Breath alcohol analysis and the lion intoxilyzer® 6000: alcohol plateau monitoring in 'normal' subjects, people of large and small stature, and patients with pulmonary disease

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INTRODUCTION

At midnight on 5 May 1983 evidential breath alcohol analysis was born in the United Kingdom as the chief method of dealing with drink-drive suspects. This procedure requires the subject to blow with some minimum exertion into the instrument, twice within about three minutes, in order to provide the two specimens of breath which are required under the British legislation. Until that date in 1983, all British drink-drive prosecutions had followed the analysis of blood or, in some cases, urine specimens, the provision of which, following his or her required verbal consent, requires, respectively, either no or very little positive action by the driver concerned.

All evidential breath alcohol instruments used by the Police in the United Kingdom are Approved devices, of which the sampling system specifications in terms of minimum acceptable breath discard volume and minimum acceptable breath flow rate are some of its essential features.

THE OFFENCE OF 'FAILURE [OR REFUSAL] TO PROVIDE' SPECIMENS OF BREATH FOR ANALYSIS

It is an offence in the United Kingdom for a drink-drive suspect who is lawfully required to supply a specimen of breath, blood or urine to fail to supply that specimen unless he has, what is stated in the legislation to be, a 'reasonable excuse'. This was defined by the High Court in London:
"... no excuse can be adjudged a reasonable one unless the person from whom the specimen is required is physically or mentally unable to provide it or the provision of the specimen would..."
Lord Justice Lawton, in Regina -v- Leonard [1973] RTR 252
This definition is now followed by the Courts in the United Kingdom when dealing with such cases, the procedure being for the Defendant to raise the issue of reasonable excuse to a reasonable standard, and for the Prosecutor then to negative the defence, if he can, beyond all reasonable doubt. However, before the defence can be raised at all it is required that the defendant, firstly, satisfies the Court that he had tried his best to supply the required specimens, and secondly, that he had made the Police officer concerned fully aware of any condition from which he was suffering which could affect his ability to supply the required breath specimens.

This means that, in law, a 'reasonable excuse' cannot excuse a wilful avoidance of providing the specimens; nor can it excuse a person from providing any specimen at all [such as blood or urine, as an alternative to breath]. So the driver must show, firstly, that he had properly tried to blow the breath specimens [many Defence cases in fact fail at this point] and, secondly, that he had a condition at the time of the test which restricted his breathing to such an extent that it was brought to below the minimum breath acceptance requirements of the instrument.

MEASUREMENT OF RESPIRATORY CAPABILITY

In assessing a person's respiratory capabilities, three measurement criteria are commonly used:

**Forced Vital Capacity - [FVC]:**
the total volume of air exhaled after a deep inspiration. In effect, it is a measurement of the total volume of the lungs;

**Forced Expiratory Volume in One Second - [FEV1]:**
the volume of breath which flows in the first second of an expiration against little resistance, after a deep inspiration. This is a measurement of the elasticity of the lungs; and

**Peak Expiratory Flow Rate - [PEFR]:**
the maximum breath flow rate achieved in a forced expiration against little resistance, after a deep inspiration. It is also an index of lung elasticity.

Each criterion is dependant on a person's sex, age and height and published tables are available [Cotes, 1985] from which to estimate the likely capabilities of various persons in 'normal' health.
THE FIRST APPROVED UK EVIDENTIAL INSTRUMENT - THE LION INTOXIMETER® 3000

Most British Police Forces currently [as at March 1997] use the Lion Intoximeter® 3000 evidential breath alcohol analytical instrument. This was Approved in 1983 and is still in use in respect of the some 2,000 drink-drive convictions which take place in England and Wales every week. The device uses a very simple breath sampling system, in which the subject's breath passes over a heated thermistor, the electrical current change through which is then integrated against time and taken as a measurement of expired volume. Each instrument is required to be set up so that breath blown at the minimum acceptable flow rate of 10 litres per minute [l/min] will be accepted if that specimen is at least 1.5 litres in volume.

However, because the thermistor-controlled sensing system does not provide a linear output of volume measurement at increasing breath flow, the greater the flow rate then the more air that must be expelled for the analysis to proceed. This feature of the instrument has not always been properly understood and has caused some workers [Morris and Taylor, 1987] to come to conclusions which were not fully in agreement with reality. The situation was later and properly explained [Gomm et al 1991 and 1993] in studies which showed that patients whose FVC's were above 2.6 litres, FEV1's above 2.0 litres, and whose PEFR's were above 330l/min were generally able to use the instrument - except for those suffering from obstructive airways disease.

In assessing ability or inability properly to blow into the Lion Intoximeter® 3000 it is only necessary, therefore, to determine whether the subject's breath volume and flow were likely to have been above or below these stated values at the time of the evidential test procedure.

THE NEW GENERATION INSTRUMENT - THE LION INTOXILYZER ® 6000

In 1994 the British Authorities issued Guidelines [Home Office and Forensic Science Service, 1994] for an instrument to replace the Lion Intoximeter® 3000. A new requirement, in addition to measuring breath volume, was for the instrument to track the breath alcohol expirogram [1] to determine when a plateau signifying the delivery of deep lung air had been reached.

1 the 'breath alcohol expirogram' is defined as the change in breath alcohol concentration during an expiration, measured against elapsed time, discard volume and breath flow rate.
The lion intoxilyzer® 6000 was submitted for evaluation and successfully completed all the required official technical procedures. For reasons of control and traceability, these evaluations by the Forensic Science Service mainly involved laboratory testing using breath simulator devices, set to generate standard but simulated alcohol expirograms, rather than the use of human subjects.

A research program at Lion was therefore commenced to investigate whether people of various ages, statures, sex and health would be able to meet the minimum breath sampling requirements of this new instrument. We were concerned to ensure that persons would be able to satisfy the minimum volume requirement [which is only 1.2 litres] and then, and perhaps most significantly, to generate alcohol expirograms which would satisfy the slope acceptance algorithms in the instrument's firmware. We were also concerned to establish below what levels of FVC, FEV1 and PEFR a subject would be unable to supply breath for analysis, or whether such a situation was more dependent on the shape of their breath alcohol expirogram.

It is to be noted that the breath flow sensor in the lion intoxilyzer® 6000, as opposed to that in its predecessor, is linear in response, so the required discard volume is not flow rate dependent.

IN VIVO STUDIES ON THE LION INTOXILYZER® 6000

Human volunteer subjects who were unfamiliar with the lion intoxilyzer® 6000 were selected and assigned to one of the following groups:

'Normal' - a cross-section of ages, and both sexes [n = 40];

'Large and fit' - male and female rowers [n = 26] in fit condition;

'Small stature' - persons whose height was less then 1.65 metres for males [n = 5], or 1.52 metres for females [n = 6]; and

'Impaired lung function' - hospital outpatients [n = 20], each suffering from one of the following lung conditions - Chronic Asthma, Chronic Obstructive Pulmonary Disease or Pulmonary Fibrosis.

Each subject completed a questionnaire about themselves. They were then weighed and their heights were measured, following which they blew into an apparatus to take measurements of their FVC, FEV1 and PEFR. Each subject was tested for alcohol before the tests commenced, to ensure a zero commencement breath alcohol level.

A lion intoxilyzer® 6000 was set up to the UK technical requirement and fitted with special additional firmware to allow the expirogram to be monitored and recorded using an external PC.
STUDY ON DISCARD VOLUME ONLY

Before consuming any alcohol, each subject blew twice into the instrument to ensure they could satisfy the 1.2 litres minimum requirement on each occasion, within the allowed 3 minute period.

Results:
All subjects could twice satisfy the 6000’s sampling requirements, except two from the outpatient group. These were a 50 year old female [FVC = 0.78 litres; FEV1 = 0.61 litres; and PEFR = 148 l/min] and a 64 year old male [FVC = 1.34 litres; FEV1 = 0.72 litres; and PEFR = 177 l/min].

The subject with the poorest respiratory capability who was nevertheless able to complete the provision of the two required specimens, both with and without alcohol in his breath, was a 72 year old man [FVC = 1.72 litres; FEV1 = 0.51 litres; and PEFR = 84 l/min].

STUDY ON DISCARD VOLUME AND ALCOHOL PLATEAU:

Each subject was then given alcohol in sufficient quantity to raise their deep lung breath alcohol concentration to at least the 35μg/100ml BrAC limit for driving in the UK. Having allowed at least 20 minutes for the dissipation of residual mouth alcohol, two further breath specimens were again requested and their complete breath alcohol expirograms were monitored by PC.

Results:
All subjects could provide specimens, with the exception of the same two patients as in Part A.

There was no systematic difference in the breath alcohol expirograms between the four groups.

CONCLUSIONS

The ability of our subjects to supply breath for analysis was not influenced by whether or not they had alcohol in their breath, despite the plateau monitoring system in this instrument. This suggests that pulmonary alcohol diffusion is not materially altered by such factors as respiratory disease or extremes of physical fitness. The ability of subjects to provide acceptable specimens of breath for analysis is more concerned with a combination of lung volume [FVC] and an ability to generate and sustain a minimum breath flow rate, as indexed by FEV1.

All but the obviously sick, who were plainly aware of their respiratory impairment, could provide the two required specimens. Further work is continuing to determine a precise cut-off
point of these lung function criteria, below which subjects would be unable to undertake this analysis.

From these initial studies we conclude that the lion intoxilyzer® 6000 should be capable of being used by most persons likely to be required to provide breath for analysis. The only exception would be people suffering from some genuine and quite serious respiratory disability; as well, of course, as those people who deliberately avoid providing specimens, in an attempt to hinder collection of evidence relating to their state of alcohol intoxication.

REFERENCES


