BREATH TESTING FOR ALCOHOL

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I. INTRODUCTION

This article describes the breath test instruments in use in this province as well as some of the basic concepts of breath testing.

There are two approved screening devices (ASDs) in use: the Alcotest 7410, which is in widest use, and the Alcolmeter SL-2. There are also three approved instruments (Als): the Intoxilyzer 5000e and the Breathalyzer, Models 900 and 900A. The emphasis will be on the instruments most recently introduced into service - the Alcotest 7410 and the Intoxilyzer 5000C - with briefer mention of the others. Before discussing these instruments, however, it may be useful to consider briefly the whole notion of breath testing. For many, this will be a review, but it will help provide some context in which to consider these instruments.

All breath tests are based on the idea that alcohol can be measured in the exhaled breath and the blood alcohol concentration (BAC) calculated from that value. Clearly, there are two independent issues here:

(i) the physiological issue - the principles and procedures needed to calculate the concentration of alcohol in the BLOOD, given a measured concentration in the BREATH,
(ii) the analytical issue - the principles, instruments and procedures needed to measure reliably the concentration of alcohol in the breath.

II. PHYSIOLOGY

For the moment, let us assume that the measurement of alcohol in breath can be done reliably so we can deal with the physiological matters first. The problem of being able to convert reliably from a breath alcohol concentration to a blood alcohol concentration (BAC) can be visualized in a simple equation:

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\text{Breath alcohol (mg/100 mL)} \times [\text{FACTOR}] = \text{Blood alcohol (mg/100mL)}
\]

Once a value for the FACTOR is known, the conversion is simple. Determining a reliable value for the FACTOR - the blood-breath ratio, as it is called - is not quite so simple. But it has been done.

To begin with, there is a sound theoretical basis for the FACTOR expressed in Henry's Law which has been known for nearly 200 years. It would probably not be helpful to delve into Henry's Law at this point. But suffice it to say, Henry's Law provides the theoretical basis to understand the behaviour of alcohol as a vapour and in solution. It gives the theoretical foundation to expect that the valid, constant FACTOR needed for the above equation actually exists. But Henry's Law does not provide a number. To get the value for the FACTOR, it is necessary to rely on empirical observation. That is, researchers get human subjects, dose them with alcohol, take breath samples and measure the alcohol in them. At the same time that the breath is being collected, the researchers take blood samples and measure the alcohol in them. It is then possible to calculate the blood-breath ratio from those measured values, ie:
Blood alcohol = FACTOR
Breath alcohol

Such measurements have been made repeatedly over the last forty years or so, in a number of labs around the world, by many different researchers. The values obtained for the blood-breath ratio quickly converged at about 2100/1, so that at the time of the introduction of the Breathalyzer in 1954, the value of 2100 for the FACTOR was widely accepted. That value was used in the Breathalyzer, and has been applied in every breath test instrument used in Canada since then.

More recent research has indicated that the blood-breath ratio is actually closer to 2300/1. Nonetheless, since using 2100 instead of 2300 as the FACTOR underestimates the BAC, there has been no move to change the FACTOR used in the breath test instruments. So, all the instruments named above - ASDs and AIs - incorporate the FACTOR of 2100 to convert breath alcohol to HAC.

These physiological notions apply regardless of the method used to measure alcohol in the breath in the first place. So the various instruments may use completely different principles to analyse the breath sample, but whatever analysis is used, the result will be converted to BAC by use of the FACTOR of 2100.

III. ANALYSIS

(A) PRINCIPLES:

There are several analytical techniques available for measuring alcohol. In all of these techniques, however, the user exploits some property that changes in a predictable fashion -
becoming more and more pronounced, for example - as the amount of alcohol in the sample changes.

The Breathalyzer relies upon the chemical oxidation of alcohol by dichromate solution. This reaction happens fairly easily under ordinary conditions of temperature and pressure. As it does, dichromate - which is intensely yellow - is converted to a pale greenish colour. The more alcohol in a sample, the greater this change of colour. Thus, by measuring the colour change from yellow to greenish, one obtains a measure of alcohol concentration. It works very reliably.

The Intoxilyzer 5000C relies on a completely different principle to detect alcohol - the principle of infrared (IR) absorption. It is a scientific fact that the alcohol molecule absorbs infrared radiation of certain specific wavelengths. The more alcohol there is present, the more infrared is absorbed. This means that, if infrared radiation is beamed through a sample of breath, any alcohol in that breath will be detected by its absorption of the radiation. The degree of absorption can be measured, and this quantity can be related to the breath alcohol concentration. As before, once a breath alcohol concentration has been measured, the blood-breath ratio can be used to calculate a value for BAC.

Both the Alcotest 7410 and the Alcolmeter SL-2 rely on the oxidation of alcohol, as the Breathalyzer does. But this chemical reaction, rather than being carried out in a solution, is carried out in a fuel cell (a small chamber containing a catalyst, such as palladium, and some electrolyte). The oxidation reaction that occurs in the fuel cell generates an electrical current directly - that is, without the intermediate step of the colour change, as in the Breathalyzer. The greater the amount of alcohol in the sample, the more extensive the oxidation reaction, and the greater the current generated. With appropriate amplification, the current is used to drive a display, which in turn provides the reading the user sees. The Alcolmeter SL-2 displays results only in terms of Pass-Warn- Fail. By contrast, on the Alcotest model used in this province (the
Alcotest 7410 GLC), the reading is in numbers for BAC up to 49 mg% - above that, the instrument simply indicates 'A' (for ALERT) for BACs between 50 and 99 mg%, and 'F' (for FAIL) for BACs of 100 mg% and greater.

(B) BREATH SAMPLING

It is widely held that a suitable sample of breath is presented only at the end of an exhalation, so that the sample is composed of deep-lung air (or alveolar air). The operator of the breath test instrument - whether ASD or AI - must judge whether the sample being supplied is suitable or not. Both of the newer instruments - the Alcotest 7410 and the Intoxilyzer 5000C - have certain features built in to help the operator collect a breath sample suitable for analysis.

In the Alcotest 7410, the instrument is set so that a subject must supply at least 1.2 litres of breath, at a rate of at least 6 litres/minute. So, the instrument requires a minimum volume of breath and a minimum rate of blow. If the subject does not meet both criteria, the instrument cancels the test, and the operator is prompted to try again.

In the Intoxilyzer 5000C, there are three criteria set: (1) the subject must blow hard enough to close a pressure switch in the instrument, and (2) keep it closed for at least 5 seconds. Once these two conditions are met, (3) the concentration of alcohol in the subject’s breath must level off substantially. Only when all three conditions are met does the Intoxilyzer proceed with measurement.

With both instruments, the set criteria define a minimum acceptable breath sample.

(C) MOUTH ALCOHOL:
With all breath test instruments, residual alcohol in the mouth is a potential source of invalid samples. This problem is completely solved by the operator making sure that the test subject takes nothing by mouth in the 20 minutes prior to the breath test. However, it is worth noting that the Intoxilyzer has incorporated a feature that detects mouth alcohol, and does so quite effectively.

(D) CALIBRATION

Like all measuring instruments, both the Alcotest 7410 and the Intoxilyzer 5000C have to be calibrated periodically to ensure that their readings correspond to actual alcohol concentrations. This is accomplished by sampling the vapour from a pure solution containing an accurately known concentration of alcohol (standard alcohol solution). The vapour is supplied by a simulator, so called because it simulates the exhalation of alcohol vapour in the breath. As long as the temperature of the alcohol solution is accurately known and fixed, then it is also known what reading the instrument must give if it is working properly.

In the case of the Alcotest, calibration is performed by a senior operator who has been trained for the task. The process is very simple: supply a sample whose reading is accurately known, and then adjust the instrument so that it reads as it is supposed to. Once the Alcotest is set this way, the setting will remain stable for at least 14 days.

With the Intoxilyzer 5000C, calibration is done in much the same manner as just described, but it is done only by a service company. The operator checks the instrument for correct calibration by analysing a standard alcohol solution each time a sample of breath is analysed. Only if the standard alcohol solution gives the proper reading is the subject's reading taken as reliable.

(E) ACCURACY
Both instruments are accurate, that is, both give readings that correspond reasonably closely to the alcohol concentration that actually existed in the blood at the time the breath sample was taken. It must be noted, however, that the Intoxilyzer 5000C, like the Breathalyzer, tends to underestimate the blood alcohol concentration. There are two reasons for this. First, the instrument uses a blood/breath ratio of 2100/1 (as noted above), and this value is considered to be somewhat lower than the value that actually exists in most subjects. Second, readings are truncated, that is, rounded down to the nearest 10 milligrams percent. For example, a breath test that gave an actual BAC reading of 158 milligrams per cent would be truncated to 150 for reporting. It has been observed that these two factors tend to give BAC readings that are 10-20 milligrams percent lower than the true blood alcohol concentration.

(F) INTERFERING COMPOUNDS

The ideal breath test instrument would be one that responds to ethyl alcohol and nothing but ethyl alcohol. Such an ideal is approached by these instruments, but not perfectly realized. Neither the fuel cell nor the infrared detector, as they are configured in these breath test instruments, is inherently specific. That is, both detectors are known to give a signal with certain compounds other than ethyl alcohol. However, lab testing has shown that such interference is, as a practical matter, confined to compounds closely related to ethyl alcohol. Methyl alcohol, for example, also known as wood alcohol, cannot be distinguished from ethyl alcohol by the Intoxilyzer 5000C. Isopropyl alcohol (rubbing alcohol) may also be indistinguishable from ethyl alcohol under some conditions. These compounds are generally more toxic than ethyl alcohol, and the qualified technician must be alert to their effects.

(G) APPROVAL OF BREATH TEST INSTRUMENTS.

Approval of both ASDs and AIs is given by the Attorney General of Canada and the list of
approved instruments is contained in the Criminal Code. All instruments are examined by the Alcohol Test Committee, a committee of the Canadian Society of Forensic Science. In the course of this evaluation, each instrument is tested for accuracy and reproducibility, using both pure alcohol solutions and human drinking subjects. In part of the evaluation protocol, the performance of the new instrument is compared to the performance of an instrument already approved (e.g., the Intoxilyzer 8000C was compared with the Breathalyzer). The new instrument must perform at least as well as the older instrument. Should the new instrument perform satisfactorily, a suitable recommendation is made to the Attorney General.