Multiple decades of technical progress: The first Dräger Alcotest with test tube came onto the market in 1953. Today, fast, precise measuring units incorporating electrochemical sensors are state of the art

Blow, Who Should

Drinking and driving is dangerous. For decades there was no measuring process available to determine a driver's **LEVEL OF INTOXICATION** quickly and reliably. In 1953 Dräger broke new ground with its first 'Alcotest'. Today, breath-alcohol measurements are even admissible in court.

Blow, read, finish: When Dräger brought its Alcotest device onto the market in 1953, it was the first time that a single breath-test could be used to find out whether or not a driver was under the influence of alcohol. Through continuous research into breath alcohol measurement, the Lübeck based company has since then developed a range of other methods based on electronic sensor systems – up to court usable measurement results, to prove an offense pursuant to Paragraph 24a of the German Road Traffic Act. "The Dräger Alcotest 7110 Evidential MK III is currently the only device with a design certification from the *Physikalisch-Technische Bundesanstalt*," says Dr. Jürgen Sohège, Product Manager at Dräger.

On the other hand there is the first Alcotest with Dräger tubes (and a plastic bag to check volume), which still serves primarily as a pretest in road traffic control to see whether somebody is intoxicated. The tubes contain sulfuric acid and yellow potassium dichromate. These basic substances react to form acetaldehyde and trivalent green chromium, during testing, when the ethyl alcohol known as ethanol passes through the tube together with the exhaled air. The intensity and extent of the coloration indicates the concentration of ethanol. If this pretest indicates a minor offense, or even a crimi-

PHOTOS: DRÄGERWERK AG & CO. KGAA

nal act (an absolute inability to drive), then further analysis is performed for confirmation.

The development of the tube is a classic example of farsighted knowledge transference from another application. The know-how comes from the gas detection systems in which Dräger has set global standards since the 1930s, says the doctorate in electrochemistry Sohège. Dräger's engineers came up with the idea for the new measuring process the morning after a company party. The measurement process was timely, because of the mass motorization after the Second World War, the number of traffic accidents caused by alcohol increased dramatically. This is reflected in the case law. Thus, also in 1953 for the Federal Republic of Germany, a blood alcohol concentration of 1.5 per mille was defined as the limit for absolute inability to drive. Similar limits were established elsewhere. The problem of driving under the influence of alcohol is a global one – as is the market for Dräger's Alcotest. In many countries the name is synonymous with alcohol testing.

From Intoxication and Steam Engines

The phenomenon of alcohol offenders on the roads was however not new in mid-20th Century, nor did it originate at the onset of automotive traffic. The automobile was not even invented when the British Parliament first made it an offense to drive under the influence of alcohol. In 1872 a Licensing Act was passed by Westminster in the hope of reducing the danger to the public caused by drunken vehicle drivers. The motor-wagon was invented by Daimler and Benz in 1886, but the first such vehicle to reach England's shores did not arrive until 1894. In spite of this, however, the traffic in industrialized Britain was already heavy enough in 1870 to elicit a ban on being "drunk while in charge of any carriage, horse, cattle, or steam engine on any highway or other public place." Yet the Licensing Act of 1872 was not much of a success. The problem has accompanied the history of mobility ever since, and is countered all over the world by means of prohibitions, monitoring, and prevention.

But what exactly constitutes 'drunk'? Until the middle of the 20th Century, the authorities lacked a quick and reliable method of determining a driver's level of intoxication at road-side control points. It is difficult to measure exactly >

The American ‘Drunkometer’ worked using a wet-chemical measuring process

The classic: Dräger’s Alcotest tubes

Borkenstein (left) and his ‘Breathalyzer’

The ‘Alcytron’ prototype: the first to feature an infrared sensor

Since the 1920s and 1930s, the relationship between blood and breath alcohol content has been proven

> how much somebody’s reactions are limited by the effect of alcohol, so instead the blood alcohol content (BAC) or the amount of alcohol in the urine is measured. These time-consuming procedures, however, are not really possible to perform on a large scale in everyday traffic monitoring.

“Then in the 1920s and 1930s it was scientifically proven that blood alcohol content could be determined by means of the breath,” explains Dr. Sohège. The American doctor Emil Bogen suggested using exhaled breath to prove BAC as far back as 1927. Decisive in this respect were the studies done by Swedish pharmacologists Göran Liljestrand and Paul Linde, which they published in 1930 *On the Expulsion of Alcohol in Exhaled Air*. Liljestrand and Linde demonstrated the link between exhaled air and blood alcohol concentration. They also assumed that the reason for this lay exclusively in the exchange of gas between the air and the blood in the lungs. Later however, the diffusion of alcohol in the entire respiratory track was recognized as the basis of the link between BAC and breath alcohol content (BrAC).

Dräger Tubes Offer the First Quick Test

The Swedish scientists concluded that “two liters of exhaled air (at 34 degrees Celsius) contain around as much alcohol as one cubic centimeter of blood.” In most countries a factor of 2,100 is used as an average ratio between the measured values of blood and breath alcohol concentration (Blood Breath Ratio, BBR). Because the statistical spread of BBR is related to a range of peripheral conditions and extends from 2,000 to 2,300, it is not normal practice to convert one measured value directly into the other unit in tests that are to be used as evidence in court. Instead, independent limits have established themselves for both breath and blood alcohol tests, each with its own validity. In Germany’s Road Traffic Act, Paragraph 24a states: “It is an offense to drive a motor vehicle on the road with 0.25 mg/l or more alcohol in the exhaled breath, or 0.5 per mille or more alcohol in the blood, or a quantity of alcohol in the body which leads to the aforementioned breath or blood alcohol concentrations.” BAC is denoted in most countries in terms of milligrams of ethanol per kilogram of blood or per liter of blood (‘per mille’), while BrAC is given in milligrams of ethanol per liter of exhaled air.

The first ever attempt to utilize the discovery of the link between BAC and BrAC to monitor road-users was the ‘Drunkometer’ which was developed in the USA in 1938 by Rolla N. Harger and which works on the basis of a wet-chemical process. “It was more of a transportable chemistry lab than a truly mobile test device,” says Dr. Sohège. When Dräger launched its Alcotest tube onto the market in 1953, it was followed in North America by the ‘Breathalyzer’ developed by Robert F. Borkenstein, which measured the BrAC using a chemical reaction which was evaluated electrically. Dräger later took over the manufacture and distribution of the Breathalyzer.

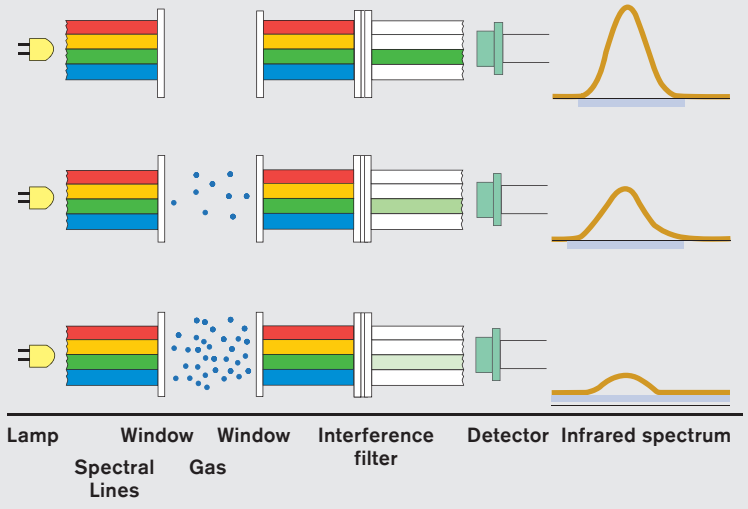
But the Dräger tubes are the first alcohol test, which was regularly used operationally on the road to get an objective assessment of the BrAC. “Since the 1950s police and road traffic authorities have known that measuring the influence of alcohol on the spot as quickly as possible is a necessary part of reliable prevention,” says Dr. Sohège. The testing tubes spread quickly as a result. They were accepted not only by the legal authorities, but also because they were so easy to read and understand by the drivers who were being monitored. Early markets alongside Germany included the United Kingdom, Sweden, and Australia.

The experts knew that the demands for alcohol analysis would be continually rising. “There was soon a demand for faster, more accurate – and therefore judicial-

Dräger took over the production of the 'Breathalyzer' from Smith & Wesson

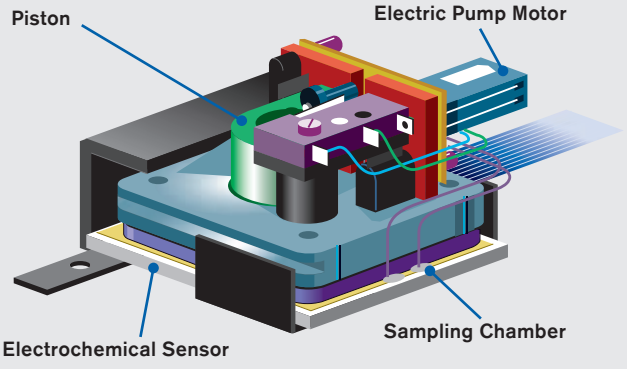
INFRARED OPTICAL SENSOR

Schematic Measurement Principle



ELECTROCHEMICAL SENSOR

Measurement System



PHOTOS: DRÄGERWERK AG & CO. KGAA, CORBIS (1), INDIANA UNIVERSITY (1)

Infrared or electrochemical sensor: the two common measuring processes for determining breath alcohol concentration levels are based on different principles. While the infrared optical sensor measures the absorption of light by ethanol, the signal generated by an electrochemical sensor is produced by the oxidation of molecules on a catalytic layer

ly useful results," says Dr. Sohège. He adds that from a criminological point of view, breath testing is the more direct of the two procedures, since the breath alcohol content which is related to the diffusion of alcohol from arterial blood provides a more direct reflection of the concentration of alcohol acting on the arteries in the brain than the blood alcohol level, which is measured in venous whole-blood, or its serum, using processes such as gas chromatography or alcohol dehydrogenase.

Measuring Equipment of the Future Will Be Based on Electronics

The new devices for testing breath alcohol which Dräger developed in the 1970s and 1980s utilize electrical and electronic systems. "When we developed this new technology we made good use of the possibilities offered by miniaturized sensors as each new generation of them came out," says Dr. Sohège. Technical input came once again from the field of gas detection systems.

Already by 1978, Dräger was showing the way things were going to go with its 'Alcytron', a prototype incorporating an infrared optical sensor. In this process a light source emits infrared radiation of a specific wavelength, which is guided through a measuring chamber and then measured by a photocell. When the gas being measured is in the chamber, it absorbs part of the radiation, reducing the strength of the signal coming from the photocell. This allows you to deduce the concentration of gas. Four years later the Alcotest 7010 >

Alcotest 7010 with an infrared optical sensor

Electrochemical sensor: Alcotest 7410

Measurements for use in court with the Alcotest 7110 Evidential

Breath alcohol based immobilizer: Interlock XT

Modern electrical engineering is the key to breath alcohol measurements

> arrived on the market, but was only used for stationary purposes.

In parallel with its infrared technology, Dräger introduced a semiconductor sensor based on tin oxide. This measuring cell was used to equip the mobile Alcotest 7310 which came onto the market in 1980. From then on, measured values could be read on the digital display just seconds after a sample had been taken at a check-point. Soon, electrochemical sensors were setting new standards in fast and accurate BrAC monitoring. In these devices the measuring chamber is charged with a precisely defined volume of air. In the chamber, the ethanol contained in the air oxidizes electrochemically on the outside layer of a measuring electrode, which acts as a catalyzer, producing a current which serves as a signal by which to produce a reading. This electrochemical sensor responds very specifically to alcohol, meaning that ketones, such as acetone, which may also be present in exhaled air cannot distort the result. The sensor was premiered in 1988 in the Alcotest 7410.

With its electrochemical sensor and infrared technology, Dräger had by 1990 established the two processes which would, over the coming years, lay the foundation for a series of innovations. The first Alcotest 7410 was used to develop a whole family of devices all the way to the 7410 Plus with its digital full-text display and electronic data transfer features. “The readings are generated in the local language of the country, this made measurements intuitively easy to follow for everyone involved,” explains Dr. Jürgen Sohège. Measuring devices incorporating electrochemical sensors have long since been standard issue for pretesting. In Germany today, virtually every police cruiser has an electronic alcohol measuring unit on board. The very latest Dräger pretest devices are the Alcotest 6510 introduced in 2004, the Alcotest 6810 (from the year 2005), and the Alcotest 7510 (2008).

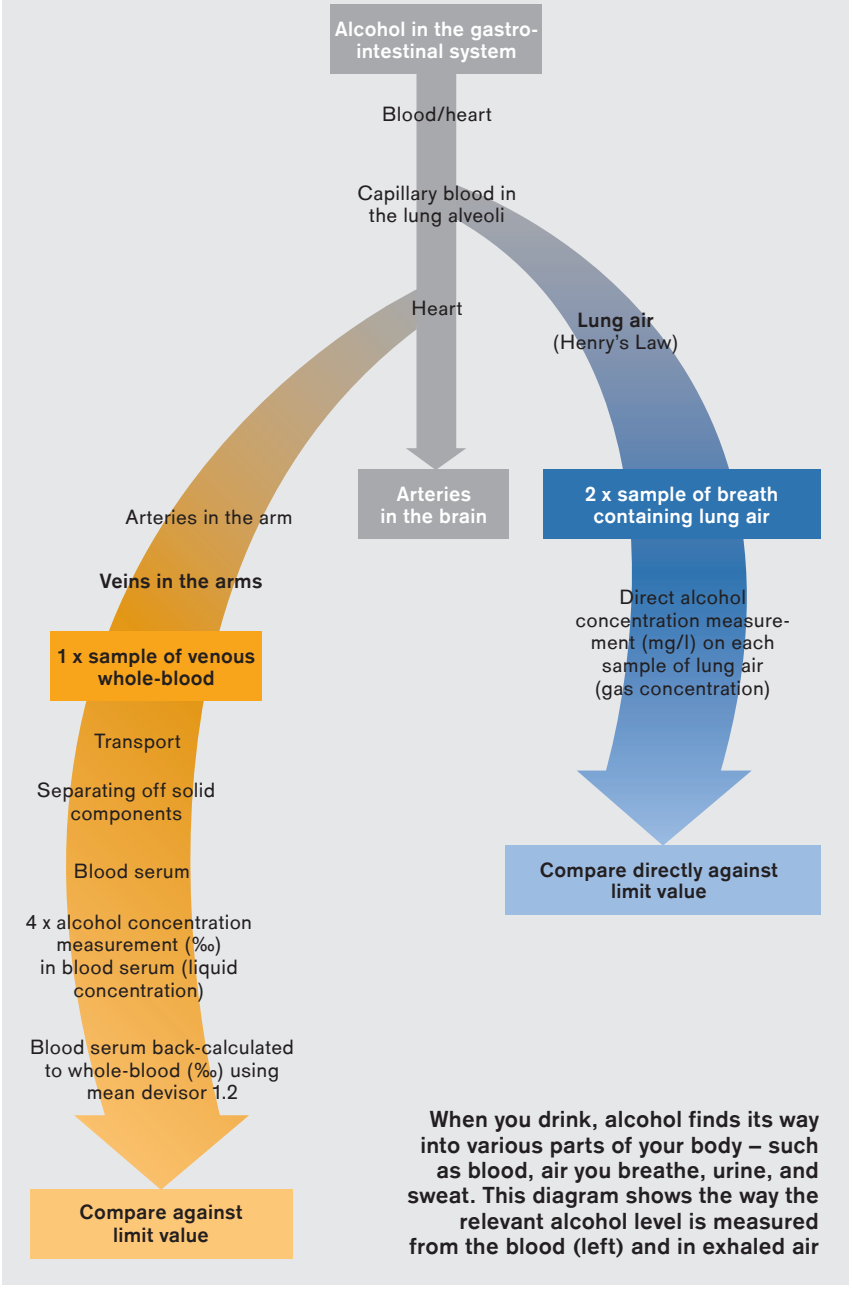
But infrared technology is also progressing nicely: the Dräger Alcotest 7110 appeared in 1985 with an infrared sensor which responded especially selectively to alcohol. The third generation of this device (1994) can, as an option, be combined with an electrochemical sensor. This dual-sensor system became standard issue four years later in the Alcotest 7110 Evidential, forming the basis for a breath alcohol monitoring method which could be used as evidence in court. “This was an absolute milestone, since the device’s redundant design guarantees particularly reliable results on a par with blood samples when used as evidence,” says Dr. Sohège. This technology’s capability was confirmed by the *Physikalisch-Technische Bundesanstalt (PTB)*, which approved the Alcotest 7110 Evidential MK III as the first ever breath alcohol measuring device whose readings could be admissible as evidence in court. A similar dual-sensor system is used in the Alcotest 9510 evidential device which was launched in 2007 and which can be used as a stationary or mobile system.

Paradigm Shift in Measurement Strategies

Since 1953, when the first Dräger-Alcotest tubes appeared, engineers are now working on systems with further improved response times to facilitate comprehensive, high-frequency traffic testing. “This is a worldwide trend for the near future,” predicts Dräger’s Product Manager Sohège. Optical filter technology is also being improved in order to produce even more accurate infrared sensors. Transdermal measurements could represent a completely new option in the future, where alcohol concentration in the blood is measured through the skin (see pages 20–21). Unlike breath testing and blood samples, this technology offers the advantage of complete cooperation-free measurement. It would benefit alcohol testing equipment which is used outside of the road traffic

With touchscreen: Alcotest 9510
Evidential measuring device

HOW ALCOHOL IS MEASURED IN THE BODY



When you drink, alcohol finds its way into various parts of your body – such as blood, air you breathe, urine, and sweat. This diagram shows the way the relevant alcohol level is measured from the blood (left) and in exhaled air

PHOTOS: DRÄGERWERK AG & CO. KGAA

field, in areas such as emergency medicine where patients could be examined for the influence of alcohol.

But the experts for alcohol measurement think beyond the improvement of existing solutions. It is about a paradigm shift – distancing itself from the subsequent control associated with preventive measure, to preventing the operation of vehicles or critical systems under the influence of alcohol. The purpose of the Dräger Interlock XT.

It is installed in passenger transport vehicles such as buses, taxis, and locomotives so as to make travel safer for passengers. But Alcohol-Interlocks are also being used in automobiles belonging to drivers who have attracted attention by drinking and driving so that they can return to the roads, but under strict stipulations (see also pages 46–49). The first Dräger Interlock, which activates the ignition only after a negative breath test, came onto the market in 1994.

Whether traffic control, Alcohol-Interlock, or long term monitoring, whether electrochemical sensors or infrared technology – each new generation of the breath alcohol testing equipment from Dräger sets new standards in the market, which brings more security in life. The Dräger Alcotest has been doing this since 1953 – ever since the first automobile drivers blew into the Dräger tube and bag to test their breath.

Peter Thomas

Information:
Precise breath alcohol testing using Dräger devices
www.draeger.com/107/diagnostic