.10	Not indicative of alcohol consumption
0.25	Positive alcohol control and unsafe to drive a vehicle
0.40	High alcohol level in the body and dangerous to drive a vehicle

BrAC readings up to 0.05 mg/L may result from naturally occurring substances in the body and are not associated with a positive measure of alcohol.

Readings up to 0.10 mg/L may occur from alcohol contamination from foods, beverages or medicines and are not indicative of alcohol consumption.

Readings of 0.25 mg/L and greater are indicative of a level of alcohol at which it is unsafe to drive a vehicle and which may lead to a traffic violation.

Readings of 0.40 mg/L and greater are indicative of a level of alcohol at which it is dangerous to drive a vehicle and which may lead to a criminal charge.

ACCESS AND USE OF SERVICE MODES

The tester has several maintenance modes:

- View firmware version
- Access calibration mode
- Unit of measure mode
- Threshold parameters mode

As a security feature, maintenance modes are accessed by pressing the power button in a particular sequence. You must enter the sequence quickly. The tester beeps each time the button is pressed correctly.

VIEW FIRMWARE VERSION

1. When **READY** is displayed, press and hold the power button.

   In a few seconds, the backlight changes to amber and the firmware version is displayed.

2. Keep holding the power button to view the firmware country-code.

3. Release the power button to return to the **READY** screen.

   NOTE: Knowing the version of firmware a tester is running can often help troubleshoot various service incidents.

ACCESS CALIBRATION MODE

1. When **READY** is displayed, press the power button in this sequence:

   (CLICK) – (CLICK) – (PRESS AND HOLD FOR 5 SECONDS)

2. The backlight flashes amber — count the number of flashes.

3. Press the power button as many times as the backlight flashed.

   UEt is displayed. This screen is for the reference solution calibration method.

4. For the gas standard calibration method, press the power button 2 times in quick succession.

   drY is displayed (you may repeat step 4 to return to the **UEt** screen).

5. With the desired calibration method displayed, press and hold the power button for 3 seconds.

   If you intend on calibrating the unit with a dry gas cylinder, then you must first input the altitude before continuing. Refer to Chapter 4 for more information.

   NOTE: If* CAL *is blinking, the date for calibration has expired. You may still continue the calibration.

   The DRIVESAFE tester is ready for calibration. Refer to Chapter 2 for calibration instructions.

CHANGE UNIT OF MEASURE

1. When **READY** is displayed, press the power button in this sequence:

   (CLICK) – (CLICK) – (CLICK) – (PRESS AND HOLD FOR 5 SECONDS)

   The backlight turns amber with the **g/dL** unit flashing.

2. Use the power button to scroll through the units of measurement.

   Available units are: BAC (g/dL, g/L, mg/dL); BrAC (mg/L, µg/dL, µg/L).

3. At the desired unit of measurement, press and hold the power button to select.

   The backlight changes to green and the chosen unit is displayed at the top of the screen.

CHANGE THRESHOLD PARAMETERS

NOTE: The threshold parameters are used to set the warning and fail levels for a breath test.

1. When **READY** is displayed, press the power button in this sequence:

   (CLICK) – (CLICK) – (CLICK) – (CLICK) – (PRESS AND HOLD FOR 5 SECONDS)

   The backlight turns amber; the current warning level is displayed with the last digit flashing.

2. Change the level as follows:
   - Press the power button repeatedly to increment the flashing digit
   - Press the power button twice in quick succession to switch to the other digits

3. When you have set the warning threshold, press and hold the power button for 5 seconds to save the warning level and to switch to the fail threshold level.

   The backlight turns red.

4. Repeat step 3 to set the fail threshold level.

5. When you have set the fail threshold, press and hold the power button for 5 seconds to save the threshold level.
   - The backlight turns green and **WAIT** flashes
   - **READY** is displayed
   - The DRIVESAFE tester will use the new levels to indicate a pass, warning or a failed test

NOTE: The unit will ensure that the warn threshold is always lower than the fail threshold.

CHAPTER 2: DRIVESAFE TESTER CALIBRATION – OVERVIEW

This chapter defines calibration and verification, describes when to calibrate and defines methods of calibration.

CALIBRATION DEFINED

The periodic process of providing a preset BrAC sample into a breath testing device to re-establish the reference standard (set point) for that device.

VERIFICATION DEFINED

The process of providing a preset BrAC sample into a breath testing device to confirm the re-established reference standard (set point) for that device.

WHEN TO CALIBRATE

To maintain accuracy, the DRIVESAFE tester requires calibration each year from the first date of use. When calibration is due, **CAL** is displayed.

CALIBRATION METHODS

There are 2 methods of calibrating the DRIVESAFE tester: the reference solution method and the gas standard method.

REFERENCE SOLUTION METHOD DEFINED

Using a known alcohol-based water solution to produce an air-to-alcohol vapour. A breath alcohol simulator device is used to thermostatically maintain the solution at a constant temperature of 34 °C, the temperature of human breath. Air is blown into the simulator, releasing a precise BrAC sample from the simulator and into the DRIVESAFE tester.

GAS STANDARD METHOD DEFINED

Using a known alcohol-based gas standard to produce an air-to-alcohol vapor. A compressed-gas cylinder is used to provide a sample directly into the DRIVESAFE tester.

CALIBRATION CYCLES

To ensure accurate results, the DRIVESAFE tester is calibrated in up to 3 cycles. The first cycle starts the calibration and the subsequent cycles are used to verify that the same threshold is reached every time.

CHAPTER 3: REFERENCE SOLUTION CALIBRATION METHOD

This section describes calibration with the ALCOSIM breath alcohol simulator and alcohol reference solution. Information includes an overview of the ALCOSIM simulator, setup instruction and calibration / verification instructions.

ALCOSIM BREATH ALCOHOL SIMULATOR – OVERVIEW

An ACS produced reference-solution calibration device, it heats up alcohol reference solution and facilitates application of air-alcohol vapour to the breath alcohol tester.

HOW IT WORKS

- Technicians add alcohol reference solution to the simulator
- The simulator heats the solution at a constant 34 ºC ± 0.2 ºC (the temperature of human breath)
- Air is blown into the simulator by mouth, using a mouthpiece
- The simulator, in turn, releases air of a precise BrAC
- The air sample is analyzed by the DRIVESAFE tester for calibration / verification

ALCOHOL REFERENCE SOLUTION

For calibration of the DRIVESAFE tester, 0.48 mg/L (100 mg/dL) solution is required. Solution is supplied in 500 mL tamper-sealed bottles. It is premixed and ready for immediate use with the simulator.

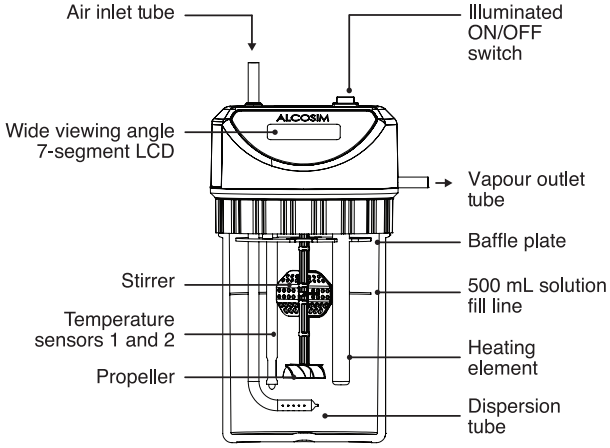
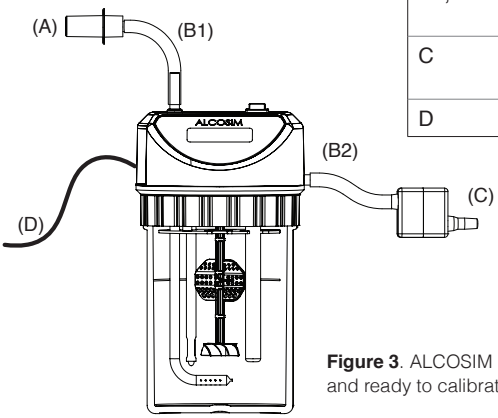


Figure 2. Factory-sealed alcohol reference solution bottle and ALCOSIM breath alcohol simulator

CALIBRATION MATERIALS

- (1) ALCOSIM breath alcohol simulator: 79-007600
- (1) AC power cable: part number depends on your region
- (1) power supply (24Vdc, 2.5A): 07-000075
- (1) 500 mL bottle of alcohol reference solution 0.48 mg/L (100 mg/dL): 95-000310
- 1.5 feet of vinyl tubing: 70-000002
- (1) square mouthpiece assembly: 95-001956
- (1) round mouthpiece: 95-000250

CONNECTION DIAGRAM



A	Round mouthpiece (for manually blowing into the simulator)
B1, B2	Vinyl tubing (cut to size by technician)
C	Square mouthpiece assembly (to the DRIVESAVE tester)
D	Power cable

Figure 3. ALCOSIM simulator connected and ready to calibrate

SET UP THE ALCOSIM SIMULATOR

1. With the simulator power disconnected, turn the top housing counter clockwise (left) and detach the top housing from the container.

2. Add the entire contents of the 500 mL solution bottle into the ALCOSIM solution container.

   The bottle contains the exact amount required for calibration, also marked on the ALCOSIM container.

3. Return the top housing to the container.

4. Connect vinyl tubing to the **AIR INLET TUBE** and the **VAPOUR OUTLET TUBE** of the simulator (see Figure 3).

5. Connect a round mouthpiece to the tubing from the **AIR INLET TUBE**.

6. Connect a square mouthpiece assembly to the tubing from the **VAPOUR OUTLET TUBE**.

7. Perform a leak check by covering the tubing from the **VAPOUR OUTLET TUBE** with your thumb and blowing into the tubing from the **AIR INLET TUBE**.

   The water should not bubble. In case of bubbling, refer to the “Troubleshooting” section of this manual.

8. Connect the power cable to the simulator power input and to a wall outlet.

Figure 4. Connecting a power cable to the ALCOSIM simulator

9. Switch on the simulator. The following occurs:
   - The LCD display illuminates and the simulator beeps
   - The propeller rotates and the heating element activates
   - **Cold** is displayed on the screen until the solution reaches 32 ºC, at which point the LCD screen displays actual solution temperature
   - The simulator heats solution at a constant 34 ºC ± 0.2 ºC

   Once the solution reaches 34 °C, wait an additional 20 minutes before calibrating the tester; this allows the solution to reach the correct conditions and concentration.

CALIBRATE THE DRIVESAFE TESTER

Press the power button on the DRIVESAFE tester.

1. Press the power button on the DRIVESAFE breath alcohol tester.

2. When **READY** is displayed at the bottom of the DRIVESAFE tester screen, press the power button quickly in this sequence (the tester beeps with each click):

   (CLICK) – (CLICK) – (PRESS AND HOLD FOR 5 SECONDS)

3. The backlight flashes amber; count the flashes for the next step.

4. Press the power button as many times as the backlight flashed.

   UEt is displayed.

5. Press and hold the power button for 3 seconds.

   CAL and **001** are displayed.

   NOTE: If* CAL *is blinking, the date for calibration has expired. You may still continue the calibration.

6. Insert the tip of the square mouthpiece into the sensor inlet of the tester.

7. Blow into the round mouthpiece of the ALCOSIM breath alcohol simulator. The tester will emit a tone to indicate proper air pressure and flow. Keep blowing until the tester tone ends and the tester clicks.

   WAIT flashes on the tester screen for up to 40 seconds.

   001, **002**, **003** and **004** indicate the current sample number.

   Once a successful calibration is complete, the tester will display **P** (Pass) and **READY**.

   If the tester displays **F** (Fail) at any time during the calibration process, repeat the procedure.

   Proceed to the next step for verification.

VERIFY ARS CALIBRATION

1. Insert the tip of the square mouthpiece assembly into the sensor inlet of the DRIVESAFE tester.

2. When **READY** is displayed on the DRIVESAFE tester screen, take a deep breath and blow moderately and continuously into the air in mouthpiece of the ALCOSIM simulator.

3. Stop blowing when the DRIVESAFE tester tone ends and the tester makes a click sound.

   When a breath sample is accepted, the DRIVESAFE tester screen displays the result within a few seconds.

   The results of the verification test should indicate a BrAC of around 0.48 mg/L (100 mg/dL), though subtle variations may be expected. If the result is ± 5 mg/dL off of 100 mg/dL, perform the calibration again.

CHAPTER 4: GAS STANDARD CALIBRATION

This section describes calibration with an alcohol gas standard cylinder.

CALIBRATION MATERIALS

- (1) 105 L, 70 F cylinder of alcohol gas standard 0.24 mg/L (50 mg/dL): 95-000426
- (1) regulator valve assembly (6 L/min flow rate): 94-000225

CONNECTION DIAGRAM

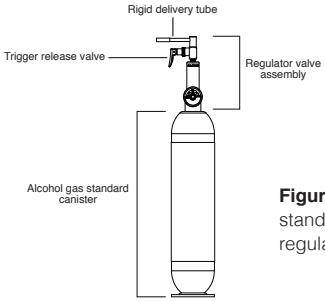


Figure 5. Alcohol gas standard canister with regulator valve assembly

CALIBRATE THE DRIVESAFE TESTER

1. Remove the protective cap of the canister and screw the regulator valve to the canister.

2. Attach the rigid delivery tube to the regulator valve.

3. Press the power button on the DRIVESAFE tester.

4. When **READY** is displayed, press the power button in this sequence:
   (CLICK) – (CLICK) – (PRESS AND HOLD FOR 5 SECONDS)

5. The backlight flashes amber — count the number of flashes.

6. Press the power button as many times as the backlight flashed.
   UEt is displayed.

7. Press the power button 2 times in quick succession.
   drY is displayed for the gas standard calibration method.

8. Press and hold the power button until the mouthpiece port glows amber.

   A blinking **000** is displayed.

9. Input the altitude by pressing the power button twice to scroll through the digits. Once the value blinks, increase the altitude by pressing the power button. Press and hold the power button to confirm the altitude.

   001 is displayed.

NOTE: Check your local altitude in meters online and divide it by 10. If unsure, leave the altitude at 000.

10. Press and hold the power button for 3 seconds.

    CAL and **001** are displayed.

    NOTE: If* CAL *is blinking, the date for calibration has expired. You may still continue the calibration.

11. Insert the delivery tube from the regulator valve into the mouthpiece port of the DRIVESAFE tester.

    Keep hold of the handset as the delivery tube is rigid.

12. Press and hold the regulator valve down to release the gas while still holding the tester. The tester will emit a tone to indicate correct gas pressure and flow.

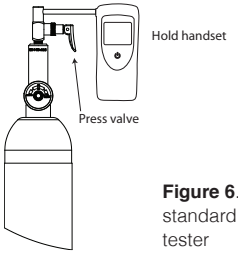


Figure 6. Delivering gas standard to the DRIVESAFE tester

13. Release the regulator valve when the tester tone ends and the tester clicks.

    WAIT flashes on the tester screen for up to 40 seconds.

    001, **002**, **003** and **004** indicate the current sample number.

    Once a successful calibration is complete, the tester will display **P** (Pass) and **READY**.

    If the tester displays **F** (Fail) at any time during the calibration process, repeat the procedure.

    Proceed to the next step for verification.

VERIFY DRY GAS CALIBRATION

1. When **READY** is displayed on the DRIVESAFE tester screen, insert the delivery tube from the regulator valve into the mouthpiece port of the DRIVESAFE tester.

   Keep hold of the handset as the delivery tube is rigid.

2. Press and hold the regulator valve down to release the gas while still holding the tester. The tester will emit a tone to indicate correct gas pressure and flow.

3. Stop blowing when the tone ends and the tester makes a click sound.

   When a breath sample is accepted, the screen displays the result within a few seconds.

   The results of the verification test should indicate a BrAC of around 0.24 mg/L (100 mg/dL), though subtle variations may be expected. If the result is ± 5 off of 0.24 mg/dL, perform the calibration again.

GENERAL TROUBLESHOOTING

Common causes of calibration failure:

- Vinyl tubing is overused or has condensation present
- The alcohol gas standard cylinder is expired
- Connections to and from the gas valve are not secured properly

CHAPTER 5: PRODUCT TECHNICAL SPECIFICATIONS

DRIVESAFE TESTER

Size:	137 mm x 59 mm x 26 mm
Weight:	155 grams
Sensor:	Electrochemical (fuel cell)
Specificity:	Alcohol only, no response to ketones or hydrocarbon
Temperature range:	0 to 50 °C
Initial test:	< 10 seconds
Breath sample:	5 second moderate and continuous breath sample
Analysis time:	< 10 seconds
Recycle time:	25 seconds
Readout format:	BAC (g/dL, g/L, mg/dL); BrAC (mg/L, µg/dL, µg/L)
Range of measurement:	0.00 to 0.75 mg/L
Accuracy:	± 5% @ 0.50 mg/L
Display:	3 digit LCD with graph and tri-colour backlight
Battery:	2 AA
Battery life:	1,000 tests
Mouthpiece:	Disposable (95-000250)
Calibration:	ALCOSIM or equivalent

ALCOSIM SIMULATOR

Size:	227 mm x 130 mm
Weight:	560 grams
Accuracy of reading:	+/- 0.05 °C
Recovery time from test:	< 5 seconds
Warm-up time from cold start:	< 10 minutes
Liquid level:	500 mL
Inlet tube:	1/4” (6.35 mm)
Outlet tube:	1/4” (6.35 mm)
Operating temperature:	0 to 34 ºC
Operating humidity:	10 to 85% RH
Storage temperature:	5 to 40 °C
Storage humidity:	10 to 85% RH
Voltage:	110 volt or 220 volt
Power supply rating:	24Vdc, 2.5A

CHAPTER 6: TROUBLESHOOTING AND ERROR CODES

DRIVESAFE TESTER – GENERAL

IF	WHAT TO DO
No power	Remove the plastic tab from the battery compartment.
No test	Change the mouthpiece. Check if **CAL** is flashing on the display. Wait 20 minutes after eating and 3 minutes after smoking – swish and swallow fresh water.
Cannot enter service mode	Press the power button quicker to complete the sequence. Make sure the handset beeps with each press.

NOTE: Knowing the version of firmware and S/N a tester is running can often help troubleshoot various issues. Read the “View Firmware Version” section of this manual.

DRIVESAFE TESTER – ERROR MESSAGES / CODES

MESSAGE	WHAT TO DO
CAL	Calibrate the handset.
E01	Change the batteries.
E02 + E05 to E11	These errors may occur during the power up sequence and indicate that the tester requires service. Contact ACS for the return procedure.
E03 to E04	The ambient temperature is outside the operating temperature range of 0 to 50 °C. Ensure that the device is being used within the correct temperature range. If problems persist, contact ACS.
E12	The ambient temperature is outside the operating temperature range of 20 to 30 °C during calibration. Ensure that the device is being calibrated within the correct temperature range. If problems persist, contact ACS.

ALCOSIM SIMULATOR – GENERAL

IF	THEN
There is a leak in the ALCOSIM simulator (solution bubbles during leak check)	Ensure that the top housing, mouthpieces and tubing are securely attached. The gasket may be damaged or misaligned; the simulator may need to be sent to an authorized service provider.
The solution does not reach or maintain 34 °C ± 0.2 ºC	Surrounding temperature may be too low. If the surrounding temperature is not the cause, the sensors or heating element may be defective; the simulator may need to be sent to an authorized service provider.
There is condensation in the vinyl tubing or mouthpieces	Fit tubing or mouthpieces on an aquarium air pump or similar setup for drying.
Calibration / verification continues to fail	Check for the following: • Worn out tubing or mouthpieces • Expired alcohol reference solution • Incorrect solution concentration • Incorrect setup and connection • Breath alcohol testing device error If the procedure continues to fail, contact a local authorized service provider or visit acs-corp.com.

ALCOSIM SIMULATOR – ERROR CODES

The following table lists and troubleshoots error codes that may be displayed on the ALCOSIM simulator screen. An error code is accompanied by a periodic beep tone.

ERROR CODE	DESCRIPTION	WHAT TO DO
Er 11	Motor malfunction.	Switch the ALCOSIM simulator off, wait 5 seconds and switch on again. If error messages persist, the simulator may need to be sent to an authorized service provider.
Er 13	Transistor malfunction.	
Er 21	Temperature sensor 1 has no current.	
Er 22	Temperature sensor 1 short circuit.	
Er 23	Temperature sensor 1 leak.	
Er 25	Electric potential meter 1 damage.	
Er 31	Temperature sensor 2 has no current.	
Er 32	Temperature sensor 2 short circuit.	
Er 33	Temperature sensor 2 leak.	
Er 35	Electric potential meter 2 damage.	
Er 41	Heater malfunction.	
Er 54	Alcohol reference solution temperature is above 34 °C ± 0.2 ºC for longer than 3 minutes. The ALCOSIM simulator attempts to restore temperature to 34 °C ± 0.2 ºC. If it cannot, the heater disables and **Er 54** is displayed.	***REMEMBER: Operate the simulator within a room temperature environment (23 °C ± 2 °C, and approx. 50% RH).*** Allow solution to cool-down. Power the ALCOSIM simulator off and power on again when appropriate.
Er 55	Alcohol reference solution temperature is above 37 °C. Heater automatically disables and **Er 54** is displayed.	If error messages persist (and the surrounding temperature is not the cause), the simulator may need to be send to an authorized service provider.

CHAPTER 7: BRAC / BAC UNITS AND CONVERSIONS

NOTE: Breath alcohol concentration (BrAC) is directly proportional to blood alcohol concentration (BAC).

BRAC – UNITS OF MEASUREMENT

mg/L	milligrams of alcohol in 1 litre of breath
µg/L	micrograms of alcohol in 1 litre of breath
µg/dL	micrograms of alcohol in 100 millilitres of breath

BAC – UNITS OF MEASUREMENT

mg/dL	milligrams of alcohol in 100 millilitres of blood
g/dL	grams of alcohol in 100 millilitres of blood
g/L	grams of alcohol in 1 litre of blood

BRAC-BAC CONVERSION CHART

BRAC			**BAC**		
mg/L	µg/L	µg/dL	mg/dL	g/dL	g/L
0.05	50	5	10	0.01	0.10
0.10	100	10	20	0.02	0.20
0.14	140	14	30	0.03	0.30
0.19	190	19	40	0.04	0.40
0.24	240	24	50	0.05	0.50
0.29	290	29	60	0.06	0.60
0.38	380	38	80	0.08	0.80
0.48	480	48	100	0.10	1.00
0.52	520	52	110	0.11	1.10
0.71	710	71	150	0.15	1.50
0.95	950	95	200	0.20	2.00
1.43	1430	143	300	0.30	3.00

CHAPTER 8: HOW THE DRIVESAFE TESTER WORKS

The DRIVESAFE tester provides accurate BrAC / BAC values by using electrochemical fuel-cell technology. The fuel cell is comprised of a porous membrane containing sulfuric acid and platinum coated electrodes on each side. It is mounted within the sample chamber of the DRIVESAFE tester.

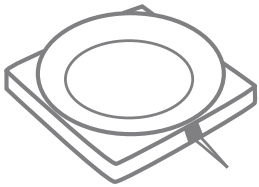


Figure 7: ACS electrochemical fuel cell

When the test subject blows into the DRIVESAFE tester, a sample of breath comes into contact with the fuel cell. If there is alcohol in the breath sample, a chemical reaction in the fuel cell generates an electrical current. The microprocessor of the DRIVESAFE tester compares the generated electrical current to a preset reference standard and calculates a precise BrAC / BAC value.

If no alcohol is present in the breath sample, no chemical reaction takes place, and no electrical current is generated. On the other hand: the more alcohol in the breath sample, the more electrical current created during the chemical reaction and the higher the calculated BrAC / BAC value.

CHAPTER 9: THE PHYSIOLOGY OF BREATH TESTING

This section will address the processes of the distribution and elimination of alcohol in the body. These processes make it possible to conduct breath analyses for alcohol and predict a breath alcohol concentration (BrAC).

Following oral consumption, alcohol is absorbed and distributed throughout the body by the circulatory system. Alcohol diffuses freely and is found in relative concentrations according to the water content of the various tissues. Alcohol is removed from the body by processes of metabolism and simple excretion, including its passage into the breath.

The relative concentration of alcohol in various bodily fluids and tissues can be predicted and correlated on the basis of their water contents (Widmark's factor – explained later). Alcohol passes unchanged from the blood stream into the breath according to the principles of Henry's Law (explained below) and, therefore, the alcohol concentration of the blood may be calculated from a breath alcohol determination.

BREATH – PHYSIOLOGY AND TERMINOLOGY

The process of respiration takes place at the juncture of the blood and the breath, within the alveolar sacs, deep in the lungs. Blood coming from the right side of the heart is pumped through the pulmonary arteries, which circulate it through the alveolar region. Blood carries with it carbon dioxide and other volatile gases that are produced in the body as a result of metabolism. These gases pass freely through the walls of the blood vessels into the alveoli. At the same time, oxygen from the breath diffuses through the alveolar walls and into the blood stream. This process is concentration-dependent: the gases diffuse from an area of higher concentration to an area of lower concentration. The pulmonary veins then carry the oxygen enriched blood from the lungs back to the left side of the heart, where it is distributed throughout the body.

Since alcohol is a relatively small molecule, it too can pass freely through the walls of the blood vessels and into the alveoli. The movement of this volatile substance (alcohol) behaves according to the principles of Henry's Law; that is, a volatile substance achieves a concentration in a gas (breath) when it is in virtual contact with the liquid (blood), which may be predicted from the temperature of the liquid, the inherent volatility of the substance (alcohol), and its concentration in the liquid.

To conduct a proper breath analysis for alcohol content, it is necessary to sample breath from the deep lung region. Many techniques have been employed for this purpose, but generally attempt to mimic the respiratory profile.

The following table provides respiratory profile terms:

Vital capacity:	The amount of air that can be exhaled, following a full inspiration without collapsing the lungs.
Tidal volume:	The amount of air that is inhaled and exhaled in the resting state.
Residual volume:	The amount of air that may be yet exhaled from the lungs following a tidal-volume exhalation.
Dead volume:	The amount of air that remains in the lungs following a complete forced exhalation.
Deep lung air:	Breath from the residual volume at the end of a complete forced exhalation.
Mixed expired breath:	Breath from the tidal volume in the resting state.

BREATH-BLOOD ALCOHOL RATIO – OVERVIEW

When alcohol leaves the blood stream and enters the breath, it reaches a point of equilibrium in the "deep lung" or alveolar region as predicted from Henry's Law. The relationship between the concentration of alcohol in the arterial blood region of the lungs and the concentration of alcohol in the breath from the deep lung region (alveoli) at the end expiratory breath temperature (34 ºC), is known as the breath-blood alcohol

ratio. This ratio has been experimentally determined by a number of research groups since Widmark's historic work in this field, and at present the most commonly accepted ratio is 2100:1. That is, 2100 parts of deep lung air contain the same amount of alcohol as 1 part of blood.

Others have found the factor of 2320-2370 to 1 can be established using re-breathed air as a means of breath alcohol determination, and have therefore proposed the adoption of 2300:1 as the international standard. While this more closely approximates the value to be predicted from Henry's Law, it does not take into consideration the practical limits of the design of breath testing instruments commonly being used for evidential and screening purposes. Thus, while the ratio of 2100:1 generally results in an under-estimation of blood alcohol concentration from a breath alcohol analysis, this is preferred to an over-estimation, when the results of the analysis are to be used to determine if it is safe to operate a motor vehicle.

BREATH-BLOOD ALCOHOL RATIO

1 mL of blood contains the same amount of alcohol as 2100 mL of breath

= 100 mg of alcohol in 210 Litres of breath

1 mole of gas occupies 22.4 Litres at STP (Standard Temperature and Pressure)
1 mole of ethanol = 46 grams

$= \frac{100}{46000} \times 22.4$ L in 210 Litres of air

= 0.047 Litres of alcohol in 210 Litres of air

= 232 ppm

According to this calculation, the DRIVESAFE device can directly measure an alcohol concentration in the range of 0 to 1000 ppm.

BREATH ALCOHOL ANALYSIS – METHODOLOGY

To ensure that a proper sample of breath from the deep lung region has been analyzed for alcohol content, a variety of techniques have been adopted that require a controlled and uninterrupted flow of breath until near complete expiration has occurred. It is the breath from the deep lung region (end expiratory) that contains the highest concentration of alcohol in equilibrium with the alcohol concentration of the blood.

Mixed expired breath has a lower alcohol concentration, since it is not in equilibrium with the blood. Thus, the means to sample breath for alcohol analysis must ensure that all of the mixed expired air is exhaled before a sample of breath from the deep lung region is captured for analysis.

Further, to ensure that the alcohol in the breath sample is representative of the alcohol concentration of the blood, one must ensure that there is no contamination of the breath sample from residual alcohol in the mouth and throat from a recent drink. This is accomplished by waiting 20 minutes after a last drink. One may also swish and swallow fresh water to remove contaminants from the mouth.

CHAPTER 10: ALCOHOL & THE PHYSIOLOGY OF THE HUMAN BODY

This section will cover the absorption, distribution, metabolism and excretion of alcohol in the human body. The word alcohol will mean ethyl alcohol. It is also called ethanol or grain alcohol. Other compounds such as methyl alcohol (wood alcohol) and isopropyl alcohol (rubbing alcohol) have similar patterns of absorption distribution and elimination as ethyl alcohol and will not be discussed here.

ABSORPTION OF ALCOHOL IN THE BODY

Alcohol is a small molecule that readily mixes with water. It can be taken into the body by any of the common routes of administration for drugs. The most practical and effective route is oral ingestion.

Absorption begins as soon as alcohol comes into contact with the tissues of the mouth and throat. Alcohol quickly passes through these tissues and enters the rich blood supply of the blood vessels in this area by a process of simple diffusion.

Unlike other complex substances – such as fats, carbohydrates and proteins – alcohol does not require preliminary digestion or breakdown for absorption, and no carrier is needed for its passage into the bloodstream.

ABSORPTION IN THE GASTROINTESTINAL (GI) TRACT

Alcoholic beverages are retained in the stomach for a period of time prior to transfer into the small intestine. The absorption of alcohol into the bloodstream can occur directly at the stomach wall, but the most rapid absorption occurs through the wall of the small intestine, which is made of a highly specialized tissue for the uptake of nutrients into the body. The small intestine has thinner walls, a greater blood supply, and a surface area one-thousand times greater than the stomach.

Regardless of the alcohol concentration of a beverage consumed, the concentration of alcohol in the small intestine rarely exceeds 1 to 2% v/v*. Typically about 30% of all consumed alcohol is absorbed from the stomach, whereas 70% is absorbed from the small intestine. Only the mouth, throat and stomach come in contact with high concentrations of alcohol, and only in the stomach is this contact prolonged.

* *v/v is the percentage of alcohol by volume*

MOTILITY IN THE GI TRACT

Another consideration with respect to the gastrointestinal tract is the motility of (the ability to move food through) the tract itself. Motility increases the passage of alcohol and determines the stomach emptying time, influencing absorption from the stomach.

FACTORS AFFECTING ABSORPTION

Factors that may affect the total rate of absorption include: the type of food and quantity of food consumed, concentration, type and volume of the consumed alcoholic beverage, rate of consumption, certain types of drugs, diseases, emotional states, and individual traits such as sex, body weight, body water content, experience with alcohol and metabolic disposition. These parameters taken together define consumption tolerance for a given individual.

As a general note, anything that will retain alcohol in the stomach will prolong absorption into the blood, while conditions that allow rapid passage of alcohol into the small intestine will hasten the rate of absorption.

FOOD TYPES AND QUANTITIES

The type and the amount of food in the stomach can determine the absorption process for a specific individual. All foods require prior digestion in the stomach before being transferred into the small intestine. Thus if food is taken with alcohol, absorption will be delayed during the digestion process. Food can decrease alcohol absorption rate by as much as 30%. Fats, proteins, and carbohydrates can also prevent contact of alcohol with the stomach wall, and thus delay absorption for a considerable period of time. In effect, the food dilutes the alcohol.

ALCOHOLIC BEVERAGES – CONCENTRATION, TYPE AND VOLUME

Beverages with an alcohol concentration of less than 20% v/v have lower rates of absorption due to the volume of water that must also be absorbed. Beverages with alcohol concentration greater than 40% v/v have delayed absorption because they cause extreme irritation to the stomach wall and pyloric valve. The quickest rate of absorption occurs with beverages having an alcohol concentration of 20% v/v.

Furthermore, it has been reported that the absorption of beer from the gastrointestinal tract may be delayed due to the absorption/digestion of inhibitory substances such as nutrients and carbohydrates. In addition, sparkling wines, and high balls containing carbonated beverages may facilitate absorption due to the carbonation itself.

RATE OF ALCOHOL CONSUMPTION

The absorption of alcohol into the bloodstream normally proceeds quite rapidly with a single dose of alcohol. The majority of alcohol is absorbed within fifteen minutes, and more than 90% of alcohol is absorbed within one hour with food in the stomach. In the situation where a high volume is consumed over a short period of time, complete absorption can take two to three hours.

Within limits: the more alcohol available for absorption in the stomach and small intestine, the greater the rate of absorption. As a result, if a beverage is consumed over a shorter interval of time, it will be absorbed more rapidly.

DRUGS AND OTHER FACTORS

Certain drugs, diseases or emotional states may cause a decrease in the activity of the stomach and small intestine and also decrease the rate of blood flow in this area. The result is a decreased rate of absorption. An opposite effect may apply if an individual is in a relaxed atmosphere: this would promote the absorption of alcohol.

Habituation may promote absorption, while compounds such as nicotine and caffeine may delay absorption.

DISTRIBUTION OF ALCOHOL IN THE BODY

Once alcohol has been absorbed into the bloodstream, it is circulated throughout the body, diffusing into body tissues and fluids, and mixing and equilibrating with total body water. Differences in distribution are seen between bodily fluids and bodily organs; however, a relatively constant ratio between them exists. The most important single factor that influences the alcohol concentration in an organ or fluid is its water content, since alcohol is soluble in water.

WIDMARK'S HYPOTHESIS

Alcohol is distributed in the body in proportion to the level of water content in the bodily tissues and fluids.

Widmark postulated that the higher the concentration of water in a given body tissue or fluid, the higher the alcohol concentration would be. For example, urine has a higher water concentration than blood and so it should have a higher alcohol concentration. On the other hand, bone and fat have little water content and so will have very low alcohol concentration.

WIDMARK'S FACTOR

The amount of alcohol that can be absorbed and distributed throughout the body depends on a person's sex, weight and fat content. The more water in a person's body, the more alcohol may be absorbed and distributed. This water content is generally dependant on the weight of the person, that is: the greater the weight of a person, the greater the water content of that individual's body. As fat tissue does not distribute alcohol, the fat content of a person's body must be considered. Females have proportionately more fat in their bodies than males; consequently, they usually absorb and distribute less alcohol than males.

The proportion of an individual's body that can distribute alcohol was determined experimentally, the values for which are given below:

Males 0.7 (or 70%)

Females 0.6 (or 60%)

Widmark's factor "r" (rho) can be expressed mathematically, as follows:

$$r = \frac{\text{Amount of Water in Entire Body}}{\text{Amount of Water in Blood}}$$

Since water mixes freely with alcohol, Widmark's factor can be redefined mathematically as follows:

$$r = \frac{\text{Amount of Alcohol in Entire Body}}{\text{Amount of Alcohol In Blood}}$$

Note that the factors 0.7 and 0.6 are approximate averages and have been determined empirically. As a result, because a female has a proportionately higher fat content, she may only absorb and distribute 6/7 as much alcohol as a male.

Because Widmark's factor establishes the relationship between the amounts of alcohol in the entire body with respect to the amount in the bloodstream, one can calculate the amount of alcohol that is absorbed in a person's body at any one time, knowing the blood concentration at that time. The following equation describes the relationship between body weight, the blood alcohol concentration (BAC) and Widmark's factor.

$$A\,(g) = p(kg) \times c(g/kg) \times r$$

A represents the total amount of alcohol absorbed in grams
p represents the body weight of an individual in kilograms
c represents the BAC in percent (w/v)
r represents the Widmark factor

Rearranging this equation and taking into the account the conversion from metric units to the imperial system, the equation for a male can be rewritten as follows:

$$\#\text{ oz (40\% spirits)} = \text{Weight (lbs)} \times \%\text{BAC} \times 0.35$$

This equation can be used as follows:

- To calculate the amount of alcohol in the body if the weight, %BAC and "r" factor are known
- To calculate the expected %BAC if the type and amount of alcohol ingested, the individual's body weight and the "r" factor are known
- The "r" factor for a given person – if the amount of alcohol ingested, the weight of the individual and the %BAC are known

This formula does not identify the origin of the alcohol or the speed of absorption and elimination. The Widmark formula is an indication of the minimum amount of alcohol absorbed into the body at the time of sampling. It does not include the still unabsorbed alcohol or that which has been eliminated. For the Widmark equation to be valid, alcohol absorption must be stopped and equilibrium reached between blood and tissues.

ELIMINATION

The elimination of alcohol from the body begins shortly after it is present in the body and continues until it has been totally removed. Elimination proceeds by two separate means: metabolism and excretion. About 90 to 98% of the total amount of alcohol consumed is removed from the body by metabolism. Metabolism, which occurs chiefly in the liver, effectively removes alcohol from the body by changing it to other compounds. An enzyme, alcohol dehydrogenise, brings about this reaction. The end products of this reaction – carbon dioxide and water – are non-toxic, and excreted from the body by natural means.

ALCOHOL > ACETALDEHYDE > ACETATE > CARBON DIOXIDE and WATER

About 2 to 10 percent of the total amount of alcohol consumed is removed from the body by excretion. Excretion of alcohol from the body means the removal of alcohol in an unchanged form. This occurs in an area where water leaves the body, or when alcohol is carried out on the breath. Examples of materials that are removed from the body and bring about the excretion of alcohol are: breath, urine, feces, sweat, tears and saliva.

Excessive breathing or urination will not significantly change the amount of alcohol that can be removed from the body by excretion. Only negligible amounts of alcohol are excreted.

RATE OF ELIMINATION

The combination of metabolism and excretion leads to the total amount of alcohol eliminated from the body. For a given individual, this amount is relatively constant. The actual amount is dependent upon a person's weight and amount of fatty tissue. For a 150 pound man, the amount of alcohol that can be eliminated from the body in one hour is approximately 25 mL of 40% v/v liquor (about 1 ounce) or 10 mL of pure alcohol. It is obvious therefore, that the sum of the amount of alcohol present in the body at any given time, and the amount of alcohol eliminated from the body since the time drinking started, should provide a fairly accurate estimate of the total amount of alcohol a given individual may have consumed.

Once absorption is completed, the BAC should decrease at a constant rate until all of the alcohol is removed. The rate of elimination is determined by monitoring the decreasing blood alcohol levels with time.

If this rate of elimination were measured in all people, it would be observed that regardless of height, weight, sex, or amount of fatty tissue, the average rate is a consistent 15 mg/dL per hour. The normal range for values of this rate is 10 to 20 mg/dL per hour. However, the average value of 15 mg/dL per hour is the standard used for equations. It is possible then to calculate with a fair degree of certainty what a person's BAC would have been at some time previous, or what it will be, given the BAC at a particular time. If no additional alcohol was consumed in the interval and the BAC of the subject have been declining over the time interval, a reasonably prediction can be made.

CHAPTER 11: PHARMACOLOGY OF ALCOHOL

Pharmacology of alcohol: the effects of alcohol on the body as these relate to mental and physical functions.

It is essential to understand the actions of alcohol in the human body in order to appreciate and recognize the symptoms or effects of alcohol on behaviour and performance. Furthermore, there are many misconceptions regarding the effects of alcohol, which can lead to false conclusions. This chapter is designed to provide a basic understanding of what alcohol does to the body and a factual basis upon which to assess the severity of these effects.

The essential component of alcoholic beverages is ethanol. In reasonable amounts, the flavouring matter or mix that is used to dilute the beverage does not cause any pharmacological effects on the body. It is solely ethanol that is responsible for the observed changes in behaviour and performance when one consumes alcoholic beverages.

Alcohol should be considered a drug, because it is a chemical that alters normal biological progresses in the body. For example, it causes diuresis (increased urine production), vasodilatation (skin flushing), increased gastric secretion, as well as immeasurable subjective sensations. Ethanol should not be underestimated in terms of its potency as a drug. Its effects are primarily and continuously upon the central nervous system – the magnitude of the effects being dependent upon the concentration of alcohol in the body. Because it is a general anesthetic and progressive depressant, acting primarily on the central nervous system, ethanol has been classified as a central nervous system (CNS) depressant (drug classification).

VISION

The consumption of alcohol results in a deterioration of visual abilities in several ways and at differing BAC levels.

Acuity – Clarity of vision is suppressed at BAC levels less than 50 mg/dL. The degree of suppression is dependent on the individual and increases with increasing BAC. Alcohol appears to have the same effect on vision as driving with sunglasses in twilight. In order to distinguish objects, a stronger illumination is required, and dimly lit objects are barely distinguishable.

Depth Perception – Depth perception is the ability to ascertain the relative distance of objects by the observer. Deterioration commences at BACs of less than 50 mg/dL.

Peripheral Vision – The experience of tunnel vision that is likely caused by the result of lessened visual scanning, or attentiveness to the periphery of one's visual field – usually occurring with BACs in the range of 50 to 100 mg/dL and greater.

Double Vision – Begins to occur with BACs in the range of 50 to 100 mg/dL, and progressively becomes worse as the BAC rises.

Glare Recovery – The eyes take longer to recover after being subjected to dazzling light, occurring with BACs less than 50 mg/dL.

Nystagmus – A nervous twitching or movement by the eye that begins at BACs less than 50 mg/dL and progressively becomes worse with increasing BAC.

OTHER SENSES

In drinking environments, it is common to experience an increase in voice levels. The cause is not due to a decrease in hearing ability but rather the lack of attentiveness.

The keenness of taste and smell are depressed.

Alcohol has a pain killing effect, and in comparison with other pain killers, it raises the pain threshold substantially.

CENTRAL NERVOUS SYSTEM

The central nervous system is more markedly affected by alcohol than any other system of the body. The belief that alcohol acts as a “stimulant” is erroneous – there is no doubt that it acts like other general anesthetics. The apparent stimulation is actually due to a depression of normal inhibitory control, and is the result of the early action of alcohol on the reticule-activating system. The reticular formation serves a regulatory and coordinating function within the nervous system (it is comparable to a telephone switchboard). For example, fibres going from the reticular formation up to the cortex (forebrain) constitute what is known as the arousal or activating system. This system alerts other parts of the cortex as well so that association takes place. Not only is the stimulus received, but connections occur from the sensory area to other areas involved in the process that we call memory and recognition. You hear a sound for example, and the impulse registers on the auditory sensory area; impulses go to other areas of the cortex and you recognize, “Ah yes, that’s a car coming along the curb beside me; I’d better step back.”

Other connections go to the hypothalamus, an area on the under surface of the brain where there are centres that control such things as heart rate, blood pressure, movements of the stomach, intestines, sweat glands – the whole series of so-called autonomic functions. These are the functions that are more typically involved in the physical reactions to emotion. The car is coming just as you are going to step off the curb; you not only hear it and recognize it, but you suddenly react. Your heart beats more quickly, adrenaline is secreted, and a state of awareness and alertness for an emergency is triggered. Other areas of the cortex are alerted, so that when memory and association have occurred, other impulses are sent from the cerebral cortex down the spinal cord and ultimately to the muscles – so that you step back. Still other connections are from the reticule formation to the motor pathways, suppressing some impulses and activating others, so that your movements are smooth and coordinated, rather than convulsive mass movements.

Alcohol acts first not on the centres of highest reason and judgment, but on these centres of arousal and coordination in the reticular formation. It has been shown that alcohol will produce effects related to this part of the brain at a concentration at which no demonstrable impairment of intellectual function occurs. For example, one

study involved a large group of university students who were put to solve problems in abstract reasoning, involving mathematical and abstract symbols, which they had to solve as rapidly as possible. Their score was expressed as the number of problems that they could solve correctly in a given time. They had to do this on separate occasions, with and without a small dose of alcohol, and they did rather better with the alcohol than without. The reason for this is simply one of relaxation. The effect of the alcohol was to diminish their alertness to external stimuli enough that they were removed a little from the immediate realities of the situation around them, and able to restrict their thoughts to the task they were carrying out.

The difficulty with this is that people are not always aware of just how much of their function depends on alertness. In demanding situations (e.g. high speed travel), intellect is not usually the limiting factor in effectiveness of performance. You may know perfectly well what to do, but a very small delay in your picking up the cue to do it may be extremely dangerous. A small dose of alcohol, while not enough to impair judgment itself, may very well make the difference between being able to and not being able to make that judgment quickly enough.

When the person is totally intoxicated or anesthetized by alcohol, it no longer makes a difference; for then, only the most intense stimuli get through to the cortex. Its importance comes into play when a person drinks sufficient alcohol to reach a stage of impairment lying between the very mildest perceptible change and full unconsciousness.

Consider the case where a person driving partially impaired suddenly sees a police vehicle. A flood of adrenaline comes into the circulation, and under stress they sober up enough that they can restore control over many of their impaired functions. Under this intensified sensory input they are able to counteract the depressant effect of alcohol to a very considerable degree – they fool themselves into believing they can do everything they are supposed to do. It is in this situation that gross errors of judgment are most likely to occur, because a person does not really recognize the full extent of their own impairment.

Thus, it may be seen that alcohol depresses the reticular activating system, thereby releasing the cortex from its integrating control with the result that the various processes related to thought occur in a jumbled, disorganized fashion, and the smooth operation of motor processes become disrupted. The messages associated with normal thought, sensation and muscular control become confused and eventually disrupted; the first processes to be disrupted are those most recently learned. The earliest effects are associated with diminished inhibition and impairment of highly organized control – judgment.

DRIVING PERFORMANCE

ATTENTION

Driving has been described as a complex, divided-attention task involving: 1) a central visual task (tracking or maintaining the vehicle lane position) and 2) a peripheral visual task (scanning the environment for objects, e.g. other traffic or potential driving hazards). When these two activities are combined into a time-shared or divided attention task, alcohol impairs driving performance at BACs as low as 50 mg/dL. Neither of the two activities appears to be impaired by alcohol when performed alone. However, when combined, performance is generally poorer on the peripheral visual task.

Alcohol impairment of performance in divided-attention tasks is most likely due to an impairment of information processing. It appears that alcohol has less effect on the processing of information from a single source than on that coming from several sources. Drivers who are under the influence of alcohol tend to concentrate on one task and neglect others in a divided-attention task.

PERFORMANCE MEASURES

When a person has only one task to attend to, tests of simple reaction time show that alcohol increases the time it takes to react to a signal when BACs are above 80 mg/dL.

Studies examining choice reaction time, where a person must attend two or more tasks at once, have reported greater alcohol impairment at lower BACs.

Drivers with BACs in the vicinity of 90 mg/dL show increased steering and brake response times, as well as less smooth use of the brake pedal.

In a study where the driving situation included emergency braking and evasive maneuvers, drivers with BACs averaging 42 mg/dL performed less efficiently than those without alcohol.

RISK TAKING

Driving an automobile is usually taken for granted as being a relatively easy task, not requiring much conscious effort or critical judgment. Yet the sensory functions of the body bombard the brain with required information, which must be assimilated and processed, such that smooth, controlled operation of the automobile results. The brain makes decisions and regulates motor activity based upon training and previous experiences. Thus, the many complete maneuvers that one makes while driving occur automatically, and one does not have to be consciously aware of them.

Any individual takes many risks when driving, for example: merging with traffic, going through an orange traffic light, proceeding through a busy intersection, passing another vehicle or a bicyclist, driving in the rain, or speeding. The risks are calculated on the basis of personal driving ability, road-worthiness of the vehicle, and on the basis of minimal perceived risks.

Because alcohol acts to depress the reticule activating system, several things occur. The alerting mechanism is depressed such that a person does not become aware of potentially hazardous or dangerous situations that the sensory functions detect. The

sensory functions themselves are deteriorated and may not be supplying complete or correct information to the brain. A person's motor functions are impaired; yet, because of alcohol's depressant effect, that person will feel less inhibited and more self confident about their driving skills. As a result, a person, after having consumed alcohol, is more likely to speed into high risk situations that would normally be avoided or treated cautiously. Loss of judgment and lessened quickness of decision making are critical in these situations.

DRIVING IMPAIRMENT

Driving ability comprises a series of automatic reactions combined with variable requirements for skill, judgment, and the ability to make unexpected, split-second decisions. It calls for coordination, anticipation, visual acuity, a computer mechanism in the brain and muscular control. Thus, driving is a very demanding action. It is not surprising, then, that numerous investigators have found that all persons are impaired in their ability to drive a motor vehicle by the time their BAC reaches 100 mg/dL. Impairment is not simply the appearance of gross physical symptoms but a deterioration of judgment, attention, loss of fine coordination and control, and possibly an increase in reaction time and diminishing of sensory functions after the ingestion of alcohol. It has to do with the objective or measurable symptoms of the effect of alcohol on the body.

PHARMACOLOGY SUMMARY

As explained, the effects of alcohol on the human body are primarily due to its depressant action on the central nervous system. The deterioration of ability and impairment of mental processes become the clinical symptoms one might expect to observe:

1. Zone of impairment: 30 to 100 mg/dL:
    - Removal of social restraints/inhibitions
    - Development of euphoria
    - Driving impairments:
        - Decrease in judgment
        - Decrease in alertness
        - Increase in reaction time
        - Increase in self confidence when not warranted

2. Zone of intoxication: 100 to 250 mg/dL:
    - Disturbed vision
    - Loss of balance, equilibrium

- Vaso-dilation:
    - Blood shot eyes
    - Flushed face
    - Dilated pupils
- Muscular incoordination:
    - Slurred speech
    - Fumbling
    - Emotional disturbance
    - Decreased pain

3. Zone of severe intoxication: 250 to 400 mg/dL:
    - Depressed reflexes
    - Apathy, inertia
    - Stupor
    - Coma

4. Death: 400 mg/dL plus:
    - Depression of respiratory centre, causing respiratory collapse; that is, stop breathing

INTOXICATION

When people speak about the effects of alcohol on a person, the word “drunk” is often used. This word deals with the subjective or observable effects of alcohol and should not be confused with impairment. In actual fact, intoxication is an advanced state of impairment in which the gross physical symptoms of the effects of alcohol are apparent: staggering, incoordination, slurred speech, and a general confused state. These symptoms usually only become apparent when the BAC exceeds 150 mg/dL.

METHODS OF SELF-EVALUATING IMPAIRMENT

Generally, it is very difficult for the individual to detect his level of impairment. A drinker may notice obvious symptoms such as dizziness and slurred speech, but since alcohol usually makes a person feel that they are performing better than is actually the case, the extent of impairment is most often grossly under-estimated.

TOLERANCE

It is a matter of common observation that some people “carry their liquor” better than others. This is due to a person’s tolerance (body tolerance vs. BAC tolerance) to alcohol. There are two types of tolerance:

BODY TOLERANCE

Two individuals consume the same amount of an alcohol beverage and achieve different BACs.

This is due to individual factors such as; body weight, stature, sex, metabolism, and any pre-existing medical conditions.

BAC TOLERANCE

Two individuals with the same BAC exhibit different symptoms of impairment. This is due to the adaptation to the effects of alcohol on a person’s motor and sensory functions (learning experience).

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