Driving Under the Influence: Determining the Breath Alcohol Level

Breathalyzers Combined with Vehicle Immobilizers

© istock.com/zstockphotos

"Driving under the influence" and vehicle immobilization are hot topics of discussion. Measurement apparatuses in automobiles are designed to lock the ignition when the driver's alcohol content is too high. It is not until the driver is able to blow an acceptable level into the alcohol ignition interlock breathalyzer that the motor can be started.

As of 2012, all states have adopted some sort of ignition-interlock laws as a sentence alternative for drunken drivers. Some states, and in Canada some provinces, even require installing an Ignition-Interlock Device (IID) for all offenders. Repeat offenses have been reduced by 70% while they are installed, but despite these laws, only about one-fifth of those arrested install the interlock.

Ignition Interlock Retrofitting

There are a growing number of people who want to voluntarily install an interlock device in their car. The reasons are manifold and range from protecting young drivers, to making sure that employees don't drink on the job. "Alcoguard" ignition locks can be ordered with Volvo as a special option, but also other technologies are making their way. The measurements are based either on breath alcohol content or alcohol levels directly under the skin.

"Breathe!" Breathalyzer as Opposed to Blood Sample

In the United States, the legal limit for driving is set at 0.08% Blood Alcohol Concentration (BAC) for those over the age of 21. There are three types for testing BAC, but the most common is breath testing. In some states, you are allowed to request a blood or urine test.

Alcohol consumption can be detected in the blood, as reabsorbed ethanol enters the bloodstream through the oral mucous membrane, the stomach, and especially the small intestine. In the lung alveoli, there is an exchange of gas between the alcohol from the arterial bloodstream and the air breathed. Therefore, alcohol consumption can be determined via

04/19 / V01 / IF / lc/application-reports/ir-technology/determining-breath-alcohol-level-ir-detectors

USA
Laser Components USA, Inc.
Tel: +1 603 821 – 7040
Fax: +1 603 821 – 7041
info@laser-components.com
www.laser-components.com

breath gas analysis. It is even possible to determine the concentration of alcohol because there is a physiological correlation between the breath alcohol content (BrAC) and the blood alcohol content (BAC) (Henry's law: average partitioning factor of 1:2100). In order to convert the result of the breath alcohol measurement to a blood alcohol concentration, a blood/breath ratio must be used. There is a lot of dispute on this subject and different countries have each adopted their own assumed value of this ratio, with 2,100:1 being used in the U.S.A. Thus, the following applies: 0.08% BAC = 0.073 g/210l BrAC.

How Breath Alcohol Content is Measured...

There are three major measurement devices based on: an electrochemical sensor, an infrared sensor, or alcosensor. We will discuss the first two:

Electrochemical Sensor

In the electrochemical detection of alcohol, the current produced in the chemical conversion of ethanol is measured.

An electrolyte and at least two opposing electrodes are located in a measuring chamber; these electrodes are connected to an ammeter. A defined air volume is blown into the measurement cell. If ethanol can be detected, a measurable current is produced via a redox reaction. One reaction partner is oxidized (i.e., it releases electrons) and the other is reduced (i.e. it absorbs electrons). The current flow produced in the chemical reaction is equal to the alcohol concentration. One problem with electrochemical sensors is the measurement accuracy, which is reduced with increasing operating hours.

IR Sensor

The easiest method is to use so-called non-dispersive infrared (NDIR) sensors to detect gases. In this method, a measurement cell is irradiated with infrared light, which is collected on the opposite side by a detector. Narrow bandpass filters (interference filters) are mounted in front of the detector.

Gases have characteristic absorption lines that make clear identification possible with the help of absorption spectroscopy. Even the gas concentration can be determined. The Lambert-Beer law, which describes the correlation between a reduction in the beam intensity and the concentration, applies here.This system exhibits long-term stability.

Select a Suitable Detector and an Appropriate Filter

Finding a suitable detector for a specific gas measurement still seems theoretically trivial. In order to measure the breath alcohol content (BrAC), the absorption lines of ethanol gas have to be analyzed. They are approximately 9.5 µm, 8.1 µm, 7.2 µm, and 3.4 µm. Theoretically, it would be sufficient to measure the detector signal at a single absorption line; however, it is important to make sure that a cross-sensitivity to other substances that are also in the breath (water, methane, and ethanol) does not exist.

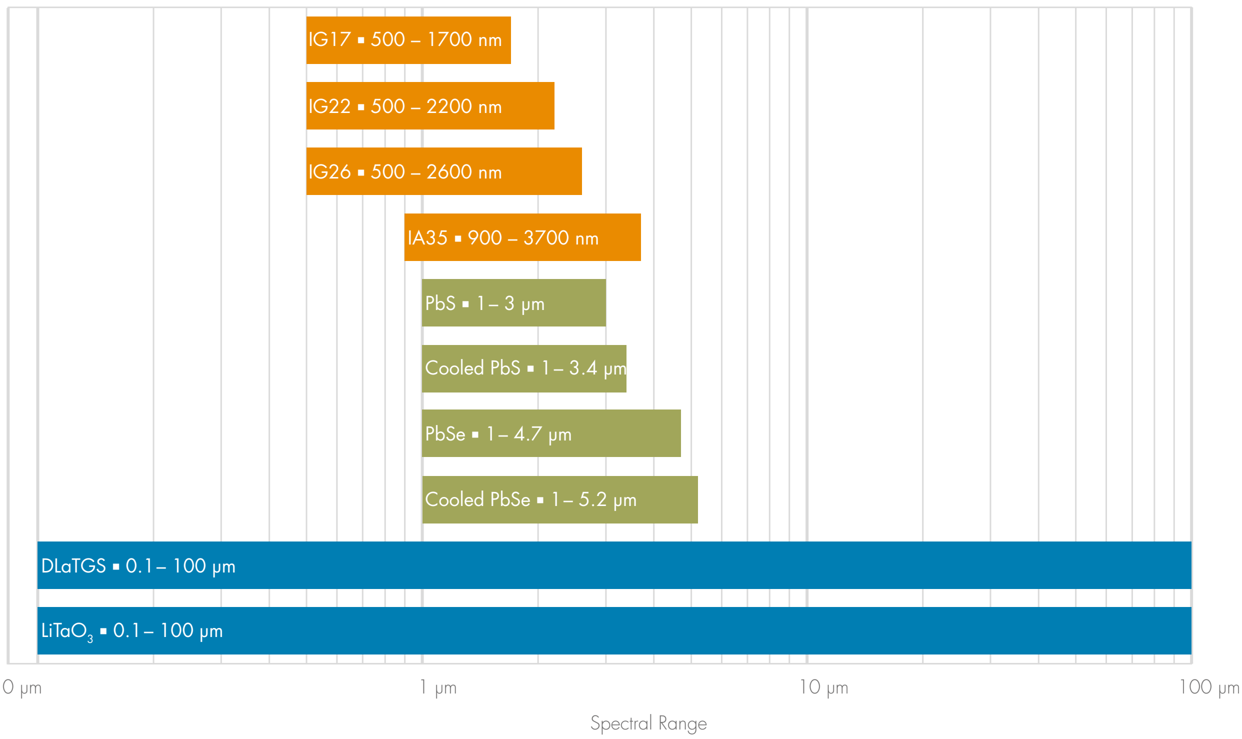
04/19 / V01 / IF / lc/application-reports/ir-technology/determining-breath-alcohol-level-ir-detectors

USA
Laser Components USA, Inc.
Tel: +1 603 821 – 7040
Fax: +1 603 821 – 7041
info@laser-components.com
www.laser-components.com

Filter Selection

IR detectors are polychromatic. A suitable filter is required to detect a specific gas or measure a specific wavelength: Bandpass filters only allow the beams of a specific wavelength range to pass.

Thus, the success of the measurement always depends on the quality of the filter: the spectral width must line up precisely with the absorption line being measured, and the transmission of the filter should be as high as possible. For BrAC measurements, analysis of the wavelengths 3.4 µm and 9.5 µm has become the standard.



Detector Selection

The shorter wavelength could be identified using different detector types: According to the overview, InAs, PbSe, cooled PbS and PbSe, and pyroelectric detectors are all suited for use. Exclusive observation at 3.4 µm is critical, because the absorption lines of water vapor and methane gas are approximately equal.

The air in the breath contains moisture. In a worst-case scenario, it would not be possible to strictly separate ethanol and water vapor at 3.4 µm. As a greenhouse gas, methane can also be detected in the air; thus, the problem is the same.

Measurement at the wavelength of 9.5 µm is more significant, thus the selection of pyroelectric detectors is more likely. The pyros can house up to four independent detector chips with an integrated bandpass filter in a single housing. One channel often serves as a reference, and the others are there for gas detection. The simultaneous measurement of a gas using two filters would be possible and is actually carried out as such in practice when a high dynamic range is required for measurement.

04/19 / V01 / IF / lc/application-reports/ir-technology/determining-breath-alcohol-level-ir-detectors

USA
Laser Components USA, Inc.
Tel: +1 603 821 – 7040
Fax: +1 603 821 – 7041
info@laser-components.com
www.laser-components.com