

# Measuring alcohol in the body



Evidential breath-alcohol analysis  
with the Alcotest® 7110 and  
Alcotest® 7110 Evidential

## Alcohol and society



51-1712-003

**In many countries around the world, the results of breath-alcohol analysis are already admissible as evidence in court. As laws change, other countries are also going the same way. Due to technological advances, today's instruments are highly accurate in measurement, simple in operation and virtually tamper-proof.**

Alcohol, loved by some and cursed by others, is appreciated by most people as a means of stimulation and relaxation. We all know that consumption of alcohol has a negative impact on our perception and impairs our performance.

However, this change in state does not necessarily need to be unpleasant, and it is not without reason that alcohol plays an important part in social situations in some countries. Alcohol stimulates, inspires, liberates and exhilarates. It removes inhibitions and makes establishing contact easier. Alcohol is missing at no celebration, at no reception, at no banquet. Alcohol is a firm fixture of our everyday life, and has been for many centuries.

Over the centuries, however, the requirements placed upon us in our social lives have changed considerably. Today we live in a modern world in which speed and technology define our daily life. Alcohol can be pleasant and fun, but the consumption of alcohol also holds many dangers.



*One draught  
above heat  
makes him a fool,  
the second mads him and  
a third drowns him!*

Shakespeare  
(from "Twelfth Night")



## Accidents under the influence of alcohol

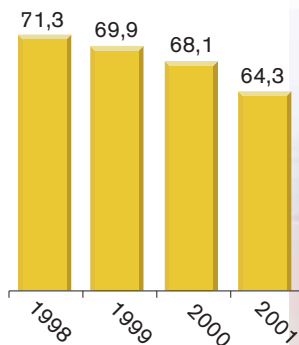


### Alcohol on our roads

When a person's consciousness is clouded by alcohol, this exposes us to many risks. Nowadays, we often encounter situations which demand our concentration and swift reactions. Who can tell how much alcohol is in his or her blood after two glasses of wine?

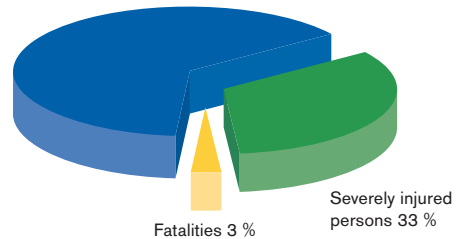
Only our conscience can help us decide how much "too much" is, yet it is precisely our conscience which becomes increasingly unable to function with each sip of alcohol.

In Germany, for example, more than 60,000 road accidents involving people under the influence of alcohol were recorded per year. The proportion of people killed and seriously injured in these accidents was particularly high, and for more than 1,000 people the accident was fatal. Every single accident which occurs due to excessive consumption of alcohol is one accident too many!



Number of traffic accidents in Germany under the influence of alcohol (in thousands)

Slightly injured persons 64 %



Such accidents show us where the limits are, making it clear what the difference between moderate and excessive can mean. Our sense of responsibility towards ourselves and others decides how we answer the question "alcohol, yes or no?".

We all have a duty to accept this responsibility to prevent risk situations and dangers from occurring in the first place. However, only accurate, unmistakable proof of alcohol can show where the limits are, and this accurate proof can be obtained only by means of technical apparatus.





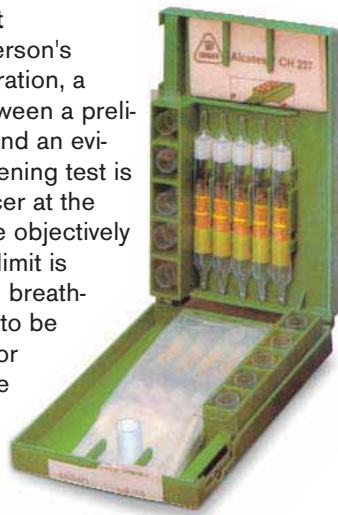
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### Alcohol screening test

When determining a person's breath-alcohol concentration, a distinction is made between a preliminary screening test and an evidential analysis. A screening test is used by the police officer at the roadside to help decide objectively whether, if a particular limit is exceeded, an evidential breath-alcohol analysis needs to be carried out afterwards or whether a blood sample will be taken.

Alcohol screening tests are performed using Alcotest tubes, in which chemicals are discoloured by the alcohol in the breath, or using the electronic Alcotest 7410 hand-held instruments.

The familiar Alcotest tube with the sample bag is probably the oldest method of obtaining proof of alcohol in a screening test. An anecdotal account of how this breath-alcohol test was invented at the beginning of the 1950s goes like this: in the morning after a party, the chemists at Dräger's test tube department each accused the next of smelling most intensively of alcohol. To clarify the matter for once and for all, an objective and accurate method of measurement had to be found, which is how the breath-alcohol test tube came into existence.



38-870

However, requirements with regard to accuracy, speed, test frequency and effective and economic use rose considerably over the years. A screening test must be able to be performed swiftly and supply accurate results, and today mainly electronic devices are used.



49-803

*Although in recent years  
the number of  
traffic accidents  
under the influence  
of alcohol has  
been falling constantly,  
it is still  
alarmingly high!*

## The physiology of alcohol



After drinking, the alcohol, or to give it its more accurate chemical name, ethyl alcohol or ethanol, is taken up by the blood in the gastro-intestinal tract and transported, via the heart and the lung, to the arteries of the brain. From the heart the blood is circulated around the rest of the body, into the arteries of the arms for example. From there it is distributed throughout the tissue and, finally, flows back through the veins.

### Effects on reaction speed

Once alcohol reaches the arteries of the brain, it affects our speed of reaction and, in sufficient quantities, instantly causes unusual, alcohol-related behaviour. The extent to which the speed of reaction is affected determines whether a person can still safely drive a car or whether there is an increased risk of accident.

To judge whether or not a person is fit to drive would require a method of directly measuring this reduction in reaction speed at the roadside, but as yet this is too expensive to be a viable option.

To obtain nevertheless a useable procedure, "auxiliary variables" are used which permit an indirect conclusion to be drawn about a person's speed of reaction: a sample of air from the lungs or a sample of venous blood from the inside of the elbow is taken and its alcohol concentration determined.

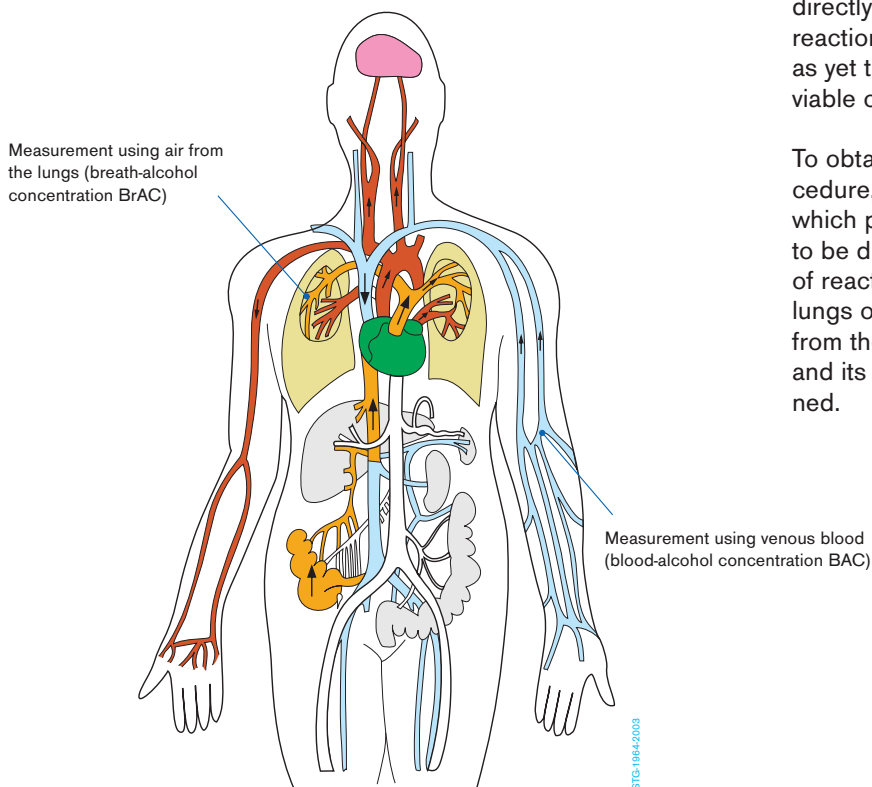
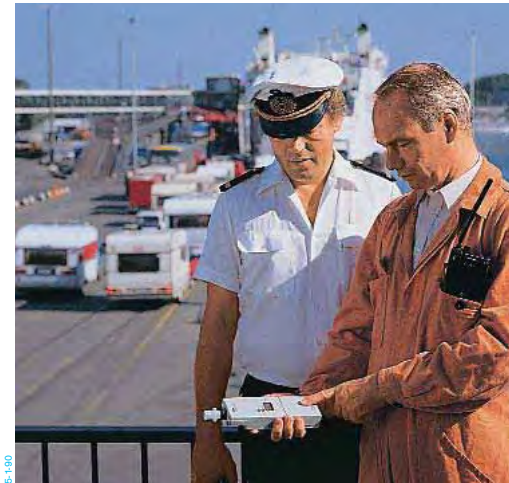


Diagram of alcohol distribution in the body



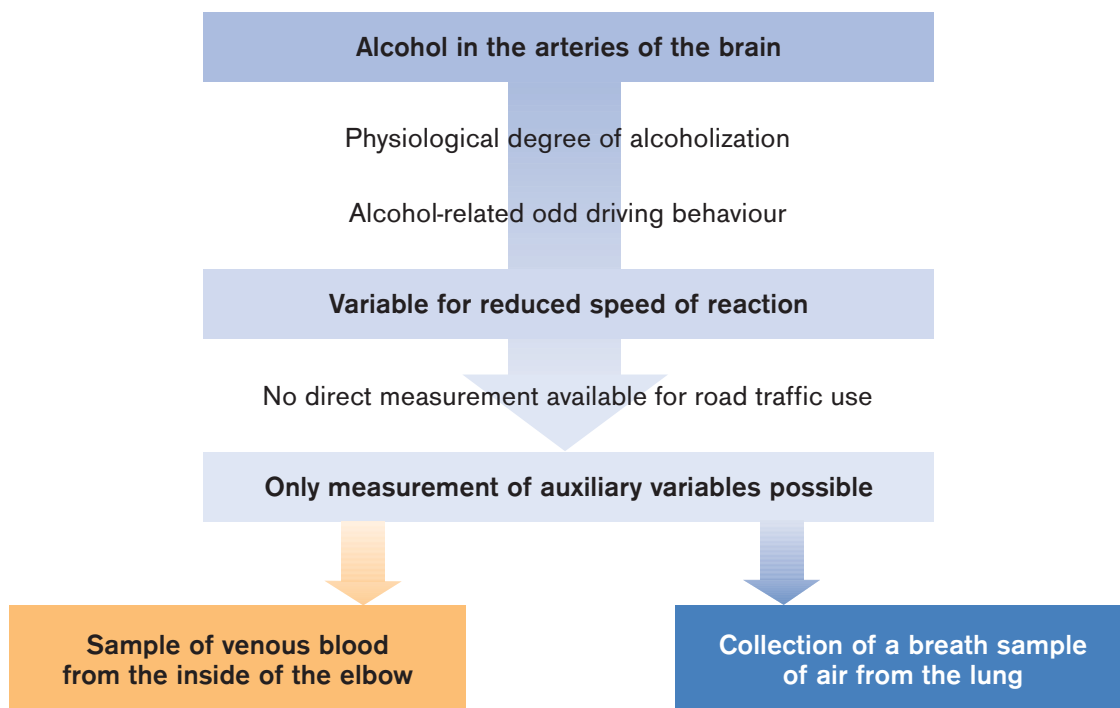
**Henry's law**

The alcohol concentration is measured using air from the lungs or venous blood.

In accordance with Henry's law, diffusion processes, which are also what causes oxygen to be taken up in the lungs, achieve a balance between the alcohol concentration in the blood in the lungs and the alcohol concentration in the air in the lungs. The breath-alcohol measurement involves directly determining this concentration.

From the heart, the blood is circulated around the rest of the body, into the arteries of the arms for example.

From there the blood is distributed throughout the tissue and, finally, flows back through the veins. A sample of this venous blood is taken from the inside of the elbow and used to determine the blood alcohol concentration indirectly by means of a further multistage procedure.



## Measurement methods in comparison



### Evidential measurement

After a positive screening test an evidential alcohol analysis must be performed. Lawmakers in different countries have set appropriate limit values for the two procedures, i.e. breath and blood alcohol analysis.

The breath-alcohol concentration (BrAC), a gas concentration, is expressed for example in milligrammes of ethanol per litre of exhaled air (mg/l). The blood alcohol concentration (BAC), a liquid concentration, is expressed for example in per mille (‰) and refers to the amount of ethanol in grammes in each litre of blood.

In many countries the lowest limit value which constitutes an offence is a blood alcohol concentration of 0.5 per mille (‰), the corresponding limit for breath-alcohol concentration being 0.25 milligrammes per litre (mg/l) of exhaled air.

### Breath-alcohol concentration – a more accurate measure

Even though the limit values for both procedures may be equivalent from a legal viewpoint, the breath-alcohol concentration nevertheless offers a more direct measure of actual impairment of driving ability.

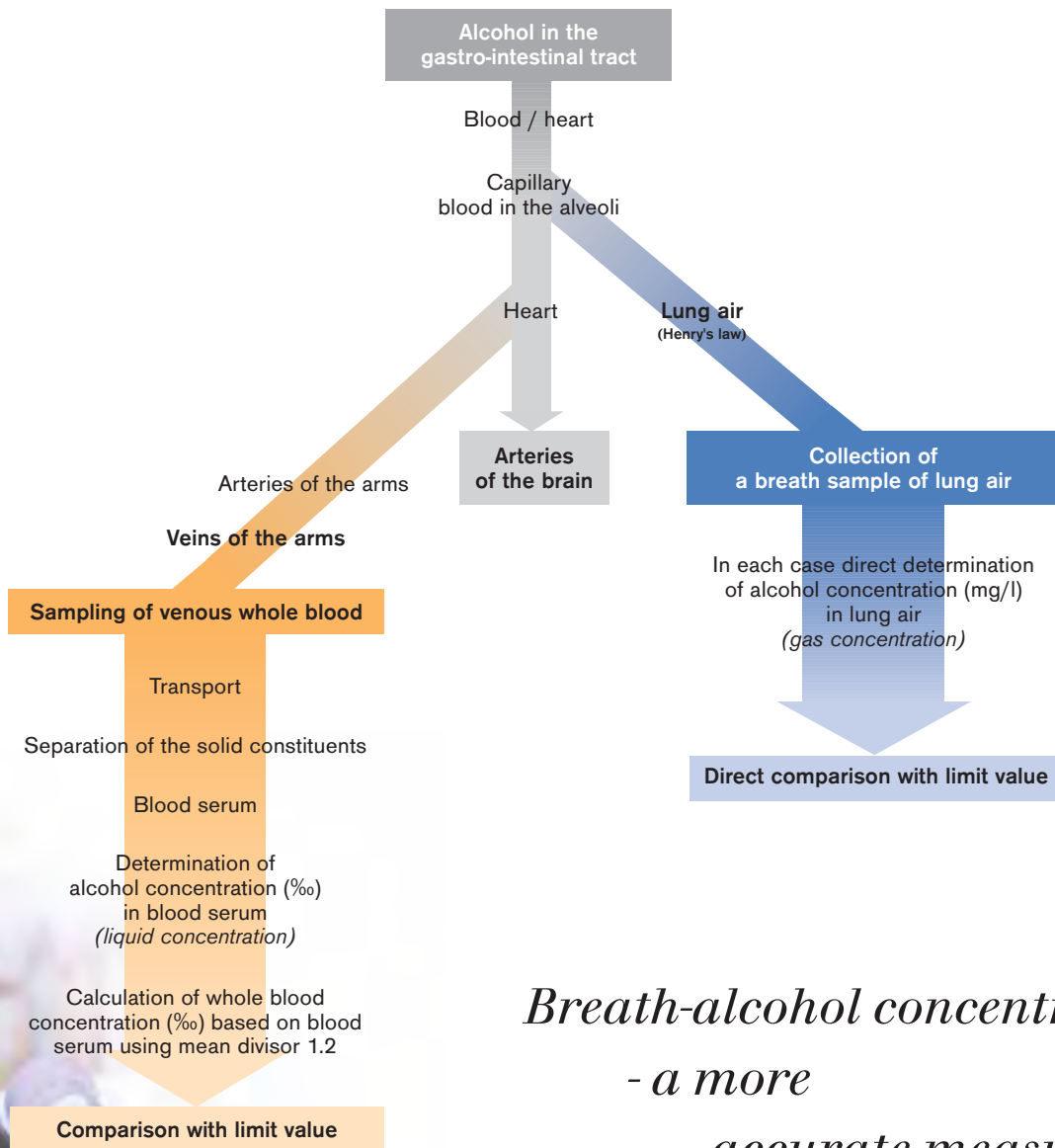
This is because of the path that alcohol takes through the body. From the place where the breath sample is taken from the lung, the blood transports the alcohol via the heart to the arteries of the brain, where the rapid increase in alcohol concentration impairs speed of reaction. Before the blood sample can be collected from the venous blood inside the elbow, however, the blood containing the alcohol is first distributed in tissue throughout the body.

A further advantage of the breath-alcohol analysis is that the alcohol content can be determined directly and documented immediately, even on site, for instance at the roadside.

### Blood alcohol analysis – a laborious process

Blood alcohol analysis first requires a doctor to take a sample of venous blood from the inside of the elbow – this may even involve a trip to the nearest hospital. The blood sample is then submitted to a forensic laboratory for analysis. The blood must first be prepared by separating its solid constituents and then analysed. Finally, once the concentration in the obtained blood serum has been determined, the alcohol concentration in the whole blood can be calculated, indirectly, using a mean value.





*Breath-alcohol concentration  
- a more  
accurate measure!*

## Alcotest 7110



STC-196C-2003

Following the introduction of the legal framework, the Dräger Alcotest 7110 and the Dräger Alcotest 7110 Evidential, devices capable of satisfying the strict requirements for evidential breath-alcohol analysis in many countries, were developed. Sophisticated technology prevents incorrect measurement results to the disadvantage of the car driver concerned (e.g. in the case of mouth alcohol), detects any attempt to manipulate the measurement and, in such cases, immediately aborts the measurement and states the reasons for the aborted measurement.

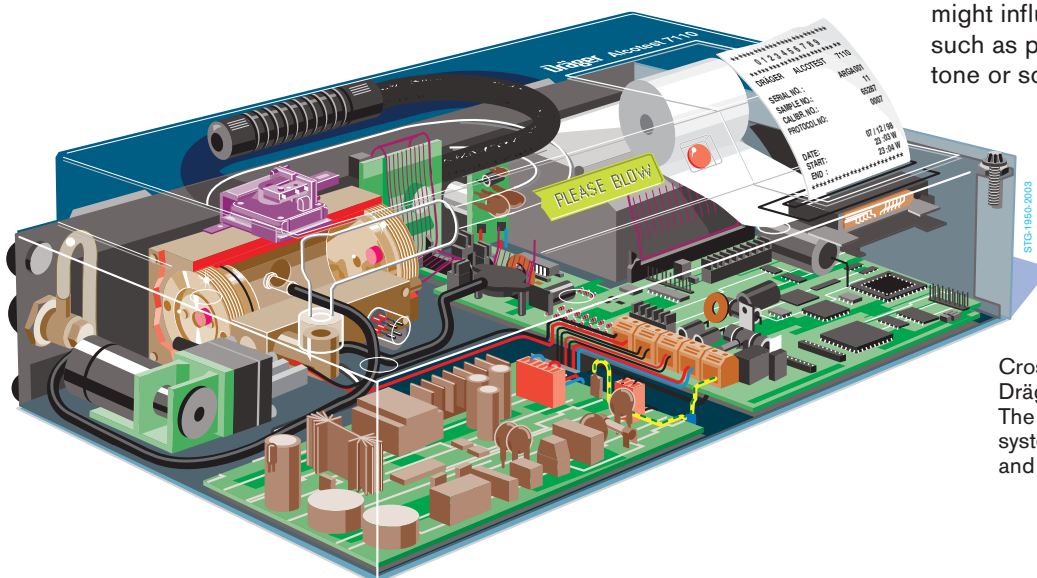
### Reliability with two individual measurements

The Dräger Alcotest 7110 Evidential always requests two individual measurements, each with a separate breath sample. The second breath sample is to be delivered by the subject two to five minutes after the first breath sample. Only if both individual results are successful and the results correspond within very close limits is the valid final result printed in a protocol by a printer. Once the breathing air enters the instrument for analysis, different parameters are determined simultaneously by two mutually independent sensors: the breath temperature, exhalation flow rate, the blowing volume and the breath-alcohol concentration.

### Reliability with two separate measuring systems

The Dräger Alcotest 7110 Evidential determines the breath-alcohol concentration using two different measuring systems: an infrared sensor and an electrochemical sensor. Both measuring systems use their respective sensors to independently measure the alcohol concentration in air exhaled deeply from the lungs, and as such each system monitors the other. The measurement is only accepted if the results provided by both sensors correspond to within very narrow limits.

By using two measuring systems with different analytical specificity, the device is able to reliably detect any interfering substances which may be present in the exhaled air and which might influence the result in any way, such as petrol or paint vapours, acetone or solvent vapours.



STC-196C-2003

Cross-sectional diagram of the Dräger Alcotest 7110. The breath hose, two sensor systems, electronics, display and internal printer can be seen.



### The infrared measuring system

A light source in the infrared optical sensor emits light at different wavelengths (colours) in the infrared range of the spectrum (i.e. not visible to the human eye). In the schematic diagram, the colours of visible light are used rather than the invisible infrared spectrum. The light passes through two windows and an interference filter which only allows penetration of certain wavelengths (the green light in the diagram). A detector measures the intensity of the incoming light and transmits a corresponding signal to the device's electronic system. If a gas (ethanol, for example) which absorbs part of the light at a particular wavelength (the green light in the diagram) is present between the two windows, the light intensity measured by the detector will drop, as will its electrical output signal.

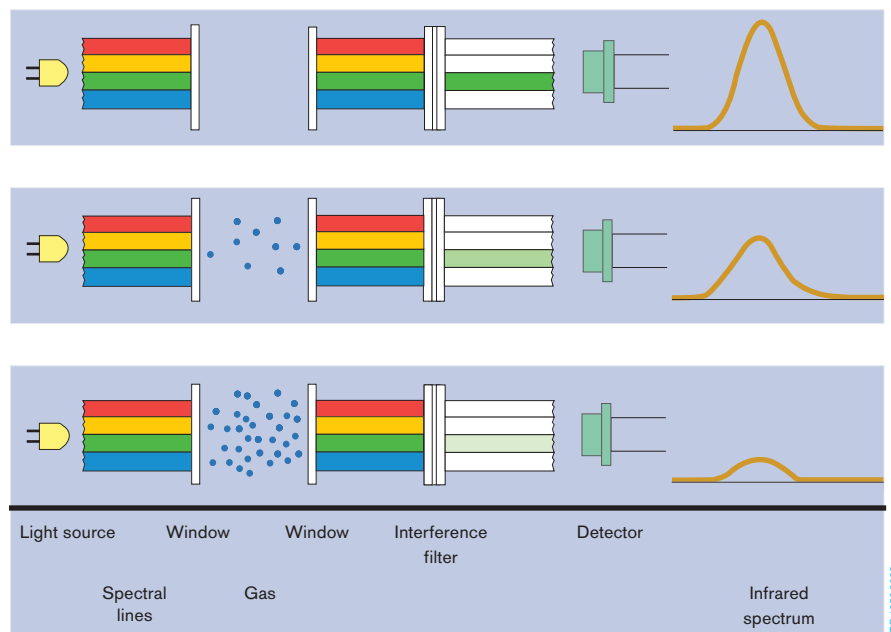
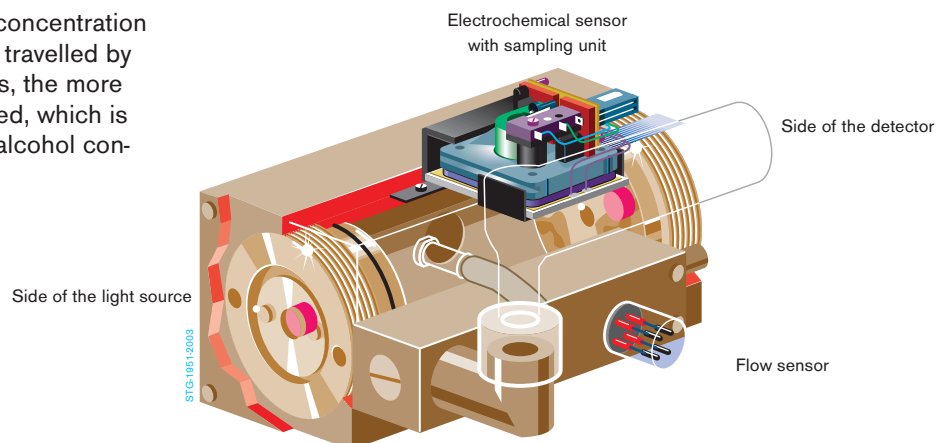


Diagram showing the measurement in the infrared optical sensor

The higher the alcohol concentration and the longer the path travelled by the light through the gas, the more the signal will be reduced, which is thus a measure for the alcohol concentration.



Infrared optical sensor with electrochemical sensor and flow sensor

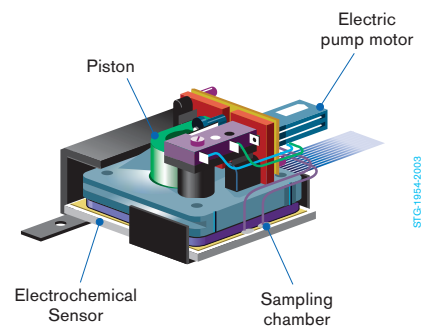
# Alcotest 7110



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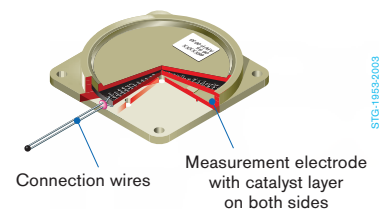
## The electrochemical measuring system

In the electrochemical measuring system, which is also used in a similar manner in the screening instrument Alcotest 7410, a piston driven by an electric motor conveys a sample of air with an exact volume into a sampling chamber. Here the electrochemical DrägerSensor selectively and highly accurately analyses the breath sample for the presence of ethanol. The alcohol to be analysed will be electrochemically oxidized on the catalyst layer of the measurement electrode. The electrons released by the reaction at the electrode cause a current to pass through the connection wires to the device's electronics. This current depends on the alcohol content in the sample chamber.



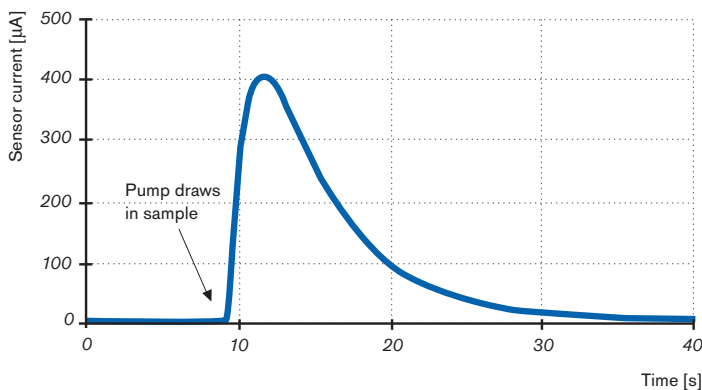
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Electrochemical measuring system



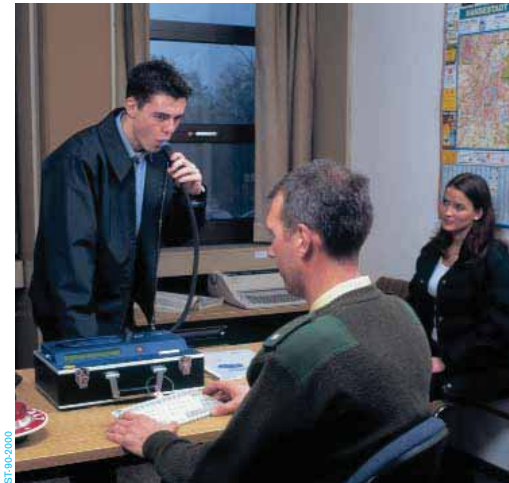
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Cross-sectional diagram of the electrochemical sensor



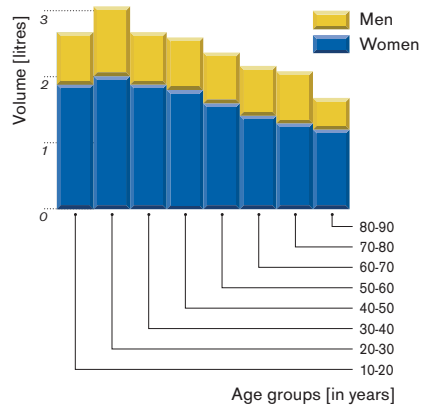
Development of the sensor current of the electrochemical sensor over time during analysis of a sample of breath containing approx. 0.5 mg/l ethanol





**Breath volume**

The volume of air which the test subject blows into the instrument is measured using one or two different flow sensors to ensure that the required minimum volume of breath - which in some countries depends on the age and sex of the test subject - is reached. This ensures that only deep lung air is analysed. Only deep lung air shows a clear correlation between the alcohol concentration in the air and that in the capillary blood in the alveoli. If the breath sample does not reach the required levels with regard to volume and flow rate, the instrument aborts the measurement.



Minimum breath volume required in Germany [litres]



# Alcotest 7110 Evidential



STC 1055-2003

### Breath temperature

Like all other components of the instrument which come into contact with the test subject's exhaled air, the Dräger Alcotest 7110 breath hose and the handle of the breath hose are heated to prevent any condensation of the breathing air.

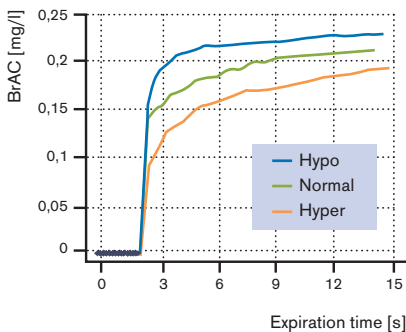
At the mouthpiece end of the breath hose of the Alcotest 7110 Evidential two additional temperature sensors, which project into the mouthpiece, record the temperature of the exhaled air flow. The alcohol concentration in the exhaled air (BrAC) increases as the body temperature and exhalation air temperature rise, due to the fact that an increased body temperature causes more alcohol in the lungs to evaporate out of the arterial blood in the lungs into the lung air. This takes place in accordance with a fixed physical principle known as Henry's law. Furthermore, as the body temperature rises, the exhalation air in the upper airways loses less of its alcohol concentration. When calculating the measurement result, therefore, the two breath temperature sensors in the breath hose are used to always relate the breath-alcohol concentration to a fixed exhalation temperature of 34 °C, ensuring that persons with for example a higher than normal body temperature are not disadvantaged by a higher measurement result.

### Ways to breathe

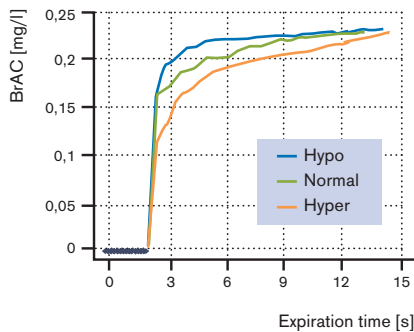
#### Hyperventilation and hypoventilation

How the test subject breathes directly before giving the breath sample, and the ambient temperature, also have an influence on the measurement of the breath-alcohol concentration at the end of the exhalation. For instance, if the test subject hyperventilates (breathes excessively) or if ambient temperatures are low, the area of the mouth and throat and the windpipe are cooled to below normal levels. This causes the temperature of the exhaled air to fall and, consequently, the uncorrected breath-alcohol concentration is lower.

Likewise, hypoventilation (shallow breathing) or high ambient temperatures can increase the temperature of the breath and thus result in a higher uncorrected breath-alcohol concentration. If on the other hand the actual measured breath temperature is used to correct the final result and relate it to an exhalation temperature of 34 °C, the way the test subject breathes and the ambient temperature will not affect the result of the measurement (Source of diagrams: Prof. Slemeyer, University of Applied Sciences Giessen-Friedberg, Germany).

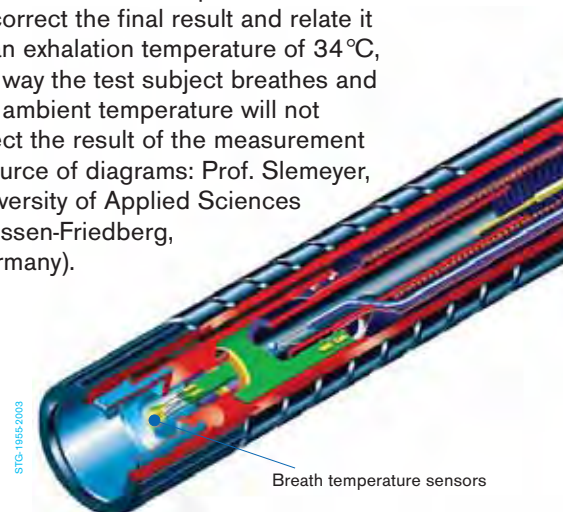


without temperature correction



with temperature correction

How different ways of breathing affect breath-alcohol concentration (BrAC)





### Mouth alcohol

If shortly before the breath sample is taken the test subject consumes a substance containing alcohol (liqueur-filled chocolates, for example, or an alcohol containing mouthspray), the exhaled air absorbs alcohol not only from the lungs, but also from these substances in the upper part of the mouth and throat. As a result, the alcohol concentration detected in the exhaled air will be higher than the concentration in the lung air.

However, within a few minutes this effect is completely cancelled out as the remaining alcohol in the mouth is taken up by the saliva or absorbed into the body. Waiting for at least 10 minutes before the measurement is performed and comparing the results of two individual measurements at intervals of several minutes excludes the possibility of residual alcohol in the mouth influencing the final result.

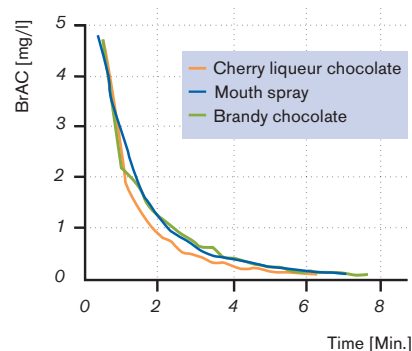
(Source of the diagram: Prof. Slemeyer, University of Applied Sciences Giessen-Friedberg, Germany).



Heated breath hose of the Alcotest 7110 Evidential

### Reliability of the measurement results

For all measurements of alcohol concentration, breath temperature and breath volume, the Dräger Alcotest 7110 Evidential - as used for example in Germany - uses two mutually independent measuring systems which monitor one other. The results of the two individual measurements produced by these individual measuring systems, carried out at an interval of several minutes, must correspond to within very narrow limits. This double sensor technology, together with the two individual measurements, ensures the high reliability of the measurement results.



Decrease in alcohol concentration over time following consumption of alcoholic substances

*The technology in the  
new evidential instruments  
prevents false  
measurements!*

## Legal bases



ST-1720-2009

### Traffic laws

National regulations stipulating appropriate limit values for breath-alcohol concentration, for example 0.25 mg/l, establish the legal basis for the application of the breath-alcohol analysis. If these limit values are violated an appropriate fine will be imposed and the driver may be banned from driving for a limited period.

### Type approvals

The Dräger Alcotest 7110 and the Dräger Alcotest 7110 Evidential satisfy the requirements of different national and international standards and regulations, for example the DIN VDE 0405 and the OIML R 126. They have been approved respectively by different national authorities such as the Physikalisch-Technische Bundesanstalt (PTB), the Laboratoire National d'Essais (LNE) and the Nederlands Meetinstituut (NMI), following an extensive series of tests. In many countries they can therefore be used for evidential breath-alcohol concentration measurement for official monitoring of road traffic.





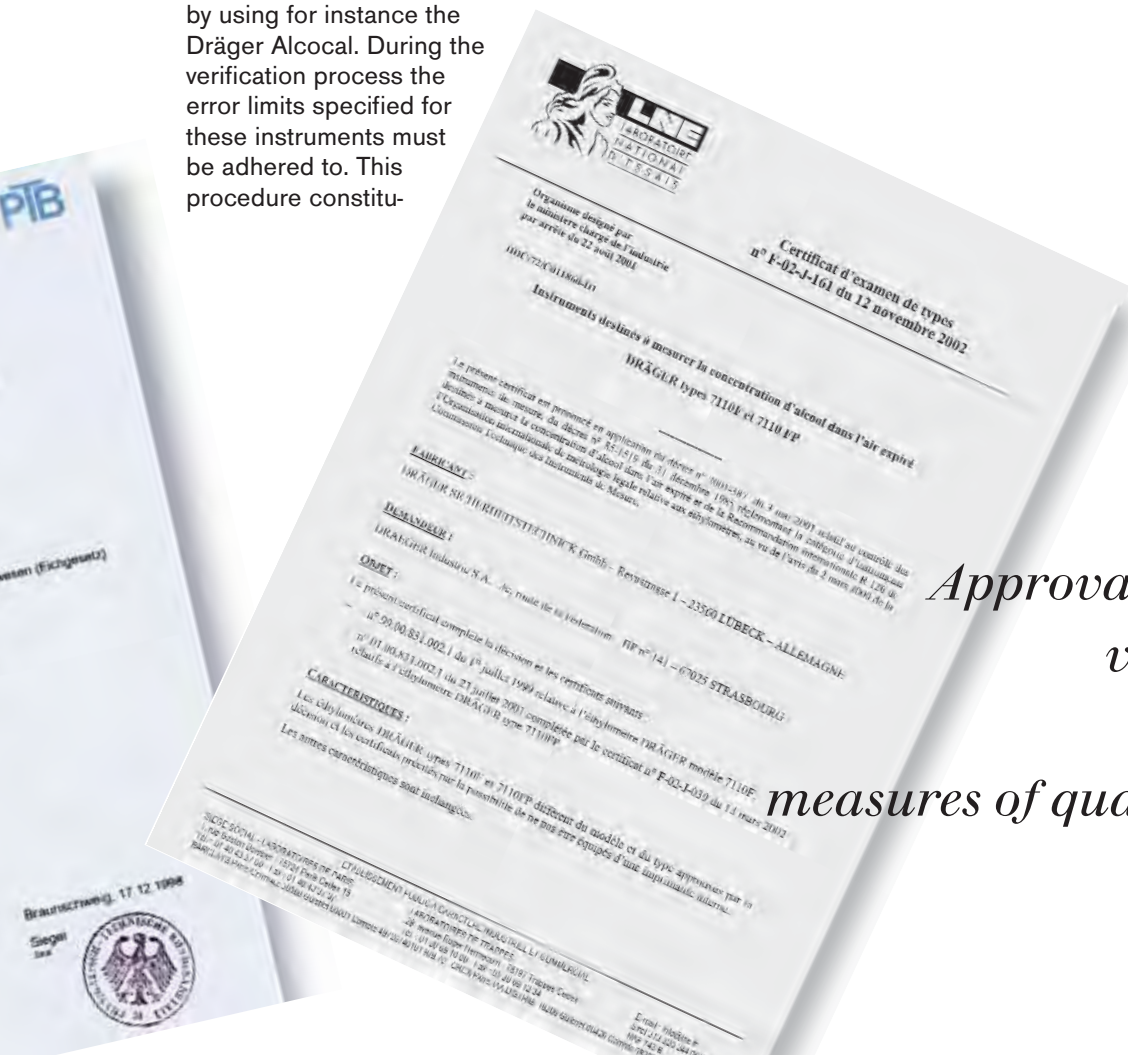


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**Verification**

Above and beyond the technical requirements and type approval, every single instrument is regularly verified in many countries by an official verification authority or independent institution, in accordance with national metrology and verification laws and respective regulations. The results are related to national statutory metrology standards by using for instance the Dräger Alcolac. During the verification process the error limits specified for these instruments must be adhered to. This procedure constitu-

tes an additional quality assurance measure which neither manufacturer nor operator can influence.



*Approval and verification as measures of quality control!*

## Interlock



ST-1721-2003

### Withdrawal of driving licence

The result of a measurement conducted by an evidential breath-alcohol analyser may lead to a person's driving licence being withdrawn. This suspension is regarded not as a penalty but rather as a road safety measure. However, many of the offenders who depend on their car for work regard the revocation of their licence as a severe punishment. Losing one's driving licence can be life-shattering. Social isolation or the resulting loss of one's job can lead to intensified alcohol abuse.

The aim of licence suspension is not to prevent a person driving a car in general, but to prevent driving while under the influence of alcohol and to encourage a change in drinking behaviour. This may be achieved by installing an interlock to the ignition systems of the vehicle. The driver must blow into the mouthpiece of the handset – only if the breath-alcohol concentration is below a pre-determined value will it be possible to start the engine.

### Measurement technology

The Dräger Interlock measures the driver's breath-alcohol concentration using the same type of electrochemical measuring system as the screening instrument Alcotest 7410 and the evidential instrument Alcotest 7110. Special software prevents tampering and circumvention of the system. All events, such as delivery of or refusal to provide a breath sample, motor starts and stops, date and time as well as the breath-alcohol concentration are recorded by a data logger.



ST-1673-2003





ST11669-2008

**Dräger Interlock -  
a road safety measure**

An alcohol ignition interlock is an aid for a driver whose driving licence has been suspended. The use of this aid does not eliminate the impairment, but ensures safe driving of the vehicle. A person with defective vision must wear eyeglasses when driving, and an alcoholic should use an interlock before being allowed to start a car. The interlock is designed to modify behaviour patterns, to educate and to prevent irresponsible operation of motor vehicles, trucks, machinery or equipment when the operator is under the influence of alcohol.

The interlock can also be used by parents to make sure that their children do not drink and drive. It allows people to learn new behavioural patterns with regard to drinking and driving.

The interlock helps in the rehabilitation process while promoting road safety.



ST11957-2003

*Interlock*

*a safe start!*

**Dräger Safety AG & Co. KGaA**

Revalstrasse 1  
D-23560 Luebeck  
Germany  
Tel. +49 451 882 - 0  
Fax +49 451 882 - 20 80  
www.draeger-safety.com

**DrägerService**

Dräger equipment must always be fully operational and safe. DrägerService offers a regular inspection service and is quickly available in the event of mal-function. Your equipment will be repaired and back in operation as quickly as possible. DrägerService facilitates the vital flow of information between client and manufacturer.

**Dräger Expertise**

Since 1889, Dräger has had an outstanding reputation for solving problems in the field of human breathing. Dräger has been deeply involved in the handling of gases, in particular hazard protection and the saving of life in medical and industrial emergencies. Many of the company's 9.800 employees are active in research and innovation to ensure that the latest techniques and scientific advances are fully tested before their inclusion in new equipment.



**Dräger Worldwide**

The Dräger sales and service organisation is spread throughout the world. It comprises more than 25 subsidiaries and associated companies to ensure that Dräger is always within easy reach of its clients and in close contact with all important markets. Dräger's ever increasing market share demonstrates the company's international competitiveness and strength.

Dräger has subsidiaries in the following countries: Australia, Austria, Belgium, Bulgaria, Canada, China, Croatia, Czech Republic, Denmark, France, Great Britain, Hungary, Indonesia, Italy, Japan, the Netherlands, Norway, Romania, Singapore, South Korea, Slovenia, Slovakia, South Africa, Spain, Sweden, Switzerland, Thailand, Yugoslavia, USA. Additionally, Dräger is widely represented in Central and South America, Africa, the Middle East, the Far East and Eastern Europe.

Represented by:

**Quality and Environmental Management**

Our mission includes the continuous improvement of our Quality and Environmental Management Systems in accordance with ISO 9001 and ISO 14001.