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. Sampling and analysis were passed into the hands of the Police, who had been trained in the operational use of the then recently Approved evidential instruments - the 'Lion Intoximeter® 3000' and the 'Camic Breath Analyser'. Each of these is a 3 micron infrared-based system, with no mouth alcohol detection software, but to guard against acetone interference the 3000 is fitted with a secondary semiconductor device.

The prescribed breath alcohol limit was set at 35 micrograms of alcohol per 100 millilitres [35µg/100ml] - equivalent to 0.35mg/l BrAC, or 0.08% BAC. However, as a safeguard, instructions were issued to the Police that drivers should not be prosecuted unless their breath contained at least 40µg/100ml of alcohol, with an additional blood/urine option being available to those drivers whose lower breath alcohol reading was not more than 50µg/100ml. British law requires the subject to provide TWO separate specimens of breath for analysis, and it is the lower of the two readings so produced that is used as the basis of the procedure, and evidence in Court.

And so, in 1983, the stage was set for the British legal fraternity to embark on a crusade against the new system: trying to gain acquittals for their clients on very often quite spurious grounds, even when the defendant had unarguably been driving with a dangerously high level of alcohol. One of the main areas of challenge was in respect of 'differences between paired breath readings', which, claimed certain defence experts, was clear evidence of an instrument error, even though the device had accurately checked its calibration using a known alcohol vapour [from a 'wet-bath' simulator] both before and after the analysis of each subject's pair of breath specimens.
BREATH ALCOHOL DIFFERENCES AND THE LION INTOXIMETER® 3000

The original reason for requiring the subject to provide two breath specimens was to use any large decrease from the first to second as an indication of mouth alcohol. But no official tolerance was ever established and each expert had his or her own view. This was partly resolved by Sir William Paton in his report [Cobb and Dabbs, 1985], who recommended a maximum difference of 20% [as a percentage of the lower figure], but this was never enshrined in any regulation or power.

Differences of over 30% were observed, which resulted in much Court debate, and, in some cases, a lingering doubt as to the reliability of the instrument involved. Some of the observed differences were interpreted in interesting ways, but with wrongful conclusions [Dossett, 1984].

By analysing data from a great many cases it became clear that the reasons for breath differences when the Lion Intoximeter® 3000 was used were attributable to two principal types of factor - these became known as instrument induced factors and subject induced factors:

Instrument induced factors - were broadly found to be:
- acetone sensor misfiring - resulting in a false reduction of one [or both] breath alcohol readings;
- sampling system setting error - which allows the subject to supply breath of top lung air only; and
- analogue/digital conversion error - resulting in an under-reading of the breath alcohol concentration.

Subject induced factors - were broadly found to be:
- difference in expired volume - so one breath specimen is composed of more deep lung air than the other;
- hyperventilation prior to blowing - resulting in a lowering of the alcohol content in that specimen; mouth alcohol - from a recent drink or use of a mouth spray deodoriser, or after regurgitation or vomiting;
- mouth irrigation - following a drink of cold water;
- a deliberate variation in blowing technique - such as 'puffing', rather than blowing continuously; and
- rapidly dissipated interfering substances present in breath - especially those derived from solvent abuse.
LION INTOXIMETER® 3000: FEATURES WHICH INCREASE THE POSSIBILITY OF BREATH DIFFERENCES

This instrument was designed in the late 1970's and first described in 1980 [Forrester, 1980]. Some of its features which have undoubtedly increased the potential for breath differences are:

**Breath sampling system**

the instrument uses a flow sensor only, with no software to monitor the breath alcohol expirogram \(^1\) during expiration. There is a minimum discard volume requirement of 1.5 litres, but no maximum: this means that two successive breath specimens can be supplied from quite different depths of the lungs, with a resulting difference in their alcohol concentrations. The sampling system also allows a quasi-continuous [rapidly puffed] specimen to be accepted, so that its alcohol level will be lower than if it had been supplied properly.

**Secondary semiconductor sensor for acetone discrimination**

this falsely reduces the alcohol reading on some breath specimens, so causing a difference if the other specimen in the pair is not similarly affected [Cobb and Dabbs, 1985].

**Mouth alcohol**

is not detected as there is no expirogram monitoring software.

**Non-specificity**

so some solvent vapours may be read wrongly as alcohol.

**SPECIFICATION AND DESIGN OF THE REPLACEMENT INSTRUMENT: THE 'LION INTOXILYZER® 6000'**

In October 1994 the British Authorities issued Guidelines for an instrument to replace the Lion Intoximeter® 3000 [Home Office and Forensic Science Service UK, 1994]. A new requirement is for the breath analysis to be aborted if the difference between the two readings is more than 15% [based on the lower reading], or by more than 5|g/100ml, whichever is the greater.

The lion intoxilyzer® 6000 was submitted for evaluation and successfully completed all the required technical procedures. These evaluations by the Forensic Science Service involved testing using precisely controlled simulator devices only [in vitro], with few tests carried out on subjects.

\(^1\) 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.
A research program was therefore commenced at Lion to investigate what magnitude of breath differences subjects could achieve in practice - in vivo. We were particularly interested to investigate whether the following aspects of the design of the new 6000, by comparison to the 3000 which it will soon replace, would minimise the possibility of significant breath differences:

Breath sampling system
in the lion intoxilyzer® 6000 the subject must provide a minimum volume of 1.2 litres, followed by software monitoring of the expirogram to detect deep lung air. The flow sensor requires breath to be blown in a fully continuous way, with even the shortest break causing the analysis to abort. This should reduce most of those subject-induced factors which are capable of causing significant breath differences in the Lion Intoximeter® 3000. In vivo subject tests were carried out on this aspect, as described in Section 5 of this paper.

Misfiring of the secondary sensor
there is no secondary sensor in the 6000, so no possibility exists for breath differences caused by misfiring of such a device.

Residual mouth alcohol
the 6000's expirogram monitoring software will detect breath specimens which are polluted by residual alcohol in the mouth or upper respiratory tract, and provide an appropriate warning to the operator, who would then be unable to use those breath readings for Court purposes.

Specificity
if a non-alcoholic substance is present in the breath at such a level that it affects the ethanol analysis outside defined tolerances then the readings obtained cannot be used and the operator is informed accordingly. This means that rapidly eluted materials, such as hydrocarbons and toluene, as may be present in the breath after solvent abuse, will be detected and cause the breath procedure to be aborted, rather than cause an apparently unexplainable significant breath difference.

IN VIVO STUDIES ON THE LION INTOXILYZER® 6000

We investigated whether subjects could manipulate their expiration technique so as to produce significant breath differences: that is, more than 15% or 5μg/100ml, whichever is the greater.

Volunteer subjects [n = 83, males and females], were given alcoholic beverages of their choice in such proportion as to raise their deep lung breath alcohol concentrations above the UK legal limit of 35μg/100ml. Of the 83 subjects selected, 40 were classified as having 'normal'
respiratory function; 17 as having impaired lung function (asthma or the effects of long term heavy smoking); while 26 were physically fit oarsmen, each with a larger than average lung capacity.

In each case, having allowed at least 20 minutes for the dispersal of mouth alcohol, the subject was instructed to deliver a full breath specimen into a *lion intoxilyzer® 6000* so as to get a true measurement of their deep lung breath alcohol concentration. He or she was then asked to expire again into the device [within one minute of the first specimen], this time in a manner only just sufficient for the instrument to accept, in terms of flow or volume. The results were:

<table>
<thead>
<tr>
<th>Subject Group</th>
<th>Size</th>
<th>Differences Over 5 Units</th>
<th>Differences Over 15%</th>
<th>'Difference' Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Normal'</td>
<td>40</td>
<td>7</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Impaired</td>
<td>17</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Large/Fit</td>
<td>26</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Nine of the 'normal' subjects were then asked to vary their manner of blowing or pre-delivery respiration, as much as they could, in an attempt to reduce the alcohol level and hence the reading on their second specimen. In most cases these 'cheated' specimens were rejected by the instrument, but of those that were not - following prolonged and deliberate hyperventilation [which was very obvious to the observer] - only two subjects could produce differences greater than 15% [16.4% and 23.6%]. In the other 7 cases the breath differences that were produced were too small to be classed as 'significant' or to cause the relevant message to be generated.

Hyperventilation cools the mouth and upper respiratory tract, so reducing the breath alcohol concentration on expiration by both condensation and reversed secondary equilibration. Although it has been reported [Schoknecht, 1992; Schoknecht and Stock, 1995] that breath temperature monitoring systems can be used to correct for such an effect, it is the generally held view outside Germany that this approach is flawed on both scientific *and* legal grounds.
CONCLUSION

Careful, overall design of the lion intoxityzer® 6000 instrument's sampling system and controlling software means that significant breath differences caused only by subject-induced factors should now occur. These factors will be attributable only to deliberate variation by the subject of his breathing technique, or to pre-breath delivery activity which, in most cases, will be obvious to the Police Officer in charge of the instrument. It is concluded, therefore, that significant breath differences should be rare in the operational use of this new evidential breath alcohol analyser.

REFERENCES


