THE DEVELOPMENT OF BREATH TESTING PROCEDURES IN NORTHERN IRELAND

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SUMMARY

Since 1968, four types of evidential breath testing instrument have been used operationally in Northern Ireland. The Ethanographe was followed in 1978 by a series of instruments, based on a relatively alcohol specific fuel cell, manufactured by Lion Laboratories, Barry, S. Glamorgan, U.K. These were the Alcolmeter AE-D1S, Auto-Alcolmeter Mk. III and Alcolmeter AE-D3, of which the latter is currently in service. Results from roadside tests have shown that the fuel cell principle is a successful basis for reliable screening devices which give a good indication of blood alcohol concentration (BAC).

INTRODUCTION

Current Road Traffic legislation in Northern Ireland, enacted in 1968, differs from that in the rest of the United Kingdom in that it incorporates offences at two levels of alcohol impairment:

(a) The "Major Offence" in which the subject is deemed to be incapable of having proper control of a motor vehicle if the BAC is in excess of 125 mg/100 ml.

(b) The "Minor Offence" in which a motorist may not drive, attempt to drive, or be in charge of a motor vehicle if the BAC exceeds 80 mg/100 ml.

The minor offence is enforced by the use of evidential breath testing equipment operated by specially trained "Authorised Constables" who have been instructed in the use of the equipment, in the effects of alcohol on the body and the resulting impairment of driving ability. When the operator suspects that a driver has been drinking and has decided that the "Major Offence" has not been committed, the driver is invited to provide a specimen of breath suitable for a breath test. If the result of the test exceeds the minor limit the driver has the statutory option under the law of accepting the reading for evidential purposes in any future prosecution, otherwise a blood or urine specimen must be provided for laboratory analysis. Experience has shown that the majority of drivers accept the breath test reading. Table 1 shows the statistics for 1988.

EQUIPMENT

During the 20 year period since breath testing was introduced in the province several instruments have been used for evidential testing:

The Ethanographe

In order to avoid the necessity of taking blood or urine samples in connection with the "Minor Offence", it was necessary to select an instrument which would be sufficiently accurate to minimise false positives and give a good indication
of BAC.

In 1968 there were relatively few evidential instruments available; therefore, after a review of the market, the Ethanographe, a photo-electric based instrument similar to the original Breathalyser, manufactured by L. Etzlinger, Geneva, Switzerland, was selected. Eventually 14 instruments were installed in modified vans, known as "Accident Prevention Units", equipped for other road safety functions as well. The breath test result, as for all subsequent instruments, was expressed in terms of blood alcohol concentration (BAC). Instrument calibration was checked with an aqueous simulator at the beginning and at the end of each tour of duty.

The Alcolmeter AE-D1S

During the 1970s new technology provided a wider choice of equipment. From the points of view of specificity and mobility one of the most promising new instruments was the Alcolmeter manufactured by Lion Laboratories. Early examples of the Alcolmeter, which is based on a relatively specific electrochemical fuel cell (1), were evaluated at the Belfast laboratory in the early 1970s.

A prototype evidential instrument known as the AE-D1 was received for evaluation in 1977 and a special version (AE-D1S) with provision for use on a 12 volt supply as well as mains was introduced into service with the police later in the year. The precision of the AE-D1S was, as expected, better than the Ethanographe and calibration with a gas simulator was more reliable. For evidential purposes, the instrument was calibrated to read 12.5% low compared to venous blood alcohol. The standard (NALCO) was prepared by Lion Laboratories on the basis of a blood:breath partition coefficient of 2300 (2). A new feature of the AE-D1S was a digital read-out with a peak hold facility. A total of 32 instruments were in operation by 1980.

Regression statistics for both the Ethanographe and the AE-D1S are given in Table 2.

Radio Frequency Interference

The susceptibility of the Alcolmeter AE-D1S to radio frequency interference (RFI) was demonstrated in the laboratory in 1985 using a 100 watt FM transmitter operating at 27 megahertz. However, with the AE-D1S installed in a test vehicle the worst case reading was at most 5 mg% with the transmitter situated at a distance of 2 metres. As this situation could only be realised in the vehicle under normal operating conditions when its own transmitter was in use, the latter was prohibited when testing was in progress. Occasional Alcolmeter operations in police stations were also discontinued in case station transmitters were used when testing was in progress. This problem was considered in the future evaluation of new equipment.

The Auto-Alcolmeter

Successful operation of the Ethanographe and the Alcolmeter AE-D1S depended on effective operator training. With manual sampling, confidence in the operator is an important factor. As the police required additional testing capacity in 1984 it was decided to evaluate the Lion Auto-Alcolmeter Mk III. As the
instrument was completely enclosed in a metal case, RFI was not a problem.
Although similar in principle to the AE-D1S this instrument was fully automated
and like its predecessor capable of dual voltage operation. The NALCO cylinder
was contained within the instrument and calibration/check calibration steps
were included in the automatic sequence devised by the Laboratory to suit local
legislation. Following modifications to the auto-sampling device several
instruments were eventually introduced into service in 1985 but they soon
proved to be unreliable in a mobile situation due mainly to voltage instability
in the vehicles' electrical systems.

A stable mains supply gave more satisfactory results; however, breath sampling,
though both pressure and time controlled, still did not always operate
reliably. Many subjects experienced difficulty in blowing. As a result of
frequent though minor electronic faults, as indicated by the light sequence on
the instrument, operator confidence was lost and, following unsuccessful
attempts to improve the quality of the power supply, the Auto-Alcolmeter was
withdrawn early in 1986.

The Alcolmeter AE-D3

Although the Auto-Alcolmeter did not realise all the advantages of a fully
automated system, it did demonstrate the benefits to be obtained from removing
the personal factor from evidential breath testing and thus placing quality
assurance within the control of a central authority. Apart from instrument
faults a weakness of the Auto-Alcolmeter was its inability to respond
satisfactorily to varied blowing techniques. Solutions for these problems
appeared to require further refinements, thus when a replacement for the
Alcolmeter AE-D1S was anticipated, a semi-automated version was considered
which would incorporate an operating program similar to that in the Auto-
Alcolmeter but retain manual sampling as in earlier instruments. An instrument
which appeared to meet our requirements was introduced by Lion Laboratories in
1986 and evaluation commenced as soon as possible as the AE-D1S complement was
becoming increasingly expensive to maintain.

Laboratory Evaluation of the Alcolmeter AE-D3

The instrument as received from Lion Laboratories was equipped with a
microprocessor controlled operating sequence based on the manual system of the
AE-D1S. The final modification of this sequence which was developed jointly by
Lion Laboratories and the NI Forensic Laboratory incorporates a calibration
check before and after the blank/subject test and is shown in Fig.1. In
addition to the automatic operating sequence which takes the user through a
predetermined series of events, the principal innovative features of the AE-D3
relative to the AE-D1S are as follows:

(a) The first event is always an automatic calibration to a pre-set value
of 70 mg%; use of an 80mg% gas standard allows a 12.5% reduction for
variation in the subject test result.

(b) Automatic zero is also incorporated thus preventing continuation of
the sequence until this condition is satisfied.

(c) The value of the first calibration check must be within 70 +/- 5 mg%
otherwise the program returns to "calibration".

369
(d) The Alcolmeter AE-D3 operates from an internal rechargeable 12 volt battery which has sufficient capacity for about 5 hours of continuous operation. When the instrument is on "standby", power may be conserved by connecting it directly to a secondary 12 volt supply, eg., a vehicle battery. The internal battery is recharged when the instrument is connected to a mains supply.

(e) An output socket for connection to a printer is provided.


Since mid 1987, 42 Alcolmeter AE-D3s have been in operational use in the province. Although there have been few technical problems compared to those in earlier instruments, a number of modifications, mostly of a minor nature, have been suggested by experience in the laboratory and in the field. The following features are in the process of being added to the AE-D3 at our request:

(a) **Radio Frequency Detector**

Although the Alcolmeter AE-D3 has been designed to be resistant to RFI, laboratory tests showed that in certain circumstances, eg, in the proximity of a powerful transmitter, interference could occur. Lion Laboratories have evaluated and fitted a device which detects RFI, aborts any test sequence and displays an appropriate symbol on the screen.

(b) **Battery Protection Circuit**

This circuit protects the internal battery from complete discharge should an operator leave the instrument on standby (without it being connected to mains or to a car battery) for a lengthy period.

(c) **Screen Illumination**

This is required to improve legibility of the display in poor light conditions.

Evaluation of Operational Results

Evidential breath testing has proceeded successfully in Northern Ireland since 1968; one reason for this has been the statutory right of the subject to refuse the breath test result and provide a specimen of blood or urine for laboratory analysis. Experience has shown that the number of refusals is low (Table 1), most subjects being willing to accept the displayed result as evidence which may be used against them in court. Because these refusals do occur we are able to compare breath test results with definitive blood or urine figures. A total of 95 such cases were obtained for examination over the two year period.

The figures have been adjusted as follows so that a direct comparison can be made:

(a) The breath results are increased so that they are based on a true calibration; the instrument is normally calibrated to 70 mg% using an
80 mg% standard (as for the Alcolmet AE-D1) thus giving the subject result a -12.5% bias.

(b) The time lapse between the breath test and blood or urine sampling is taken into account. It is assumed that subjects are in the post absorption phase with a rate of BAC decrease of 15 mg% per hour.

(c) Urine values are converted to blood equivalents using the 3:4 blood:urine ratio.

The linear regression analysis is shown in Fig. 2. For comparison a similar procedure was applied to the same number of results obtained with the Alcolmeter AE-D1S (Fig. 3) and the Ethanolomat (Fig. 4). As there are no proceedings against drivers whose breath tests indicate a BAC less than 80 mg%, no results below the limit are available for these surveys.

DISCUSSION

Results Obtained with The Alcolmeter AE-D3

The corrected blood alcohol (x) and breath test results (y) are well correlated (r = 0.91) but the slope of the equation (b = 0.89) is less than unity with an intercept of 16 mg%. The precision of the AE-D3 is indicated by the standard error estimate (Syx) of 17.6 mg% equivalent to 12.4% of the mean breath alcohol concentration (142 mg%). The regression coefficient (b) indicates that the Alcolmeter AE-D3 results have an average proportional error of 11% biased so that the breath result is lower than the actual blood level. Assuming that the blood:breath partition coefficient of 2300:1 is physiologically correct (2) the reason for this bias is probably that police operators tend to take early breath samples when testing real subjects. This negative bias is of course reinforced in an operational setting by the 12.5% calibration reduction built into the system software. The breath tests outlined in this study were performed in the field and under these conditions perfectly correlated results are more difficult to achieve than those obtained under controlled laboratory conditions. Even with results from well trained operators errors can easily arise from a number of sources including:

(a) Mouth alcohol - subjects are advised to wait 20 minutes before testing to disperse mouth alcohol but many do not take up this option.

(b) Correction factors - those based on the assumptions that all subjects are in the post-absorption phase (3) and eliminate alcohol at a constant 15 mg% per hour during the intervening period and that the blood:urine conversion factor is always 3:4.

(c) Poor manual sampling - manual sampling by competent operators has been found to be very successful but early sampling will of course produce low results from bronchial air.

It is likely that under tightly controlled conditions the correlation of the AE-D3 would be significantly improved as a series of readings from a gas standard indicate that it is a precise instrument. Each subject test run contains a calibration and two check calibrations (using the NALCO cylinder).
Typically the check calibrations are within +/- 3 mg% although the instrument software allows deviations up to +/- 5 mg%. It maintains a system quality control such that a subject test will not be allowed to take place if preliminary checks do not meet the program criteria.

The results from this study compare favourably with others of a similar type. For example, Jones (4) analysed results obtained with the Alcolmeter pocket model screening device under operational conditions and repeated the trial under controlled conditions (5). Driver, et al. (6) carried out a study using the Intoxilyser Model 4011A and blood and breath samples from DUI arrestees. Table 2 shows the regression parameters for each of the breath test instruments used in N.Ireland since 1968. An improvement in precision can be seen. Also shown for comparison are equivalent statistical results obtained by Jones and by Driver et al., referred to above.

CONCLUSION

The Alcolmeter AE-D3 has proved to be a suitable instrument to modernise Northern Ireland’s breath testing programme. Its fuel cell detector is the basis for a transportable, relatively alcohol specific breath testing machine which is sufficiently accurate to test subjects evidentially. The modern microprocessor controlled system reduces operator involvement to a minimum, consistent with manual sampling, introduces built-in quality control and is robust enough to withstand the rigours of daily police operations.

REFERENCES


Fig 2 Regression plot for AED3 breath results against blood alcohol concentration

\[ y = 16.2 + 0.89x \quad r = 0.911 \]
\[ n = 94 \quad \text{Syx} = 17.6 \text{ mg} % \]

Fig 3 Regression plot for AE-D15 breath results against blood alcohol concentration

\[ y = 34.8 + 0.73x \quad r = 0.783 \]
\[ n = 95 \quad \text{Syx} = 29.2 \text{ mg} % \]

Fig 4 Regression plot for Ethanographe breath result against blood alcohol concentration

\[ y = 25.4 + 0.88x \quad r = 0.756 \]
\[ n = 93 \quad \text{Syx} = 34.5 \text{ mg} % \]
FIG. 1

OPERATION PROCEDURE FOR

AE-D3 NI

NORMAL SUBJECT TEST

SWITCH ON

WAIT

Calibration light OFF
Ready/wait light RED

CALIBRATE
Calibration light ON
Ready/wait light GREEN

CALIBRATION CHECK 1
Calibration light flashing
Display flashing "1"
Ready/wait light GREEN

(YES) PRESSED

CALIBRATION SWITCH?

(NO)

BLANK CHECK
Calibration light OFF
Display flashing 000
Ready/wait light GREEN

SUBJECT SAMPLE
Calibration light OFF
Display flashing "S"
Ready/wait light GREEN

CALIBRATION CHECK 2
Calibration light flashing
Display flashing "2"
Ready/wait light GREEN

PRINT OUT

374
Table 1

<table>
<thead>
<tr>
<th>Group</th>
<th>No</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of vehicles stopped</td>
<td>82,238</td>
<td></td>
</tr>
<tr>
<td>No. required to provide breath specimen</td>
<td>2,405</td>
<td>2.9% of drivers stopped appear to have consumed alcohol</td>
</tr>
<tr>
<td>No. refused to provide breath specimen</td>
<td>32</td>
<td>1.3% of those required to provide specimen</td>
</tr>
<tr>
<td>No. unable to provide breath specimen</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>No. in excess of prescribed limit</td>
<td>955</td>
<td>39.7% of drivers tested were above limit</td>
</tr>
<tr>
<td>No. who refused to accept breath test result (above limit) and were required to provide blood or urine</td>
<td>50</td>
<td>5.2% of those above limit</td>
</tr>
<tr>
<td>No. of above group whose blood or urine result was below prescribed limit</td>
<td>8</td>
<td>0.8% of those above limit on breath test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16.0% of those who refused breath result</td>
</tr>
</tbody>
</table>

Remarks:
- 2.9% of drivers stopped appear to have consumed alcohol
- 1.3% of those required to provide specimen
- 39.7% of drivers tested were above limit
- 5.2% of those above limit
- 0.8% of those above limit on breath test
- 16.0% of those who refused breath result

Table 2

Comparison of the performance of breath testing instruments used in Northern Ireland since 1968. Also shown are results obtained by Jones (4, 5) using the Alcometer Pocket Model and by Driver et al. (6) using the Intoxilyser 4011A.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>n</th>
<th>Std Error Est. (mg%)</th>
<th>Std Error % of mean</th>
<th>r</th>
</tr>
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<tbody>
<tr>
<td>Ethanolgraphie (1968-1977)</td>
<td>93</td>
<td>34.5</td>
<td>19.5</td>
<td>0.75</td>
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<tr>
<td>Lion AE-D1S (1977-1987)</td>
<td>95</td>
<td>29.2</td>
<td>18.6</td>
<td>0.78</td>
</tr>
<tr>
<td>Lion AE-D3 (1987-1989)</td>
<td>94</td>
<td>17.6</td>
<td>12.4</td>
<td>0.91</td>
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<tr>
<td>Lion Pocket Model:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>field trial</td>
<td>333</td>
<td>21.0</td>
<td>21.0</td>
<td>0.84</td>
</tr>
<tr>
<td>controlled trial</td>
<td>289</td>
<td>8.5</td>
<td>17.0</td>
<td>0.95</td>
</tr>
<tr>
<td>Intoxilyser 4011A:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>field trial</td>
<td>---</td>
<td>12.3</td>
<td>8.2</td>
<td>0.96</td>
</tr>
</tbody>
</table>