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The Intoxilyzer 5000C—A Computerized Infrared Evidentiary Breath Alcohol Instrument

by
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The authors discuss in this article the Intoxilyzer 5000C which has been approved by the Attorney General of Canada as an "approved instrument" for use in Canada as of 26 August 1992. Unlike the Breathalyzer, the Intoxilyzer 5000C uses an infrared absorption detection system in order to test for alcohol consumption. The authors explain in detail the operation of the Intoxilyzer 5000C. According to the authors, the Intoxilyzer 5000C has been shown to be a reliable, accurate evidential breath alcohol instrument which will be able to carry on the tradition of high standards in breath alcohol testing established by the Breathalyzer.

Les auteurs discutent, dans cet article, de l'appareil nommé "Intoxilyzer 5000C" qui a été approuvé par le Procureur général du Canada comme "appareil approuvé" et dont l'utilisation au Canada était légale à partir du 26 août 1992. Contrairement à l'ivressomètre, cet appareil comporte un système détectant l'absorption des rayons infrarouges afin de vérifier la quantité d'alcool consommé. Les auteurs expliquent en détail le fonctionnement de cet appareil. Selon eux, il a été démontré que l'appareil constitue un instrument fiable et précis permettant d'obtenir, par le biais d'une analyse d'échantillons d'haleine, des éléments de preuve relatifs à la consommation d'alcool et qu'un tel appareil saura respecter les normes élevées qui ont été établies par l'ivressomètre dans le domaine de l'analyse des échantillons d'haleine.

INTRODUCTION

The first practical medicolegal application of breath alcohol testing was described by Bogen in 1927.[1] Over the next 35 years, several breath alcohol testing instruments were developed, mainly

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* Centre of Forensic Sciences, Toronto, Ontario.

1 E. Bogen, "Drunkenness: A Quantitative Study of Acute Alcoholic Intoxication" (1927) 89:18 J. Am. Med. Assn. 1508.

based on chemical oxidation methods for the detection of alcohol. The Breathalyzer® has been the most widely used and successful of these instruments; it was designed by Professor Robert Borkenstein in 1954 and has been used in Ontario since 1956.[2] Since then, other instruments based on different methods of detection have evolved. For example, the A.L.E.R.T.™ uses a semiconductor to detect alcohol; the Alco-Sûr™ and Alcolmeter S-L2™ use a fuel cell. In 1971, breath alcohol instruments based on infrared absorption ("IR") detection were developed.[3] Infrared spectroscopy is a well-established technique in chemistry and has become a widely used detection procedure for evidentiary breath alcohol testing instruments.

The Intoxilyzer 5000C uses an IR absorption detection system and has been shown to meet the standards of the Canadian Society of Forensic Sciences Alcohol Test Committee.[4] It was approved by the Attorney General of Canada as an "approved instrument" for use in Canada on August 26th, 1992.[5] The Intoxilyzer 5000C will begin to be used in Ontario starting in 1993.

BASIC PRINCIPLES OF INFRARED SPECTROSCOPY

Infrared is a specific form of energy in the spectrum of electromagnetic radiation (Figure 1). "Infrared" means "below red" and is a region of the electromagnetic spectrum with longer wavelength (lower energy) than visible red light, and thus is invisible to the human eye. Wavelengths of electromagnetic radiation between 0.7 and 1,000 micrometres are considered infrared. Light visible to the human eye occurs at wavelengths between about 0.7 and 0.4 micrometres. A micrometre is a unit of length which is one-millionth of a metre and is commonly referred to as a micron.

A molecule such as ethyl alcohol has a unique structure consisting of carbon, hydrogen and oxygen atoms. As a result of its

2 D.M. Lucas & R.C. Charlebois, "Blood, Breath and Urine Alcohol Analysis in Canada" (1978) 11:2 Can. Soc. Forens. Sci. J. 75.

3 R.A. Harte, "An Instrument for the Determination of Ethanol in Breath in Law-Enforcement Practice" (1971) 16:4 J. Forens. Sci. 493; Y. Fukui & Y. Yamamoto, "Determination of Breath Alcohol by Infrared Gas Analyser" (1971) 11 Med. Sci. Law 182.

4 "Recommended Standards and Procedures of the Alcohol Test Committee" (1986) 19:3 Can. Soc. Forens. Sci. J. 164.

5 TR/92-167, C. Gaz. 1992.II.3807.

unique structure, there are certain wavelengths of infrared energy that are absorbed by the molecule and others that are not. Different chemical molecules will have a unique IR absorption pattern. For ethyl alcohol, the greatest absorption of IR energy occurs in the 3.35 to 3.50 microns region.

The Intoxilyzer 5000C uses IR absorption at the wavelengths of 3.39 and 3.48 microns to detect alcohol. An additional wavelength of 3.80 microns is used as a reference, as there is no significant absorption of IR energy by alcohol or other components of human breath at this wavelength. The IR absorption pattern for ethyl alcohol is shown in Figure 2, which shows the 3 wavelengths used by the Intoxilyzer.

LAMBERT-BEER LAW

The determination of the alcohol concentration is based on the Law of Absorption, or the Lambert-Beer Law. This law was first established in the eighteenth century and can be expressed as the following mathematical equation:

$$I = I_o * e^{-abc}$$

where I is the final intensity of IR energy (after passing through the sample)
I_o is the initial intensity of the IR energy
e is a mathematical constant equal to 2.71
a is the absorption coefficient for ethyl alcohol
b is the IR energy path length through the sample
c is the concentration of ethyl alcohol present in the sample

The Intoxilyzer 5000C measures both the initial and the final IR energy intensity. The sample path length and absorption coefficient are known, therefore the instrument can determine c, or the alcohol concentration of the sample.

Of particular significance is the lack of dependency of the Lambert-Beer Law on volume. This gives the Intoxilyzer the ability to instantaneously and continuously analyse the concentration of ethyl alcohol in the sample without being dependent on a fixed sample volume as is the Breathalyzer.

DESCRIPTION OF THE INTOXILYZER 5000C

The Intoxilyzer 5000C is manufactured by CMI Inc. (Colorado Mountain Industries) of Owensboro, Kentucky, a subsidiary of MPD Inc. The Intoxilyzer 5000 was first manufactured in 1982 and has been used extensively throughout the U.S.A. since 1984. The 5000C is a model of the Intoxilyzer 5000 used in Canada, and the C refers to Canada. It is a computerized, automated breath alcohol testing instrument which allows the technician to conduct a breath alcohol testing procedure by pressing just one button. The Intoxilyzer 5000C prints the results of the tests on a card. Incorporated in it is a sampling system that requires a subject to deliver a minimum volume of sample, an interferant detection system to allow selective measurement of alcohol, and a radio frequency interference ("RFI") detection system. The Intoxilyzer 5000C continuously monitors its functions throughout the testing; if they are not within defined parameters, an error message results and the procedure is terminated.

The instrument dimensions are approximately 47 cm by 45 cm by 14 cm high. A diagram of the exterior of the Intoxilyzer 5000C is shown in Figure 3. A photograph is shown in Figure 4. A keyboard may be attached to the instrument to allow for entry of data such as the name of the subject and the driver's licence number. A simulator containing Alcohol Standard is also attached by Tygon tubing to the simulator inlet at the side and to the simulator outlet at the back of the instrument.

A simulator is a device for producing a known concentration of alcohol in air by the equilibration of alcohol between water and air at a temperature of 34°C. This "simulates" alcohol-containing breath samples. The simulator consists of a jar which can contain 500 ml of an Alcohol Standard. A heater protrudes into the Alcohol Standard to provide the elevated temperature. The temperature is regulated by a thermostat, and a small plastic propeller rotates to continuously mix the Alcohol Standard to ensure complete equilibrium. The Intoxilyzer 5000C has a closed system to recirculate the alcohol-containing air of the simulator, resulting in minimal depletion of the Alcohol Standard. Over a hundred tests may be conducted before the Alcohol Standard must be changed.

THE SYSTEMS OF THE INTOXILYZER 5000C

A schematic of the 3 basic systems of the Intoxilyzer 5000 is shown in Figure 5: the optical system, the breath/air flow system and the electronic and microprocessing system.

(a) Optical System

The optical system consists of an infrared energy source, a tungsten filament halogen light bulb which is coated on one side with a reflective material so that the IR energy generated by the bulb will be directed into the sample chamber. The sample chamber is a nickel plated tube 1.9 cm in diameter and 28.6 cm in length. The volume is 81 ml. At each end of the sample chamber are lenses which focus the IR energy through the sample chamber and onto the detector. There is a filter wheel rotating at approximately 1,800 rpm between the exit lens and the detector. The filter wheel has three filters which transmit IR energy at 3.39, 3.48 and 3.80 microns, and allow only energy of these wavelengths to reach the detector. The detector converts the IR energy into an electrical signal. As alcohol-containing air from either a simulator or subject test is introduced into the sample chamber, the alcohol molecules absorb the IR energy at wavelengths of 3.39 and 3.48 microns. They will not absorb the IR energy at 3.80 microns, so that can be used as the reference. The greater the concentration of alcohol in the sample chamber, the greater the decrease of 3.39 and 3.48 microns IR energy received at the detector. This causes a decrease in the electrical signal relative to the signal generated by the 3.80 IR reference wavelength. The electrical signal is then processed by the electronic and microprocessor system into a numerical result. The electronic and microprocessor system compares the ratio of IR light at 3.39 and 3.48 microns to determine if there may be an interferant in the sample.

(b) Breath/Air Flow System

The breath/air flow system consists of the heated external breath inlet tube, the internal breath tubing, the selector (three way) valves, the sample chamber, the pump, the pressure switch, one way valve, and the intake and exhaust ports. The three way valves are controlled by the microprocessor and are opened and closed appropriately depending on whether a simulator test, a blank or a subject test is conducted. For a blank test, the pump draws room air through the external heated breath tube (see Figure 3), through the sample chamber, and out the breath and pump exit. For a simulator test, the pump and the three way valves are activated so that the alcohol-containing vapour is drawn into the sample chamber and out the simulator vapor exit back into the simulator. This closed loop allows for minimal loss of alcohol in each test. Before a subject test, the tubing is purged of alcohol containing air by another blank test. In the subject test, the pump is not activated, the subject blows through the mouthpiece and heated breath tube into the chamber, and the breath leaves through the breath and pump exit. A one way (check) valve is placed in the tubing at the exit to prevent a subject from sucking the breath sample back. When the subject blows with enough pressure, a 6-inch pressure switch is activated (equivalent to 6 inches or 15 centimetres of water pressure). The instrument determines the minimum acceptable sample by a time and pressure switch and by slope detection. When the minimum volume of sample has passed through the system, the instrument signals the technician. By this method, the initial breath sample which is low in alcohol concentration is vented and deep lung (alveolar) breath is collected in the sample chamber.

(c) The Electronic and Microprocessing System

This system is the "brains" of the instrument. It constantly monitors all systems to ensure they are functioning properly. The microprocessor controls all operations of the instrument, opening and closing the three way valves, activating the pump, the audible tones, the display, and the printer. The microprocessor also converts the electric energy from the IR detector into a numerical result.

OPERATION OF THE INTOXILYZER 5000C

(a) Testing Sequence

When the instrument is first turned on, it emits an audible tone, and the pump is activated to fill the tubing and sample chamber with room air. A "NOT READY" message is displayed because the instrument requires approximately 15 minutes to heat up to the operating temperature of 45°C. After this temperature is reached and a stabilization time is allowed, the instrument conducts a series of diagnostic checks, including the status of the electronics and microprocessor, temperature, and printer and electronics. As each check is passed, the instrument emits a tone. If any of these checks are not within the proper parameters, an "ERROR" message is displayed and a breath test sequence cannot proceed until the error is corrected.

After the diagnostic checks are successfully completed, the message "CMI / MPD INC INTOXILYZER — ALCOHOL ANALYZER MODEL 5000C — PUSH BUTTON TO START TEST" is scrolled across the screen, and the time and date are displayed. The entire message is repeated until the technician initiates the test sequence by pushing the START button.

When the START button is pushed, the instrument displays the message "INSERT CARD." After the test record card is properly inserted, if a keyboard is attached, the instrument flashes a series of questions regarding the subject, such as name, date of birth, and driver's licence number. The information is entered using the keyboard, and the instrument allows the technician to review the data to check for accuracy. If there is no keyboard attached, no questions will be flashed on the screen, and the technician will write the information on the test record card before inserting it.

The instrument then conducts a blank test by activating the pump and the valves and displays on the screen "AIR BLANK .000." The 3 digits are the result of the air blank. If potential interfering compounds of varying concentration are detected in the room air, an error message "AMBIENT FAILED" appears on the screen, a high-low tone sounds, and the test sequence is terminated. After the air blank is successfully completed, a series of ">>>>>>>>>>" is displayed as the instrument conducts a series of ten internal checks and establishes a stable baseline. If there is any problem, the instrument will emit a high-low sound, display an error message on the screen and terminate the test sequence.

Next the instrument conducts an Alcohol Standard test; the pump and the valves are activated and air is drawn through the simulator into the sample chamber and recycled back. The instrument displays the message "CAL CHECK .000," which refers to the calibration check. The three digits that appear after the CAL CHECK indicate the result of the standard test. Normally an Alcohol Standard will be used that has a target value equivalent to 100 mg of alcohol in 100 ml of blood (mg/100ml) or .100 g of alcohol in 100 ml of blood (g/100ml). As does the Breathalyzer, this instrument displays the result in g/100ml, which are the units of measurement commonly used in the U.S. By multiplying this figure by 1000, the units used in Canada (mg/100ml) can be obtained.

After the calibration check (Alcohol Standard test), another air blank is conducted to clear the breath/air sampling system of alcohol-containing air and replace it with room air. The instrument will display the message "AIR BLANK .000." Again the internal checks are conducted and the message ">>>>>>>>>>" is scrolled across the screen. If all the internal checks are satisfactory, the message "PLEASE BLOW/R INTO MOUTHPIECE UNTIL TONE STOPS" is displayed. The message "PLEASE BLOW/R" is repeated until the subject starts to provide a sample. If the subject blows into the instrument with enough force, the tone is activated by the pressure switch and the timing sequence starts. The tone is emitted as long as the subject continues to blow with enough force. If the subject stops blowing before an acceptable sample is collected, the tone stops and the message "PLEASE BLOW" is flashed on the screen and an intermittent tone is sounded. If the subject fails to provide the sample after 2-3 minutes, a high-low tone sounds and the message "DEFICIENT SAMPLE" flashes on the screen. If the subject refuses to provide a sample, the operator types "R" on the keyboard, the message "REFUSED" flashes and a high-low tone is sounded.

When the subject successfully provides the minimum sample, the result is displayed, then another air blank is conducted. The instrument then prints the results of the subject test, blank test and Alcohol Standard test, the location and serial number of the instrument, the date and time, the subject's name and other data. The entire sequence can be completed in approximately 3 minutes.

After at least 15 minutes, the entire sequence is repeated for the subject and those results are also printed on the card. Again if there is any problem with the instrument or the correct sequence is not followed (such as the subject providing a sample before the proper time), a high-low tone sounds, an error message appears on the screen and the test sequence is terminated.

A summary of the breath testing sequence is shown in Table 1. Since the procedure is repeated, the instrument conducts a total of six blank tests, forty separate internal checks, and two calibration or Alcohol Standard checks for each subject.

(b) Determination of Acceptable Breath Sample Volume

For accurate breath alcohol testing, it is important to analyze deep lung or "alveolar" breath. The volume of breath that will be required to be exhaled in order to obtain this sample varies according to the subject's lung capacity or forced vital capacity ("FVC"). The forced vital capacity for healthy subjects depends on age, sex, and height. Men tend to have a greater FVC than women, a taller person will have a greater FVC than a shorter person, and a person over 40 years of age will tend to have a lower FVC than a younger person. The FVC can vary from 1.68 liters (l) in a female subject who is 132 cm in height and 65 years of age or older to 7.85 l in a 25-year-old male who is 216 cm in height.[6]

The breath sampling system takes into account this biological variability and adjusts the time required to blow into the instrument depending on the capacity of the individual's lung. For a subject with a small lung capacity, only 5 seconds may be required to obtain a minimally acceptable sample. For someone with a large lung capacity, it may require 15 seconds to obtain a minimally acceptable breath sample.

The Intoxilyzer 5000C has 3 sampling criteria before it will accept a breath sample:

1. PRESSURE: The subject must blow hard enough to obtain a steady tone (15 cm of water pressure).
2. TIME: The subject must maintain at least that pressure for 5 seconds.
3. SLOPE: The subject's breath alcohol concentration during exhalation must level off or plateau (*i.e.*, the slope must be close to zero).

The first two criteria must be satisfied before the slope detector system is activated. As the subject exhales, the Intoxilyzer 5000C

6 R.J. Knudson, R.C. Slatin, M.D. Lebowitz & B. Burrows, "The Maximum Expiratory Flow-Volume Curve" (1976) 113 Am. Rev. Respir. Dis. 587.

is analyzing the breath alcohol concentration in the sample chamber and is updating the result every 0.6 seconds. The microprocessor/electronics system then measures the increase in breath alcohol concentration in that time period. As the subject exhales and alveolar or deep lung breath is obtained, the breath alcohol concentration levels off or plateaus; when this plateau is detected, the instrument signals the technician that the minimum sample volume has been provided.

Testing at the Minnesota Bureau of Criminal Apprehension Laboratory has shown that the minimum acceptable breath sample volume varied between 0.45 l and 1.32 l depending on the subject.

(c) Mouth Alcohol Detection

The slope detector is also used by the Intoxilyzer 5000C as an additional safeguard to determine the presence of alcohol in the mouth. If a subject consumes any alcohol-containing solution (*e.g.*, some mouthwashes, cough medicines, etc.) and provides a breath sample shortly thereafter, the breath alcohol concentration will be falsely high due to the residual alcohol in the mouth. This effect has been known since 1927. Depending on the alcohol concentration and amount of solution, this effect will disappear in 5-15 minutes. By having a waiting period of at least 15 minutes before providing a breath sample, there would be no mouth alcohol effect. In Canada, an additional safeguard is the proper duplication of the two breath samples taken at least 15 minutes apart.

Since the Intoxilyzer 5000C is equipped with a slope detector to determine the minimally acceptable breath sample volume, it is also used to determine mouth alcohol. With a subject who has recently consumed alcohol, as he or she exhales, the breath alcohol concentration increases by a greater rate than with a subject without mouth alcohol; the slope then decreases dramatically as breath is exhaled and the alcohol concentration in the mouth decreases. The slope detector determines this negative slope, recognizes this change as due to mouth alcohol, and flashes the error message "INVALID SAMPLE."

(d) Interferant Detection

The Intoxilyzer 5000C compares the electrical signals generated by the IR detector at the 3.39 microns and 3.48 microns to detect and adjust for possible interfering compounds. It is based on the principle that interfering compounds will not absorb IR energy to the same extent as ethyl alcohol at both wavelengths. The instrument determines a constant difference between the electrical signal generated by the detector at these two wavelengths. This difference should be maintained if only ethyl alcohol is analyzed.

Table 2 illustrates how this is accomplished. For room air, the electrical signal generated at 3.48 microns can be described as six units, and for 3.39 microns as four units — the difference being two units. This difference will be maintained if only ethyl alcohol is analyzed. If ethyl alcohol is introduced into the sample chamber, the IR energy will be absorbed by the ethyl alcohol molecules and there will be a decrease in the electrical signal generated by the IR detector. If the 3.48 microns signal decreases to five units, then the 3.39 microns signal must decrease to three units, maintaining the two unit difference. If ethyl alcohol and acetone are analyzed, the 3.48 microns signal may decrease to four and a half units. The electrical signal at 3.39 microns will decrease even more, as this wavelength is strongly absorbed by acetone. The difference between the signals of the two wavelengths is now three and a half units, not two units. The instrument adjusts the result to account for the difference in signal, and if the concentration of the interfering compound is high, the instrument will display the error message "INTERFERANT."

(e) Radio Frequency Interference Detection

The Intoxilyzer 5000C is constructed to be resistant to possible radio frequency interference ("RFI"). There is another safeguard in that the external breath tube also has an antenna to detect strong RFI. When this is detected the instrument ceases testing and the error message "INHIBITED—RFI" is displayed.

(f) Alcohol Data Acquisition and Management System (ADAMS)

The Intoxilyzer 5000C may be connected by modem and telephone line to a central computer using the ADAMS program. Data that is collected by each instrument can be downloaded and stored in this computer which eliminates the traditional hand-managed filing and retrieval method for statistics generated by impaired driving offences.

ACCURACY

The accuracy of the Intoxilyzer 5000C is similar to that of the Breathalyzer models 900 or 900A. In fact, the Breathalyzer was used as a reference instrument in one of the evaluations of the Intoxilyzer 5000C conducted for the Alcohol Test Committee of the Canadian Society of Forensic Science.

In one laboratory study, using an alcohol simulator at a concentration equivalent to 100mg/100ml, the average result of twenty tests with the Intoxilyzer 5000 was 100 mg/100ml.[7] In a laboratory study of twenty Breathalyzer models 900 and 900A, using a simulator and the same alcohol concentration, the average result was also 100 mg/100ml.[8] The precision of the measurements in both studies was very close; for the Intoxilyzer 5000 the correlation coefficient was 1.6 per cent, and for the Breathalyzer it was 2.5 per cent. Any coefficient of variation less than 5 per cent is usually considered good for quantitative analysis.

With respect to the accuracy of the Intoxilyzer compared with the actual blood alcohol concentration ("BAC") of subjects, it is calibrated using the same apparent blood breath ratio ("BBR") as the Breathalyzer (2100:1). Since the actual average BBR is approximately 2300:1, the Intoxilyzer 5000C as well as the Breathalyzer will tend to read slightly lower than the blood alcohol concentration. This is shown in a field study of 395 suspected impaired drivers who had an Intoxilyzer 5000C test conducted and then had a blood sample collected less than 1 hour later.[9] When the Intoxilyzer 5000 results were compared with the blood alcohol concentrations, 67 per cent of the Intoxilyzer 5000 results were more than 10 mg/100ml *lower* than the actual BAC, and 21 per cent of the results were within 10 mg/100ml of each other. In only 2 per cent of the cases was the Intoxilyzer 5000 result more

7 B.A. Goldberger & Y.H. Caplan, "Infrared Quantitative Evidential Breath-Alcohol Analyzers: In Vitro Accuracy and Precision Studies" (1986) 31:1 J. Forens. Sci. 16.

8 Y.H. Caplan, D.T. Yohman & M. Schaefer, "An In Vitro Study of the Accuracy and Precision of Breathalyzer Models 900, 900A and 1000" (1985) 30:4 J. Forens. Sci. 1058.

9 P.M. Harding, R.H. Laessig & P.H. Field, "Field Performance of the Intoxilyzer 5000C: A Comparison of Blood and Breath-Alcohol Results in Wisconsin Drivers" (1990) 35:5 J. Forens. Sci. 1022.

than 10 mg/100ml higher than the blood, due mainly to the Intoxilyzer 5000 tests being conducted up to 1 hour before the blood samples were collected. The elimination of alcohol from the blood in that time caused the blood samples to be lower in alcohol concentration.

The authors conclude in their study that:

> No evidence was found of falsely elevated BrAC [breath alcohol concentration] results that could be attributed to unusually low individual blood to breath alcohol ratios, endogenous or exogenous interfering compounds, residual mouth alcohol or electromagnetic interference. Overestimation by the Intoxilyzer 5000 was infrequent and of small magnitude. Indeed most of the differences shown could be eliminated if the amount of alcohol theoretically eliminated in the time elapsed between breath and blood specimen collection were added to the BAC.[10]

SPECIFICITY

Since there are other volatile compounds that can absorb IR energy similar to alcohol at some wavelengths, some of the early IR instruments that used only one wavelength could be potentially susceptible to interference and falsely elevated results. By using the three wavelength system, the Intoxilyzer 5000C can detect a number of possible interfering compounds, as previously described.

This instrument can detect and screen out possible interference from two common endogenous compounds, acetone and acetaldehyde. A number of other compounds will also be detected by the interferant detector. There has been only one published report of a false BrAC by an Intoxilyzer 5000 caused by inhalation of a volatile compound.[11] In this case, a 52-year-old cabinet maker who had a 20-year history of work-related exposure to lacquers and paints and did not use any protective mask was tested by an Intoxilyzer 5000 45 minutes after he left work. The result was 310 mg/100ml, and 12 minutes later the Intoxilyzer result had decreased to 240 mg/100ml. In both instances the Intoxilyzer 5000 printed that there was an interferant detected. A blood sample that was collected between the time of the first and

10 Ibid. at 1027.

11 M.A. Edwards, W. Giguiere, D. Lewis & R.C. Baselt, "Intoxilyzer Interference by Solvents" (1986) 10 J. Analytical Toxicol. 125.

second Intoxilyzer 5000 tests was analyzed and found to have no alcohol, but a blood toluene concentration of 1.1 mg/100ml.

This case illustrates that although the Intoxilyzer 5000 result was incorrect, the interferant was detected. Additionally, it illustrates how quickly volatile compounds like toluene, found in paints and lacquers, disappear from the blood. The elimination is exponential rather than linear as for alcohol. This would cause the difference between the two breath results to be greater than the 20 mg/100ml suggested by the Alcohol Test Committee. Not only can the interferant be detected by the use of three wavelengths, but also by the poor duplication of the two Intoxilyzer 5000 tests taken at least 15 minutes apart.

In a more realistic study of solvent inhalation, subjects were exposed for 4 hours to toluene, 1,1,1, trichloroethane and butane, at the maximum upper concentrations recommended for workplaces prescribed by the Health and Safety Executive in the United Kingdom. The subjects obtained no positive result on an IR instrument after 20 minutes exposure to fresh air.[12] The highest false positive result was obtained in one subject after butane exposure. It was 18 mg/100 ml 1 minute after exposure, which decreased to 0 within 20 minutes, again showing the rapid, exponential removal of these volatiles from the breath.

More importantly, laboratory and field studies of subjects exposed to domestic painting situations with and without ventilation showed that after 10 minutes' exposure to fresh air, no false results were obtained on an IR instrument.[13] As concluded by Dubowski:

> The theoretical consideration of chemical interference in any such IR analysis by any of the thousands of compounds other than the analyte of interest is rendered moot by the fact that any such potential interferant must satisfy a series of biological and chemical conditions that are rarely, if ever, coincident in nature. Therefore in operational practice in breath-alcohol testing of drinking drivers, the universe of potential chemical interferants is so limited that chemical interference is not a significant problem.[14]

12 R. Gill, S.E. Hatchett, et al., "The Response of Evidential Alcohol Testing Instruments With Subjects Exposed to Organic Solvents and Gases. I. Toluene, 1,1,1,-Trichloroethane and Butane" (1991) 31:3 Med. Sci. Law 187.

13 R. Gill, H.E. Broster, C.G. Broster, et at., "The Response of Evidential Breath Alcohol Testing Instruments With Subjects Exposed to Organic Solvents and Gases. II. White Spirit and Nonane" (1991) 31:3 Med. Sci. Law 201; R. Gill, M.D. Osselton, J.E. Broad, et al., "The Response of Evidential Breath Alcohol Testing Instruments With Subjects Exposed to Organic Solvents and Gases. *III. White Spirit Exposure During Domestic Painting*" (1991) 31:3 Med. Sci. Law 214.

RELIABILITY

The Intoxilyzer 5000C is a very reliable instrument. As with most instruments, the mechanical parts are subject to more breakdown and wear than the electronic parts. As long as the instrument is plugged into a surge protector, the electronics parts should be trouble-free for many years. In the U.S.A., the most common problem with the Intoxilyzer 5000 is printer malfunction. However, the malfunctioning of the printer does not effect the accuracy of the test; it simply means that there would be no printed copy available at that time, and the technician would have to obtain the results directly from the digital display.

To determine the alcohol concentration, the Intoxilyzer 5000C compares the initial and final intensity of the IR energy (I_o and I in the Lambert-Beer Law). It is not the actual IR intensity that is critical but the change in the IR intensity. By measuring the change and not the actual IR energy, the accuracy of the Intoxilyzer is unaffected by slight voltage fluctuations, dirt, dust, or slow changes in the intensity of the IR source. This comparison method is similar in principle to the Breathalyzer. The Breathalyzer compares the colour change in the potassium dichromate solution of the ampoule. The actual concentration of the potassium dichromate is not important, only the colour change. Therefore, variations in the potassium dichromate concentration will not affect the accuracy of the test, but will affect the workload.

Batteries in the Intoxilyzer prevent loss of data in the event of a power blackout. To ensure a proper workload, the Intoxilyzer will signal the technician if the workload potential decreases to below 423 mg/100ml. Any error that could affect the accuracy of the breath test will cause the instrument to cease testing and display an error message.

In addition, the technician monitors the instrument to detect any problems and to ensure that the strict standards of breath al-

14 K.M. Dubowski, "The Technology of Breath-Alcohol Analysis" U.S. Department of Health and Human Services, Rockland, Maryland, 1992.

cohol testing are applied. The technician ensures that the alcohol standard result is within +/— 10 mg/100ml of the target value, the blank tests are less than 10 mg/100ml, and the truncated results of the two subject tests are not more than 20 mg/100ml apart. If all of these standards are met, the Intoxilyzer 5000C will produce very reliable results.

CONCLUSION

The Intoxilyzer 5000C has been shown to be a reliable, accurate, evidential breath alcohol instrument which employs infrared energy for the detection and quantification of alcohol. The Intoxilyzer 5000 has been used extensively in the U.S.A. since 1984 and is a well-established and thoroughly tested instrument. The Intoxilyzer 5000C will be able to carry on the tradition of high standards in breath alcohol testing established by the Breathalyzer.

Figure 1

The Electromagnetic Spectrum

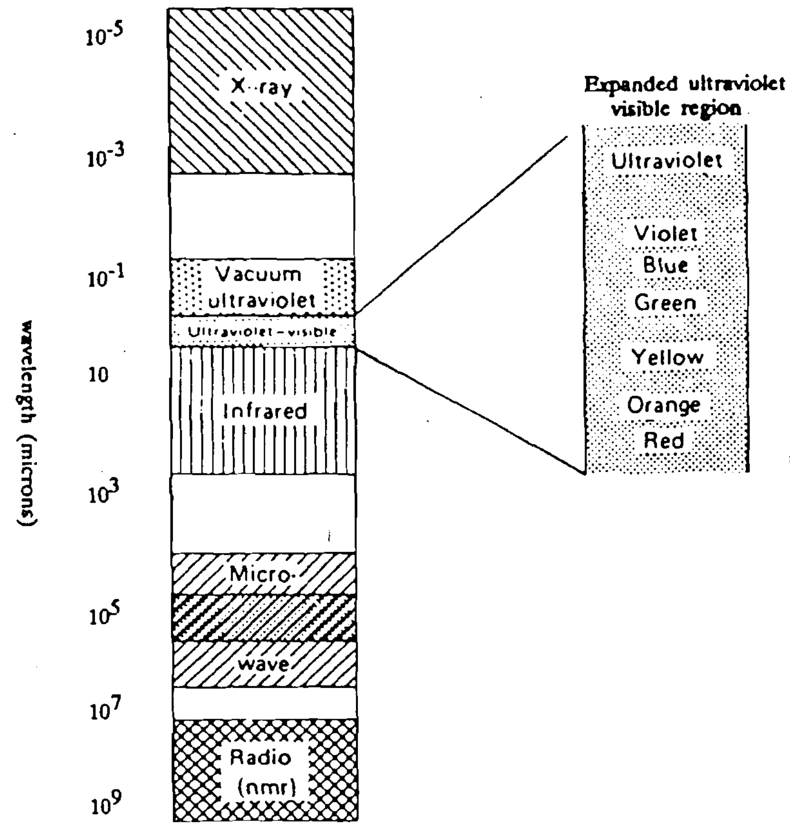


Figure 2

The Infrared Absorption Pattern for Ethyl Alcohol

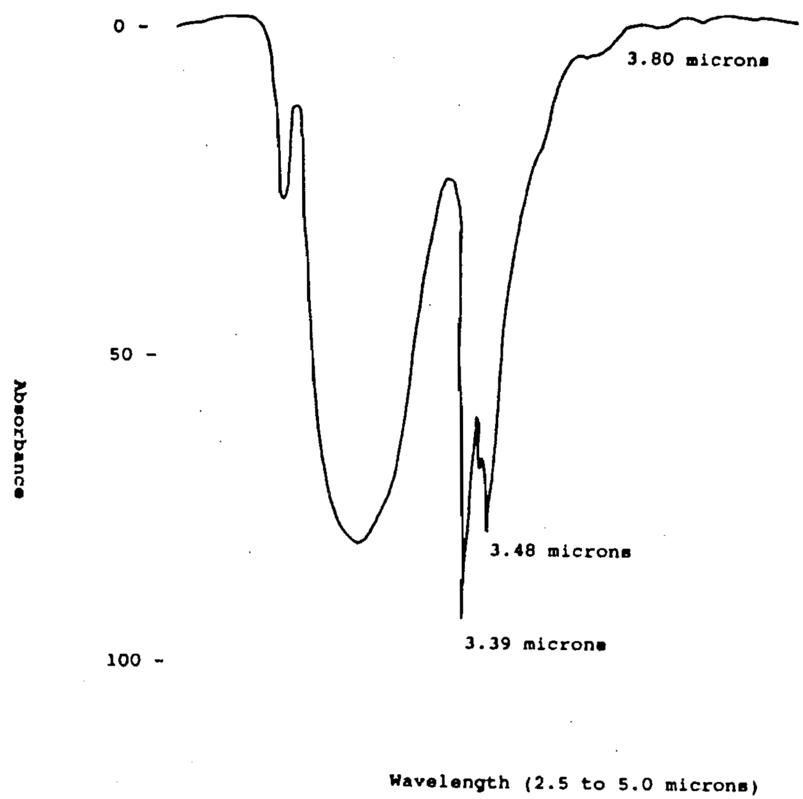
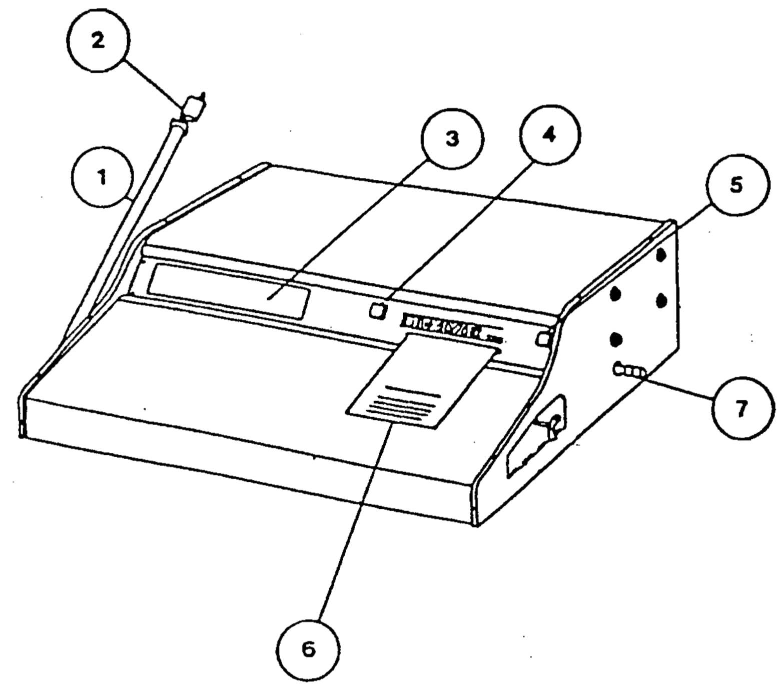


Figure 3

The Intoxilyzer 5000C



1. Heated Breath Tube
2. Mouthpiece
3. Digital Display
4. Start Test Switch
5. Power Switch
6. Test Record (inserted into Printer)
7. Simulator (Alcohol Standard) Inlet

Figure 4

Intoxilyzer 5000C

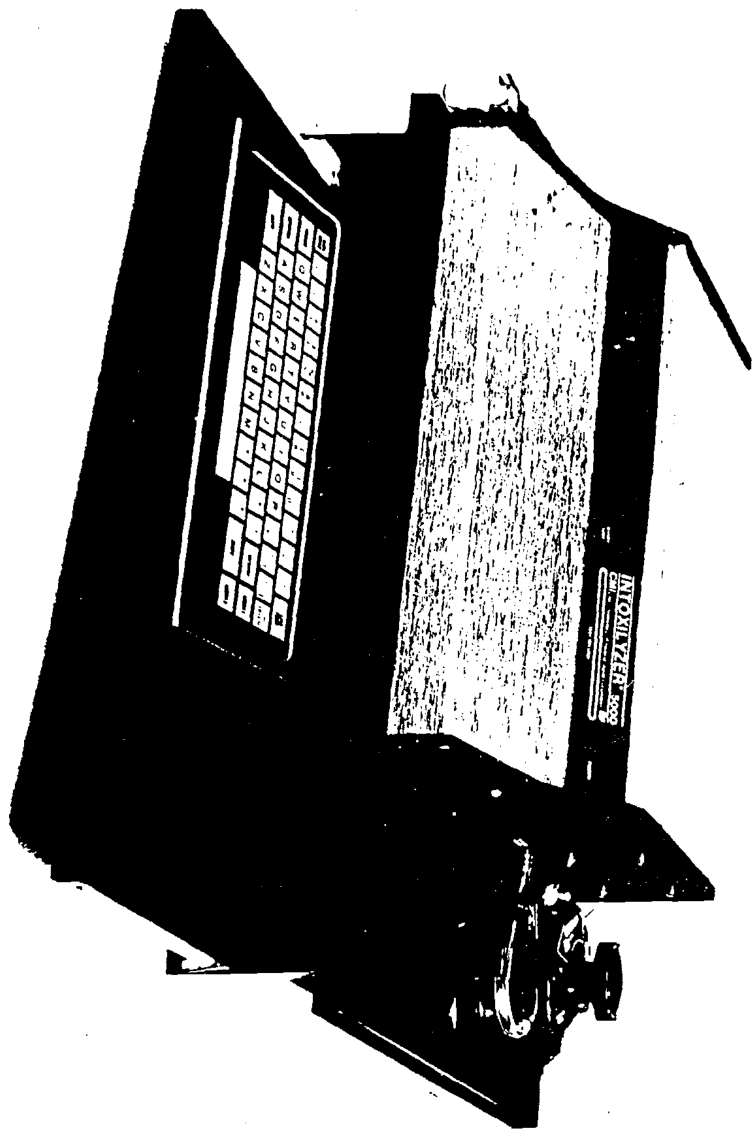


Figure 5

Functional Diagram of the Intoxilyzer 5000C

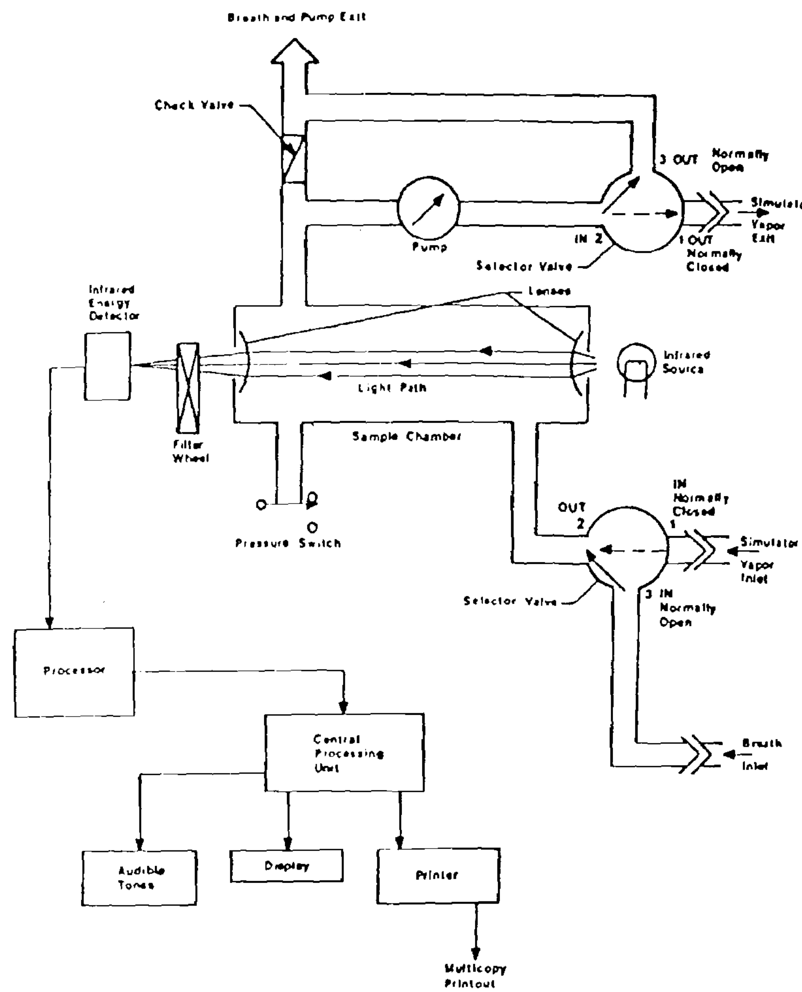


Table 1

The breath alcohol testing sequence of the Intoxilyzer 5000C in Ontario. This sequence is repeated for each subject.

Blank Test
Internal Checks
Calibration Check (Alcohol standard test)
Blank Test
Internal Checks
Subject Test
Blank Test
Results are printed

Table 2

Detection of possible interfering compounds by the comparison of electrical energy generated at 2 IR wavelengths.

	Electrical Energy Generated by the IR Detector (defined as units)		
	3.48 microns	3.39 microns	difference
Initial (room air)	6	4	2
Alcohol only	5	3	2
Alcohol and acetone	4.5	1	3.5