# Parameter test distillations for the superficial essential oils

E. F. K. Denny, Denny McKenzie Associates Pty., Ltd.
Lilydale, Tasmania, Australia

In an earlier paper* this author suggested a method by which it appeared possible to calculate the through-put of a new distillery for essential oils during the planning phase if two relevant parameters were known. It was proposed that the oil from a *single* gland of an herb would form a circular surface patch when the gland bursts on contact with the steam in the distillery. This patch would have a basic area (a) and distillation would reduce its radius to nil at a rate proportional to the actual speed of the passing steam in the basic time (t) minutes; designated parameter *(t)*.

During the initial heating period at any level of the plant charge, this basic area may be increased by an amount (da) by oil from each lower layer of herb having unit thickness. Steam of similar actual speed will *then reduce the surface oil areas* at the top of a lavender charge having height (H), from (a + H.da) to nil in (T) minutes, and this is the extraction time for the charge.

The factor of increase in extraction time due to raising charge height from H to H' is given by equation 1.

$$\frac{T'}{T} = \left(\frac{a + H'.da}{a + H.da}\right)^{1/2}$$

From any two accurately timed charges of different height, the *increment parameter (x)* can be derived from equation 1 by expressing (a) in terms of (da) such that a=x.da. Then the observed results of either charge will give the value of parameter (t) from the general expression for extraction time (equation 2).

$$T = t\left(1 + \frac{H}{x}\right)^{1/2}$$

The previous paper showed a table comparing calculated extraction times with those actually observed under various conditions *in different seasons*. The present paper gives the original distillery observations for five test charges of lavender genotype "MS." The present calculations, also given in full, use a new set of entirely optional "standard conditions" and these are now the same for both the 1975 and 1976 seasons.

## Parameter tests—general method

Three or more charges of similar herb, but having different heights, are distilled with steam of similar quality under virtually ambient atmospheric pressure. *Precise two-minute fractions* of the distillate are caught in separate buckets and then allowed to settle out in separatory funnels before the volumes of water and oil in each are measured and recorded beside the time each bucket was removed from under the condenser outlet. The *mass of each charge and the* dimensions of its top layer for cross-section area are also recorded.

The progressive total of the oil produced is then graphed against the clock time and a suitable systematic curve drawn as nearly as *possible through the* points observed. This curve will be extended by estimate to indicate approximately where it would become asymptotic with the time axis, and thereby, give a figure for the total oil content of the charge. Due to the presence of plant waxes and so forth other bodies will continue to be distilled long after all valuable essential oil has been exhausted. This makes it very difficult to get a usable "estimated virtual exhaustion" (E.V.E.) figure for the oil content of the charge by continuing the distillation well beyond any *normal* end-point.

## Standard conditions

In practice it is neither possible nor necessary to ensure that all the test distillations are run under identical conditions. Oil yields, rates of flow, and even charge *cross-section areas may* have to vary between one run and another. Nonetheless, each distillation must be truly comparable with all the others. To effect this a number of "corrections" must be applied to convert the actual results observed to those that

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would have been recorded if it had been possible to conduct all the tests under identical standard conditions.

Any realistic set of conditions may be adopted as standard. In the present tests the following have been.

- Charge top cross-section area 1.026 $m^2$ for charge mass up to 310 kg.
- For larger charges a still extension is used with a top area of 1.1675 $m^2$.
- At normal density of packing a 300 kg charge is 95 cm high.
- The standard rate of distillate water flow is 3170 ml/minute.
- The standard oil content for this herb is taken at 9.09 ml/kg.
- The standard end-point is when oil production falls to 10 ml/minute.

*Determining start time of average distillate flow*

The total amount of water in all buckets except the first is divided by the time taken for it to pass. This gives the average flow rate for the distillation. The water in the first bucket is then divided by this average flow rate to get the time it should have taken to pass. The virtual start time of the distillation is then this amount of time earlier than that at which the first bucket was removed from under the condenser outlet.

*Determining clock time of end-point*

For the extraction times of all charges to be comparable they must have a common end-point when all oil patches on the top of the charge have been reduced to the same nearly negligible but none the less equal terminal radius, designated (q). Herbs of similar origin will have oil glands of similar average size so that variations in oil content may be taken as accurately reflecting the variations in the number of glands present on the top layer of the charge per unit area. To ensure that a variable number of oil patches have been reduced to the same radius (q):

$$\text{True comparable terminal oil flow} = \text{Standard flow} \times \frac{\text{Actual oil content in ml/kg}}{\text{Standard oil content}}$$

Similarly, variation in the rate of distillate waterflow affects the amount of oil delivered per minute. If this were faster than the standard rate it would result in the oil patches on the top layer of the charge being reduced below radius (q) if the appropriate correction is not made such that:

$$\text{True comparable terminal oil flow} = \text{Standard flow} \times \frac{\text{Distillate water's actual flow at end-point}}{\text{Standard distillate water flow}}$$

This true comparable oil flow can be depicted by a straight line on the graph of oil produced against clock time. The point where it makes a tangent to the curve shows the clock time of the end-point and the oil produced at that time. The time interval from the virtual start to this end-point is the extraction time under actual conditions.

*Standardising extraction time*

Assuming equal density of packaging in all charges, the rate of steam displacement will be proportional to the rate of distillate flow. Theoretical considerations have suggested that the rate at which the oil patch radii recede is proportional to the steam's rate of displacement. The actual extraction time will therefore vary inversely as the rate of distillate flow, such that:

$$\text{Comparable extraction time} = \text{Actual time} \times \frac{\text{Actual distillate water flow}}{\text{Standard water flow}}$$

Also, at any given rate of distillate flow the steam's rate of displacement inside the still is inversely proportional to the cross-section area of the charge. In the case of lavender the top layer of herb receives the greatest build-up of oil during the initial heating period and the surface oil patches at that level take the most time to shrink to radius (q). It follows that it is only necessary to consider the effect of varied cross-section area at the top of the charge such that:

$$\text{Comparable extraction time} = \text{Actual time} \times \frac{\text{Standard cross-section area}}{\text{Actual cross-section area}}$$

These two corrections convert the extraction time under actual conditions to the time that would be observed under the standard conditions.

It should be noted that, other conditions being unchanged, variations in charge cross-section area do not affect the terminal oil flow for determining end-point. The variation in the number of oil glands present on the top layer of the charge will be exactly compensated by the change in the amount of steam traversing each in unit time.

*Standardising charge height*

The build-up of oil on the top layer of the charge during the heating period, before distillate starts to flow, depends on the concentration of the oil vapour condensing onto it. In the case of lavender and other herbs of similar behaviour, each lower layer of equal oil content and specific heat may be regarded as making an equal contribution to this condensing oil. As far as charge height is concerned, the effects of variations in the herb's oil content and the variations in still cross-section area are adequately compensated if a virtual charge height is used such that:

$$\text{Comparable charge height} = \frac{\text{Estimated virtual exhaustion oil content (EVE)}}{\text{Standard oil content per unit height}}$$

It will usually be convenient to adopt one of the test charges as having a normal oil content per unit of charge height and then use this figure as the standard.

*Estimated virtual exhaustion (E.V.E.) oil content*

It is quite impossible to determine accurately the exact time that a distillation ceases to produce valuable essential oil. It is, therefore, both experimentally and operationally convenient to treat the extraction as coming to an end at a point where the rate of oil production ceases to defray the cost of operation; the so called "commercial end-point." Nonetheless, we require a working estimate of the total oil content of the charge and this can only be obtained by extending the graph of oil produced against time, and testing the various estimates till compatible figures are obtained. As both a guide to and a check on this estimation, the oil not recovered at the commercial end-point will be proportional to the herb's oil content per kilo, since the number of glands remaining at radius (q) is also proportional to this oil content.

## Parameter test procedure

- Prepare and weigh three or more differently sized charges of similar test herb. Carry out distillations catching each two-minute fraction of the distillates in a separate bucket. Tabulate times the buckets were changed and the volumes of water and oil in each (see Tables I and II). Draw graph of progressive oil produced against clock time, making a systematic curve as nearly as possible through the points observed. In cases of very uneven distillate flow it may be necessary to graph the oil produced against the water passed and adopt virtual clock times derived from the standard rate of water flow (see figs. 1 and 2). This will not normally be necessary. In the present tests, the curves nowhere depart from the observed points by more than 0.1%.
- Adopting the oil content per kilo of the midsized charge as standard for the herb under test, and using the standard distillate water flow rate to modify the actual flow around the end point, determine the comparable terminal oil flow. Draw tangent to graph and find the clock time of the end point and oil recovered as described in "Determining Clock Time of End-point," above.
- Determine average distillate water flow and virtual start time of distillation. Ascertain extraction time under actual conditions using equation 1.
- Apply corrections in "Standardising Extraction Time," above, to the actual extraction time to ob-

Table I. Parameter test distillations 1975 - lavender genotype "MS"

Distillery observations February 3, 1975

| Charge Details | CLOCK time bucket removed | WATER in fraction ml | OIL in fraction ml | PROGRESS total oil produced ml |
|---|---|---|---|---|
| No. 978/75 | 1503 | 2300 | 475 | |
| | 1505 | 5805 | 1005 | 1480 |
| Mass 301 kg | 1507 | 5900 | 545 | 2025 |
| Cross-section area $1.026 m^2$ | 1509 | 5950 | 253 | 2278 |
| | 1511 | 6045 | 144 | 2422 |
| | 1513 | 5520 | 79 | 2501 |
| Oil content at "Estimated Virtual Exhaustion" | 1515 | 5485 | 63 | 2564 |
| E.V.E. = 2736 ml oil | 1517 | 5485 | 46 | 2610 |
| | 1519 | 6130 | 36 | 2646 |
| Adopted as standard charge for oil content | 1521 | 6140 | 27 | 2673 |
| in these tests | 1523 | 6150 | 17 | 2690 |
| | 1525 | 6150 | 12 | 2702 |
| No. 979/75 | 1601 | 3990 | 575 | |
| | 1603 | 6140 | 430 | 1005 |
| Mass 175 kg | 1605 | 6275 | 180 | 1185 |
| | 1607 | 6350 | 105 | 1290 |
| Cross-section area $1.026 m^2$ | 1609 | 6360 | 66 | 1356 |
| | 1611 | 6285 | 48 | 1404 |
| E.V.E. = 1506 ml oil | 1613 | 6355 | 32 | 1436 |
| | 1615 | 6370 | 22 | 1458 |
| | 1617 | 6310 | 18 | 1476 |
| | 1619 | 6370 | 14 | 1490 |
| No. 981/75 | 1914 | 2660 | 600 | |
| | 1916 | 5060 | 1000 | 1600 |
| Mass 420 kg | 1918 | 5280 | 795 | 2395 |
| Cross-section area | 1920 | 5440 | 550 | 2945 |
| $1.1675 m^2$ | 1922 | 5550 | 420 | 3365 |
| | 1924 | 5660 | 305 | 3670 |
| E.V.E. = 4518 ml oil | | | | |
| | 1926 | 5715 | 220 | 3890 |
| | 1928 | 5760 | 155 | 4045 |
| | 1930 | 5330 | 115 | 4160 |
| | 1932 | 5875 | 94 | 4254 |
| | 1934 | 5890 | 61 | 4315 |
| | 1936 | 5945 | 52 | 4367 |
| | 1938 | 5975 | 39 | 4406 |
| | 1940 | 6010 | 33 | 4439 |
| | 1942 | 6000 | 20 | 4459 |
| | 1944 | 5990 | 19 | 4478 |

### Note on Seasonal Conditions—Table I

1975 was a year of above average rainfall and exceptionally lush growth, which led to more and heavier stalk being cut with the flowers than is normally the case. The oil content per kilo of harvested material is scarcely more than 80% of normal for this genotype.

Table II. Parameter test distillations 1976 – lavender genotype "MS"

Distillery observations January 22, 1976

| Charge Details | CLOCK time bucket removed | WATER in fraction ml | OIL in fraction ml | PROGRESS total oil produced ml |
|---|---|---|---|---|
| No. 619/76 | 1752 | 3730 | 620 | |
| | 1754 | 6160 | 550 | 1170 |
| Mass 156 kg | 1756 | 6470 | 220 | 1390 |
| Cross-section area | 1758 | 6550 | 115 | 1505 |
| $1.026m^2$ | 1800 | 6630 | 75 | 1580 |
| | 1802 | 6620 | 52 | 1632 |
| E.V.E. = 1760 ml oil | | | | |
| | 1804 | 6650 | 36 | 1668 |
| | 1806 | 6640 | 25 | 1693 |
| | 1808 | 6640 | 18 | 1711 |
| | 1810 | 6630 | 14 | 1725 |
| No. 614/76 | 1555 | 5900 | 1380 | |
| | 1557 | 6105 | 1190 | 2570 |
| Mass 473 kg | 1559 | 6840 | 1030 | 3600 |
| Cross-section area | 1601 | 6630 | 800 | 4400 |
| $1.1675m^2$ | 1603 | 6740 | 610 | 5010 |
| | 1605 | 6690 | 460 | 5470 |
| E.V.E. = 6435 ml oil | | | | |
| | 1607 | 6780 | 287 | 5757 |
| | 1609 | 6790 | 190 | 5947 |
| | 1611 | 6790 | 175 | 6072 |
| | 1613 | 6770 | 91 | 6163 |
| | 1615 | 6870 | 69 | 6232 |
| | 1617 | 6750 | 50 | 6282 |
| | 1619 | 6820 | 42 | 6324 |
| | 1621 | 6810 | 33 | 6357 |
| | 1623 | 6830 | 27 | 6384 |
| | 1625 | 6830 | 17 | 6401 |

**Note on Seasonal Conditions—Table II**

Rainfall was only just adequate in 1976 to produce a good crop of flowers. Green growth was somewhat restricted and very little stalk was cut with the flowering heads. This led to the highest yields of oil per kilo of cut material that we have ever recorded. At the same time very warm weather helped the stills to run at a much faster rate of distillate flow than was used in 1975. This gives a good opportunity to demonstrate the adaptability of the parameters for varied yields and rates of steam displacement.

Figure 1

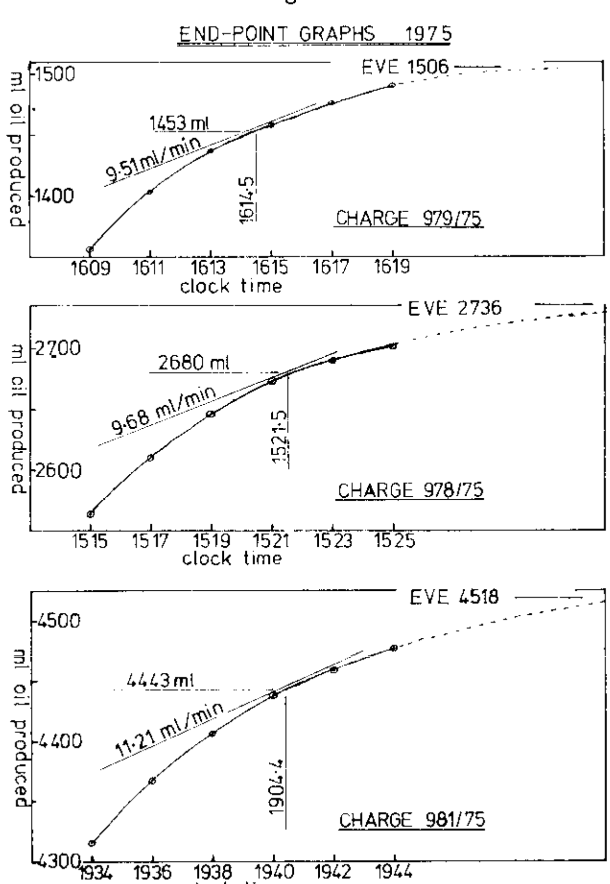


Figure 2

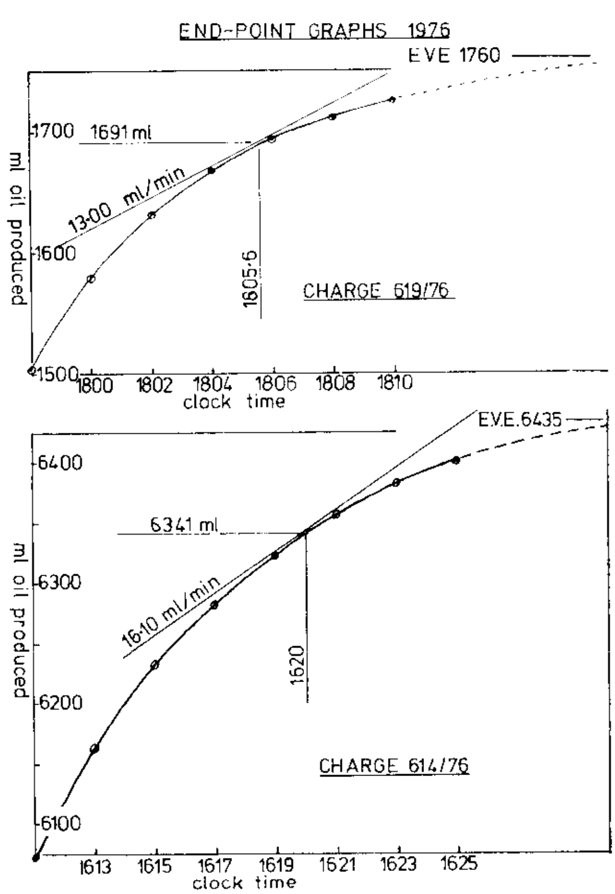

Table III. Results under standard conditions

| Charge No. | Time | Height |
|---|---|---|
| 979/75 | 14.68 min = T1 | 52.47 cm = H1 |
| 978/75 | 17.73 min = T2 | 95.32 cm = H2 |
| 981/75 | 21.43 min = T3 | 157.42 cm = H3 |
| 619/76 | 15.19 min = T4 | 61.32 cm = H4 |
| 614/76 | 24.93 min = T5 | 224.22 cm = H5 |

tain the extraction time under standard conditions. Tabulate the times under standard conditions at T1, T2, T3, and so forth (see Table III).

- Using the oil content of the midsized charge per unit of its actual height derive virtual heights for the smaller and larger charges as set out in "Standardising Charge Height," above. Tabulate these as H1, H2, H3, and so forth (see Table III).
- Using these figures for T and H from any two charges, equation 1 will allow parameter (x) to be determined by expressing (a) in terms of (da) such that a=x.da, for herb of this oil content per kilo.
- With a value for (x), and T and H taken from either of the charges used in (f), the value of parameter (t) can be found from equation 2. This will be the basic time for the test herb under the standard rate of displacement of the steam.
- Parameters (t) and (x) may now be used with equation 2 to calculate extraction times for all other charges for which virtual heights have been derived. These may be compared with the times that would have been observed under standard conditions.
- Finally, it is desirable to check that the quantity of oil abandoned by stopping distillation at the commercial end-point is proportional to the herb's oil content per kilo. If there is a wide discrepancy in this, it may be necessary to reconsider the figures for E.V.E. and recalculate both (t) and (x).
- Once the reliability of the parameters has been confirmed they can be adapted to obtain extraction times for any other stills processing herb of the same type to the same end-point even though yields and rates of steam displacement may be different. The methods of adaptation are given at the end of the worked examples.

The value of this procedure is obviously a question of cost-benefit. With two assistants, a competent operator could carry out the tests done on lavender "MS" described in this paper in one day's work in the distillery, and about three days in the office. Normally, this would be less costly than building the distillery and then finding it did not have the required handling capacity.

*Conversion of distillery observations to standard conditions*

*Charge No. 978/75* (see fig. 1) was adopted as having the oil content per kilo and per cm of charge height to be used as standard for this herb.

Standard still, area 1.026 $m^2$
Mass: 301 kg
Actual charge height: (301/300) x 95=95.32 cm
Total oil content on basis of E.V.E.: 2736 ml
Standard oil contents for this herb in all tests:
2736/301=9.09 ml/kg and
2736/95.32= 28.7 ml/cm layer
Distillate water flow in end-point region: 3069 ml/min
Terminal oil flow at end-point: 10 x (3069/3170)= 9.68 ml/min
From the graph this occurs at 1521.5 hrs
Output is 2680 ml oil
Average water flow from 1503 to 1521 is 2914 ml/min

| | |
|---|---|
| Virtual time to pass first bucket at this flow: 2300/2914 | = 0.789 min |
| Plus time from 1503 to 1521.5 | =18.500 min |
| Equals extraction time (actual conditions) | =19.289 min |
| Extraction time (standard conditions): 19.289 (2914/3170) | =17.73 min |

Virtual height=actual height (this charge only): 92.32 cm

*Charge No. 979/75* (see fig. 1)
Area 1.026 $m^2$
Mass: 175 kg
E.V.E.: 1506 ml
Oil content: 8.61 ml/kg
Water flow about end-point: 3183 ml/min
Terminal oil flow: 10 x (8.61/9.09) (3183/3170)= 9.51 ml/min
This occurs at 1614.5 hrs
Output is 1453 ml oil
Average water flow from 1601 to 1615 is 3152 ml/min

| | |
|---|---|
| Virtual time for first bucket: 3990/3152 ml/min | = 1.266 min |
| Plus time from 1601 to 1614.5 | =13.5 min |
| Equals extraction time (actual conditions) | =14.766 min |
| Extraction time (standard conditions): 14.766 (3152/3170) | =14.68 min |

Virtual height at standard oil content: 1506/28.7 =52.47 cm

*Charge No. 981/75* (see fig. 1)
Still extension, area 1.1675 $m^2$
Mass: 420 kg
E.V.E.: 4518 ml
Oil content: 10.76 ml/kg
Water flow about end-point: 3003 ml/min
Terminal oil flow: 10 x (10.76/9.09) (3003/3170)= 11.21 ml/min
This occurs at 1940.4 hrs
Output is 4443 ml oil
Average water flow from 1914 to 1940 is 2827 ml/min

| | |
|---|---|
| Virtual time for first bucket: 2660/2827 | = 0.940 min |
| Plus time from 1914 to 1940.4 | = 26.4 min |
| Equals extraction time (actual conditions) | = 27.340 min |
| Extraction time (standard conditions): 27.34 (2827/3170) (1.026/1.1675) | = 21.43 min |

Virtual height at standard oil content: 4518/28.7=157.42 cm

*Charge No. 619/76* (see fig. 2)
Area 1.026 $m^2$
Mass: 156 kg*
E.V.E.: 1760 ml
Oil content: 11.28 ml/kg
Water flow about end-point: 3320 ml/min
Terminal oil flow: 10 x (11.28/9.09) (3320/3170)= 13.00 ml/min
This occurs at 1805.6 hrs
Output is 1691 ml oil
Average water flow from 1752 to 1806 is 3266 ml/min

| | |
|---|---|
| Virtual time for first bucket: 3730/3266 | = 1.142 min |
| Plus time from 1752 to 1805.6 | =13.6 min |
| Equals extraction time (actual conditions) | =14.742 min |
| Extraction time (standard conditions): 14.742 (3266/3170) | =15.19 min |

Virtual height at standard oil content: 1760/28.7=61.32 cm

*Charge No. 614/76* (see fig. 2)
Still extension, area 1.1675 $m^2$
Mass: 473 kg
E.V.E.: 6435 ml
Oil content: 13.60 ml/kg
Water flow about end-point: 3410 ml/min
Terminal oil flow: 10 x (13.6/9.09) (3410/3170)= 16.09 ml/min
This occurs at 1620.0 hrs
Output is 6341 ml oil
Average water flow from 1555 to 1620 is 3361 ml/min

| | |
|---|---|
| Virtual time for first bucket: 5900/3361 | = 1.755 min |
| Plus time from 1555 to 1620 | =25.0 min |
| Equals extraction time (actual conditions) | =26.755 min |
| Extraction time (standard conditions): 26.755 (3361/3170) (1.026/1.1675) | =24.93 min |

*In the earlier paper the mass of this charge was incorrectly shown as 152 kg.

Virtual height at standard oil content:
6435/28.7=224.22 cm

*Deriving parameters (x) and (t)*

Use formula $\left(\frac{T2}{T1}\right)^2 = \frac{a + H2.da}{a + H1.da}$

to derive (x) from a = x.da:

$$\left(\frac{17.73}{14.68}\right)^2 = 1.4587 = \frac{a + 95.32\ da}{a + 52.47\ da}$$

x = 40.946

Use formula $t = T\left(\frac{x}{x + H}\right)^{\frac{1}{2}}$

to derive (t) from results of Charge No. 978/75

$$t = 17.73\left(\frac{40.946}{40.946 + 95.32}\right)^{\frac{1}{2}} = 9.719 \text{ mins.}$$

*First check on reliability of parameters derived*

Use equation 2 to calculate extraction times for the other charges under standard conditions, and compare these times with those actually observed under the same conditions. Find extraction time (T3) if (H3) is given as 157.42 cm as in Charge No. 981/75. Time observed was 21.43 mins.

$$T3 = 9.719\left(1 + \frac{157.42}{40.946}\right)^{\frac{1}{2}} = 21.39 \text{ min.}$$

Find (T4) if (H4) is given as 61.32 cm as in Charge No. 619/76. Time observed was 15.19 mins.

$$T4 = 9.719\left(1 + \frac{61.320}{40.946}\right)^{\frac{1}{2}} = 15.36 \text{ min.}$$

Find (T5) if (H5) is given as 224.22 cm as in Charge No. 614/76. Time observed was 24.93 mins.

$$T5 = 9.719\left(1 + \frac{224.22}{40.946}\right)^{\frac{1}{2}} = 24.73 \text{ min.}$$

*Second check on reliability of parameters*

Check that the oil abandoned in each charge (i.e. E.V.E. less oil recovered), per sq.m of top layer area, is proportional to oil content/kg (see Table IV).

## Adaptability of parameters

The extraction time (T) is inversely proportional to the rate of distillate flow and T=t.F(H/x). If the steam speed over herb surfaces is altered by a factor (c), the extraction time becomes T/c ≡ (t/c).F(H/x). It follows that extraction times for differing rates of flow may be calculated if the numerical value of parameter (t) is varied inversely as the change in the rate of displacement of the steam inside the still.

Using a virtual height to allow for variations in the herb's oil content per kilo treats charge height as being proportional to the number of layers of herb each containing the same quantity of oil as did the standard charge per unit of charge height. This is convenient in parameter tests where the value of (x) is yet to be found. In calculating extraction times for charges of known actual height, differing oil contents per kilo of herb may be allowed for by varying the numerical value of (x) inversely as the factor of change in potential yield. If the herb's oil content is expected to alter by a factor (b), the following obvious identity for extraction time will apply:

$$T = t\left(1 + \frac{b.H}{x}\right)^{1/2} \equiv t\left(1 + \frac{H}{x/b}\right)^{1/2}$$

Table IV. Second check on reliability of parameters

| | 979/75 A | 978/75 B | 981/75 C | 619/76 D | 614/76 E |
|---|---|---|---|---|---|
| Mass kg | 175 | 301 | 420 | 156 | 473 |
| E.V.E. ml oil | 1506 | 2736 | 4518 | 1760 | 6435 |
| Oil recovered ml | 1453 | 2680 | 4443 | 1691 | 6341 |
| Oil abandoned ml - gross | 53 | 56 | 75 | 69 | 94 |
| Oil abandoned ml/m$^2$ of area | 51.75 | 54.58 | 64.24 | 67.25 | 80.51 |
| Oil content ml/kg | 8.61 | 9.09 | 10.76 | 11.28 | 13.60 |
| Charges compared | A:B | B:C | A:C | D:C | C:E |
| Ratio oil loss per sq.m | 1.055 | 1.177 | 1.241 | 1.047 | 1.253 |
| Ratio oil contents per kg | 1.056 | 1.184 | 1.250 | 1.048 | 1.264 |
| | A:D | A:E | B:D | B:E | D:E |
| Ratio oil loss per sq.m | 1.300 | 1.556 | 1.232 | 1.475 | 1.197 |
| Ratio oil contents per kg | 1.310 | 1.580 | 1.241 | 1.496 | 1.206 |

The parameters cannot be adapted to terminal rates of oil flow which differ from that used when they were determined. Parameters for other chosen commercial end points can always be found by reworking from the original distillery observations using the appropriate terminal oil flow.

The parameters cannot be readily adapted to the use of steam with properties greatly different from that used in the test distillations. The earlier paper discussed very briefly the effect of saturated and super-heated steam under differing pressure, but this was from a purely academic viewpoint. The variations in the steam's moisture content, which may or may not be associated with changes in operating pressure, are very important to efficient distillation, but their effects are more or less imponderable.

## Anomalous yields

Every effort was made to ensure that the herb used in the three 1975 distillations was as similar as possible. The same applied to the 1976 season's tests. Nonetheless, the smaller charges consistently return smaller yields of oil per kilo. This is due to an orderly phenomenon that could be discussed on another occasion.