UKIAFT Guidelines for Performing Alcohol Technical Defence Calculations

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Introduction

This version of the guidelines updates version 2.1, issued in December 2014, and encompasses recent investigations into uncertainty in total body water and in strengths of alcoholic beverages. Changes are highlighted.

Alcohol Technical Defence (ATD) calculations may be required in a number of casework situations involving drinking and driving.
These guidelines are designed to ensure, where possible, a consistent approach to such casework within the United Kingdom and Republic of Ireland. There are potentially many parameters that could be used for such calculations which could produce a different evidential outcome given the same information. These guidelines are designed to minimise such potential problems but are not a guide on 'how to perform' the calculations.

The Law

In England, Wales and Scotland the relevant legislation is contained within the Road Traffic Offenders Act 1988, Section 15.2 and in Northern Ireland in Article 18(2) of the Road Traffic Offenders (Northern Ireland) Order 1996:-

Evidence of the proportion of alcohol or any drug in a specimen of breath, blood or urine provided by or taken from the accused shall, in all cases be taken into account and, subject to subsection (3) below, it shall be assumed that the proportion of alcohol in the accused's breath, blood or urine at the time of the alleged offence was not less than in the specimen.

That assumption shall not be made if the accused proves:-
(a) that he consumed alcohol before he provided the specimen and
(i) in relation to an offence under section 3A, after the time of the alleged offence, and
(ii) otherwise, after he had ceased to drive, attempt to drive or be in charge of a vehicle on a road or other public place, and
(b) that had he not done so the proportion of alcohol in his breath, blood or urine would not have exceeded the prescribed limit and, if it is alleged that he was unfit to drive through drink, would not have been such as to impair his ability to drive properly.

There is no such provision within the Republic of Ireland Road Traffic Act 2011.

Situations where a forensic scientist can be requested to perform calculations include:-

Post-incident drinking (the "hip flask" defence)
Where a motorist claims to have consumed alcohol after driving but before their evidential sample has been supplied and it is therefore necessary to calculate the contribution from this additional alcohol consumed.

Laced drinks defence ("special reason" for not disqualifying)
Where a motorist claims to have unknowingly consumed alcohol e.g. where extra alcohol has been added to a drink, and calculations are required to allow for this extra alcohol.

Back-calculation
A calculation to extrapolate the measured alcohol level to a previous time. This may be required when a motorist has absconded from the scene of a collision or driving incident and thereby delayed sampling or been injured and taken to hospital, again delaying sampling. It is also a requirement of Section 3A of the Road Traffic Act 1988 Amended 2006 (e.g. causing death by dangerous driving); regional variations may apply. Ultimately it is for lawyers to decide whether or not such a calculation can be used at court.

Time to driving
A calculation to determine at what time the motorist's blood or breath alcohol level would have fallen below the prescribed limit where they have been arrested under an "in charge" offence.

Recommendations for Practitioners

A number of recommendations on the information required to perform such calculations, what calculations should be performed and what parameters should be used are detailed below:-

(a) Information Required

In order to be able to carry out the calculations that may be required, the following information should be obtained:-

Tests & Circumstances
Time of driving incident
Time of screening breath test and result
Time of evidential breath analysis and result
Time and analytical result of other sample e.g. blood

Subject Details
Name
Age
Gender at birth

Height
Weight

If the weight of the subject is not available but the height and build is provided, it may be possible to estimate the motorist's weight from tables

Food & Drink Consumption
Details of food consumption within previous 24 hours
Details of alcohol consumption over the previous 24 hours. It is important to include as much detail as possible – such as times of drinking (especially the start time), volumes consumed and brands
Details of medication (if any)
Medical conditions

Volumes & Strengths
Bottle and can sizes in United Kingdom and Republic of Ireland:-

A normal bottle of spirit is 70cl (700ml) but 1 litre bottles (1000ml) are readily available. Bottles are also available at half-sizes (350ml) and small (200ml). Miniatures, where available, are generally 50ml in volume

A standard bottle of wine is 750ml; half-bottles are increasingly available (375ml). Quarter bottles (normally 187ml) may also be sold.

Bottles of beer are either 500ml, 330ml or 275ml although occasionally other sizes may be available e.g. 660ml or 1 pint (568ml).
Cans of beer can be sold in many different sizes. Most common will be 500ml, 440ml or 330ml but others are available.

Alcopop bottles are generally 275ml in size although supermarkets often sell these in 700ml bottles.

Drinks measures in Licensed Premises
United Kingdom
Spirits are sold in measures of either 25ml or 35ml for a single. If information is not known 35ml should be assumed but clearly stated in the report/statement. In the Isle of Man spirits are still served as 1/5 gill (28.4ml).

Wine is sold in various sizes of glass:-
125ml (small); N.B. this is 'standard' for champagne
175ml (small or standard*)

250ml (standard or large*)
Some may even sell a 500ml glass as a large glass

*depending on the establishment's policy

A standard measure for a fortified wine is 50ml

Republic of Ireland
A standard measure of spirit is 35.5ml.
187ml (1/4 bottle) is a standard glass of wine.

Drink strengths

The alcohol content, alcohol by volume (ABV), of stated brands of drinks can be readily found via internet searches or by contacting the manufacturer or distributor. The drink strength may well vary, even within brand, depending on whether it is in a can or is being sold as draught.

A recent paper investigated variations in ABV of packaged beer from their stated content (Maskell et al., 2018). Although the overall finding was of large variations in actual versus stated alcohol content further investigations (Reid et al. 2018) showed that large brewers had only a small variation (RMSE* +/-0.1%, range -0.3 to +0.1%) but with micro-breweries ('Craft beers') having larger variation. Variation within the latter was investigated for standard and strong beers. RMSE for standard beers of strength ≤5.5% ABV was found to be +/-0.4%, range -1.6 to +1.5% and for strong beers (>5%ABV) was +/-0.5%, range -1.6 to +1.2%.

Consequently no allowance in calculations needs to be made for the large brewers, which comprise most of the casework undertaken, but if a small brewery beer is involved the practitioner should be aware of the possible variation and proceed with caution if the outcome is close to the prescribed limit. The approach taken must be detailed within the statement/report.

*RMSE = root mean square error

If the can/bottle is not available, or the brand is unknown, the following are suggested (Table 1) as typical mean values (from Maskell et al., 2017).

Whatever value is used should be clearly stated in the report/statement although every effort should be made to obtain details of the brand consumed.

Type of Beverage	Alcohol concentration by volume (ABV)
Draught lager (all)	4.5%
Draught lager (standard)	4.1%
Draught lager premium)	4.8%
Bottled lager	4.6%
Draught bitter/ale	4.8%
Bottled craft beer	5.7%
Bottled stout/porter	4.0%
Cider (all)	5.5%
Craft cider	6.0%
Cider (cans)	5.0%
Cider (fruit, bottled)	4.1%
Red wine	13.1%
White wine	12.0%
Rose wine	10.5%
Champagne	12.2%
Prosecco	11.1%
Sherry	17.1%
Port	19.8%
Vodka (all)	39.0%
Gin (all)	38.2%
White rum	43.1%
Dark rum	39.0%
Spiced rum	36.1%
Whisky (all)	40.2%
Brandy (Cognac)	40.0%
Alcopops	4.0%
Premixed spirits	5.2%

(b) Calculations

Alcohol Distribution

Many ATD calculations require the so-called Widmark factor to be determined. This is a measure of the proportion of the person's body weight that is available for alcohol distribution and takes into account weight, height and age.

Various methods exist for calculation of such a factor, including the very widely used methods described by Forrest and Watson et al., and are actually "modified Widmark factors". A recent paper has investigated uncertainty associated with total body water (TBW), which impacts the Widmark factor calculation, and considered these assorted methods (Maskell et al., 2019). The authors found that Forrest and Watson et al., the two

methods previously recommended by UKIAFT, still offer the best outcomes. In addition to uncertainty in TBW, a bias was found in some situations and which should be corrected for where required.

It is recommended that for males Watson et al. is the preferred method, whilst for females the Forrest method gives the most reliable factor.
The Watson et al. calculation where age, weight and height for males are known needs no correction for bias in the factor calculated. Where only age and weight are known for the Watson et al. calculation a correction of +0.01 should be made.
A small bias was found in the Forrest equation such that 0.01 should be subtracted from the value calculated to give the mean value for females.

Following a calculation to determine the modified Widmark factor, allowances for uncertainty within these calculations for factors should be made. To allow for uncertainty a 95% distribution limit has been calculated for both methods and this should be taken into consideration when undertaking ATD calculations in forensic casework. The relevant data is tabulated below and also includes the 68% distribution limit as may be applicable to other casework types.

Table 2 Correction Factors for Volume of Distribution

Method	Bias in Vd	68% Range	95% Range
Forrest for females	-0.01	-0.07 to 0.01	-0.13 to 0.17
Watson et al. (age, wt & ht known) for males	0.00	-0.02 to 0.04	-0.14 to 0.12
Watson et al. (wt known) for males	0.01	-0.02 to 0.04	-0.13 to 0.13

When performing ATD calculations the full range of possible values for the modified Widmark factor should be calculated, as well as the value derived from the usual method of calculation for the equation used, but now with bias corrected where applicable. An example is given below. It should be noted that 1 in 20 motorists are still likely to fall outside of this 95% range.

Modified Widmark Factor calculation –an example

A road traffic collision occurred at midnight and a 54 year-old male is arrested after leaving the scene. He supplies a lower evidential breath test of 67µg% at 1.27am (NB all times GMT).
Weight 13 stone (82.55kg)

Height 5ft 10 ins (1.78m).

Using the method of Watson et al. for a male
TBW = 2.447 – 0.09516y + 0.1074h + 0.3362w = 44.14

Modified factor (r) = TBW/(w x 0.84) = **0.64**

Using the data from the table 2 there is no adjustment for bias from the calculated factor of 0.64.
The allowance for uncertainty in this calculation from the same table, using a 95% distribution limit for Watson et al. for males where age, weight and height are known, is from -0.14 to +0.12.

Therefore the range for the factor is **0.50 to 0.76**

The recommended alcohol calculations should then be performed for r = 0.64 and also for the range of possible values using 0.50 and 0.76. All values should be reported.

The particular method used must be included in the practitioner's statement/report, along with any modifications.
If insufficient detailed information has been supplied for calculating an accurate modified Widmark factor (e.g. weight, height) certain assumptions may be made but these must be detailed in the statement so they can be challenged if necessary. Steps should be taken to ascertain the required information or provide a fair estimate. Any estimates made should be clearly stated in the practitioner's statement/report.
It should be noted that caution should be used when applying the factors to older motorists and also those with a very high BMI as the models may not be so accurate.

Water Distribution Constant: The calculations should be modified to reflect the proportion of water in whole blood, by substituting the water distribution constant for plasma (0.80) with the constant for whole blood (0.84) when appropriate (Trudnowski and Rico, Snyder et al., Lentner).

Alcohol Consumption
A standardised approach is suggested for performing calculations as follows:-

1. Calculate the contribution of the alleged post-incident alcohol consumption or the alcohol contained in a laced drink.

2. Calculate the estimated blood or breath concentration in the absence of the post-incident, or laced drink, at the time of the evidential analysis

3. Calculate the estimated blood or breath concentration in the absence of the post-incident or laced drink contribution at the time of the incident. This should be extrapolated ("back-calculated") from the test after allowance for the post incident consumption has been deducted but must only be performed where this calculation is scientifically viable (see below).
N.B. In certain situations it may be necessary to change the order and back-calculate from the test and then subtract the post-incident consumption unless the calculation programme, if used, can deal with negative numbers.

4. Calculate the expected blood or breath alcohol concentration at the time of the evidential sample using the total alcohol consumption claimed by the motorist. The concentration is derived by calculation of the maximum contribution from all of the drinks consumed and then allowing for alcohol elimination between the start of drinking and the time of the evidential test.

5. An optional additional calculation is to estimate the motorist's blood or breath concentration at the time of the incident, from the claimed pre-incident consumption. This involves the calculation of the maximum contribution that the claimed pre-incident drinking could have produced, but also allowing for the possibility that this may not have been completely absorbed (depending on the times involved).

Validity of Back Calculation
(a) The stated drinking scenario should be thoroughly examined to ensure that the motorist's alcohol level would not have fallen to zero at any point in the time period under investigation (e.g. between drinks). If this could have occurred the calculation must be modified accordingly. It may be that a concentration could have fallen to zero at a fast elimination rate but not a slow one and this should be considered carefully.

(b) Some, simple, cases may require only a back calculation, which involves adjustment for alcohol elimination between the time of an incident and the evidential analysis (which may be below the limit). This can include situations for example where a motorist has left the scene or been hospitalised leading to a significant delay in testing.

(c) Back-calculations should not normally be performed where the motorist has consumed alcohol within 60 minutes of the incident/sampling. If the last drink was more than 2 hours previously a back-calculation is considered to be safe. If a meal has been consumed then caution should be applied if a back-calculation is required to between 1 and 2 hours after last drinking and a caveat should be stated.

(d) Back-calculations should only be undertaken when a measured blood alcohol concentration is greater than 20mg%. Below this Michaelis-Menten kinetics should be used. The practitioner must be familiar with this method of calculation.

(e) If the post-incident alcohol consumption accounts for the measured alcohol concentration a back-calculation may not be valid or required.

N.B. When calculations from urine alcohol concentrations are attempted they should be converted to blood equivalents, using a ratio of 1.33 : 1 urine : blood for the purpose of the calculation. Consideration of the time of the urination and that of the previous (discarded) specimen should be taken into account, when the information is available, as the blood equivalent concentration relates to the mid-point between the times of supplying the discarded and evidential specimens, assuming the bladder was emptied. Following calculations the concentration should be converted back to urine for the purposes of reporting.

Alcohol Elimination

A paper by Jones suggests a range of 10 to 35mg%/hr with a "most likely" of 15mg%/hr for social drinkers and 19mg%/hr for likely heavy drinkers. Following discussions as to the most appropriate studies for elimination rates in the drinking and driving scenario it was agreed to adopt those suggested by Jones and Andersson which showed a range from 9 to 29mg%/hr with a most likely rate of 19mg%/hr. The quoted range is a 95% confidence interval. Therefore 1 in 20 motorists are still likely to fall outside of this range.

Any calculations from low blood alcohol concentrations (<20mg%) must take Michaelis-Menten kinetics into consideration (Lewis).

Blood to Breath Ratios

In a large survey in the 1980s written up in the Paton Report (Cobb and Dabbs), only 0.5% of subjects were found to have a blood to breath ratio <2000:1 and 3.4% had a value >3000:1. Therefore it is suggested that calculations involving conversion from breath alcohol concentrations to blood alcohol concentration equivalents take into account a range of blood to breath concentration ratios from 2000:1 to 3000:1 (as well as the stated blood alcohol elimination rate range). The most-likely blood to breath ratio should be taken as 2300:1.

When calculating the likely breath alcohol concentration from a stated alcohol intake the blood to breath partition ratio is relevant and should be taken as 2300 to 1. No ranges should be applied since this calculation will specifically address the situation where the blood supply, carrying the alcohol, is in contact with the alveoli in the lungs. This ratio varies little between individuals and depends on the partition ratio of alcohol between

blood and air at 34°C (expired air temperature) but with allowance for alcohol lost and gained on inspiration and expiration.

(c) Reports

Report content and format will vary depending on the case circumstances, and the customer requirement but the following components are suggested as a minimum for the content.

The format varies widely currently but a suggestion is made to provide clarity and consistency between practitioners.
Streamlined/abbreviated statements/reports should be used with caution for ATD casework and must contain sufficient information for decisions to be made by the Prosecution.

Report content

The following information must be included in all statements and reports:-
Practitioner's qualifications and experience
Purpose of statement/report
Information received
Receipt and results of examination of any items submitted
The scientific basis of the calculation (this can be included as a standardised appendix)
The information/assumptions on which the calculations are based
Comments including calculations
Conclusions
A comment that the report/statement has been compiled in accordance with published UKIAFT ATD Guidelines, including version number, could also be included.

Statement/report format

In post-incident drinking and laced drink cases, the following calculations should be included. In order to maximise the clarity of the report/statement it is suggested that each calculation has a separate heading. A logical order has been suggested:-

1. The contribution due to the additional alcohol, using the widest range of values.

2. The estimated result in the absence of the post-incident, or laced drink, at the time of the test using the widest range of values.

3. The estimated concentration in the absence of the post-incident or laced drink contribution at the time of the incident.

4. The expected blood or breath alcohol concentration at the time of the evidential test based upon the total intake of alcohol as claimed by the motorist and a comparison

between this and the actual measured value with a comment stating whether or not the alleged total alcohol consumption is consistent with the results obtained, using the widest range of values.
[N.B. If the result is only consistent with the claimed pattern if extreme factors are used this should be stated and may be important to the court when assessing the likelihood or otherwise of evidence presented. If the calculations are not compatible with the results and claimed drinking pattern, a warning should be included that caution is required when considering the remainder of the practitioner's statement. This would normally only apply if the motorist's account details insufficient alcohol; an adverse comment should only be used in situations where extra alcohol is detailed in exceptional circumstances e.g. where an unrealistically large amount of additional alcohol has been claimed]

If the lower end of the range in a breath calculation falls between the prescribed limit and charging threshold (i.e. prosecution limit) this must be clearly stated.

The Practitioner should proceed with caution if detailing the amount of alcohol "missing" from a motorist's account (i.e. where a deficit in the total alcohol calculation exists) as this would enable a motorist to change their drinking history and approach another Practitioner (see Forrest and Williams) since prior involvement of another Practitioner does not have to be disclosed by the Defence.

As it is not known which alcohol concentration will be used at court calculations to the time of the incident, as well as to the time of the evidential test, are recommended to be included in a report/statement. All information is then available for the Prosecution to proceed as they wish.
The practitioner should always carefully consider the assumptions made in their calculations, particularly when they are aware of uncertainties surrounding case information such as the nature and volume of the alcohol consumed and possible inaccuracies in weight, height etc.
When a calculated range is close to the prescribed limit or the charging threshold (prosecution limit) extra care should be taken in wording statements and any uncertainties clearly expressed to avoid possible miscarriages of justice.

In a situation where clearly more alcohol has been consumed than stated, as we cannot say when this extra alcohol had been consumed, the statement must clearly reflect that it is not possible to specify whether this additional alcohol consumption occurred before or after the incident, or both.

Selected references

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Version Control

Version	Author	Release Date	Amendment
1.0	M. Scott-Ham	Nov 2013	First draft
1.1	M. Scott-Ham	Apr 2014	Second draft
1.2	M. Scott-Ham	May 2014	Third draft
2.0	M. Scott-Ham	May 2014	Released version
2.1	M. Scott-Ham	Oct 2014	Minor changes
3.0	M. Scott-Ham	Jan 2019	Draft version including 1. Uncertainty in TBW and ABV 2. Updating ABV table for drinks where brand not known