ALCOHOL AND BREATH ALCOHOL MEASUREMENT

There are two means of electronically measuring the breath alcohol concentration. One method is by using an infrared and the other method is a fuel cell.

Infrared Cell

Alcohol strongly absorbs infrared energy at mainly two wavelengths namely 3,4 microns and 9,5 microns. 9,5 microns is referred to as the primary wavelength in the measurement of ethyl alcohol, or ethanol, the alcohol that is present in alcoholic beverages. Other substances absorb infrared energy at 3,4 microns therefore absorption at 9,5 microns, the primary wavelength, is used to determine alcohol concentration. In the infrared cell used to measure the alcohol concentration an infrared beam is passed through the breath/alcohol mixture and detected by an infrared detector. The greater the concentration of alcohol in the breath sample the greater the amount of infrared light that is absorbed (Lambert-Beer)

The process of analysis of a breath sample for alcohol by infrared cell as follows:

1. The breath sample is captured in the infra-red cell
2. Infrared energy from the source passes through the breath sample. The alcohol in the breath sample absorbs some of the infrared energy.
3. The energy absorbed is related to the amount of alcohol present.
4. The reduction of infrared energy is detected and measured by the infrared detector the amount of reduction being proportional to the concentration of alcohol in the breath sample.

Fuel Cell

In the fuel cell an electro-chemical reaction between alcohol and oxygen produces an electric current proportional to the concentration of alcohol in air.

The process of analysis of a breath sample for alcohol by the fuel cell is as follows

1. The breath sample is introduced to the fuel cell
2. The alcohol in the sample is chemically oxidized at the anode
3. At the same time, oxygen (from the atmosphere) is chemically reduced at the cathode.
4. A current flow, proportional to the concentration of alcohol, is produced between the two electrodes.

DRAGER ALCOTEST 7110

The Drager Alcotest 7110 uses two means of measuring the breath alcohol concentration. One measurement is performed in an infrared cell and the other in a fuel cell. Other substances will also produce a voltage at the terminals of the fuel cell and therefore the purpose of the fuel cell is to detect the presence of any substance other than alcohol. Should there be another substance present then the reading between the fuel cell and the infrared cell will differ. If the difference exceeds 5% then the measurement process is stopped and no reading is displayed or printed. An indication of the presence of an interferent is indicated.

Measurement Process

After the instrument self tests and zero tests, the breath sample is introduced into the instrument via a delivery tube. From the delivery tube the sample enters the infrared cell and is analysed. A small portion of the breath sample in the infrared cell is taken into the fuel cell. That portion of the breath sample is analysed by the fuel cell. The instrument does two whole processes automatically. The two results are compared and then a second self-test and zero tests take place, and then the result is displayed and printed out. The instrument self-checking process takes place continually while the instrument is in use. If any of the self-checking processes detect a fault, or one result is not confirmed by the other, the instrument will indicate that a fault has been detected and will automatically abort the analysis. The instrument also aborts the analysis if a self or zero test fails.

Operating the equipment

After being switched on, the instrument takes approximately 15 minutes to warm up during which period the testing is inhibited. After warm up the testing is started and details entered via the keyboard.

After the operator information has been entered the instrument automatically pumps ambient air through the sample hose and the internal measuring cells, the instrument performs a zero test and self test. On completion of a successful zero and self test the driver has approximately two minutes to blow into the mouth piece. The sample hose is removed from its storage recess and the driver is then required to blow into the mouthpiece. Sufficient air has been blown through the sample hose when the bar graph is complete. The breath sample is now analysed for alcohol content. The measurement cell is then automatically flushed with ambient air and another zero and self-test performed. The result of the measurement is displayed on the LCD display and then printed on the printout.

Conditions when Measurements are not taken

The following conditions will result in no reading being displayed or printed (the conditions are displayed on the LCD display)

1. Check Airway-obstruction of the breath sampling system
2. Zero Test Error-contamination of ambient air
3. Insufficient Sample-no sample provided by driver
4. Alcohol in Mouth-contaminant alcohol in breath sample
5. Range Exceeded-result of analysis exceeds range of accurate measurement
6. Interferent Detected-presence of interfering substance detected

In each case the cause of termination of the test is printed together with the time and date of occurrence, followed by TEST DISCONTINUED.

LION INTOXILYSER 5000P-SA

In the Lion Intoxilizer the absorption of infrared light by ethanol at the so-called primary analytical wavelength is used to determine its concentration. To differentiate between ethanol and other organic contaminants, the absorption by the breath specimen of infrared light at three additional but characteristic secondary wavelengths is also measured. The

ratio of these four absorption measurements to each other is then compared with those taken during the initial factory calibration process of the instrument, the values of which are stored in memory. If the relative absorption values obtained on the breath specimen differ by more than a specified amount from the stored values then the presence of a substance other than ethanol i.e. an interfering substance, is detected, in which case a message “interfering substance” is indicated.

Any changes in the light beam used in the infrared cell are detected by a fifth filter, which acts as a reference. This filter transmits light at a wavelength where ethanol and any other contaminants do not absorb the infrared light. The infrared light is detected and comprehension for any changes in light intensity is made.

These five filters are housed on a wheel that rotates at 2 400 revolutions per minute. This means that infrared absorption is measured at each of the five wavelengths forty times per second.

Measurement Process

After the instrument self and zero tests, the breath sample is introduced into the instrument via a delivery tube. From the delivery tube the sample enters the infrared cell and is analysed. The instrument does the whole process automatically. A second self and zero tests take place, and then the result is displayed and printed out.

The instrument self-checking process takes place continually while the instrument is in use. If any of the self-checking processes detect a fault the instrument will indicate that a fault has been detected and will automatically abort the analysis. The instrument also aborts the analysis if a self or zero tests fails.

Operating the equipment

After switch on, the instrument takes approximately 15 minutes to warm up during which period the testing is inhibited. After warm up the testing is started and details entered via the keyboard.

After the operator information has been entered the instrument automatically pumps ambient air through the breath tube and the internal measuring cells, the instrument performs an Air Blank test. On completion of a successful Air Blank test the driver has approximately three minutes to blow into the mouthpiece. The sample hose is removed from its storage recess and the driver is then required to blow into the mouthpiece. This 3-minute period allows up to 5 attempts to blow. Indication that sufficient air has been blown through the sample hose occurs when the tone stops. The breath sample is now analysed for alcohol content. The measurement cell is then automatically flushed with ambient air and another Air Blank test performed. The result of the measurement is displayed on the LCD display and printed on the printout.

Conditions when Measurement are not taken

The following conditions will result in no reading being displayed or printed (the conditions are displayed on the LCD play)

1. Specimen Incomplete- Subject has not provided required specimen (1,2 litres of

breath) within 3 minutes.
2. Mouth Alcohol-Residual mouth alcohol detected
3. Interfering Substance- Substance other than ethanol detected
4. Ambient Air Fail-Air Blank reading of 0 mg/l not obtained.
5. Out of range-Subjects breath alcohol level exceeded 2.2 mg/l

In each case the cause of termination of the test is printed together with the time and date of occurrence.

6. Computer and software requirements-Computer and Peripheral Hardware, Software Requirements, Software Operational Requirements.

As the specification covers a large number of tests, some of which are destructive, type testing is performed on a sample of each make and model of EBT. Note that not each and every EBT of a particular make and model is subject to testing to SABS 1793, as this is impractical.

In order to ensure that EBT's remain within the limits of accuracy as specified by SABS 1793 each and every unit should be subject to calibration testing periodically. This usually takes place every six months. It does not mean however that the equipment is no longer accurate after 6 months but is rather to give confidence firstly to the operator and secondly to the courts that the equipment is accurate.

Calibration testing only tests the accuracy of measurement at a number of concentrations of ethanol in air, usually at the legislated limit and at one level below and one level above the limit. It does not test for compliance with all the requirements of the SABS specification. Calibration can be done by using a calibrated gas concentration (dry gas method) or a wet bath simulator. At present the CSIR calibrate the EBT's using the dry gas method.

RELATIONSHIP BETWEEN BLOOD ALCOHOL AND BREATH ALCOHOL

Alcohol is absorbed through the alimentary canal into the blood stream in which it is distributed throughout the body affecting the nervous system, especially the brain. The blood alcohol level is a measure of the degree to which a person is likely to be affected. In the past blood samples have been taken and subjected to a complicated analysis to determine the concentration of alcohol in the blood.

Taking a blood sample is invasive and its analysis is intricate and time-consuming. Fortunately alcohol is a drug, which is volatile enough to appear in the expired breath. Thus some of the alcohol, which has been consumed and absorbed into the blood, evaporates into the air in the lungs. The concentration of alcohol in a person's breathe
Is dependent on the concentration of alcohol in the blood. The higher the blood alcohol levels the higher the breath alcohol level, and vice versa. This relationship follows well-established physical and physical and physiological principles. Thus breath alcohol analysis is also a measure of the degree to which a subject is affected by the consumption of alcohol.

The method by which alcohol gets into the blood stream and thence into the breath is initially through the stomach and intestines. The liquids (alcoholic drink) passes quickly from the mouth into the stomach and then more slowly into the small intestine. Very little

alcohol is absorbed through the mucus lining of the mouth and the stomach: the vast majority is absorbed through the walls of the small intestine. The duodenal walls are permeable to small compounds such as nutrients from digested food. Food is broken down by enzyme action in the intestine and the nutrients are small and soluble enough to pass through the walls of the gut, which are richly supplied by the blood vessels. The blood absorbs and carries away the nutrients from the digested food. This process of digestion requires time whereas alcohol being a small soluble molecule requires no such breakdown.

It diffuses directly into the walls of the digestive tract entering the blood in the network of capillaries supplying these organs. (This explains the rapid effect of alcohol consumption) The capillary vessels feed ultimately into the portal vein, which carries the blood with the nutrients and the alcohol to the liver where some of the alcohol (and certain desirable components from the digestive tract) is eliminated. The rest is transported to all parts of the body, including the brain.

The blood from the intestine goes via the liver and joins the used blood from other organs in the vena cava and flows to the right-hand side of the heart. From the right ventricle the blood is pumped to the lungs via the pulmonary artery. In the lungs the blood vessels divide and subdivide becoming capillaries that line the tiny airspaces, the alveoli, containing deep lung air. The alveoli are fine capillaries created by the branching and rebranching of the bronchial tubes. The tissues of the lung are so thin the blood and the air are virtually in contact facilitating the exchange of oxygen and carbon dioxide. If the blood contains alcohol some of the alcohol is lost into the alveolar air, the amount of alcohol going into the air of the lungs is proportional to the amount of alcohol in the blood. This is how the alcohol gets into the breath.

From the lungs the blood returns to the left ventricle of the heart via the pulmonary vein, from where the fresh blood (and alcohol if present) is pumped to the various organs of the body. The brain is richly supplied. Alcohol that is absorbed into the blood is quickly distributed throughout the body.

From the liver the blood flows to the heart whence it is pumped through the lungs. In the lungs the blood is aerated gaining oxygen and giving up carbon dioxide. If the blood contains alcohol some of the alcohol is lost into the alveolar air: the amount going into the air of the lungs is proportional to the amount of alcohol in the blood. The relationship between breath alcohol level and blood alcohol level follows Henry's Law which states that if one has a given concentration of vapour (alcohol) in the air then, at equilibrium, one would have a definite concentration of that material in the liquid (blood).

From the lungs the oxygenated blood (containing alcohol if present) returns to the heart for
Distribution throughout the body, the brain being richly supplied. For an average healthy man each heartbeat displaces about 70ml of blood. Since at rest the average heart rate is about 70 beats per minute the heart will pump about 5 litres per minute. As an average man has about 5 litres of blood (woman about 4.5 litres) in the blood vascular system, the

blood circulates quickly and freely. Alcohol that is absorbed into the blood is therefore quickly distributed throughout the body.

The alcohol in the blood is eliminated mainly through the action of the liver (95%) where it is broken down to carbon dioxide and water. The remaining alcohol (5%) is eliminated unchanged in the urine-very small amounts are eliminated in the breath and perspiration.

Evidential Breath Testing

The test for breath alcohol requires that breath in equilibrium with the blood be tested, that is alveolar air. For this reason sufficient breath must be exhaled during the test to ensure that alveolar air is measured; corridor air contains lesser amounts of alcohol in the exhaled breath with increasing levels of alcohol until a plateau is reached which will be the alcohol in the alveolar air. This will require about one litre of breath to be exhaled through the instrument detect an aberration in the test will be aborted.

Mention is sometimes made that the presence of mouth alcohol can affect the results of breath alcohol testing since the procedure requires a sample of lung air to be blown into the instrument through a mouthpiece. Mouth alcohol would result in the instrument initially detecting a high alcohol level followed by a lower level from the upper lung air and then a different level from the deep lung air. This would be a deviation from the expected normal test, and the test would be terminated and no result recorded. Before a subject is to be tested the procedure should include a waiting period of at least 20 minutes before the test commences. After this time any mouth alcohol would have then been swallowed or absorbed.

Any mixture which contains alcohol and which is taken by mouth will contribute to the alcohol in the body, so the alcohol in a cough mixture will be absorbed in the same way as alcohol in alcoholic beverages.

The specification for evidential breath testing equipment requires that foreign gases (such as methanol, isopropanol, acetone, ethyl acetate and toluene) that could be in a breath sample together with alcohol should cause no cross-sensitivity in the evidential breath test, or cause no excessive variation, failing which the test would be automatically discontinued. Sometimes persons with severe diabetes could have acetone in their breath at a higher level than the equipment is designed to tolerate, in which case the instrument would automatically terminate the test.