



INDIANA UNIVERSITY

BORKENSTEIN
COURSE

Center for Studies
of Law in Action

Evidentiary IR Breath Testing/Intoxilyzer® 5000C

by

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Evidentiary IR Breath Testing/ Intoxilyzer® 5000C*

James Wigmore, Jeff Patrick
and Rick Libman†

This paper was presented at a workshop presented at the Canadian Society of Forensic Science, 42nd Annual Conference in Toronto, Ontario, 26-30 September 1995. James Wigmore and Jeff Patrick have been responsible for implementing the use of the Intoxilyzer 5000C approved instrument in Ontario. The authors review the history of the development of the Intoxilyzer as well as the breath test sequence and operation of the Intoxilyzer 5000C. Numerous charts and diagrams are included.

Cet article a été soumis à un atelier lors de la 42^e Conférence annuelle du Canadian Society of Forensic Science tenue à Toronto (Ontario) du 26 au 30 septembre 1995. James Wigmore et Jeff Patrick ont été responsables de l'introduction de l'utilisation de l'appareil de détection approuvé Intoxilyzer 5000C en Ontario. Les auteurs révisent l'historique du développement du Intoxilyzer ainsi que la succession des étapes du test d'échantillon d'haleine et le fonctionnement du Intoxilyzer 5000C. Plusieurs tableaux et graphiques y sont inclus.

“The introduction of microprocessor-controlled infrared based instruments during the last decade has at last persuaded the authorities in many countries to put aside the chromic acid ampoules, cover up the knurled knob and pointer, and set the null galvanometer on the Breathalyzer 900 to zero for the last time ...”

Smith, D., 1993

* This paper was prepared for the Canadian Society of Forensic Science, “The Forensic Menage: Changing Realities,” 42nd Annual Conference, September 27, 1995, Toronto, Ontario. The moderator of this workshop was Joel Mayer, Head of Toxicology, Centre of Forensic Sciences, Toronto, Ontario.

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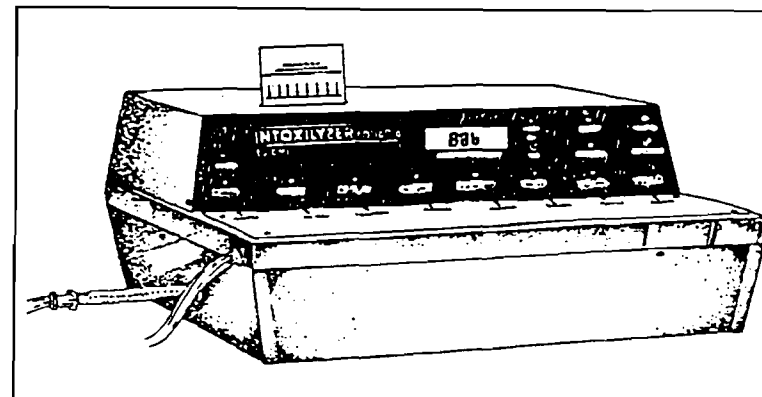
HISTORY OF THE INTOXILYZER

- 1971 — “Omicron” Intoxilyzer
 — “CMI” (Colorado Mountain Industries)
 Intoxilyzer 4011
 Intoxilyzer 4011A
 Intoxilyzer 4011ASA
- 1984 — Intoxilyzer 5000 first used in Minnesota
 1992 — Intoxilyzer 5000C gazetted in Canada
 1994 — Intoxilyzer 5000C first used in Canada
 CMI Inc. was purchased by MPD Inc. which also owns MPH.

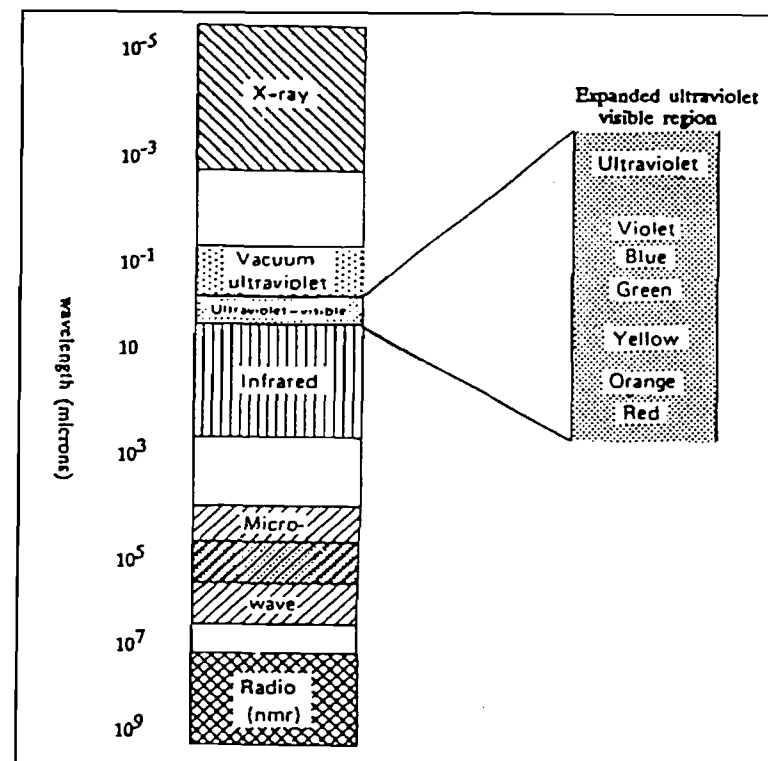
EARLIER MODELS OF THE INTOXILYZER

Intoxilyzer 4011	3.39 microns
Intoxilyzer 4011A	3.42 microns
Intoxilyzer 4011A-27	3.42 microns
Intoxilyzer 4011 AS-A (Texas)	3.39 - 3.48 microns (Interferant detection)

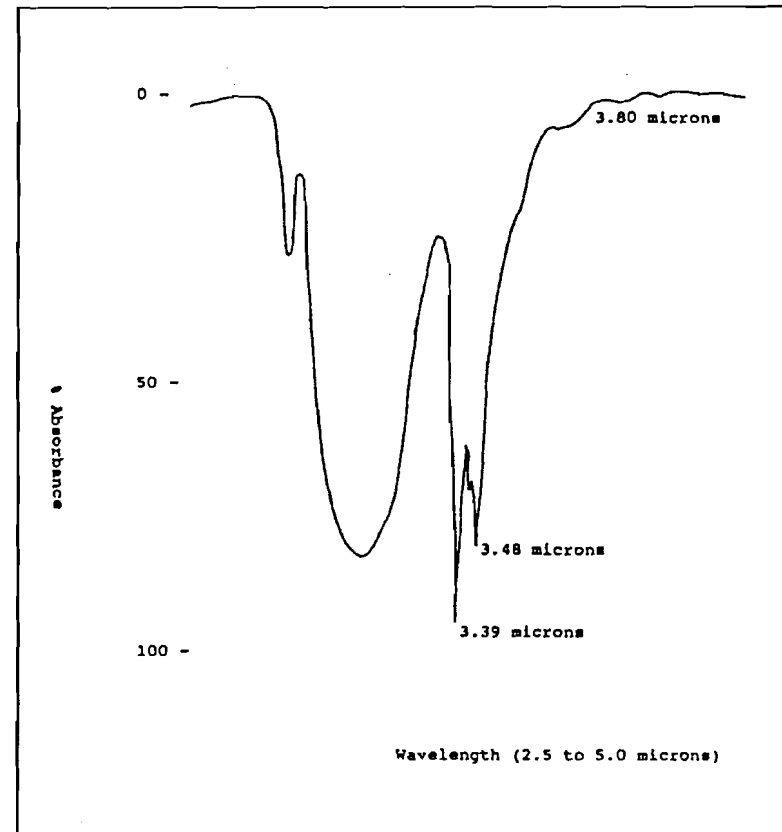
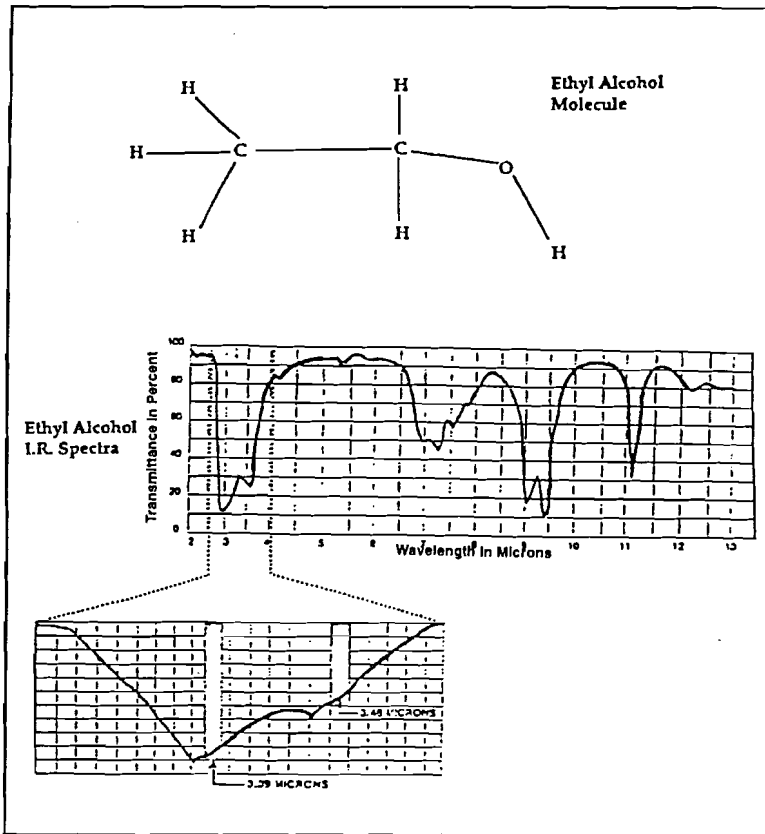
- All these models were manual, not totally automatic.
 All had mirrors in the sample chamber to reflect the IR light back and forth to increase the pathlength (2.7 m).
 No keyboard to enter data.



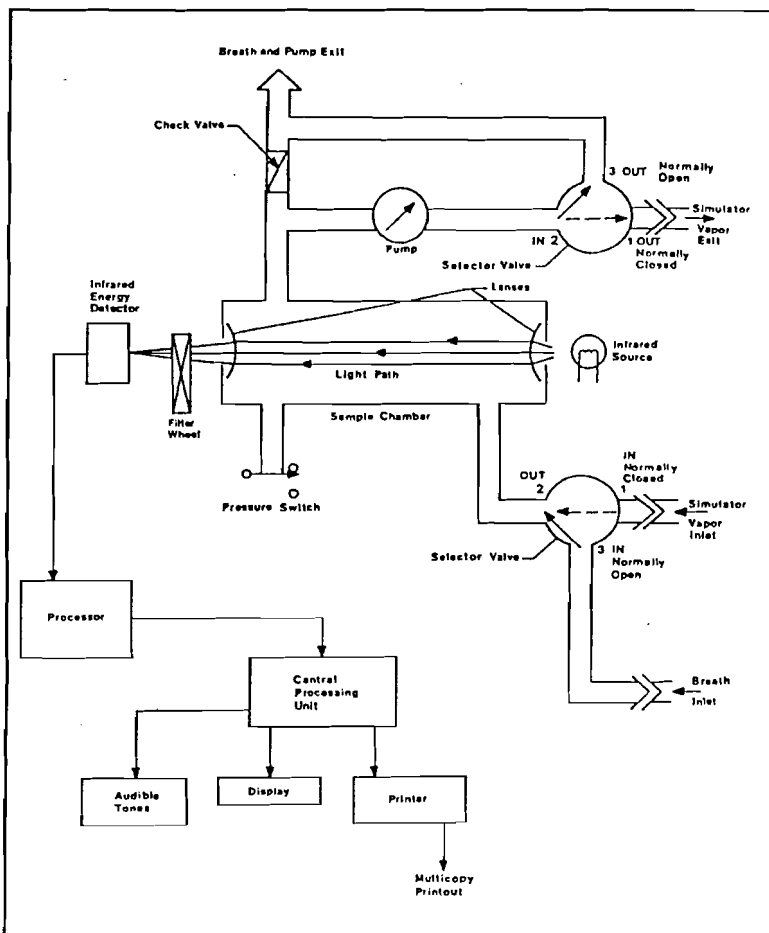
Intoxilyzer 4011AS-A



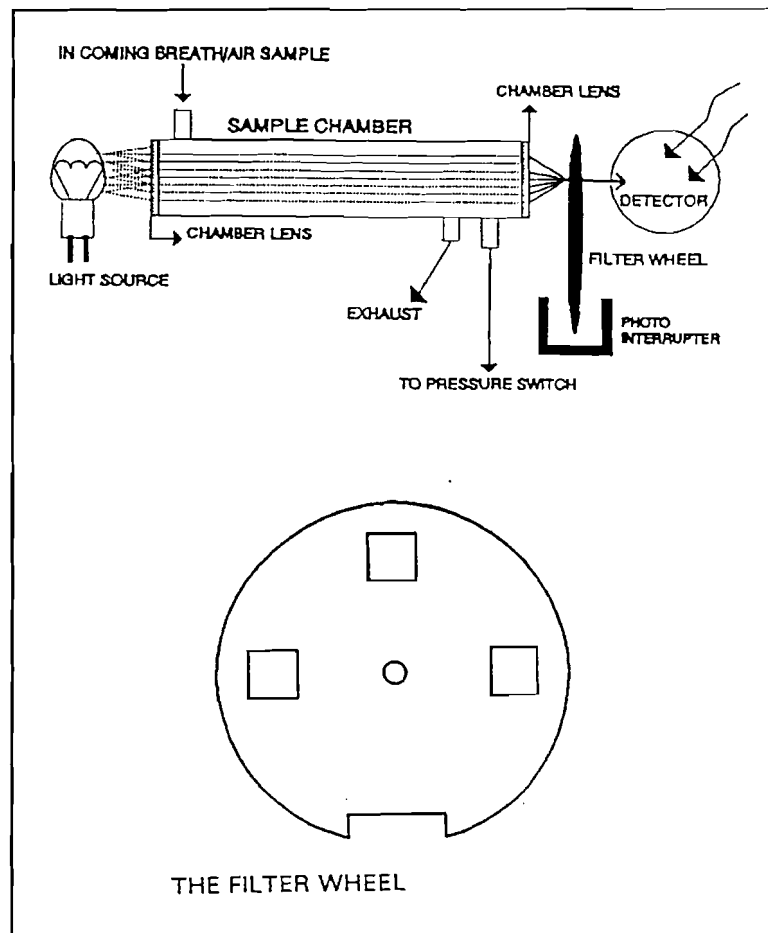
The Electromagnetic Spectrum



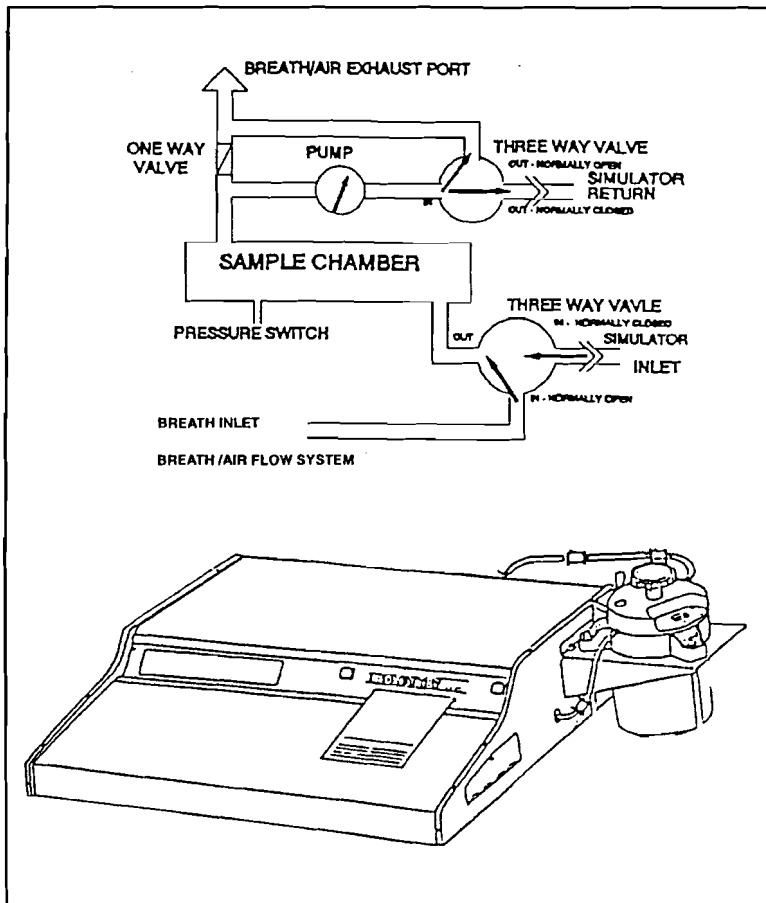
The Infrared Absorption Pattern for Ethyl Alcohol



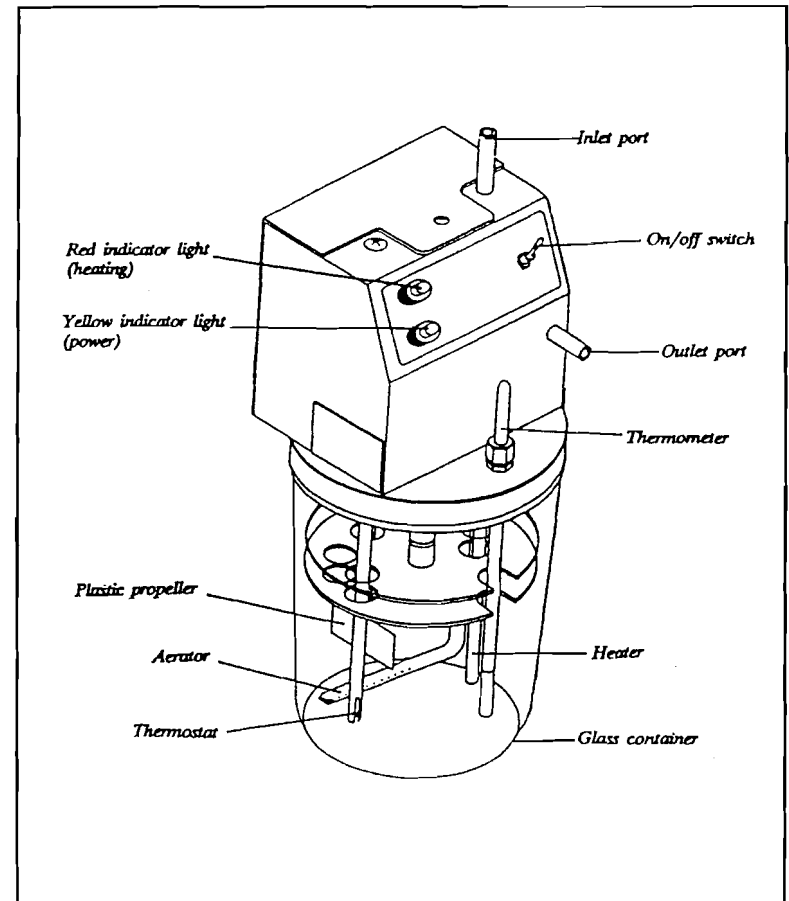
FUNCTIONAL DIAGRAM — Intoxilyzer 5000 instrument equipped with Vapor Circulation option



The Optical System



Simulator connected in recirculation mode with the Intoxilyzer 5000C



Guth Laboratories Model 34C Simulator

Accuracy and Precision of Representative Breath-Alcohol Analyzers: In Vitro (Simulator) Tests*						
Device	No. of Replicate Tests	Vapor-Alcohol Concentration (g/210 L)				
		Target Value	Result Mean	S.D.	C.V.	Span
Breathalyzer®, Model 900A	20	0.100	0.099	±0.0015	1.5%	0.098-0.103
GC-Intoximeter, Mark IV	36	0.100	0.099	±0.0013	1.3%	0.097-0.102
BAC DataMaster	25	0.100	0.097	±0.0015	1.5%	0.096-0.101
Intoxilyzer 5000-D	45	0.100	0.100	±0.0012	1.2%	0.098-0.102

*Author's experimental data

Dubowski, 1991

Technology of Breath-Alcohol Analysis

Harding et al., 1990 Wisconsin Study

395 paired breath-blood samples obtained from arrested drivers in which the samples were collected within 1 hour of each other.

Breath was usually collected before the blood.

67% Intoxilyzer 5000 results were more than 10 mg/100ml below the BAC.

31% both results were within 10 mg/100ml of each other.

Only 2% of results was Intoxilyzer 5000 more than 10 mg/100ml higher.

Table 1 — Instances in which the Intoxilyzer 5000 breath-alcohol result exceeded the blood-alcohol result by more than 0.01.

Intoxilyzer 5000, g/210 L	Blood-Alcohol, g/dL	Difference	Elapsed Time,* min
0.28	0.262	0.018	58
0.15	0.129	0.021	53
0.31	0.298	0.012	31
0.21	0.198	0.012	41
0.19	0.169	0.021	50
0.16	0.149	0.011	58
0.15	0.133	0.017	48
0.10	0.082	0.018	34

*Elapsed time between breath and blood sampling.

"No evidence was found of falsely elevated BrAC results that could be attributed to unusually low individual blood- to breath-alcohol ratios, endogenous or exogenous interfering compounds in the breath, residual mouth alcohol, or electromagnetic interference. Overestimation of BAC by the Intoxilyzer 5000 was infrequent and of small magnitude. Indeed, most of the differences shown in Table 1 could be eliminated if the amount of alcohol theoretically eliminated in the time elapsed between the breath and blood specimen collection were added to the BAC."

Occupational Exposure to Solvents

Two subjects worked in an auto bodyshop.

Tested on four occasions while painting cars.

Worked in a 30 x 25 foot room that was ventilated by two fans.

Sprayed about five gallons of solvent based paint.

Solvents were acetate, xylene, toluene, propylene glycol, n butyl alcohol, ethyl alcohol, isobutyl alcohol, and diacetone.

Within 10 minutes after the end of exposure, all subjects tested 0.00 on an Intoxilyzer 5000.

"When one considers the quick dissipation of solvents from the

Operation of the Intoxilyzer 5000C

When the instrument is first activated by the power (on/off) switch, it emits an audible tone, the pump is activated to fill the tubing and sample chamber with room air, the start test switch is deactivated and the screen message "NOT READY" appears.

The Intoxilyzer 5000C requires 10-15 minutes to heat the instrument to operating temperature of 45°C and to stabilize the electronics. The instrument then conducts a series of internal or diagnostic checks, and the instrument displays the following messages sequentially:

PROM CHECK ####
 RAM CHECK ####
 TEMP CHECK
 PROCESSOR CHECK
 PRINTER CHECK

After each check the instrument emits a tone indicating that check has been successfully conducted. At the end of the checks the Intoxilyzer 5000C displays "DIAGNOSTIC OK". If there is a problem the instrument will emit a high-low tone for 5 seconds and display an ERROR message.

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. The flashing message "PUSH BUTTON" is repeated; the flashing indicates that the instrument is waiting for the technician to push the button. The date and time are displayed and should be checked for accuracy by the technician. If the date or the time requires to be changed, then the technician can enter the new date and time by the keyboard.

The entire message is repeated until the technician initiates the test sequence by pushing the START switch. The instrument then displays the flashing signal "INSERT CARD". The technician is required to insert the test record card properly. The card should be centered in the printer and the flat surface of the card should be inserted at a 90° angle to the printer and not the front panel of the instrument.

After the test record card is properly inserted into the instrument,

in the Intoxilyzer 5000C with a keyboard, a series of questions will appear on the screen regarding the subject's name, driver's license number, date of birth and the technician's name, etc. This information is entered using the keyboard; the instrument then asks if the technician wants to review the data entered. The message "REVIEW DATA? Y/N" appears. The technician should always respond the first time by typing Y (yes). The data that was entered is then displayed on the screen, allowing the technician to correct any entry errors. The instrument again asks if the technician wants to review the data. If the technician is satisfied that the information entered is correct, then "N" should be typed in response.

The Intoxilyzer 5000C then conducts an air blank, by activating the pump and the three way valves. The pump creates a vacuum which draws in room air through the heated external breath tube, through the internal breath tube and sample chamber and out the exhaust port. While the blank is being conducted, the instrument is constantly analysing the room air and showing the results on the screen. If a variable concentration of potential interfering compound is detected then the high-low tone sounds and the message "AMBIENT FAILED" appears.

After the air blank is conducted, the message >>>>>>>>>> appears as the instrument conducts 10 system checks and 3 internal standards. If any problem is detected by the instrument then a high-low tone sounds and an ERROR message will appear on the screen.

Next the instrument conducts an Alcohol Standard test. The pump and the three way valves are activated and air is drawn through the alcohol simulator into the sample chamber and recycled back into the simulator. The message "CAL CHECK .000" is displayed, which means "Calibration Check". The 3 digits that appear after the CAL CHECK are the result of the standard test. This result increases as the sample chamber becomes filled with the alcohol vapor and an equilibrium is established.

The instrument then conducts another BLANK TEST to clear the sample chamber and tubing of alcohol containing air. As the blank is being conducted, the result of the Alcohol Standard test will decrease from approximately .100 to .080 to .040 etc. until a .000 appears. This indicates that the sample chamber and the tubing is being cleared of vapour from the standard test. The instrument again conducts the system checks and establishes a zero reference point, and the message >>>>>>>>>> appears. If all system checks and internal standards 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 a tone is activated, which continues as long as the subject continues to blow with sufficient pressure. If the subject stops blowing before the minimally accepted sample is collected, the tone will stop and the message "PLEASE BLOW" is displayed on the screen. The instrument emits an intermittent tone. If the subject fails to provide the sample after 2-3 minutes, a high-low tone sounds and the message "DEFICIENT SAMPLE" appears on the screen. If the subject refuses to provide a sample the operator types "R" on the keyboard (R means "Refused") and the message "REFUSED" is displayed on the screen and a high-low tone is sounded.

After the subject provides an acceptable breath sample, the screen goes blank for about a second and the message "SUBJECT TEST ###" appears. This is the test result of the analysis of the sample that is present in the chamber, which is the last part of a forced exhalation (alveolar air). Next an air blank is conducted, and the result of the subject test will decrease lower and lower as the subject's breath is vented out the instrument and replaced with room air. The instrument then prints the results of the subject test, the blank tests and the alcohol standard test, the location and serial number of the instrument, the date and time, the subject's name and other information that was entered by the technician. The instrument then displays "TEST COMPLETED". The entire sequence can be completed in approximately 3 minutes.

After at least 15 minutes, the entire sequence is repeated.

Breath Sampling System

The total volume of breath a subject can exhale after a maximum inhalation is known as Forced Vital Capacity (FVC). The FVC varies according to the subject's age, height and sex. In general males have a greater FVC than females. The FVC also increases with height and is related to age. The greatest FVC occurs in subjects 20-40 years of age, which decreases in subjects 65 years of age and older.

The extremes of FVC vary from 1.68 L for a 65-year-old female, 132 cm in height, to 7.85 L for a 25-year-old male of 216 cm in height. The breath sampling system of the Intoxilyzer 5000C has a unique system that allows for this biological variability, such that depending on the FVC of the subject, the amount of time required for a minimally

acceptable sample can vary from 5 to 15 seconds.

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 lungs. For a subject with a small lung capacity, only 5 seconds may be required to obtain a sample that is acceptable by the instrument. For someone with a large lung capacity, it may require 15 seconds to obtain a sample acceptable to the instrument.

If alcohol is present in the subject, the BrAC will begin to rise rapidly as the breath exhaled approaches the alveolar region, the BrAC as it is exhaled reaches a plateau. Once the BrAC plateau is reached, then the alveolar or deep lung air is obtained. The amount of breath that must be exhaled to reach this plateau depends on the FVC of the subject. The greater the FVC, the greater volume of breath will have to be exhaled. The Intoxilyzer 5000C automatically evaluates three separate but interrelated criteria before accepting a breath sample. The three criteria are:

-
1. PRESSURE The subject must blow with approximately 15 cm of water pressure to activate the tone.
 2. TIME The subject must blow for approximately 5 seconds.
 3. SLOPE The subject's BrAC must level off or plateau.
-

Initially, the subject must first provide enough pressure to activate the 15 cm pressure switch, the timer is then activated for approximately 5 seconds, and after that the slope of the expired BrAC curve is determined. As soon as the slope criteria are reached, the instrument determines that the sample is adequate. A "0" will appear in front of the subject's result to indicate to the technician that the minimally adequate sample is obtained. The technician should allow the subject to blow at least an additional 2 seconds to ensure a more than minimally adequate sample. The technician should not tell the subject to stop blowing, but should allow the subject to blow as long as possible. The longer the subject blows, the more accurate the result.

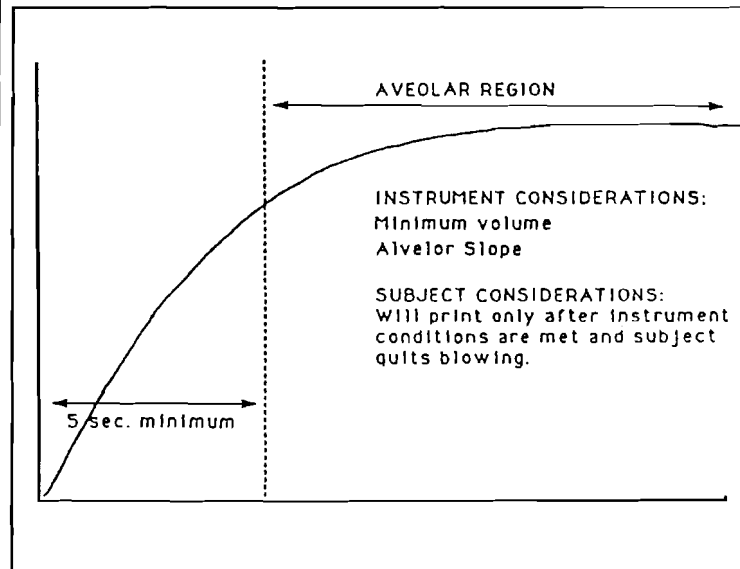
During the sample delivery, the instrument is conducting a series of IR analyses on the incoming breath sample. The instrument determines the alcohol concentration of the sample every 0.6 seconds and compares it with the concentration 0.6 seconds earlier; this

BREATH SAMPLING CRITERIA

The Intoxilyzer automatically evaluates three separate but interrelated criteria before accepting a breath sample.

1. **PRESSURE:** The subject must blow hard enough to get a steady tone.
2. **TIME:** The subject must blow for at least 5 seconds.
3. **SLOPE:** The subject's alcohol concentration must level off.

BREATH TEST RESULTS AS SEEN BY INTOXILYZER



If the instrument criteria of pressure, time, and slope have been met, and the subject stops blowing; the Intoxilyzer will accept the sample, display the alcohol concentration and then print out the entire test sequence with alcohol concentration results.

This unique combination of sample validation and operational flexibility assures optimum field accuracy.

determines the slope. A common type of slope detector criteria is a +2, -1. This means that as soon as the increase in BrAC every 0.6 seconds is less than a +2 increase or -1 decrease, a minimally adequate sample is accepted.

For example, if a subject, after providing 15 cm of water pressure for 5 seconds, has a result shown every 0.6 seconds of .102 .106 .110 .114, the instrument will not accept the sample as the increase in BrAC is greater than .002.

If, however, the subject, after meeting the pressure and time requirements, shows a result every 0.6 seconds of .140 .144 .145 .146, this sample will be accepted as the slope or the increase in BrAC is less than .002.

Mouth Alcohol Determination by Slope Detection

The slope detector is also used as a mouth alcohol detector. This is especially important in those jurisdictions in which only one breath test is provided. In Ontario, the mouth alcohol detector is just another safeguard to add to the 15-minute waiting period and the duplicate of two breath samples at least 15 minutes apart.

In contrast to the normal BrAC exhalation, the increase in BrAC in someone who has recently consumed alcohol will rise at a much steeper slope, and then drop quickly as the residual mouth alcohol is removed from the sample. In this case, there would be a drop of greater than .001 and the mouth alcohol detector would be activated (as below).

For example, if someone consumes alcohol just prior to providing a breath sample, the slope of the alcohol concentrations every 0.6 seconds may be: .110 .130 .150 .165 .170 .165 .160. The decrease of BrAC of .005 would activate the mouth alcohol detector and the sample would be recorded as "INVALID SAMPLE". This message would flash across the display and a high-low tone would sound. When this occurs, test the subject again after at least 15 minutes. The residual mouth alcohol should be removed during this period and a proper sample would be collected. A third test, at least 15 minutes later, must be conducted.

Interferant Detector

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 to the same extent as ethyl alcohol at both wavelengths. For example, the most common potential interfering compound in the breath is acetone. Elevated acetone concentrations are present in the breath of diabetics who are not under proper medication, subjects who are fasting, and subjects who are on a high protein, low carbohydrate diet. Interestingly, the acetone

concentration drops dramatically after the consumption of alcohol, making the incidence of high acetone concentrations in the breath of drinking drivers very remote.

IR at 3.39 microns is substantially absorbed by acetone, but not IR at 3.48 microns. The instrument determines a constant difference between the electrical signal generated by the detector at these two wavelengths; this difference is maintained only if ethyl alcohol is present.

Table 1 illustrates how this is accomplished. For a sample of room air the electrical signal generated at 3.48 microns can be described as 6 units and for 3.39 microns as 4 units. The difference is 2 units. This difference will be maintained if only ethyl alcohol is present. 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 5 units, then the 3.39 microns signal must decrease to 3 units, maintaining the 2 unit difference. If ethyl alcohol and acetone are present, the 3.48 microns signal may decrease to 4.5 units. The electrical signal at 3.39 microns will decrease even more, as this wavelength is strongly absorbed by acetone. The difference is now 3.5 units, not 2 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". The Intoxilyzer 5000C not only detects acetone but also automatically adjusts for its effect so that the alcohol results are accurate. Although other potentially interfering compounds, e.g., toluene, can be detected, the instrument cannot adjust the result accurately.

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

	3.48 microns	3.39 microns	difference
Initial (room air)	6	4	2
Ethyl alcohol only	5	3	2
Ethyl alcohol and acetone	4.5	1	3.5*

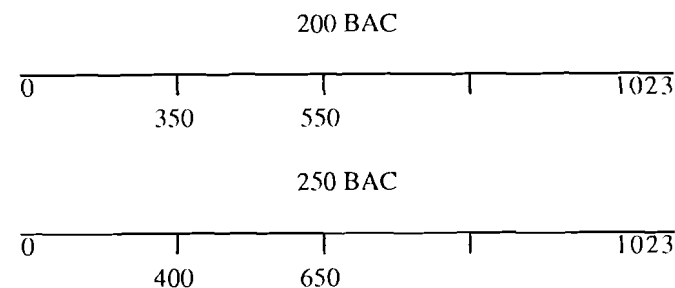
Differential Voltage Monitoring (DVM)

The DVM is the combined output of the signals generated by all three wavelengths of IR energy. The DVM determines the stability of all three signals. During the >>>>>>>>> part of the breath test procedure, the DVM is checked to see that it is within the parameters of .000 to .600 and if there is any positive or negative drift. If the DVM is not within these parameters, then the instrument will sound a high-low tone indicating the error, and an ERROR message will appear, either PROCESSOR ERROR 3, 4, or 5. The instrument will then display the DVM value. By monitoring the displayed DVM value, the technician can determine what is wrong and how to correct the ERROR.

The DVM can be thought of as the scale of the instrument. Rather than a visual scale graduated from 0.0 to 0.40 as is for the Breathalyzer, the DVM scale is electronic, each 0.001 unit on the DVM scale being equivalent to approximately 0.001g/100ml of alcohol. For simplicity the DVM scale will be referred to as a whole number. The scale of the DVM is between 0 and 1023, which is 2^{10} , the binary equivalent of this number. The DVM is normally set at 350. If this was the DVM at the start of the breath test, and the BAC was 200 mg/100ml, the DVM would increase to 550, as each unit of DVM is equivalent to 1 mg/100ml BAC.

If the DVM was at 400 at the start of the breath test and the BAC was 250, the DVM would be 650; again BAC is added to the DVM to result in the final DVM. The actual number of the DVM is not important as long as the DVM is constant before each test. The instrument is looking at the change in DVM for a breath test, not the actual number.

As dust and dirt enter the sample chamber, the DVM increases, since some of the IR light is absorbed by the dust. Again the actual



DVM value is not important; it is the change in DVM after the breath test. Therefore dust and dirt in the sample chamber will not affect the accuracy of the analysis but will affect the workload of the instrument. The highest value the DVM can be is 1023. Therefore, if the DVM started at 900, any BAC greater than 123mg/100ml would exceed the limit. To ensure that there is adequate workload, an ERROR message (PROCESSOR ERROR 5) occurs if the DVM exceeds 600. This allows a workload of at least 423mg/100ml. New instruments and instruments that have been recently maintained or repaired should have a DVM of about 350; this allows a workload of 673mg/100ml.

If a PROCESSOR ERROR 5 occurs and the displayed DVM result is *23, this means the IR source is burned out. The instrument uses the symbol * for the unit 10.

Obtaining Acceptable Breath Samples

Due to the pressure, time and slope requirements, more coaching of the subject is required to obtain an acceptable breath sample for the Intoxilyzer than for the Breathalyzer. If the subject has a high BAC, more time may be required to obtain the BrAC plateau as indicated by the Slope Detector. If the subject blows too hard, he or she may have difficulty reaching the BrAC plateau. A moderate pressure is all that is required.

Remember, the Intoxilyzer cannot be conned or fooled into accepting a poor sample. If the subject starts blowing out the side of the mouth, or places the tongue over the mouthpiece or tries to suck back, the Intoxilyzer will not accept the sample.

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