The Determination of Taste and Odour in Potable Waters 1994

Methods for the Examination of Waters and Associated Materials

LONDON: HMSO

First Published 1994

ISBN 0 11 752967 2

HMSO

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Methods for the Examination of Waters and Associated Materials

This booklet contains methods for the qualitative and quantitative determination of taste and odour in waters. An on-site method is also described for continuous odour monitoring.

No performance data are available for the methods described in this booklet.

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About this series

Introduction

This booklet is part of a series intended to provide authoritative guidance on recommended methods of sampling and analysis for determining the quality of drinking water, groundwater, river and seawater, waste water and effluents as well as sewage sludges, sediments and biota. In addition, short reviews of the more important analytical techniques of interest to the water and sewage industries are included.

Performance of methods

Ideally, all methods should be fully evaluated with results from performance tests reported for most parameters. These methods should be capable of establishing, within specified or pre-determined and acceptable limits of deviation and detection, whether or not any sample contains concentrations of parameters above those of interest.

For a method to be considered fully evaluated, individual results encompassing at least ten degrees of freedom from at least three laboratories should be reported. The specifications of performance generally relate to maximum tolerable values for total error (random and systematic errors), systematic error (bias), total standard deviation and limit of detection. Often, full evaluation is not possible and only limited performance data may be available. An indication of the status of the method is shown at the front of this publication on whether or not the method has undergone full performance testing.

In addition, good laboratory practice and analytical quality control are essential if satisfactory results are to be achieved.

Standing Committee of Analysts

The preparation of booklets in the series 'Methods for the Examination of Waters and Associated Materials' and their continuous revision is the responsibility of the Standing Committee of Analysts. This committee was established in 1972 by the Department of the Environment and is managed by the Drinking Water Inspectorate. At present there are nine working groups, each responsible for one section or aspect of water quality analysis. They are:

1.0 General principles of sampling and accuracy of results
2.0 Microbiological methods
3.0 Empirical and physical methods
4.0 Metals and metalloids
5.0 General non-metallic substances
6.0 Organic impurities
7.0 Biological monitoring
8.0 Sewage works control methods
9.0 Radiochemical methods

The actual methods and reviews are produced by smaller panels of experts in the appropriate field, in co-operation with the working group and main committee. The names of those members associated with these methods are listed at the back of the booklet.

Publication of new or revised methods will be notified to the technical press. An index of methods and the more important parameters and topics is available from HMSO (ISBN 0 11 752669 X).

Every effort is made to avoid errors appearing in the published text. If however, any are found, please notify the Secretary.

Dr D WESTWOOD
Secretary

5 August 1994

Warning to Users

The analytical procedures described in this booklet should only be carried out under the proper supervision of competent, trained analysts in properly equipped laboratories.

All possible safety precautions should be followed and appropriate regulatory requirements complied with. This should include compliance with The Health and Safety at Work etc Act 1974 and any regulations made under the Act, and the Control of Substances Hazardous to Health Regulations 1988 SI 1988/1657. Where particular or exceptional hazards exist in carrying out the procedures described in this booklet then specific attention is noted. Numerous publications are available giving practical details on first aid and laboratory safety and these should be consulted and be readily accessible to all analysts. Amongst such publications are those produced by the Royal Society of Chemistry, namely 'Safe Practices in Chemical Laboratories' and 'Hazards in the Chemical Laboratory', 5th edition, 1992; by Member Societies of the Microbiological Consultative Committee, 'Guidelines for Microbiological Safety', 1986, Portland Press, Colchester; and by the Public Health Laboratory Service 'Safety Precautions, Notes for Guidance'. Another useful publication is produced by the Department of Health entitled 'Good Laboratory Practice'.

A Odour in Potable Waters

The determination of odour using the methods set out in this booklet relies on the subjective judgement of a limited number of individuals. Three methods are included in Part A of this booklet.

A1 The sample is smelled at ambient temperature followed by a subsequent classification of the odour in terms of intensity and nature.

A2 A quantitative determination of the threshold odour number is made in which the intensity of the odour is determined at 25°C by a group of people and a numerical value determined from the geometric mean of the results obtained.

A3 A continuous odour monitor is used in water treatment plants for on-line monitoring of odours. The odour is amplified by raising the temperature of the sample.

Methods A1 and A2 are primarily directed towards assessing compliance with the qualitative and quantitative odour requirements in The Water Supply (Water Quality) Regulations 1989, as amended and The Water Supply (Water Quality) (Scotland) Regulations 1990, (The Regulations).

Other methods exist for flavour-profile analysis and developments are currently being made in the instrumental detection of some odours.

Listed below are a number of compounds capable of causing odours in water, together with their typical odour threshold concentrations (OTC). The OTC will vary for different people (due to their differing olfactory sensitivity) perhaps by up to 2–3 orders of magnitude, and are given solely to indicate their relative odour causing potentials.

Compound	Odour description	Odour threshold concentration (μg/l)	
Ammonia	Sharp, pungent	40	
Pentylethanoate	Pear drops	5	
Acetophenone	Sweet/almonds	65	
Benzaldehyde	Sharp/almonds	35	
Benzothiazole	Rubber	80	
Biphenyl	Musty	0.5	
Chlorine		100–500	Dependent on pH.
2–Chlorophenol	Phenolic	2	Produced during water treatment chlorination when phenol is present in the water.
4–Chlorophenol		250	
2, 4 Dichlorophenol	Medicinal	2	
2, 6–Dichlorophenol	Medicinal	3	
2, 4, 6–Trichlorophenol	Medicinal	>1000	
Butanoic acid	Sweaty	50	
Diethyl sulphide	Garlic	0.25	
Dimethyl sulphide	Rotting vegetables	10	
Geosmin	Musty/earthy	0.015	
Linalool	Woody/aromatic	60	
Menthol	Camphorous/minty	2	
2–Methylphenol	Creosote	71	
3–Methylphenol	Creosote	330	
4–Methylphenol	Creosote	45	
2–Methylisoborneol	Musty/camphor	0.02	
Phenol	Carbolic	>1000	
2–Ethyl–5, 5–dimethyl–1, 3–dioxane	Musty/nutty/sweet	0.01	

A1 Qualitative method for the determination of odour

A1.1 Principle

The sample is smelled at ambient temperature and any odour is assessed in terms of its intensity and nature.

A1.2 Field of application and interferences

This method is primarily directed towards assessing the compliance of potable water samples with the requirements for qualitative odour in The Regulations. In treated waters which have been chlorinated, the chlorinous odour may mask, or enhance, the presence of other smells.

A1.3 Apparatus

A1.3.1 General

It is recommended that glassware is reserved solely for odour determinations, and when not in use is stored in a clean condition so that accidental contamination is avoided.

A1.3.2 Cleaning of Apparatus

Clean sample bottles before use by soaking thoroughly overnight in a dilute solution of a strong detergent and then rinse thoroughly with odour-free water (see section A2.4.1). Detergents containing phosphates or added perfumes should not be used.

Alternatively, an automatic dishwasher supplied with water at not less than 60°C and a detergent described above may be suitable.

A1.3.3 Sample Bottles

Wide-mouthed glass-stoppered bottles of at least 500 ml capacity are recommended. If, for any reason non-glass bottles are used, then these should be thoroughly tested before use to ensure that no odour is imparted to, or removed from, the sample.

A1.3.4 Accommodation

The room in which the tests are carried out should be free from interfering odours (for example cooking, chemicals, paints, polishes, air-fresheners and room de-odorizers etc) and other distractions such as draughts, noise and the presence of onlookers.

A1.4 Sampling and sample preservation

Collect the sample (with no headspace) in an appropriate clean bottle. The sample should be kept cool and tested as soon as possible after collection. If storage is unavoidable, store in a refrigerator at 4°C. Do not store for longer than 72 hours before analysis.

A1.5 Testers

It is recommended that testers carrying out this analysis should be members of the panel used in Method A2. See section A2.7 and Appendix 1 for precautions and evaluation techniques.

A1.6 Analytical procedure

Step	Procedure	Notes
A1.6.1	Decant a portion of sample from the sample bottle so that the bottle is approximately half full, note a.	(a) If the sample has been cooled it should first be brought to ambient temperature.
A1.6.2	Shake the bottle and contents, remove the stopper, smell the sample and, if an odour is detected, to classify it according to its intensity and nature, see section A1.7 for a typical list of odours, note b.	(b) Solutions should be smelled by holding each bottle at the base and immediately applying the nose to the mouth of the bottle. The stopper should be replaced as soon as the odour has been assessed.

A1.7 Typical list of odours

Intensity	Nature
No smell	Ammoniacal
Very mild	Bad eggs (sulphide)
Mild	Chlorine (bleach)
Strong	Earthy
Very strong	Farm-like
	Nature
	Fruity
	Medicinal (for example TCP)
	Milky
	Musty
	Oily
	Organic solvent
	Phenolic
	Soapy
	Sweet
	Yeasty
	Other (please specify)

A2 Quantitative method for the determination of threshold odour number

A2.1 Performance characteristics of the method

A2.1.1	Determinand	Odour at 25°C.
A2.1.2	Type of sample	Potable waters.
A2.1.3	Basis of method	Dilution of the sample with odour-free water until odour is no longer detectable.
A2.1.4	Range of application	Threshold odour number (TON) 1 to 10 (equivalent to dilution number (DN) 0 to 9). Higher numbers can be determined by using alternative dilution series.
A2.1.5	Lower reporting limit	Threshold odour number 1 (Dilution number 0).
A2.1.6	Sensitivity	Depends on the combined sensitivity of the panellists.
A2.1.7	Bias	Depends on the range of the diluted samples used in the test.
A2.1.8	Interferences	Chlorine interferes and should be neutralised prior to analyses.
A2.1.9	Time required for analysis	For one sample; diluter 60 minutes, plus 10 minutes per panellist.
A2.1.10	Expression of results	The threshold odour number is used throughout the procedure, with a conversion to dilution number as a final step for assessing compliance with The Regulations.

A2.2 Principle

The threshold odour number (TON) of a sample is that dilution of the sample (with odour-free water) whose odour is no longer detectable when compared with odour-free water itself (see section A2.4.1). If no odour is detectable in a sample without dilution then the TON is one, if a one to one dilution is required for the odour to be no longer discernible, then the TON is two (ie combined volume of sample and blank, divided by volume of sample). Expressed mathematically,

$$TON = (A + B) / A$$

where A = volume of sample, and
B = volume of odour-free water used to dilute the sample.

The TON of each panellist used in the test procedure is used to calculate a geometric mean TON. This mean TON is converted to a dilution number (DN), the unit of measurement used in The Regulations, by subtracting one. Hence (TON — 1) = DN. Thus a mean threshold odour number of four is equivalent to a dilution number of three. It is essential that results for samples taken for statutory purposes are expressed in units of dilution number.

Throughout the procedure described in this booklet, the threshold odour number rather than the dilution number (DN) is used. The conversion to dilution number only occurs at the final stage. This is because the mean TON is calculated as a geometric mean of the individual TON results reported for each panellist.

Potentially, the test involves three stages. If a sample is known to exhibit a marked odour, it is advisable to start at method A2.8.3.

Method A2.8.1 The sample is screened at 25°C by at least three panellists (see section A2.7) to ascertain whether any odour can be detected. If no odour is detected the sample is recorded as having a TON of 1 and the analysis is complete; if an odour is detected then method A2.8.2 is carried out.

Method A2.8.2 The sample is tested to evaluate whether the TON is less than 3 at 25°C. This test is organised by a person who prepares a 2:1 dilution of the sample with odour-free water and presents the diluted sample and odour-free water to the panellists in a specific manner. If no odour is detected in the diluted sample, then the sample is recorded as having a TON of less than 3 and the analysis is complete. It is recognised that the actual TON of certain samples will be exactly 3, but for the purposes of this method are reported as less than 3. If an odour is detected then method A2.8.3 is carried out.

Method A2.8.3 The sample is subjected to an ascending/descending triangle test to evaluate the TON.

This part of the test procedure produces a measure of the odour intensity in a sample at 25°C; it does not attempt to identify the odour. The dilution intervals used in the test have been chosen so as to be close to the dilution number specified in The Regulations, ie DN = 3. If the test is carried out for other purposes, or if the sample exhibits a much stronger odour, an alternative series of dilutions may be more suitable.

A2.3 Field of application

This method is primarily directed at assessing the compliance of samples with UK Regulations. It may be used for other purposes, but alternative sample dilutions should be considered. The method is applicable only to treated waters known to be safe for testing. In treated waters which have been chlorinated, any chlorinous odour may mask or enhance other odours. For assessing compliance with The Regulations, samples should be de-chlorinated before the evaluation is carried out.

A2.4 Reagents

Use analytical reagent grade chemicals unless otherwise indicated.

A2.4.1 Odour-free water

Odour-free (blank) water used for rinsing glassware, dilution of samples and as a reference water should preferably be water appropriate to the area, and where possible, similar in composition to the type of water being tested. It should preferably be borehole water which has been judged by the testing panel to be free from odour at 25°C.

Alternatively, prepare by passing distilled water down a glass column (for example 50 mm diameter and 100 cm in length), filled with fresh technical grade activated carbon (6 to 14 mesh), at a flow rate not exceeding 10 litres per hour. This water should be prepared daily and judged by the testing panel as being free from odour at 25°C.

NOTE – This water should not be used for tasting since the carbon may act as a growth medium for bacteria.

The water should be collected in clean glass-stoppered glass containers reserved for this purpose, and should be used or discarded within 12 hours of collection. If, for any reason non-glass containers are used, then these should be thoroughly tested before use to ensure no odour is imparted to the water by the container.

A2.4.2 Sodium thiosulphate solution

(Approximately 0.0125M). (1 ml is equivalent to approximately 0.5 mg $C1_2$). Dissolve 3.5g of sodium thiosulphate pentahydrate ($Na_2S_2O_3.5H_2O$) in distilled or equivalent grade water and dilute with water to 1 litre. Store in a dark glass bottle. The addition of 1 ml of this reagent will neutralise up to approximately 1 mg/1 of residual chlorine in 500 ml of sample.

A2.5 Apparatus

A2.5.1 General

It is recommended that glassware is reserved solely for TON determinations, and when not in use is stored in a clean condition so that accidental contamination is avoided.

A2.5.2 Cleaning of Apparatus

Clean sample bottles, glasses and volumetric glassware before use by soaking thoroughly overnight in a dilute solution of a strong detergent and then rinse thoroughly with odour-free water. Detergents containing phosphates and added perfumes should not be used.

Alternatively, an automatic dishwasher supplied with water at not less than 60°C and a detergent described above may be suitable.

Sample bottles may be sterilized by autoclaving before use.

A2.5.3 Water Bath or Incubator

Capable of maintaining a temperature of 25 ± 1°C throughout the bath.

A2.5.4 Taste/Odour glasses

Glasses consisting of a cup supported by a stem resting on a base are suitable. The opening of the cup must be narrower than the convex part of the cup. These glasses are available from, or through, good wine merchants or department stores.

These glasses are designed to trap volatile components. Similar vessels or enclosed containers may also be suitable. However, alternative containers should be thoroughly tested before use to ensure they do not reduce or increase the odour of the sample.

A2.5.5 Sample bottles

Glass-stoppered bottles of at least 500 ml capacity are recommended. If, for any reason non-glass bottles are used, then the bottles should be thoroughly tested before use to ensure that no odour is imparted to, or removed from, the sample.

A2.5.6 Accommodation

The room in which the tests are carried out should be free from interfering odours (for example cooking, chemicals, paints, polishes, air-fresheners and room de-odorizers etc) and other distractions such as draughts, noise and the presence of onlookers.

A2.6 Sampling and sample preservation

Collect the samples in relevant clean bottles leaving no headspace (see section A2.5.5). The sample should not be de-chlorinated at the time of collection.

Samples should be kept cool and tested as quickly as possible after collection. If storage is unavoidable store in a refrigerator at 4°C. Do not store for longer than 72 hours before analysis.

A2.7 Panellists

For assessing the TON of samples, the panel should ideally be composed of people familiar with the odour of the source to be analysed. Realistically this may not be possible where samples from many sources are being evaluated in any one particular laboratory.

The pool of panellists should consist of as many people as possible, ideally not less than twelve, who may or may not be laboratory analysts. At least three panellists are used on any one particular day. Ideally, panellists should be used at least once per week. Persons of high or low sensitivity will cause bias in the results recorded. All panellists should therefore be screened to eliminate those persons possessing high or low sensitivity. Procedures should exist for the retrospective judgement of panellists in order to assess the suitability of those persons considered for panel membership (see Appendix 1). Increasing the number of appropriate persons in the panel will enhance the reliability of the results reported.

The panellists should be free from colds or allergies that affect odour response, should not eat or smoke for a minimum period prior to the test (for example up to 1 hour), and on the day prior to the assessment should avoid the use of perfumes or cosmetic preparations of any kind, including scented soap for hand washing.

A panellist should not assess the odour of more than ten samples or diluted samples, together with the associated odour-free blanks, in any one session without a short break. If any of the samples has a pronounced odour, a short rest period or break may be required before continuing with the tests. It has been found that the consumption of a water biscuit and/or a dilute sucrose solution both followed by a short break can speed recovery.

In addition to the panellists, a person (sometimes referred to as a diluter, co-ordinator or panel leader) is required to prepare the diluted samples, to offer them to the panellists and to record and collate the results. It is imperative that this person carries out the manipulations with respect to samples, diluted samples and odour-free blanks out of sight of panellists and should not be used as one of the odour assessors.

A2.8 Analytical procedure

Step	Procedure	Notes
A2.8.1	**Initial Testing**	
A2.8.1.1	Estimate the volume of sodium thiosulphate solution (see section A2.4.2) required to de-chlorinate the sample, note a. Add the appropriate volume (± 0.1 ml) to the sample, carefully mix and replace the stopper.	(a) This operation should be carried out on a separate portion.
A2.8.1.2	Place up to ten de-chlorinated undiluted samples in suitably labelled containers (see sections A2.5.4) in a water bath or incubator at 25˚C. Include at least one sample of odour-free (blank) water (see section A2.4.1) per four test samples, subject to a minimum of at least two odour-free blanks in any batch of tests (notes b and c).	(b) The container may be the original sample bottle or a tasting glass covered with a watch glass. However, it is recommended that different panellists do not smell from the same container. Portions must be decanted from the sample bottle into individual glasses for each panellist to assess individually. (c) The samples and blanks should not be identifiable to the panellist by means of appearance or container. If samples are turbid or coloured, consideration should be given to covering all containers with aluminium foil before they are presented to the panellist.
A2.8.1.3	When the test solutions have attained 25˚C, present the samples and blanks to one member of the odour panel, note d. Ask the panellist to identify and record any solution which has an odour.	(d) To smell the solution hold the stem of the glass, gently swirl the contents, remove the watch glass and immediately sniff the contents at the mouth of the glass. Replace the watch glass as soon as the odour has been assessed. The odour should be assessed as quickly as possible, and a quick decision reached.
A2.8.1.4	Repeat step A2.8.1.3 using at least two additional panellists.	
A2.8.1.5	The results of each batch of test results for any panellist will be valid only if at least 60% of the blanks are identified as being odour-free, (see Table 1), note e. If a set of results is found to be invalid then step A2.8.1.3 should be carried out by additional panellists, note f.	(e) If blank samples are persistently identified by panellists as having an odour, then the odour-free water may not be of adequate quality (see section A2.4.1). (f) If one panellist persistently identifies the blank water as having odour then consideration must be given to removing that person from the panel (see Appendix 1).
A2.8.1.6	If a sample is identified as being odour-free by at least 60% of those panellists with valid results, then the sample is reported to have a TON of one (see Table 2). This equates to a dilution number of zero (see A2.2).	
A2.8.1.7	If fewer than 60% of those panellists with valid results identify the test sample as being odour-free then the sample must be further tested using the procedures in A2.8.2 and/or A2.8.3 (see Table 2).	
A2.8.2	**Intermediate Screening**	
A2.8.2.1	Estimate the volume of sodium thiosulphate solution (see section A2.4.2) required to de-chlorinate the sample, note a. Add the appropriate volume (± 0.1 ml) to the sample, carefully mix and replace the stopper.	a) This operation should be carried out on a separate portion.

A2.8.2.2	Make a 2:1 dilution of the sample with odour-free blank water. For example, dilute 70 ± 5 ml of the test sample to 210 ± 10 ml using odour-free (blank) water (see section A2.4.1).	
A2.8.2.3	Place the following solutions in suitable glasses (see section A2.5.4) in a water bath or incubator at 25˚C and cover each with a watch glass, notes b and c. A1 Blank (odour-free) water A2 Blank (odour-free) water A3 Diluted sample (see step A2.8.2.2) B1 Blank (odour-free) water B2 Blank (odour-free) water B3 Diluted sample (see step A2.8.2.2)	(b) Time will be saved if sufficient glasses for all the panellists (see section A2.8.2.6) are temperature-equilibrated at one time. It is recommended that different panellists do not smell from the same container. (c) The diluted samples and blanks should not be identifiable to the panellist by means of appearance or container. If samples are turbid or coloured, consideration should be given to covering all containers with aluminium foil before they are presented to the panellist.
A2.8.2.4	Allow all the solutions to attain 25˚C (15 minutes in a water bath is usually sufficient) then present in random order the three A series solutions to one member of the odour panel, note c. Request the panellist to smell a portion of the three solutions and to record whether there is a difference in odour between any of the three solutions. If the panellist reports a difference, request which solution is different and record the observation, notes d and e.	(d) Pre-prepared tick sheets may be suitable for recording the observations. (e) To smell the solution hold the stem of the glass, gently swirl the contents, remove the watch glass and immediately sniff the contents at the mouth of the glass. Replace the watch glass as soon as the odour has been assessed. The odour should be assessed as quickly as possible, and a quick decision reached.
A2.8.2.5	Repeat step A2.8.2.4 using the three B series solutions.	
A2.8.2.6	Repeat steps A2.8.2.4 and A2.8.2.5 using at least two additional panellists.	
A2.8.2.7	If the diluted sample is not identified in steps A2.8.2.4–A2.8.2.6 by any of the panellists then the sample has a odour threshold number of less than 3, notes f and g.	(f) If blank samples are persistently identified by panellists as having an odour greater than the sample, then the odour-free water may not be of adequate quality (see section A2.4.1). (g) If one panellist persistently identifies the blank water as having an odour, then consideration should be given to removing that person from the panel (see Appendix 1).
A2.8.2.8	If at least one of the panellists has identified the diluted sample in both the A and B series, then consideration should be given to testing the sample using the procedure in section A2.8.3.	
A2.8.2.9	If the diluted sample in either series is not identified as having an odour by at least 60% of panellists then the sample is reported to have a TON of less than 3, (see Table 3), (see section A2.8.2.7), providing the considerations of A2.8.2.8 have not been implemented.	
A2.8.2.10	If greater than 40% of the panellists identify the diluted sample in at least one of the series, then the sample must be further tested using the procedures in section A2.8.3.	

A2.8.3 Ascending and Descending Triangle Test

A2.8.3.1 Estimate the volume of sodium thiosulphate solution (see section A2.4.2) required to de-chlorinate the sample, note a. Add the appropriate volume (± 0.1 ml) to the sample, carefully mix and replace the stopper.

(a) This operation should be carried out on a separate portion.

A2.8.3.2 Prepare a series of dilutions of the test sample by diluting the appropriate volume of the sample (±5%) to 200 ±10 ml using odour-free (blank) water (see Table 4), notes b and c.

(b) See section A2.4.1 for the preparation of blank water.

(c) Experience may show that larger dilutions (ie solutions G and H) shown in Table 4 are rarely, if ever, required. In this case, these dilutions can be omitted and only made if required.

A2.8.3.3 Place portions of the diluted samples prepared in step A2.8.3.2 in suitable glasses, cover with watch glasses and place in a water bath or incubator at 25˚C, notes d and e.

(d) See section A2.5.4 regarding suitable glasses.

(e) Conversely, the blank and diluted samples can be temperature-equilibrated and then transferred to odour glasses. This procedure will require more water bath or incubator capacity, but will reduce temperature equilibration time. It is recommended that different panellists do not smell from the same container.

A2.8.3.4 Allow the solutions to attain 25˚C (15 minutes is usually sufficient for small volumes).

A2.8.3.5 Present in random order to one member of the odour panel three glasses containing respectively two blanks and the diluted sample, solution E (Table 4) note f.

(f) Since the sample is suspected of possessing an odour after examination by procedures A2.8.1 and A2.8.2, the sequence starts using solution E. The sequence can be started with an alternative dilution if required, for example if the sample is believed to possess very strong odour.

A2.8.3.6 Request the panellist to smell a portion of the three solutions and to record whether there is a difference in odour between any of the three solutions. If the panellist reports a difference, request which solution is different.

Record the observations made, notes g and h.

(g) The diluted samples and blanks should not be identifiable to the panellist by means of appearance or container. If samples are turbid or coloured, consideration should be given to covering all containers with aluminium foil before they are presented to the panellist.

(h) To smell the solution hold the stem of the glass, gently swirl the contents, remove the watch glass and immediately sniff the contents at the mouth of the glass. Replace the watch glass as soon as the odour has been assessed. The odour should be assessed as quickly as possible, and a quick decision reached.

A2.8.3.7 The result is recorded as either

(i) yes – there is a difference and an odour was detected in the diluted sample. Proceed to step A2.8.3.8.

or

(ii) no – there is no difference and panellist cannot identify diluted sample. Proceed to step A2.8.3.9.

A2.8.3.8 Repeat steps A2.8.3.5 to A2.8.3.7 proceeding up the dilution series with the next most dilute sample solution in the dilution series until, either the panellist cannot identify the diluted sample, or the end of the series is reached, note i.

(i) If the end of the dilution series is reached and the diluted sample is still identified then a further more dilute series will have to be prepared. The dilutions in this further series should preferably form a geometric series.

A2.8.3.9 When the panellist cannot identify the diluted sample repeat steps A2.8.3.5 to A2.8.3.7 proceeding down the dilution series with the next most concentrated sample solution in the sample dilution series, note j.

(j) The decision process is shown schematically in Figure 1.

A2.8.3.10 If the panellist identifies the diluted sample at this more concentrated strength re-test the solution previously presented to the panellist.

If the panellist again cannot detect the diluted sample in this series record the threshold odour number for the sample for that panellist as $\sqrt{(V_Z \times V_Y)}$, recorded to one decimal place, where V_Z is the relevant calculation value for the more dilute solution and V_Y is the relevant calculation value of the more concentrated solution. (Table 4), note k.

(k) For example, a panellist may detect an odour in solution E (Table 4 $V_E = 4$), fail to detect an odour in solution F ($V_F = 6$) and on re-testing again detects an odour in solution E. The result for the sample for that panellist would be $\sqrt{(4 \times 6)} = 4.9$.

If the panellist this time identifies the diluted sample, ie does not duplicate the earlier result, then revert to step A2.8.3.5 but using the next most dilute sample in the sample dilution series.

Ultimately the situation should be reached where the panellist either has twice not identified the diluted sample at a given dilution, but has identified it at a lower dilution, or has twice identified the diluted sample at a given dilution, but cannot identify it at the next highest dilution. In either case, the threshold odour number for the sample for that panellist is the geometric mean of the two relevant calculation values, note 1.

(l) See Table 5 for relevant examples.

A2.8.3.11 Repeat steps A2.8.3.5 to A2.8.3.10 for at least two additional panellists.

A2.8.3.12 The overall TON for the sample is calculated as the geometric mean of the individual panellist's results. ie $TON_y = (T_1 \times T_2 \times T_3 \ldots\ldots \times T_y)^{1/y}$ where T_1 to T_y are the individual panellist's threshold numbers, y is the number of panellists and TON_y is the TON of the sample.

The result is rounded to the nearest whole number, notes m and n,

(m) If the individual panellist's results for a given sample are respectively 2.4, 3.5 and 4.9, then the overall TON for the sample would be $(2.4 \times 3.5 \times 4.9)^{1/3} = 3.45$ which is rounded off to 3.

(n) Because the number is a geometric mean, results are rounded off as shown in Table 6.

A2.8.3.13 Subtract one from the overall TON (ie TON_y) to obtain the dilution number for that sample, note o.

(o) Results must be quoted as dilution numbers – see section A2.2.

A3 Determination of odour (on-site) by a continuous odour monitor

A3.1 Principle

The method gives a qualitative on-line measure of odour, which is invaluable in the early detection of potential problems. The method is applicable to raw, partially-treated and treated waters but see sections A2.3 and B1.3.

The water under test is heated to a temperature of 60°C for at least 30 seconds, after which time, it is sprayed in a continuous stream into a bell-jar. The odour thus collected and amplified in intensity is detected at the neck of the bell-jar and classified according to the list given in section A1.7.

A3.2 Apparatus

The apparatus is described in Figure 2 and requires a water pressure of 70–80 kPa (10–12 psi) and a 3 kw heater.

To prevent the build up of pathogenic organisms in the system (see section A1.3.2) the apparatus should be constructed so that the constituent parts can easily be dismantled for cleaning purposes.

A3.3 Installation and operation of continuous odour monitors (Smell Bells)

The following recommendations are made in order to minimise the possible risk of operators being exposed to pathogenic organisms.

(i) Use short direct runs of pipework from the water intake to the heater, and from the heater to the bell-jar.

(ii) Dead legs and over-sized pipework should be avoided.

(iii) WRc or approved materials and fittings should be used, ie materials which have been tested to BS 6920.

(iv) If necessary, the intake pipework should be insulated in order to keep the water cold prior to heating.

(v) The water should be uniformly heated to 60°C (minimum) for not less than 30 seconds in a suitable unit which can easily be dismantled for cleaning.

(vi) The water temperature probe should be located near the outlet of the heater chamber, it should be periodically checked for accuracy.

(vii) The water should be sprayed onto the inner surface of the bell-jar as an unbroken stream in a fan shape. Jets which produce fine mists should be avoided.

(viii) The smell bell water jet, bell-jar and base should be cleaned regularly, for example monthly. The heater unit may require dismantling and cleaning less frequently, for example annually.

(ix) If smell bells have not been used for a period exceeding 1 month, the apparatus and its associated pipework should be disinfected and thoroughly flushed out prior to use.

A3.4 Analytical procedure

Step	Procedure	Notes
A3.4.1	The "smell bell" is plumbed into the system, the odour of which is required to be monitored, (section A3.3 and note a).	(a) If this method is to be applied to waterworks control, the influence of terminal chlorination on the odour may be significant and a decision should be taken on whether the measurement is required on water supplied to the consumer. The chlorinous odour of treated water may mask other odours which may become apparent after distribution. The odour of de-chlorinated water may be examined by first de-chlorinating by in-line injection of 1% m/v sodium thiosulphate solution.
A3.4.2	The thermostat is set to maintain a temperature of 60°C maintained for a minimum of 30 seconds.	
A3.4.3	Odour is detected by removing the watch glass from the mouth of the bell-jar and smelling the contents. An immediate subjective assessment of odour is thus achieved (note b).	(b) In order to gain an early indication of the presence of odours it may be advantageous to use testers who are more sensitive at detecting odours in water.
A3.4.4	The result is expressed as a description and intensity according to the list described in section A1.7.	

B Taste in Potable Waters

The determination of taste using methods set out in this booklet relies on the subjective judgement of a limited number of individuals. Two methods are included in this booklet.

B1 The sample is tasted at ambient temperature followed by a subsequent classification of the taste in terms of its intensity and nature.

B2 A quantitative determination of the threshold taste number is made in which the intensity of the taste is determined at 25°C by a group of people and a numerical value determined from the geometric mean of the results obtained.

These methods are primarily directed towards assessing compliance with the qualitative and quantitative taste requirements in The Water Supply (Water Quality) Regulations 1989, as amended, and The Water Supply (Water Quality) (Scotland) Regulations 1990, (The Regulations).

When water possesses an odour it may, almost certainly, possess a taste. However, a distinct taste may arise from a sample that possesses no odour. Several dissolved metal ions, such as iron, manganese, potassium, sodium and zinc can be detected by taste whilst not giving rise to any perceptible odour.

Many complaints received from consumers are specifically concerned with poor taste, and the rapid identification of such tastes often assists in the elucidation of the cause. Several tastes can be correlated with specific water treatment problems and an experienced person who has a particularly sensitive palate may be able to give early warning of the appearance of a taste in a raw or treated water before it becomes of sufficient intensity to be apparent to consumers. (However, see section B1.3 on hazards). As a consequence, remedial measures may be applied at the treatment works in order to prevent, or reduce, problems associated with taste in the distribution system.

The determination of taste is also important in the testing of materials which may be used in contact with potable water. In these circumstances, samples of the material that are to be used in contact with drinking water are immersed in taste-free water for a pre-determined period of time, usually twenty-four hours. At the end of this period, the 'soak water', ie water used in the immersion process, is tested for the presence or absence of any taste.

B1 Qualitative method for the determination of taste

B1.1 Principle

The sample is tasted at ambient temperature and any taste is assessed in terms of intensity and nature.

B1.2 Field of application

This method is primarily directed towards assessing the compliance of potable water samples with the requirements for qualitative tasting in The Regulations. The method is only applicable to treated waters known to be safe for ingestion (see section B1.3). In treated waters which have been chlorinated, the chlorinous taste may mask or enhance other tastes.

B1.3 Hazards

Taste tests should only be performed on samples known to be safe for ingestion. Samples that are known or suspected of being contaminated with bacteria, viruses, parasites or any hazardous chemicals should not be tested.

Regardless of the type of sample being tasted, the taster should, as a precaution, be instructed not to swallow any of the test sample under any circumstance.

B1.4 Apparatus

B1.4.1 General

It is recommended that glassware be reserved solely for taste determinations, and when not in use is stored in a clean condition so that accidental contamination is avoided.

B1.4.2 Cleaning of apparatus

Clean sample bottles before use by soaking thoroughly overnight in a dilute solution of a strong detergent and then rinse thoroughly with taste-free water (see section B2.5.1). Detergents containing phosphates and added perfumes should not be used.

Alternatively, an automatic dishwasher, supplied with water at not less than 60°C and detergent described above, may be suitable.

Sample bottles may be sterilized by autoclaving before use.

B1.4.3 Sample bottles

Glass stoppered bottles of at least 500 ml capacity are recommended. If for any reason non-glass bottles are used then these should be thoroughly tested before use to ensure that no taste is imparted to, or removed from, the sample.

B1.4.4 Taste/Odour glasses

Tasting glasses consisting of a cup supported by a stem resting on a base are suitable. The opening of the cup must be narrower than the convex part of the cup. These glasses are available from or through good wine merchants or good department stores.

Similar vessels or other enclosed containers may also be suitable. However, alternative containers should be thoroughly tested before use to ensure they do not reduce or increase the taste of the sample.

B1.4.5 Accommodation

The room in which the tests are carried out should be free from interfering odours (for example cooking, chemicals, paints, polishes, air-fresheners and room de-odorizers etc) and other distractions such as draughts, noise and the presence of onlookers

B1.5 Sampling and sample preservation

Collect the sample in an appropriate clean bottle leaving no headspace.

The sample should be kept cool and tested as quickly as possible after collection. If storage is unavoidable, store in a refrigerator at 4°C. Do not store for longer than 72 hours before analysis.

B1.6 Testers

It is recommended that testers be members of the tasting panel used in Method B2. See section B2.8 and Appendix 1 for precautions and evaluation techniques.

B1.7 Analytical procedure

Step	Procedure	Notes
B1.7.1	Decant a portion of the sample into a suitable glass, see section B1.4.4., note a.	(a) If the sample has been cooled it should first be brought to ambient temperature.
B1.7.2	Ask the tester to taste the sample and, if a taste is found, to classify it according to its intensity and nature (see section B1.8 for a typical list of tastes), notes b and c.	(b) The sample may be tasted directly from the sample bottle providing only one taster is carrying out the test, and the sample is not used for any other purpose. (c) Solutions should be tasted by taking into the mouth whatever volume of water is comfortable, holding it for several seconds and then discharging it without swallowing (see section B1.3).

B1.8 Typical list of tastes

Intensity	Nature
No taste	Astringent
Very slight	Bitter
Slight	Bituminous
Strong	Chemical
Very strong	Chlorinous
	Chlorophenol
	Cucumber
	Decayed vegetable
	Earthy
	Fishy
	Flat
	Geranium
	Inky
	Metallic
	Mouldy
	Musty
	Oily
	Rubber
	Saline
	Sharp
	Sour
	Spirit
	Sweet
	Weedy
	Other (please specify)

B2 Quantitative method for the determination of threshold taste number

B2.1 Performance characteristics of the method

B2.1.1	Determined	Taste at 25°C.
B2.1.2	Type of sample	Potable waters.
B2.1.3	Basis of method	Dilution of the sample with taste-free water until taste is no longer detectable.
B2.1.4	Range of application	Threshold taste number (TTN) 1 to 10 (equivalent to dilution number (DN) 0 to 9). Higher numbers can be determined by using an alternative dilution series.
B2.1.5	Lower reporting limit	Threshold taste number 1 (Dilution number 0).
B2.1.6	Sensitivity	Depends on the combined sensitivity of the panellists.
B2.1.7	Bias	Depends on the range of the diluted samples used in the test.
B2.1.8	Interferences	Chlorine interferes and should be removed prior to analyses.
B2.1.9	Time required for analysis	For one sample; diluter 60 minutes, plus 10 minutes per panellist.
B2.1.10	Expression of results	The threshold taste number is used throughout the procedure, with a conversion to dilution number as a final step for assessing compliance with Regulations.

B2.2 Principle

The threshold taste number (TTN) of a sample is that dilution of the sample (with taste-free water) whose taste is no longer detectable when compared with taste-free water itself (see section B2.5.1). If no taste is detectable in a sample without dilution then the TTN is one, if a one to one dilution is required for the taste to be no longer discernible, then the TTN is two (ie combined volume of sample and blank, divided by volume of sample). Expressed mathematically,

$$TTN = (A + B) / A$$

where A = volume of sample, and
B = volume of taste-free water used to dilute the sample.

The TTN of each panellist used in the test procedure is used to calculate a geometric mean TTN. This mean TTN is converted to a dilution number (DN), the unit of measurement used in The Regulations, by subtracting one. Hence (TTN - 1) = DN. Thus a mean threshold taste number of four is equivalent to a dilution number of three. It is essential that results for samples taken for statutory purposes are expressed in units of dilution number.

Throughout the procedure described in this booklet, the threshold taste number rather than the dilution number (DN) is used. The conversion to dilution number occurs only at the final stage. This is because the mean TTN is calculated as a geometric mean of the individual TTN result reported for each panellist.

Potentially, the test involves three stages. If a sample is known to possess a taste, it is advisable to start at method B2.9.3.

Method B2.9.1 The sample is screened at 25°C by at least three tasters (see section B2.8) to ascertain whether any taste can be detected. If no taste is detected the sample is recorded as having a TTN of 1 and the analysis is complete. If a taste is detected then method B2.9.2 is carried out.

Method B2.9.2 The sample is tested to evaluate whether the TTN is less than 3 at 25°C. This test is organised by a person who prepares a 2:1 dilution of the sample with taste-free water and presents the diluted sample and taste-free water to the panellists in a specific manner. If no taste is detected in the diluted sample, then the sample is recorded as having a TTN of less than 3 and the analysis is complete. It is recognised that the actual TTN of certain samples will be exactly 3, but for the purposes of this method are reported as less than 3. If a taste is detected then method B2.9.3 is carried out.

Method B2.9.3 The sample is subjected to an ascending/descending triangle test to evaluate the TTN.

This part of the test procedure produces a measure of the taste intensity in a sample at 25°C; it does not attempt to identify the taste. The dilution intervals used in the test have been chosen so as to be close to the dilution number specified in The Regulations, ie DN = 3. If the test is carried out for other purposes, or if the sample possesses a much stronger taste, an alternative series of dilutions may be more suitable.

B2.3 Field of application and interferences

This method is primarily directed at assessing the compliance of samples with The Regulations. It may be used for other purposes but alternative sample dilutions should be considered. The method is applicable only to treated waters known to be safe for ingestion. (see section B2.4). In treated waters which have been chlorinated, the chlorinous taste may mask or enhance other tastes. For assessing compliance with The Regulations, samples should be de-chlorinated before the evaluation is carried out.

B2.4 Hazards

Taste tests should be performed only on samples and reference waters known to be safe for ingestion. Samples that are known or suspected of being contaminated with bacteria, viruses, parasites or hazardous chemicals should not be tasted.

Regardless of the type of sample being tested, the panellists should, as a precaution, be instructed not to swallow any test sample under any circumstance.

B2.5 Reagents

Use analytical reagent grade chemicals unless otherwise indicated.

B2.5.1 Taste-free or blank water

The blank water should be both relevant to the samples under investigation and selected on the basis of having the least, or most neutral taste. Where possible it should be similar in composition to the type of water being tested.

The water should be collected in clean glass-stoppered glass containers reserved for the purpose and should be used or discarded within 72 hours of collection. If for any reason non-glass bottles are used, then these should be thoroughly tested before use to ensure no taste is imparted to, or removed from the sample, by the bottle.

B2.5.2 Sodium thiosulphate solution

(Approximately 0.0125M). (1 ml is equivalent to approximately 0.5 mg $C1_2$). Dissolve 3.5 g of sodium thiosulphate pentahydrate ($Na_2S_2O_3.5H_2O$) in distilled or equivalent grade water and dilute with water to 1 litre. Store in a dark glass bottle. The addition of 1 ml of this reagent will neutralise up to approximately 1 mg/1 of residual chlorine in 500 ml of sample.

B2.6 Apparatus

B2.6.1 General

It is recommended that glassware is reserved solely for TTN determinations, and when not in use is stored in a clean condition so that accidental contamination is avoided.

B2.6.2 Cleaning of Apparatus

Clean sample bottles, glasses and volumetric glassware before use by soaking thoroughly overnight in a dilute solution of a strong detergent and then rinse thoroughly with taste-free water. Detergents containing phosphates and added perfumes should not be used.

Alternatively, an automatic dishwasher supplied with water at not less than 60°C and a detergent described above may be suitable.

Sample bottles may be sterilized by autoclaving before use.

B2.6.3 Water Bath or Incubator

Capable of maintaining a temperature of 25 ± 1°C throughout the bath.

B2.6.4 Taste/Odour glasses

Tasting glasses consisting of a cup supported by a stem resting on a base are suitable. The opening of the cup should be narrower than the convex part of the cup. These glasses are available from or through good wine merchants or department stores.

The glasses specified are principally for odour evaluation which is likely to be carried out at the same time as the taste evaluation. They are designed to trap volatile components in the glass. Similar vessels or other enclosed containers may also be suitable. However, all glasses should be thoroughly tested before use to ensure they do not reduce or increase the taste of the sample.

B2.6.5 Sample bottles

Glass stoppered bottles of at least 500 ml capacity are recommended. If, for any reason non-glass bottles are used then the bottles should be thoroughly tested before use to ensure that no taste is imparted to, or removed from, the sample.

B2.6.6 Accommodation

The room in which the tests are carried out should be free from interfering odours (for example cooking, chemicals, paints, polishes, air-fresheners and room de-odorizers etc) and other distractions such as draughts, noise and the presence of onlookers.

B2.7 Sampling and sample preservation

Collect the samples in relevant clean bottles leaving no headspace (see section B2.6.5). The sample should not be de-chlorinated at the time of collection.

Samples should be kept cool and tested as quickly as possible after collection. If storage is unavoidable store in a refrigerator at 4°C. Do not store for longer than 72 hours before analysis.

B2.8 Panellists

For assessing the TTN of samples, the panel should ideally be composed of people familiar with the taste of the source to be analysed. Realistically this may not be possible where samples from many sources are being evaluated in any one particular laboratory.

The pool of panellists should consist of as many people as possible, ideally not less than twelve, who may or may not be laboratory analysts. At least three panellists are used on any one particular day. Ideally, panellists should be used at least once per week. Persons of high or low sensitivity will cause bias in the results recorded. All panellists should therefore be screened to eliminate those persons possessing high or low sensitivity. Procedures should exist for the retrospective judgement of panellists in order to assess the suitability of those persons considered for panel membership (see Appendix 1). Increasing the number of appropriate persons in the panel will enhance the reliability of the results reported.

The panellists should be free from colds or allergies that affect taste response, should not eat or smoke for a minimum period prior to the test (for example up to 1 hour), and on the day, prior to the assessment, should avoid the use of perfumes or cosmetic preparations of any kind, including scented soap for hand washing.

A panellist should not assess the taste of more than ten samples or diluted samples, together with the associated taste-free blanks, in one session without a short break. If any of the samples has a pronounced taste, a short rest period or break may be required before continuing with the tests. It has been found that the consumption of a water biscuit and/or a dilute sucrose solution both followed by a short break can speed recovery.

In addition to the panellists, a person (sometimes referred to as a diluter, co-ordinator or panel leader) is required to prepare the diluted samples, to offer them to the panellists and to record and collate the results. It is imperative that this person carries out the manipulations with respect to samples, diluted samples and taste-free blanks out of sight of panellists and should not be used as one of the taste assessors.

B2.9 Analytical procedure

Step	Procedure	Notes
B2.9.1	**Initial Testing**	
B2.9.1.1	Estimate the volume of sodium thiosulphate solution (see section B2.5.2) required to de-chlorinate the sample, note a. Add the appropriate volume (± 0.1 ml) to the sample, carefully mix and replace the stopper.	(a) This operation should be carried out on a separate portion.
B2.9.1.2	Place up to ten de-chlorinated undiluted samples in suitably labelled containers (see sections B2.6.4) in a water bath or incubator at 25°C. Include at least one sample of taste-free (blank) water (see section B2.5.1) per four test samples, subject to a minimum of at least two taste-free blanks in any batch of tests (notes b and c).	(b) The container may be the original sample bottle or a tasting glass covered with a watch glass. However, it is recommended that different panellists do not taste from the same container. Portions must be decanted from the sample bottle into individual glasses for each panellist to assess individually. (c) The samples and blanks should not be identifiable to the panellist by means of appearance or container. If samples are turbid or coloured, consideration should be given to covering all containers with aluminium foil before they are presented to the panellist.
B2.9.1.3	When the test solutions have attained 25°C, present the samples and blanks to one member of the taste panel. Ask the panellist to identify and record any solution which has a taste, note d.	(d) Solutions should be tasted by taking into the mouth whatever volume of water is comfortable, holding it for several seconds and then discharging it without swallowing, (see section B2.4). The taste should be assessed as quickly as possible, and a quick decision reached.
B2.9.1.4	Repeat step B2.9.1.3 using at least two additional panellists.	
B2.9.1.5	The results of each batch of test results for any panellist will be valid only if at least 60% of the blanks are identified as being taste-free, (see Table 1), note e. If a set of results is found to be invalid then step B2.9.1.3 should be carried out by additional panellists, note f.	(e) If blank samples are persistently identified by panellists as having a taste, then the taste-free water may not be of adequate quality (see section B2.5.1). (f) If one panellist persistently identifies the blank water as having taste then consideration must be given to removing that person from the panel (see Appendix 1).
B2.9.1.6	If a sample is identified as being taste-free by at least 60% of those panellists with valid results, then the sample is reported to have a TTN of one (see Table 2). This equates to a dilution number of zero (see B2.2).	
B2.9.1.7	If fewer than 60% of those panellists with valid results identify the test sample as being taste-free then the sample must be further tested using B2.9.2 and/or B2.9.3 (see Table 2).	
B2.9.2	**Intermediate Screening**	
B2.9.2.1	Estimate the volume of sodium thiosulphate solution (see section B2.5.2) required to de-chlorinate the sample, note a. Add the appropriate volume (± 0.1 ml) to the sample, carefully mix and replace the stopper.	(a) This operation should be carried out on a separate portion.

B2.9.2.2	Prepare a 2:1 dilution of the sample with taste-free blank water. For example, dilute 70 ± 5 ml of the test sample to 210 ± 10 ml using taste-free (blank) water (see section B2.5.1).	
B2.9.2.3	Place the following solutions in suitable glasses (see section B2.6.4) in a water bath or incubator at 25 °C and cover with a watch glass, notes b and c. A1 Blank (taste-free) water A2 Blank (taste-free) water A3 Diluted sample (see step B2.9.2.2) B1 Blank (taste-free) water B2 Blank (taste-free) water B3 Diluted sample (see step B2.9.2.2)	(b) Time will be saved if sufficient glasses for all the panellists (see section B2.9.2.6) are temperature equilibrated at one time. It is recommended that different panellists do not taste from the same container. (c) The diluted samples and blanks should not be identifiable to the panellist by means of appearance or container. If samples are turbid or coloured, consideration should be given to covering all containers with aluminium foil before they are presented to the panellist.
B2.9.2.4	Allow all the solutions to attain 25°C (15 minutes in a water bath is usually sufficient) then present in random order the three A series solutions to one member of the taste panel. Request the panellist to taste a portion of the three solutions and to record whether there is a difference in taste between any of the three solutions. If the panellist reports a difference, request which solution is different. Record the observation, notes d, e and f.	(d) Taste tests should be performed only on samples known to be safe for ingestion. No portion of any sample should be swallowed under any circumstances. (e) Pre-prepared tick sheets may be suitable for recording the observations. (f) Solutions should be tasted by taking into the mouth whatever volume of water is comfortable, holding it for several seconds and then discharging it without swallowing. The taste should be assessed as quickly as possible, and a quick decision reached.
B2.9.2.5	Repeat step B2.9.2.4 using the three B series solutions.	
B2.9.2.6	Repeat steps B2.9.2.4 and B2.9.2.5 using at least two additional panellists.	
B2.9.2.7	If the diluted sample is not identified in steps B2.9.2.4–B2.9.2.6 by any of the panellists then the sample is reported as having a threshold taste number of less than 3, notes g and h.	(g) If blank samples are persistently identified by panellists as having a taste greater than the samples then the taste-free water may not be of adequate quality, see section B2.5.1. (h) If one panellist persistently identifies the blank water as having taste then consideration should be given to removing that person from the panel (see Appendix 1).
B2.9.2.8	If at least one of the panellists has identified the diluted sample in both the A and B series, then consideration should be given to testing the sample using the procedure in section B2.9.3.	
B2.9.2.9	If the diluted sample in either series is not identified as having a taste by at least 60% of panellists, then the sample is reported to have a TTN of less than 3, (see Table 3), (see section B2.9.2.7), providing the considerations of B2.9.2.8 have not been implemented.	

B2.9.2.10 If greater than 40% of the panellists identify the diluted sample in at least one of the series, then the sample must be further tested using the procedures in section B2.9.3.

B2.9.3 Ascending and Descending Triangle Test

B2.9.3.1 Estimate the volume of sodium thiosulphate solution (see section B2.5.2) required to de-chlorinate the sample, note a. Add the appropriate volume (± 0.1 ml) to the sample, carefully mix and replace the stopper.

(a) This operation should be carried out on a separate portion.

B2.9.3.2 Prepare a series of dilutions of the test sample by diluting the appropriate volume of the sample (± 5%) to 200 ± 10 ml using taste-free (blank) water (see Table 4), notes b and c.

(b) See section B2.5.1 for the preparation of blank water.

(c) Experience may show that larger dilutions (ie solutions G and H) shown in Table 4 are rarely, if ever, required. In these cases these dilutions can be omitted and only made if required.

B2.9.3.3 Place portions of the diluted samples prepared in step B2.9.3.2 in suitable glasses, cover with a watch glass and place in a water bath or incubator at 25˚C, notes d and e.

(d) See section B2.6.4 regarding suitable glasses.

(e) Conversely, the blank and diluted samples can be temperature-equilibrated and then transferred to tasting glasses. This procedure will require more water bath or incubator capacity but will reduce temperature equilibration time. It is recommended that different panellists do not taste from the same container.

B2.9.3.4 Allow the solutions to attain 25 ˚C (15 minutes is usually sufficient for small volumes).

B2.9.3.5 Present in random order to one member of the taste panel three glasses containing respectively two blanks and the diluted sample (solution E, Table 4), note f.

(f) Since the sample is suspected of possessing a taste after examination by procedures B2.9.1 and B2.9.2, the sequence starts using solution E. The sequence can be started with an alternative dilution if required, for example if the sample is believed to have a very strong taste.

B2.9.3.6 Request the panellist to taste a portion of the three solutions and to record whether there is a difference in taste between any of the three solutions.

If the panellist reports a difference, request which solution is different. Record the observations made, see notes g, h and i.

(g) The diluted samples and blanks should not be identifiable to the panellist by means of appearance or container. If samples are turbid or coloured, consideration should be given to covering all containers with aluminium foil before they are presented to the panellist.

(h) Taste tests should be performed only on samples known to be safe for ingestion. No portion of any sample should be swallowed under any circumstances.

(i) Solutions should be tasted by taking into the mouth whatever volume of water is comfortable, holding it for several seconds and then discharging it without swallowing (see section B2.4). The taste should be assessed as quickly as possible, and a quick decision reached.

B2.9.3.7 The result is recorded as either

(i) yes – there is a difference and a taste was detected in the diluted sample. Proceed to step B2.9.3.8.

or

(ii) no – there is no difference and panellist cannot identify diluted sample. Proceed to step B2.9.3.9.

B2.9.3.8 Repeat steps B2.9.3.5 to B2.9.3.7 proceeding up the dilution series with the next most dilute sample solution in the dilution series until, either the panellist cannot identify the diluted sample, or the end of the series is reached, note j.

(j) If the end of the dilution series is reached and the diluted sample is still identified then a further more dilute series will have to be prepared. The dilutions in this further series should preferably form a geometric series.

B2.9.3.9 When the panellist cannot identify the diluted sample, repeat steps B2.9.3.5 to B2.9.3.7 proceeding down the dilution series with the next most concentrated sample solution in the sample dilution series, note k.

(k) The decision process in shown schematically in Figure 1.

B2.9.3.10 If the panellist identifies the diluted sample at this more concentrated strength re-test the solution previously presented to the panellist.

If the panellist again cannot detect the diluted sample in this series, record the threshold taste number for the sample for that panellist as $\sqrt{(V_Z \times V_Y)}$, recorded to one decimal place, where V_Z is the relevant calculation value for the more dilute solution and V_Y is the relevant calculation value of the more concentrated solution. (Table 4), note l.

If the panellist this time identifies the diluted sample, ie does not duplicate the earlier result, then revert to step B2.9.3.5 but using the next most dilute sample in the sample dilution series.

Ultimately, the situation should be reached where the panellist either has twice not identified the diluted sample at a given dilution but has identified it at a lower dilution, or has twice identified the diluted sample at a given dilution, but cannot identify it at the next highest dilution taste. In either case, the threshold taste number for the sample for that panellist is the geometric mean of the two relevant calculation values, note m.

(l) For example a panellist may detect a taste in solution E (Table 4 $V_E = 4$), fail to detect a taste in solution F ($V_F = 6$) and on re-testing again detects a taste in solution E. The result for the sample for that panellist would be $\sqrt{(4 \times 6)} = 4.9$.

(m) See Table 5 for relevant examples.

B2.9.3.11 Repeat steps B2.9.3.5 to B2.9.3.10 for at least two additional panellists.

B2.9.3.12 The overall TTN for the sample is calculated as the geometric mean of the individual panellist's results. ie $TTN_y = (T_1 \times T_2 \times T_3 \ldots\ldots \times T_y)^{1/y}$ where T_1 to T_y are the individual panellist's threshold numbers, y is the number of panellists and TTN_y is the TTN of the sample, note n. The result is rounded to the nearest whole number, note o.

(n) If the individual panellist's results for a given sample are respectively 2.4, 3.5 and 4.9, then the overall TTN for the sample would be $(2.4 \times 3.5 \times 4.9)^{1/3} = 3.45$ which is rounded off to 3.

(o) Because the number is a geometric mean, results are rounded off as shown in Table 6.

B2.9.3.13 Subtract one from the overall TTN (ie TTN_y) to obtain the dilution number for that sample, note p.

(p) Results must be quoted as dilution numbers – see section B2.2.

TABLES

Table 1 – Identification of blanks as being taste/odour-free (Methods A2.8.1 and B2.9.1)

Number of blanks in series	2	3	4	5	6	7	8
Minimum number of blanks that should be identified as possessing no taste/odour	2	2	3	3	4	5	5

Table 2 – Assigning a TTN/TON of one (Methods A2.8.1 and B2.9.1)

Number of panellists with valid results	3	4	5	6	7	8
Number of panellists who should identify a given sample as being taste/odour-free, so enabling the sample to be assigned a TTN/TON = 1	2	3	3	4	5	5

Table 3 – Assigning a TTN/TON of less than 3 (Methods A2.8.2 and B2.9.2)

Number of panellists	3	4	5	6	7	8
Minimum number of panellists who should not identify the diluted sample in either the A or B series, so assigning the sample a TTN/TON of less than 3.	2	3	3	4	5	5

Table 4 – Sample Dilution Series (Methods A2.8.3 and B2.9.3)

Solution	A	B	C	D	E	F	G	H
Relevant calculation value	–	1	2	3	4	6	8	10
Volume of sample (ml)	–	200	100	70	50	33	25	20
Volume of blank water (ml)	200	0	100	140	150	167	175	180
Total volume (ml)	200	200	200	210	200	200	200	200

Note: Solutions A, B and D may already be available.

Table 5 – TTN/TON reported for individual panellists (Methods A2.8.3 and B2.9.3)

Dilution of sample in which no taste/odour detected	Z	2	3	4	6	8	10
Dilution of sample in which a taste/odour was detected	Y	1	2	3	4	6	8
Allocated TTN/TON for that sample and panellist	$\sqrt{(Z \times Y)}$	1.4	2.4	3.5	4.9	6.9	8.9

Table 6 – Rounding off geometric mean values (Methods A2.8.3 and B2.9.3)

Value of overall threshold number (see sections A2.8.3.13 and B2.9.3.12)	Reported threshold number
0 – 1.414	1
1.415 – 2.449	2
2.450 – 3.464	3
3.465 – 4.472	4
4.473 – 5.477	5
5.478 – 6.481	6
6.482 – 7.483	7
7.484 – 8.485	8
8.486 – 9.487	9

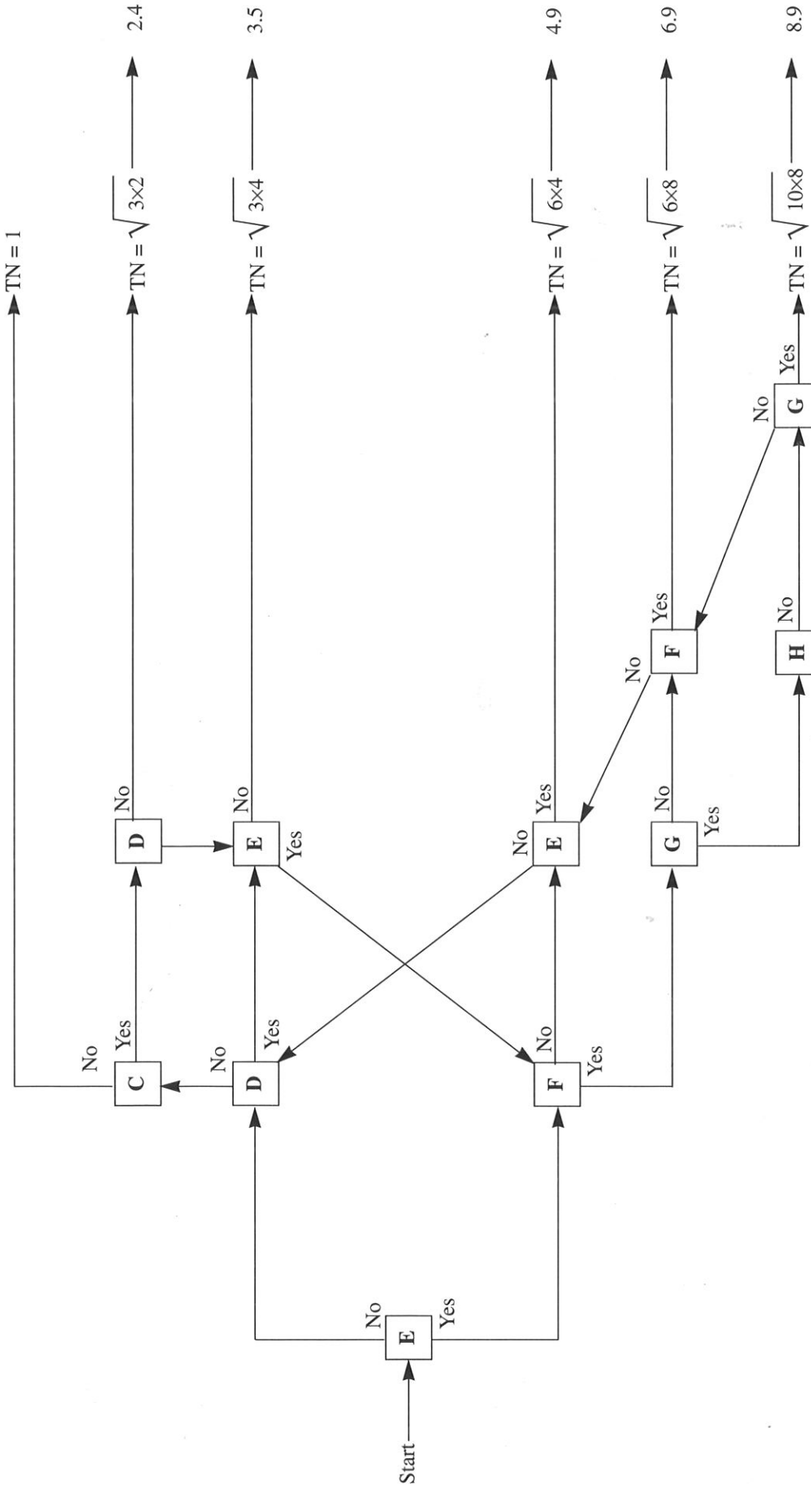


Figure 1 Measurement of threshold number by an individual panellist using ascending/descending triangular testing (sections A2.8.3 and B2.9.3)

Notes:

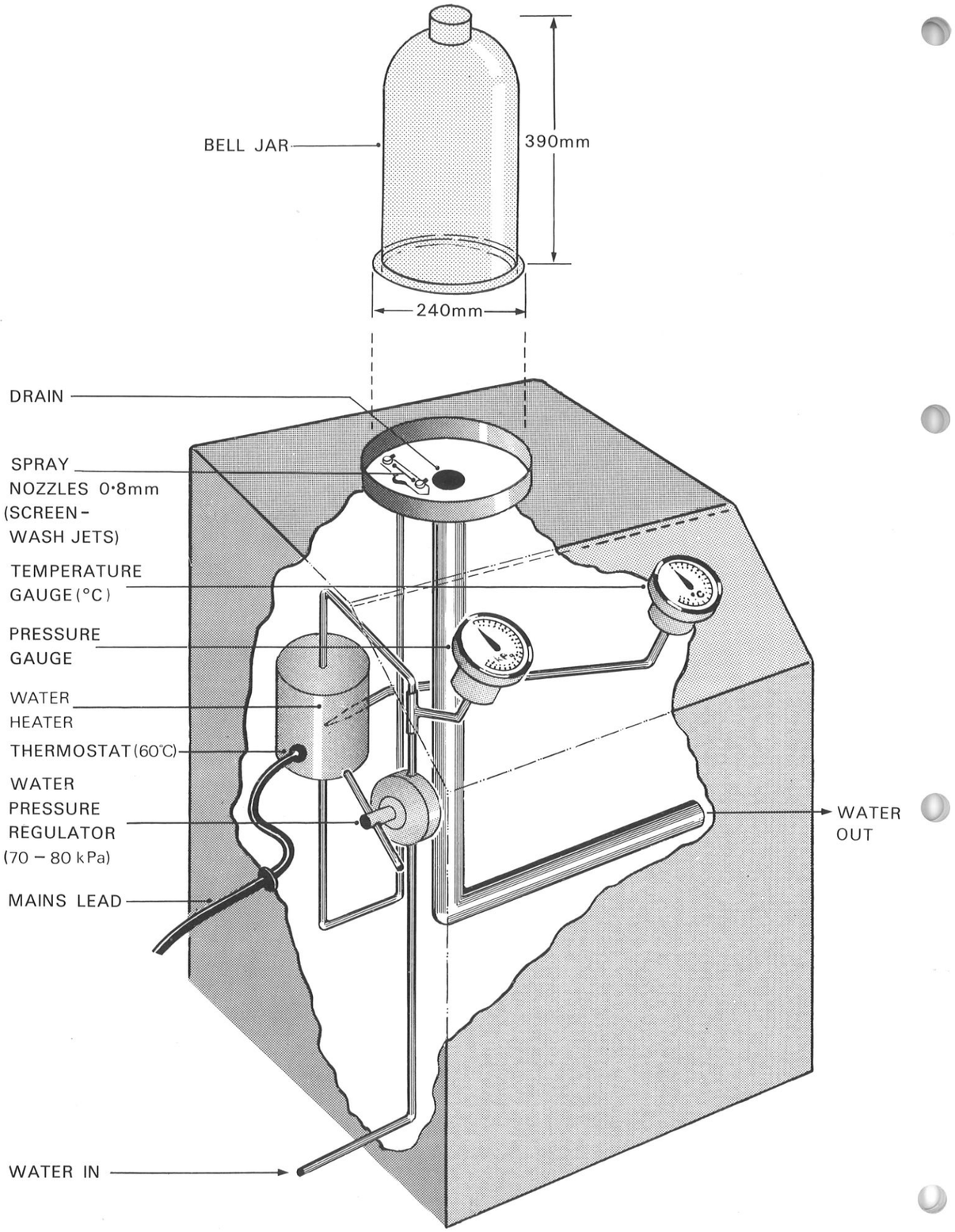
(i) Letters in boxes indicate relevant sample dilutions (see sections A2.8.3.5 and B2.9.3.5).

(ii) At each stage the panellist is requested to ascertain whether there is a difference in taste/odour.

(iii) The results of individual panel members must be combined (see sections A2.8.3.12 and B2.9.3.12).

(iv) Yes/No indicates whether a difference was discernible.

Figure 2 Cutaway view of an apparatus for the assessment of Odour — 'Smell Bell'



Appendix 1

Selection of Panellists for Taste and Odour Evaluation

1 Introduction

An example of a two stage procedure is outlined which is designed to produce a list of candidates considered acceptable as panellists for taste and odour evaluations. It is recommended that a screening system is developed for monitoring the performance of panellists with real samples by comparison of results obtained from individual panellists.

2 Self-evaluation

A list of candidates for consideration as panellists can be completed and kept as a record, (for example see Form 1). Candidates are asked, for example whether they have any allergies, possess extreme sensitivity to taste or smell, and similar questions to determine whether they can be considered suitable. Those who appear suitable have a tick (which can be dated) entered against their name, those unsuitable have a cross entered. Those candidates considered unsuitable should not be used as panellists.

Form 1

Name	Self-evaluation	Date	Screened	Date

(i) Place a tick in the self-evaluation column if a candidate does not suffer from allergies and has not admitted lack of, or excessive, sensitivity to taste and odour (ie candidate is suitable, see 2 above).
(ii) If circumstances indicate that a person is unsuitable place a cross in the relevant column and do not consider for use as a panellist.
(iii) In the screened column enter either "yes" (ie candidate passed a screening procedure) or "no" (ie candidate failed the screening procedure), (see 1 above).

3 Daily check

All candidates who are considered suitable as panellists on a long term basis should be further questioned on the day the tests are to be carried out, to determine whether they remain suitable on the day; for example whether any person considered is suffering from a cold, thus affecting their potential suitability.

A daily check-list, for example see Form 2 should be completed on a daily basis for any person proposed as a panellist. The person should be used only if the responses to the questions posed indicate that the candidate is suitable.

Ask the prospective panellist the following type of questions to ascertain if they are suitable: for example

(i) Do you have a cold or sore throat, or is there any other reason why you might be unsuitable for use in taste and odour evaluations?
(ii) In addition, at the time of testing ask whether the prospective panellist has eaten, drunk (for example alcohol) or smoked in the last hour.

Any person replying affirmatively to any of the above questions should be considered unsuitable for the panel.

Form 2

DATE	ENTER YES OR NO			COMMENTS
NAME	Q1	Q2	Q3	

Analytical Quality Control

1 Routine control

Once a method has been selected for routine use, a system of analytical quality control should be adopted in order to validate the analysis. At least one control standard should be analysed with each batch of samples and the results plotted on a control chart. Corrective action should be taken if one value falls outside of an action limit or 2 consecutive values exceed a warning limit.

2 Estimation of the accuracy of analytical results using these methods

None of the methods given in this booklet have been thoroughly investigated and before general use, the accuracy achievable should be known. It would be of great value if any laboratory using or considering the use of any of these methods would estimate the accuracy of its own analytical results and report the findings to the Secretary of the Department of the Environment's Standing Committee of Analysts.