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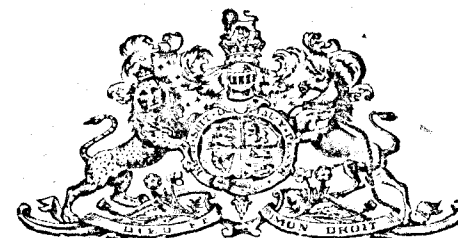
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FINAL REPORT
ON
METHODS FOR DETERMINING OBSCURATION
AT
INDIAN CUSTOM HOUSES.

BY
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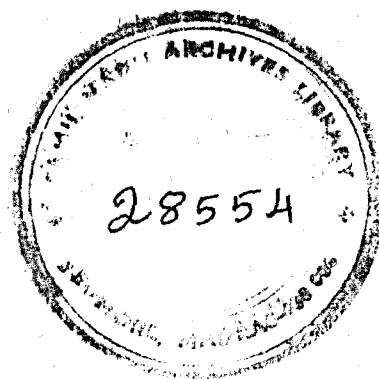


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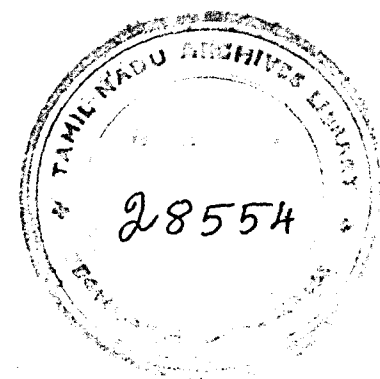
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I.
FINAL REPORT
ON
METHODS FOR DETERMINING OBSCURATION
AT
INDIAN CUSTOM HOUSES.

Terms of reference and scope of enquiry.

1. In their letters Nos. 4373—4374-Exc., dated 31st August 1910, the Government of India requested the Governments of Bengal, Bombay and Madras to arrange for a series of tests of the comparative merits of the English system of determining obscuration in imported spirits and of a method proposed by Lieutenant-Colonel Bedford in his No. 340, dated 27th April 1910, addressed to the Inspector General of Excise and Salt.

2. It was recommended that 100 samples of all sorts should be examined by the two methods at each custom house, the remnant of each sample to be retained for check analysis at this laboratory when called for. As further matters of enquiry,—

(a) tables showing the hydrometer and thermometer indications given by other samples of the same brands were requested, with a view of testing the practical revenue effects of the method of reckoning obscuration in hydrometer-degrees; and

(b) tables showing the excess strengths found (at times) in India over those stated in British customs certificates, were asked for.

Conduct of the enquiry.

3. In accordance with the above, tests were made during the months (January-February) and results were received as follows:—

	Calcutta.	Bombay.	Madras.
By English method	100 tests	100 tests	—
By Colonel Bedford's method	100 „	100 „	100 tests.
By local methods (for purposes of comparison).	14 „	100 „	100 „
Total number of results	214	300	200

4. In his No. 392, dated 11th April 1911, addressed to the Inspector General of Excise and Salt, Colonel Bedford forwarded a preliminary report based upon (a) check analyses made on a small portion of the original samples (about 10 per cent.) and (b) a critical comparison of the results as recorded and the principles underlying the various methods employed. To strengthen the evidence a short series of tests to be made in the hotter months of the year was proposed.

5. These tests were sanctioned in April and in accordance with the instructions contained in the Inspector General's No. 304, dated 19th April 1911, I prepared in bulk six typical spirits and on May 20th forwarded samples (in duplicate) to each custom house together with a copy of directions for carrying out the English method with certain added precautions considered desirable in India.

6. Under the same instructions I now enclose with this, the respective reports* in original on:—

* Not printed.

(a) the cold weather tests (100 samples at each port);

(b) the hot weather tests (6 samples at each port); and

(c) a copy of the memorandum on the English method referred to above.

Appendix V.

7. Each of the custom houses tested the samples by its own local method. These results, whilst they do not strictly come within the terms of reference, form a valuable body of work which appears in Appendix IV tabulated and criticised in a manner similar to that adopted in the body of this report.

Nature of the samples.

8. The 100 samples tested at each port in the *cold weather* were received in the ordinary course of routine examination for assessment of duty. They represent the first systematic attempt to compare actual results at different places by similar methods. No one sample, however, was known to be strictly identical with any other and the mass of figures resulting from 300 samples (each tested in two or more ways) is large and not easy to present in a simple manner.

The *hot weather* results number 54 only, but each sample is represented by 9 tests all strictly comparable amongst themselves and with the results obtained in this laboratory.

The Collector of Bombay has remarked that these hot weather samples are not representative of the samples commonly received for examination. This criticism is considered in Appendix I.

The true values of the samples.

9. The preliminary report was based upon check analyses of about 30 (10 per cent. of the total) of the cold weather samples. This number has now been brought up to about 100 (30 per cent. of the total) to afford a more suitable body of evidence. These check analyses were at first carried out by Colonel Bedford's method which gives here results closely concordant with those of the pyknometer method at 60° F., a method which requires the greatest care and knowledge even in this laboratory. The obscurations so obtained here were frequently higher than found at the ports and during the investigation of the cause of this, it was realised that what the pyknometer method, Colonel Bedford's method and all other methods attempt indirectly, can be done more simply in a *direct* manner, and with greater accuracy. Instead of determining, by methods open to grave sources of error, two spirit-strengths and taking their difference, the third missing quantity can be found by a single operation free from all the errors that occur in spirit measurement and temperature adjustment and the loss of spirit during distillation and collection. It may be safely asserted that the results of these check analyses are correct to within $\frac{1}{10}$ th of a degree proof, an accuracy unattainable by any indirect method of finding obscuration.

10. The hot weather samples were prepared in such quantity that each could be repeatedly tested; four methods may be specially mentioned.

(1) Determination of apparent and real strength by pyknometer at 60° F.

(2) Determination of apparent and real strength by pyknometer at air temperature.

The fable employed for this is similar to that used at Madras but revised and corrected in many places.

(3) Production of obscuration by adding solid cane sugar when preparing the samples and directly observing the obscuration produced on the hydrometer.

(4) Direct determination of obscuration by finding the extract-gravity in a pyknometer.

Method (3) gave the obscuration to within a few tenths by direct observation, whilst the other methods enabled the actual figure to be ascertained with the greatest possible accuracy.

Cold weather results.

11. In Appendix II the check results are tabulated against the original figures. Here they are summarised, the average differences being presented as percentages of the real obscuration. These quantities, though small, represent large money values in the course of a year, so that not only is a percentage statement legitimate but its practical bearing is realised more readily than by a statement in proof-degrees.

TABLE I.

Percentage loss of true obscuration by the English method.

	Calcutta.	Bombay.	Madras.
Brandies	12 per cent.	10 per cent.	No returns
Whiskies	56 "	19 "	"
Gins, sweetened	5 "	9 "	"
" dry	Total loss	57 "	"
Rums	18 per cent.	30 "	"

TABLE II.

Percentage loss of true obscuration by Colonel Bedford's method.

	Calcutta.	Bombay.	Madras.
Brandies	11 per cent.	26 per cent.	23 per cent.
Whiskies	23 "	Total loss	51 " (3 failures.)
Gins, sweetened	1 "	11 per cent.	2 " gain
" dry	Total loss	Total loss	Method failed.
German white spirit	...	...	6 times too high.
Arrack	...	...	Method failed.
Rums	12 per cent.	57 per cent.	2 per cent.

Hot weather results.

12. These were few in number, so the actual figures are given here.

TABLE III.

Obscuration in proof-degrees by English method at the ports, compared with true obscuration.

	Calcutta.	Bombay.	Madras.	True.
1. Brandy, 7.3 U. P.	3.8	4.1	4.1	4.3
2. Whisky, 9.7 U. P.	0.8	0.9	1.0	1.2
3. Gin, sweetened, 15.1 U. P.	8.7	8.9	9.1	8.8
4. Gin, dry, 20.0 U. P.	0.4	0.6	0.4	0.6
5. Rum, 35.7 O. P.	3.3	4.7*	3.1	3.7
6. Strong spirit, 54.5 O. P.	0.1	2.0*	10.6* } 0.7	
			9.5 }	

*Failures.

TABLE IV.

Obscuration in proof-degrees by Colonel Bedford's method at the ports, compared with true obscuration.

	Calcutta.	Bombay.	Madras.	True.
1. Brandy, 7.3 U. P.	3.8	4.8	4.4	4.3
2. Whisky, 9.7 U. P.	1.0	0.8	0.6	1.2
3. Gin, sweetened, 15.1 U. P.	8.9	9.3	9.1	8.8
4. Gin, dry, 20.0 U. P.	0.4	0.3	0.6	0.6
5. Rum, 35.7 O. P.	3.3	4.1 } 2.8		3.7
		3.6 }		
6. Strong spirit, 54.5 O. P.	0.2	0.5	0.6	0.7

Results by the English method.

13. Table III shows that very satisfactory results are obtainable even in the hot weather for under-proof spirits by the English method assisted by leading-tube and cooled receiver. For over-proof spirits the method breaks down. Of six results, three are quite defective, one being seriously too high and the other two absolute failures. The three others show a loss of about half a degree proof. The cold weather tests gave little information on this point but what there is, is in the same direction. It is obvious that any method to be adopted must be able to deal with high-strength spirits accurately and the English method clearly fails to stand this test. The reason is that by the time most of the spirit has passed into the receiver, there is insufficient water left in the still to sweep out the spirit vapour remaining in the apparatus. The whole accuracy of the obscuration results depends on this last degree or so of spirit.

14. If the water necessary for this is added, then the bulk of distillate collected exceeds the original bulk taken and the strength cannot be found without special measurements which are no part of the method.

15. On this ground alone, then, the English method is inadmissible, unless a separate and further method for dealing with high-strength spirits is also adopted, as is the case at present in the Bombay method. Examination of the cold weather results (Table I) shows that even with under-proof spirits the English method does not rise to a desirable level of accuracy. The four hot weather tests of under-proof strength doubtless received a special amount of care (owing to their small number) greater than could possibly be given in the course of ordinary routine. The cold weather samples, many in number, are a truer test of the level of accuracy attainable in ordinary work.

16. According to Table I quite serious losses ranging from 10% to over 5% of the total obscuration dealt with, would occur. The fiscal meaning of these figures is that a corresponding proportion of legitimate revenue would be sacrificed. Not only are the losses considerable but they vary seriously at different ports. At Calcutta the percentage loss of obscuration on whiskies is 56%, on rums 18%; at Bombay these proportions are reversed. One essential of any method is that it should give similar results at different places and there is little doubt that the finding that the same spirit is differently assessed for obscuration at different ports is a grievance with the importers. Adoption of the English method for under-proof spirits would not help to remove the present grievance. A control system is proposed in order to secure uniformity in results, the success of which depends on the adoption of a method that gives sharp and concordant results anywhere and is free from inherent difficulties.

17. From a customs point of view the quantity of spirit (about 250 c.c.) and from a laboratory point of view the time taken in distillation (1½ hours) are serious drawbacks to the English method and were considered valid objections to the first edition of Colonel Bedford's method.

18. The proposal to remove them by using a miniature hydrometer requiring only 100 c.c.s to float it, cannot be accepted, because the reason why good results are obtainable at all by the English method with under-proof spirit is that so large a bulk as 250 c.c. is distilled. This leaves a sufficient quantity of spirit-free water towards the end of distillation to sweep out spirit vapour from the apparatus. I am satisfied that if the amount of spirit is to be reduced the losses in distillation will be still greater.

19. The exact nature of the English method is perfectly well recognised in England. It was originally applied to wines to ascertain whether they exceeded 30° proof strength a (low) proportion of alcohol much in favour of the process. When results by it approach the figure mentioned closely, "samples are forwarded to a laboratory for exact rating by a pycnometer method (Importation Code, paragraph 350)." Up to the year 1881 the strength of brandy and rum was for the purposes of duty assumed to be that indicated by Sikes's hydrometer irrespective of the amount of solid matter which they might contain in solution. After that date a check on such obscuration was authorised chiefly to prevent it at any time becoming unreasonable in amount, not as a direct instrument for collection of increased revenue. This is clear from the method of determination.

The inexact wine method was permitted and it is applied at small ports by quite untrained men as being sufficiently exact to guard against deliberately attempted fraud. The results so obtained are checked by occasional samples sent to the London custom house. This is a check not so much on the accuracy of the results, because a rough agreement is accepted, but a check on the integrity of the officers, that is, to ensure their doing the work assigned to them.

20. This policy is entirely different to that at present adopted in India where the obscuration is regarded as a method of enhancing the revenue. The assessment is made in special laboratories for the purpose, and since the date of Colonel Warden's publication (*Estimation of Alcohol in Imported Spirits*) in 1892 these have been required to return the obscuration to the nearest tenth of a degree proof and the whole amount so found is calculated for duty. For such purpose the approximate English method has been rejected, time after time, e.g., by the Chemical Examiner to Bengal in 1892, the Chemical Analyser to Bombay, the present Deputy Abkari Commissioner, Madras, in charge of the Board's Laboratory and the Director of the Central Excise Laboratory for India.

21. The adoption of the English method now, for use in all custom houses in India, would in my opinion, without securing the uniformity of results so much desired, constitute a change in the present policy of collection, a definite and continuous loss of revenue hitherto collected, and a serious obstacle to the proposed system of control. It would necessitate increased expenditure of time and material in the laboratories and the adoption of a supplementary method for high-strength spirit.

Results by Colonel Bedford's method.

22. This method is rightly to be regarded as the English method so modified that all spirit strengths, even the highest, may be tested by it. Thus in Table IV, the high-strength obscurations are returned with a considerable degree of accuracy and of the whole series of hot weather tests, 18 in number, only three are seriously wrong. As before remarked, these tests owing to their limited number were carried out more successfully than the long series of 100 cold weather tests.

23. The evidence of these latter, however, as typical of what would happen in sustained routine work cannot be ignored. The Madras results are particularly adverse. It should be stated that practically all the samples showing notably low results at the ports were re-examined by this method and very much better results were obtained here. This possibility, however, of different operators returning such different results is a serious defect in the method just as it is a defect in the English method. The history of this method is rather curious. When first proposed, it was reported on very favourably in comparison with local methods. As a result of the tests now under report, it has been condemned by all the ports—by Madras, in comparison with the Madras local method, and by Calcutta and Bombay in comparison with the results afforded by the English method. At the former the ground of criticism is the legitimate one of accuracy, at the two latter it is merely that of apparent expediency. The facts that the results obtained both by the English and Colonel Bedford's method at Calcutta and Bombay are equally away from the truth was not realised and the preference is given to the English method owing to its freedom from calculation. No allowance is made for the fact that applicability to all strengths of spirit is secured in Colonel Bedford's method by this calculation. Such criticism therefore would have little weight if the results obtained at the ports had been of a high degree of accuracy.

24. Unfortunately such is not the case, even when allowance is made for the effect of inexperience on the part of the operators. It is certainly a substantial improvement on the English method inasmuch as it deals with high-strength spirits. In view, however, of the poor results actually obtained, and of other possibilities to be mentioned later, I am not disposed to advise the adoption of this method.

Other methods.

25. As neither of the methods under consideration satisfies the required conditions of accuracy and uniformity in result, it becomes necessary to consider other possibilities. The local methods at present in use at the ports are reviewed in Appendix IV, together with the results obtained during these tests. Briefly, the Calcutta method (Colonel Warden's) gives results which are generally too high, and the Madras method also gives results in excess of the truth. Moreover, both systems arrive at the obscuration figure by subtracting an apparent strength, found by the hydrometer, from a real strength, found by a pycnometer method, and this principle is objectionable.

26. If time allowed, which it does not, the real strength of every consignment received at the custom house should be accurately determined, under which circumstances the apparent strength and obscuration would be of no importance. I am informed that during last year about 500 tests of obscuration were carried out at Calcutta and a similar number at Bombay, on which about 3,000 consignments were passed at the former and 6,000 consignments at the latter port; that at Madras all consignments in bulk (cask) are directly tested for real strength, but only about 20% of consignments in bottles are so tested. Thus the majority of spirits received at Indian ports have to be passed

on a reading of the apparent strength by hydrometer, to which is added an obscuration result separately determined on earlier similar samples, and this system must evidently continue in force.

27. The Bombay method has been devised with a special reference to the need for an accurate obscuration-figure. Every determination is checked by a separate evaporation and weighment, in a dry state, of the solids producing the obscuration. This affords an admirable check on the accidents to which distillation and collection of spirit are liable; but the method is correspondingly lengthy and the results are uniformly below the truth. Further, no attempt is made to distil high-strength spirits (over-proof), and the results for these depend merely on the evaporation test used ordinarily as a check.

28. All the present methods determine obscuration in a tedious indirect manner and the need of a simple direct method is obvious.

The extract-gravity method.

29. With the hot weather samples this laboratory issued a request to each port to measure off (at air-temperature) a given volume of each sample, to drive off the spirit by evaporation, make up the aqueous residue to the original bulk and report the gravity (by pycnometer) of this liquid in each case together with the temperature of weighment. These gravity results were corrected to 60° F. here (in the manner of a saccharometer table) and converted to values in proof-degrees of spirit.

30. The results are shown in the following table :—

TABLE VI.

Obscuration by extract-gravity method (proof-degrees).

	Calcutta.	Bombay.	Madras.	True.	Madras repeat with own bottle.
1. Brandy	4.3	4.3	4.3	4.3	4.4
2. Whisky	1.2	1.1	1.3	1.2	1.3
3. Gin, sweetened . .	8.6	8.6	8.8	8.8	8.8
4. Gin, dry	0.6	0.6	0.5	0.6	0.6
5. Rum	3.7	3.7	3.7	3.7	3.7
6. Strong spirit . . .	0.6	0.7	0.6	0.7	...

31. These results do exhibit that accuracy and strict accordance amongst different operators which are so essential. The simplicity of the method is proved by the fact that the instructions for carrying out this new method were scarcely more lengthy than the brief description given above and were so successfully applied at the first attempt without personal instructions of the kind that was found desirable in connection with the English and Colonel Bedford's methods.

32. The time required to be spent on each sample by a trained man only amounts to a few minutes, his most important task being to weigh in a pycnometer at air-temperatures a liquid that in most cases is practically water, and to observe its temperature. The true weight at 60° F. is read from a table and the final result in proof-degrees is at once found from another table. The result is not affected by errors in reading the apparent strength, in fact an exact knowledge of that quantity is not required. All other methods demand an accurate measurement of real strength and an equally accurate determination of apparent strength.

33. By this extract-gravity method all the difficulties and delays that occur in the repeated measurement of spirit and adjustments of temperature required in other processes, the losses that occur in the distillation and collection of spirit under tropical conditions, the complicated apparatus such as distilling flasks with rubber connections, water condensers, cooled receivers, leading-tubing, etc., are swept away.

34. The principle of the method is simply this. The real and apparent strength of any obscured spirit, when expressed in terms of

gravity, differ by an amount which represents the gravity of the soluble substances causing the obscuration. If the spirit is entirely removed, and the original bulk restored by addition of water, the gravity due to these substances can be determined directly. This, owing to the liquid being water with a minute proportion of solids in solution, can be weighed with far more facility and precision than can any mixture of water with a large proportion of alcohol. This weight, found at one operation, is moreover the measure of what is actually wanted for the purpose in hand. All other methods arrive at this by finding, first of all, two other quantities (one of which presents great difficulties), and subtracting them.

35. On several occasions here one man has determined the obscuration of twelve samples in the course of a day, the time devoted in them being about two hours (an average of 5 or 6 minutes to each), thus leaving the remainder of the working day for other work of the laboratory.

36. For simplicity, rapidity and certainty of results, this extract-gravity method has in my experience overwhelming advantages over all present methods.

Apparatus required.

37. This is of an elementary description and is found for the most part in the present laboratories. Thus they all contain suitable balances, whilst the 1,000 grain pycnometer (perforated-stopper pattern without cap) is the type now used at Bombay and Madras and has been used in the past at the other laboratories. Graduated cylinders holding 100 c. c. and evaporating dishes are part of the normal stock of a laboratory as also water baths; suitable forms of the last can be readily obtained, made of galvanised iron, in the bazaar at the cost of a rupee or two. It is clear that even the pycnometer and balance can be replaced by a saccharometer at the sacrifice of a little accuracy.

B.—On the recording of obscuration in hydrometer-stem degrees instead of proof-degrees.

38. The evidence afforded by the custom houses on the practical advantage of such a change is of a very slender description for reasons which are stated by the Collector of Customs, Calcutta.

39. Only one example (No. 76 in statement B of the Calcutta cold weather report*) shows any appreciable difference resulting from the two methods.

* Not printed.

In this example the obscuration of a sweetened gin determined at 70° F., when applied at 84° F., gave a duty-strength by the proof-degrees method, 0.5 degree higher than by reckoning in stem-degrees. In the other examples—whiskies, brandies and rums—the difference is negligible.

40. The matter can be investigated by the help of Sikes's Tables and without actual records which may indeed be influenced by errors of observations. It is only necessary to suppose any apparent strength and any obscuration at any temperature. The apparent strength is looked up in the tables at a higher or a lower temperature (different by ten or twenty degrees) corrected to real strength by the supposed obscuration expressed in both systems, and the resulting obscurations at the new temperature by both methods compared. This can be done for all possible obscuration and over the whole spirit range of the tables. It is found that any obscuration determined at a lower temperature, when applied in proof-degrees at a higher, gives a slightly too high real strength, that is, the obscuration is too great and requires diminishing. Conversely, if obscuration is determined at a higher and applied in proof-degrees at a lower temperature, it is slightly too low. The fact of course is that the real strength remains constant and the change really occurs in the apparent strength. This is because it is read by a table adapted for mixture of spirit and water only, not for the presence of a third substance in notable proportions and the obscuration-figure changes its value as a consequence of its definition (*i.e.*, difference between real and apparent strength). This change in obscuration only assumes recognisable proportions when the obscuring substance is present in large amount, and even then only for a certain specially sensitive part of the spirit table.

41. For spirits above proof-strength the obscuration only varies by 1 per cent. of itself for ten degrees temperature difference. The change is therefore clearly negligible for over-proof spirits. As regards under-proof spirits, the change has its maximum value, at apparent strengths of 30 U. P. where it is about 3 per cent. of an actual obscuration of 10 proof-degrees (*i. e.*, 0.3 degree proof) for ten degrees of temperature difference. For smaller obscurations, the change is less and does not exceed 0.1 proof-degree for six proof-degrees or less of obscuration, which again is negligible.

42. Of 1,015 different brands (under-proof strength) examined for obscuration at the Bombay custom house from April 1907 to June 1910, 97 per cent. contained not more than 6 degrees proof of obscuration, being whiskies, brandies, rums, dry gins and factitious spirits of all kinds, so that the great majority of spirits are unaffected.

43. The change under discussion is only recognisable for a temperature difference of ten degrees Fahrenheit, in the case of less than 2 per cent. of the brands imported over this period. In these the error is 3 per cent. of the obscuration, or about 0.3 degree proof. Even this error disappears when this obscuration is determined at a temperature near that at which the apparent strength of later samples is read, that is, by avoiding large temperature differences. It appears inadvisable to institute a new method of recording obscuration, which is liable to confusion with the present method when under 2 per cent. of the imported brands (that is, only highly sweetened gins) are affected and these only for a certain small range of strength and under special conditions of temperature which can easily be avoided.

44. The table compiled for use with the extract-gravity method gives true obscuration for a temperature of 80° F., which is a good average temperature, and it will always be possible to arrange to read highly sweetened gins (of the particular strength affected) well within ten degrees of this temperature, whilst for other spirits even this precaution is quite unnecessary.

C.—On the excess in spirit-strength found (at times) in India over those stated in British customs certificates.

45. The evidence collected on this matter is inconsiderable, but certain main facts present themselves amongst the figures supplied—

- (a) Only 26 per cent. of the Calcutta cold weather samples and 6 per cent. of those at Bombay were supplied with certificates, whilst at Madras the proportion is not stated. Certificates would thus appear to be the exception rather than the rule, so that opportunities of disagreement arise occasionally rather than regularly.
- (b) The certificate strength given for whiskies, dry gins and some rums is undoubtedly the apparent strength. Such returns must differ from Indian strengths, which are real strengths, by firstly the actual obscuration (whatever it may be) and secondly by an amount which is due to the system adopted in England of reading the hydrometer to the next higher fifth and the thermometer to the next higher degree, a system which results in quite appreciable under-valuation of the spirit-strength.

Thus 18 of the 26 Calcutta certificates refer to the spirit of the kinds just mentioned and the invoice strengths are lower than the apparent strengths found in Calcutta by amounts ranging from 0.1 to 1.3 proof-degree with an average value of 0.7 degree.

- (c) The certificate strength in regard to brandies, sweetened gins and some rums is a real strength according to English requirements, that is, a value deliberately under-read and also subject to the errors inherent in the approximate English system for finding real strengths and which necessitate its replacement by "an exact laboratory method when an exact rating is required" (Importation Code, paragraph 150). It is thus clear that disagreements are in main due to the entirely different policies adopted in the two countries. In India an accurate determination is aimed at; in England the result is admittedly approximate and low, *e.g.*,

the small obscuration in spirits referred to under (b) is ignored, the hydrometer-strength of all spirits is under-read and the more heavily obscured spirits are returned by an approximate method.

46. This difference in policy appears to be accepted by some importers, for I was informed at Bombay that the results of that custom house are rarely called in question. Whilst the general tendency is for the British inexact strengths to be lower than the more exact Indian ratings, instances of the contrary are not wanting. Two bottled whiskies in the Madras list have invoice (apparent) strengths which, despite a distinct amount of obscuration, are higher than the real strengths determined at Madras. It is clear then that the British certificates are only general statements, and I am informed that a high degree of accuracy is never attempted, the object being to assist identification.

47. The present investigation shows, however, that whilst Bombay consistently returns obscurations somewhat below the truth, the Calcutta and Madras results are generally in excess of the truth. Noticeable differences may thus arise between assessments of one and the same spirits at different ports, and this probably represents the real force of the objections raised. Complaints at Calcutta and Madras may be understood under such circumstances. No real grounds of complaint would exist in the future if the principle is clearly laid down that duty in India is levied on the full real strength in all cases and if concordant results are secured by a method which removes the discrepancies in obscuration-figures at present existing between the results at different ports.

48. It has been shown that both the English obscuration method and Colonel Bedford's method entirely fail to do this and that the extract-gravity method alone does it with success, the reason being that by the last method the obscuring matter is determined directly independently of all the troubles connected with spirit measurement and collection, and by what is perhaps the simplest of all accurate laboratory operations, namely, the weighing of a pyknometer filled at air-temperatures with a liquid that is practically water.

49. In conclusion, it is clearly impossible to reconcile two entirely different policies, and it is unfortunate that the results obtained under them should have been brought into collision without a due appreciation of the essential fact. I am satisfied that the new method now proposed will enable the present policy in India to be continued with the fullest justice to the importers and a great saving of labour to the ports' laboratories.

General conclusions.

50. (A) The experimental facts collected in the body of the report, together with those detailed in Appendices II, III and IV, show the following defects in the present methods for determining obscuration:—

- (a) The English method and the Bombay method fail for high-strength spirits and give low results for other spirits.
- (b) Colonel Bedford's method gives low results generally and the calculation is found tedious.
- (c) The Calcutta (Colonel Warden's) method and the Madras method give high results.
- (d) All the above necessitate exact measurements of spirit, careful adjustments of temperature and the objectionable process of distillation.
- (e) The results by both Colonel Bedford's and the English method largely depend on a personal factor as shown by the different results obtained by different workers.
- (f) The extract-gravity method gives accurate results; it has no personal factor as shown by the accurate and identical results obtained by four different workers; the saving of laboratory time, laboratory space (*i.e.*, on the working bench) effected by it and the elimination of the sources of error mentioned above at (d) are signal advantages.

- (B) The practical revenue effect of recording obscuration in hydrometer stem-degrees instead of in proof-degrees is negligible.
- (C) The British customs certificates should be regarded rather as descriptive labels than as strict analytical statements.

KASALI :
The 15th September 1911. }

R. L. JENKS,
Officer in charge, Central Excise Laboratory

APPENDIX I.

ON THE CHARACTER OF THE HOT WEATHER SAMPLES ISSUED FROM THIS
LABORATORY.

Extract from the Bombay Collector's letter No. C-9231, dated 8th June 1911.

"The spirits in respect of which these tests were made are obviously not representative of the spirits which pass through the custom house in the ordinary course of trade. Samples of brandy or whisky which were sent down for test from Kasauli are not typical of the brandies and whiskies which are ordinarily imported, while dry gin should ordinarily show no obscuration, and I confess I can see no advantage in selecting, as has been done for this particular test, samples which do not represent the ordinary imports."

From the above it will be seen that the whisky and brandy and the unusually high obscuration in the dry gin are specially objected to. As regards the last, the facts are :—

Dry gins.	Spirit-strength.	Obscuration.
C. E. L. hot weather sample No. 4	20.0 U. P.	0.7 proof.
Bombay cold weather sample No. 6	28.8 U. P.	0.7 proof.
Calcutta „ No. 42	19.9 U. P.	0.0 proof.
Madras „ No. 8	18.6 U. P.	0.4 proof.

Thus the obscuration objected to is exactly that of the (only) sample of dry gin which occurs in the Bombay list of cold weather samples, and its spirit-strength agrees with that of dry gin found in the Calcutta and Madras lists.

The facts regarding the whisky and brandy objected to are similar. It was impossible to prepare a single sample representing all the variations found (in each class of spirit) not at one port only but all the ports considered together, but the utmost care was taken to adhere to figures actually found amongst the 300 cold weather samples. Among these at least a dozen each of the whiskies and brandies agree quite closely as regards both spirit-strength and amount of obscuration (and nothing else matters) with the test samples issued by this laboratory, and a large number agree in one or the other particular. Thus a special effort was made to issue samples representative of what is received at all the ports. The objection now under reference, moreover, is invalid on wider grounds. Any method, worth consideration, must return correctly not only normal spirit-strengths and obscuration-values but abnormal values which by accident or design may and do occur from time to time.

APPENDIX II.

Cold weather obscuration results by the English method at the ports compared with the true results.

No.	Calcutta.	True.	No.	Bombay.	True.
(25 U. P. to Proof.)			(15 U. P. to 25 U. P.)		
<i>Brandies.</i>			<i>Brandies.</i>		
3	0.2	0.5	13	6.9	5.9
14	0.2	0.6	18	0.5	1.4
17	0.2	0.5	28	0.55	0.9
21	2.1	4.3	29	4.7	4.7
44	3.8	5.5	31	0.0	0.3
70	6.3	5.9	37	3.7	5.0
75	5.3	5.2			
87	3.8	3.9			
88	3.8	4.0			

Average loss 10 per cent.

Average loss 12 per cent.

(25 U. P. to 5 O. P.)			(20 U. P. to Proof.)		
<i>Whiskies.</i>			<i>Whiskies.</i>		
9	0.0	0.2	1	0.4	0.3
18	0.0	0.1	9	0.0	0.3
20	0.0	0.3	16	0.6	0.7
24	0.9	0.7	17	0.7	0.8
28	0.2	0.3			
33	0.0	0.5			
82	0.0	0.3			
89	0.2	0.5			
91	0.3	0.6	7	0.5	0.2
22	0.1	0.4			

Average loss 19 per cent.

High result.

Average loss 56 per cent.

(30 U. P. to 15 U. P.)			(30 U. P.)		
<i>Gins.</i>			<i>Gins.</i>		
26	9.3	10.1	4	6.7	8.6
63	9.8	10.2	5	12.0	12.1
65	7.6	8.0	7	6.7	7.1
76	8.4	8.6			

Average loss 5 per cent.

Average loss 9 per cent.

<i>Dry gins.</i>		
4	0.0	0.3
42	0.0	0.2
74	0.0	0.1

Total loss.

(14 U. P. to 35 O. P.)

<i>Rums.</i>		
77	1.6	1.5
96	0.7	1.3
97	1.1	1.3
98	0.8	1.0
99	1.2	1.5
100	0.9	1.1

Average loss 18 per cent.

<i>Dry gins.</i>		
6	0.6	1.4

Loss 57 per cent.

(25 U. P. to 15 U. P.)		
<i>Rums.</i>		
1	2.3	1.4
High result.		
6	0.7	1.0
8	0.7	1.1

Average loss 30 per cent.

Madras.—No returns by this method.

APPENDIX III.

Cold weather obscuration results by Colonel Bedford's method at the ports compared with the true results.

No.	Calcutta.	True.
<i>Brandies.</i>		
3	0.2	0.5
14	0.2	0.6
17	0.2	0.5
21	2.5	4.3
44	4.0	5.6
70	6.5	5.9
75	5.8	5.2
87	3.8	3.9
88	3.9	4.0
Average loss 11 per cent.		
<i>Whiskies.</i>		
9	0.0	0.2
18	0.2	0.1
20	0.0	0.3
24	1.1	0.7
28	0.2	0.3
33	0.2	0.5
82	0.0	0.3
89	0.3	0.5
91	0.5	0.6
92	0.3	0.4
95	1.6	1.8
Average loss 23 per cent.		
<i>Gins.</i>		
26	9.3	10.1
63	10.2	10.2
65	8.0	8.0
76	9.0	8.6
Average loss 1 per cent.		
<i>Dry gins.</i>		
4	0.0	0.3
42	0.0	0.2
74	0.0	0.1
Total loss.		
<i>Rums.</i>		
77	1.6	1.5
96	1.0	1.3
97	1.2	1.3
98	0.8	1.0
99	1.3	1.5
100	1.0	1.2
Average loss 12 per cent.		

Results by Colonel Bedford's method at the ports—contd.

No.	Bombay.	True.
<i>Brandies.</i>		
13	6.1	5.9
18	0.0	1.4
28	0.0	0.9
29	4.1	4.7
31	0.0	0.3
37	3.2	5.0
Average loss 26 per cent.		
<i>Whiskies.</i>		
1	0.0	0.3
7	0.2	0.2
9	0.0	0.3
16	0.0	0.7
17	0.0	0.8
Average loss 91 per cent.		
<i>Gins.</i>		
4	5.9	8.6
5	12.2	12.1
7	6.6	7.1
Average loss 11 per cent.		
<i>Dry Gins.</i>		
6	0.0	1.4
Total loss.		
<i>Rums.</i>		
1	1.5	1.4
6	0.0	1.0
8	0.0	1.1
Average loss 57 per cent.		

Results by Colonel Bedford's method at the ports—concl'd.

No.	Madras.	True.
	<i>Brandies.</i>	
9	0.2	0.5
10	3.5	4.2
18	0.5	0.8
28	3.3	3.7
36	1.1	2.4
37	1.1	2.2
38	1.4	2.3
39	1.4	2.3
49	6.1	6.7
57	0.0	0.5
62	4.0	5.0
64	0.5	0.6
92	0.2	0.5

Average loss 23 per cent.

	<i>Whiskies.</i>	
5	0.6	0.8
7	0.5	0.7
35	0.0	0.9
43	0.0	0.5
52	0.3	0.3
61	0.2	0.4
77	0.3	0.3

Average loss 51 per cent.

24	—0.2	0.5
68	—0.1	0.4
81	—0.2	0.4

Failure.

	<i>Gins.</i>	
42	7.7	7.9
53	10.3	10.0
56	9.4	9.0

Average gain 2 per cent.

	<i>Dry gins.</i>	
8	—0.2	0.1
72	—0.4	0.2

Total failure.

	<i>Rums.</i>	
4	2.1	2.7
14	2.0	2.1
15	2.3	1.7

Average loss 2 per cent.

	<i>German white spirit.</i>	
86	0.8	0.0
87	0.7	0.0
88	0.4	0.3
89	0.5	0.0
90	0.5	0.2

Six times too high.

	<i>Arrack.</i>	
13	—0.1	0.5
33	—0.2	0.1

Total failure.

APPENDIX IV.

THE RESULTS BY PRESENT METHODS IN USE AT CALCUTTA, BOMBAY AND MADRAS.

A.—The Calcutta method.

The method hitherto used is that elaborated by Lieutenant-Colonel Warden in his "Rules for the estimation of Alcohol in Imported Spirits (1892)." As the title and an examination of the work show, this was designed to find real strengths. No method of finding the apparent strength is laid down, nor is the word obscuration mentioned. In the absence of directions, the apparent strength used has been that found by Sikes's hydrometer, and the obscuration-figure thus depends on the use of two dissimilar methods which is objectionable in principle. The method, as regards finding real strength, has inherent fallacies and very great practical difficulties in a tropical climate. Two volumes of distillate are collected from every volume of sample distilled. This is to permit of high-strength spirits being determined, but it is in direct conflict with a principle stated at some length in the work, namely, that the distillate may be adjusted at air-temperature (instead of the standard 60°F.) *as long as its volume is the same* as that of the sample. The collection of two volumes of distillate introduces a dilatation error (for which no provision is made) and also emphasises certain inaccuracies in the spirit tables employed. The gravity of the spirit is found in a pyknometer filled at 60°F. This involves special cooling for filling and a special cap to retain the excess volume consequent on the return of the spirit to its air-temperature, a necessary condition for weighing. The whole process is unduly troublesome and tedious, and duplicate results which agree are difficult of attainment even by an experienced worker. The following figures illustrate the kind of results obtained:—

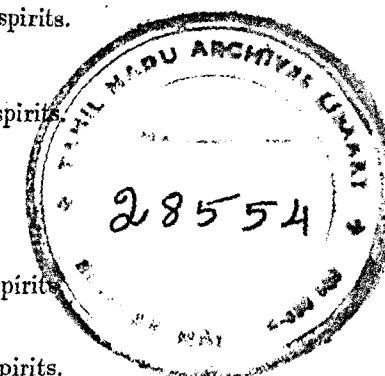
Results by Calcutta method for obscuration.

Cold weather tests.	By Warden's method.	True.	
No.			
18	0.9	0.1	} U. P. spirits.
28	0.8	0.3	
33	1.1	0.5	
91	0.4	0.6	} O. P. spirits.
92	1.0	0.4	
97	1.4	1.3	
99	1.1	1.5	
Hot weather tests.			
1	5.6	4.3	} U. P. spirits.
2	1.1	1.2	
3	9.2	8.8	
4	1.5	0.6	} O. P. spirits.
5	4.8	3.7	
6	1.0	0.7	

The inaccuracy of the results, specially the large proportion of excess values amongst under-proof spirits, condemns the method, whilst its practical difficulties are such that a different method is urgently desired.

B.—The Bombay method.

The Bombay method is a true (though indirect) obscuration method, inasmuch as the apparent strength is obtained by a method similar to that used for the real strength and of equal accuracy. Moreover, the results are controlled by a weighing of the solid matter causing the obscuration, the weight so obtained being interpreted on the principle that 0.5 per cent. of solids is equivalent to 1 degree proof obscuration. Over-proof spirits are not distilled as the resulting loss of spirit is generally greater than any obscuration present. The actual obscuration of these is calculated from the solids by the above rule which is a very approximate one. Of the under-proof spirits which are



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N12-

distilled (except when the solids amount to less than 0.1 per cent.), one volume of distillate is collected from one volume of sample. The gravity of the distillate and consequent real strength of the sample is found by weighment in a pyknometer filled at air-temperature which eliminates the troubles of spirit expansion and deposition of dew. The gravity so found is translated into proof-terms by the help of the specific gravity table at the end of Sikes's Tables. The apparent strength of the sample (*i.e.*, before distillation) is found in a similar manner by weighment in a pyknometer at air-temperature. The amount of sample distilled is only 100 c. c. which suffices to fill a 1,000-grain bottle instead of the 250 c. c. required to float a glass hydrometer, so that distillation is shorter. In principle, the method, apart from high-strength spirits, is an improved English method and it yields similar results, that is, losses, as the table shows.

Results by Bombay method for obscuration.

SAMPLE NUMBER. Cold weather tests.	OBSCURATION. Bombay method.	True.
<i>Brandies.</i>		
13	7.5*	5.9
18	0.6	1.4
28	0.5	0.9
29	4.9	4.7
31	0.0	0.3
37	3.9	5.0
19 per cent. loss.		
<i>Whiskies.</i>		
1	0.3	0.3
7	0.3	0.2
9	0.0	0.3
16	0.8	0.7
17	0.7	0.8
9 per cent. loss.		
<i>Gins, sweetened.</i>		
4	6.8	8.6
5	12.2	12.1
7	7.3	7.1
6 per cent. loss.		
<i>Dry gin.</i>		
6	0.7	1.4
50 per cent. loss.		
<i>Rums.</i>		
1	2.1*	1.4
6	0.7	1.0
8	0.7	1.0
30 per cent. loss.		

Hot weather tests.

1	4.2	4.2	} U. P. spirits.
2	1.0	1.2	
3	9.0	8.8	
4	0.7	0.6	
5	3.4	3.7	} O. P. spirits.
6	{ -1.65 } { +0.05 }	0.7	

* Excess results excluded from average.

Thus the result of the long-continued routine tests in the cold weather are quite similar in kind to those obtained (at Bombay) on the same samples by the English method, namely, general losses arising in the distillation and collection of the spirit. It will be observed that very good results indeed can be obtained, *i.e.*, loss in distillation, given time and care, can be obviated as shown by the hot weather tests above. This is the experience of this laboratory with the English method, but it is found that the time and care required make an unwarrantable demand upon the laboratory staff and no certainty is assured except by a duplicate analysis. In all indirect (distillation) methods the handling of the distillate affords no clue to the amount of obscuring material eliminated, whilst a direct method, such as the extract-gravity method, brings the material directly under notice in such a way that its amount can be roughly estimated (whether high or low) and the gravity figure shows at once that the amount must lie within certain distinct and narrow limits. In the Bombay method, apart from questions of accuracy of result, a trained operator has to make three separate weighments on each sample instead of the single one required by the extract-gravity method.

C.—The Madras method.

This method resembles that used at Calcutta (Warden's) inasmuch as attention is concentrated on the real strength of the spirit found by a pyknometer, the apparent strength being found by the hydrometer and the obscuration by subtracting the two quantities. In other words, it is not only an indirect method but also a "mixed" method. Over-proof spirits are diluted so as to collect two volumes of distillate from one of sample, and as the adjustments are made at air-temperature, the dilatation error of Colonel Warden's method must occur in this. This is what Colonel Bedford meant by saying in his interim report that "the correction-table cannot at the same time serve for undiluted as well as for diluted distillates." Of under-proof spirits, one volume of distillate is collected from one of sample, so that the general losses, shown as occurring during distillation in the English and Bombay methods, must also exist in the ordinary routine testing of under-proof spirits at Madras, although exceptional care and trouble and duplication of tests will practically eliminate these as already stated. The real strength of the distillate is found by a pyknometer filled not at 60°F. but at air-temperature. This avoids the difficulties of spirit expansion and deposition of dew, but a table has to be used to correct such weighings to their true value at 60°F. It is obvious that everything turns upon the accuracy of this correction-table and much time has been spent here over its examination. The table proves to be identical with that given in a briefer form by Liversidge (Analyst, 1897, page 153) who clearly contemplated corrections for temperatures only a few degrees removed from 60°F. For the purposes of the Madras laboratory, these corrections, per 1°F. of temperature, have been multiplied by factors as large as 20 and 30 to supply corrections for weighments at 80°F. to 90°F. The corrections for high-strength spirits more or less stand such multiplication but those for low-strength spirits do not. In view of the general usefulness for other purposes of such a table when correct and in order to understand the Madras results, it has been found necessary to investigate the matter and to compile a full and correct table. Contrary to expectation, however, the Madras obscuration-figures are usually in excess of the truth.

Results by Madras method for obscuration.

SAMPLE NUMBER. Cold weather tests.	OBSCURATION. Madras method.	True.
<i>Brandies.</i>		
9	1.2	0.5
10	4.5	4.2
18	1.7	0.8
35	4.3	3.7
36	2.3	2.4
37	2.4	2.2
38	2.3	2.2
39	2.4	2.3

Results by Madras method for obscuration—concl'd.

SAMPLE NUMBER. Obscuration.
Cold weather tests. Madras method. True.

Brandies—concl'd.

49	6.6	6.7
57	0.9	0.5
62	6.2	5.1
64	1.6	0.6
92	1.0	0.5

18 per cent. gain.

Whiskies.

5	1.1	0.8
7	1.3	0.7
24	0.2	0.5
35	0.5	0.9
43	0.5	0.5
52	0.5	0.3
66	1.0	0.4
68	0.2	0.4
77	0.7	0.3
81	1.0	0.4

35 per cent. gain.

Gins.

42	8.1	7.9
53	11.0	10.0
56	9.7	9.0
58	0.4	0.1
72	0.3	0.2

8 per cent. gain.

4	3.0	2.7
14	2.2	2.1
15	3.0	1.7
50	1.8	2.2
70	0.7	2.2

Irregular.

German white (high-strength) spirit.

86	1.3	0.0
87	1.4	0.0
88	1.4	0.3
89	1.3	0.0
90	1.3	0.2

13 fold result.

Arracks.

13	0.4	0.5
33	0.1	0.1

Agreement.

Hot weather tests.

1	4.8	4.3
2	1.4	1.2
3	9.5	8.3
4	0.6	0.6
5	3.4	3.7
6	0.5	0.7

I am unable to explain the extraordinary results for high-strength German spirit Nos. 86, 87 and 89 returned as containing 1.3, 1.4 and 1.3 proof-degrees

of obscuration due to sugar. These were specially examined here with the following results:—

- (a) The maximum residue, probably traces of insoluble matter, was under 0.01 per cent. corresponding by the approximate rule to less than 0.02 of a degree proof obscuration; (b) this did not reduce Fehling's solution; and (c) when treated with water, a liquid of exactly 1,000 gravity was obtained.

In conclusion, it is clear from a survey of the three methods that the same brandy might be brought into Bombay and Madras and have its obscuration under-estimated at the former port by 20 per cent. and over-estimated by a similar amount at the latter. An importer observing a difference of about 1.5 degrees proof would naturally consider he had cause for complaint.

This instance illustrates the need for a system which returns obscuration-figures at different ports with variations of not more than 0.2 or 0.3 proof-degree between any two results on the same spirit.

The preliminary trial given to the extract-gravity method (*vide* paragraph 30 in main report) shows that the new method is readily capable of this, apart from its superior rapidity and simplicity.

APPENDIX V.

Note on the English method of testing spirits for obscuration in India by the Sikes's hydrometer before and after distillation according to the system given in "Gauging Instructions", paragraph 86, modified by the use of Colonel Bedford's leading-tube and water-seal during distillation and his revised Sikes's Tables throughout.

(1) *Quantity*.—Ascertain the minimum amount of spirit required to float (at each and every reading on its stem) one of the spindles forming the glass 5-part hydrometer selected for this work. Probably 250 c. c. will suffice and a flask marked to hold 250 c. c. at 60° F. (or 15.5° C.) will be in the laboratory. Some spindles require rather more spirit and it may be necessary to specially mark a suitable glass flask for the purpose of this work.

(2) Find the apparent or hydrometer strength of the sample by means of the glass hydrometer and thermometer in the usual manner.

(3) Rinse out the flask referred to in (1) with a little of the spirit (unless it is known to be absolutely clean and dry) and then fill carefully to the mark noting the temperature (T°). If the temperature happens to be a half degree, the flask should be slightly warmed or cooled until the thermometer, when placed in the spirit, stands at a whole degree.

(4) Transfer the contents of the measuring-flask into the distillation-flask, washing it out with a minute quantity of water, these washings to go into the distillation-flask [see note to (7)].

(5) Use the measuring-flask as a receiver by passing the glass leading-tube attached to the condenser into it so as to touch the bottom of the flask and add just sufficient water to the receiver to cover the point of the leading-tube, thus making a water-seal [see note to (7) and directions for Colonel Bedford's method].

(6) Affix the distillation-flask to the condenser tightly and distil with a small flame.

NOTE.—A fragment of ignited pumice may be placed in the distillation-flask to assist regularity of boiling and also 1 c. c. of 1 per cent. alkali solution to fix the acidity.

(7) Distil slowly until the distillate reaches to within a quarter of an inch or so from the mark on the neck of the receiver; the position of the receiver must be adjusted from time to time, so that the leading-tube is never immersed more than $\frac{1}{2}$ inch in the distillate and towards the end of distillation is above the surface of the distillate.

NOTE.—If the washings used in (4) and the water-seal in (5) are both very small, it may not be possible to distil quite so far as here described without so far reducing the contents of the distillation-flask that its floor becomes dry and cracks. On the other hand, if the washing and water-seal are too large in quantity, spirit may be left in the distillation-flask. As a guide, not more than about 3.5 c. c. should be used in (4) and (5) each.

(8) Wash the outside of the leading-tube into the receiver with a few drops of water, remove the receiver from the still, agitate its contents to attain a uniform mixture, observe its temperature and adjust this by cooling the outside of the flask until it is the same as in (3), that is, T° . Rinse the thermometer into the receiver with a few drops of water (at T°) and then add water drop by drop until the line mark is reached.

NOTE.—If the receiver is set on a dish containing water or sometimes even particles of ice, it will be found that less time is required in adjusting the temperature of the distillate to T° .

(9) Pour the distillate into the trial jar used in (2) and read its strength by the glass hydrometer.

(10) The difference between the proof-strengths found in (9) and (2) is the obscuration in proof-degrees.

R. L. JENKS,

Officer in charge, Central Excise Laboratory.

KASALI;
The 15th May 1911.

APPENDIX VI.

Directions for conducting the extract-gravity method of determining obscuration.

A. Measure off at air-temperature 100 c. c. of the spirit in a marked flask or cylinder.

B. Transfer this to a dish (about 4½ inches diameter of glass or porcelain) and evaporate it down on a water-bath to about 10 c. c. Add 20 c. c. of water and continue evaporation for about a quarter of an hour. Never evaporate to dryness.

C. Add distilled water and return the whole to the measuring vessel, rubbing loose any deposit with a rubber-tipped glass rod; make up to the original volume, disregarding the temperature, and mix thoroughly. (Small traces of insoluble flocculent matter may be neglected.)

D. Fill a pyknometer (holding 1,000 grains of distilled water at 60°F. and of the perforated stopper pattern without cap) with this liquid and weigh to the second decimal place in grains, carefully recording the actual temperature of the liquid to 1/5°F.

E. Correct this gravity to gravity at 60°F. by Table I and find the obscuration by reference to Table II.

NOTES.—Table II gives obscuration in proof-degrees for the great majority (about 96 per cent.) of potable imported spirits. For sweetened gins and other high obscurations, use Table III, interpolating where necessary.

Table I should also be used for adjusting the pyknometer to its true content at 60°F.

Details requiring little or no attention.

Measurement in A.—This need not be closer than $\frac{1}{2}$ c. c. and the vessel need not be washed out into the evaporation dish, draining being sufficient; it may then be at once used to measure another sample. Sweetened gins, however, and other highly obscured spirits should be washed out and treated more carefully.

Measurement at C.—The vessel need not be dry, but it must be free from spirit; the adjustment of volume here also need not be scrupulously exact. In dealing with several samples, it is convenient to at once pour these aqueous extracts each into a beaker as its bulk is made up. For this purpose again the vessel need not be washed unless a sweetened gin has been dealt with.

TABLE I.

To find the true gravity at 60° F. from the weight at higher temperatures when a pycnometer holding 1,000 grains of distilled water at 60° F. is used.

Temperature F°.	Weight in grains of the aqueous extract.							Temperature F°.
	990	995	1,000	1,005	1,010	1,015	1,020	
70°	1.00	0.94	0.88	0.89	0.90	0.91	0.93	70°
71°	1.12	1.06	1.00	1.01	1.03	1.04	1.06	71°
72°	1.24	1.19	1.13	1.15	1.16	1.18	1.20	72°
73°	1.36	1.31	1.26	1.28	1.30	1.32	1.34	73°
74°	1.48	1.43	1.38	1.40	1.43	1.46	1.48	74°
75°	1.60	1.56	1.51	1.54	1.57	1.60	1.63	75°
76°	1.74	1.69	1.64	1.67	1.71	1.74	1.77	76°
77°	1.87	1.82	1.78	1.81	1.85	1.88	1.91	77°
78°	2.01	1.96	1.92	1.95	1.99	2.02	2.05	78°
79°	2.14	2.10	2.06	2.09	2.12	2.16	2.19	79°
80°	2.27	2.23	2.20	2.23	2.27	2.30	2.33	80°
81°	2.42	2.38	2.35	2.38	2.42	2.45	2.49	81°
82°	2.56	2.52	2.49	2.53	2.57	2.61	2.65	82°
83°	2.70	2.67	2.64	2.68	2.73	2.77	2.81	83°
84°	2.84	2.81	2.78	2.83	2.88	2.92	2.97	84°
85°	2.98	2.95	2.92	2.98	3.03	3.08	3.13	85°
86°	3.15	3.12	3.09	3.14	3.19	3.24	3.29	86°
87°	3.31	3.28	3.25	3.30	3.35	3.41	3.45	87°
88°	3.48	3.44	3.41	3.46	3.51	3.56	3.61	88°
89°	3.64	3.60	3.57	3.62	3.67	3.72	3.77	89°
90°	3.80	3.76	3.72	3.77	3.83	3.88	3.93	90°
91°	3.97	3.92	3.88	3.94	4.00	4.06	4.12	91°
92°	4.13	4.09	4.05	4.12	4.18	4.25	4.31	92°
93°	4.30	4.26	4.22	4.29	4.36	4.43	4.50	93°
94°	4.46	4.42	4.38	4.45	4.54	4.63	4.69	94°
95°	4.63	4.59	4.55	4.63	4.72	4.80	4.88	95°
96°	4.81	4.78	4.75	4.83	4.91	4.99	5.07	96°
97°	5.00	4.97	4.94	5.02	5.10	5.18	5.26	97°
98°	5.19	5.16	5.13	5.21	5.29	5.37	5.45	98°
99°	5.38	5.35	5.33	5.40	5.48	5.57	5.64	99°
100°	5.57	5.54	5.52	5.59	5.67	5.75	5.83	100°

NOTE.—These correction figures represent grains to be added to the actual weight found, according to the temperature of filling and the vertical column to which the actual weight found nearest belongs. The corrected weight is the gravity at 60° F.

TABLE II.

For directly finding the obscuration in potable spirits (other than sweetened gin) from the extract-gravity at 60° F.

Extract-gravity at 60° F.	APPARENT STRENGTH BY HYDROMETER.								Extract-gravity at 60° F.
	U. P. 9	U. P. 12	U. P. 15	U. P. 18	U. P. 21	U. P. 24	U. P. 27	U. P. 30	
	Obscuration in proof-degrees.								
1,000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,000.0
.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	.2
.4	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	.4
.6	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.7	.6
.8	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.9	.8
1.0	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.0
.2	1.0	1.0	1.0	1.1	1.1	1.2	1.2	1.3	.2
.4	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.5	.4
.6	1.3	1.3	1.3	1.4	1.4	1.5	1.6	1.7	.6
.8	1.4	1.5	1.5	1.6	1.6	1.7	1.8	1.9	.8
2.0	1.6	1.7	1.7	1.8	1.8	1.9	2.0	2.1	2.0
.2	1.7	1.8	1.9	2.0	2.0	2.1	2.2	2.3	.2
.4	1.9	2.0	2.0	2.1	2.1	2.2	2.3	2.4	.4
.6	2.0	2.1	2.2	2.3	2.3	2.4	2.5	2.6	.6
.8	2.2	2.3	2.3	2.4	2.5	2.6	2.7	2.8	.8
3.0	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.0
.2	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	.2
.4	2.6	2.7	2.8	2.9	3.0	3.2	3.3	3.4	.4
.6	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	.6
.8	2.9	3.0	3.1	3.2	3.3	3.5	3.6	3.7	.8
4.0	3.1	3.2	3.3	3.4	3.5	3.7	3.8	3.9	4.0
.2	3.3	3.4	3.5	3.6	3.7	3.9	4.0	4.1	.2
.4	3.4	3.5	3.6	3.7	3.8	4.0	4.2	4.3	.4
.6	3.6	3.7	3.8	3.9	4.0	4.2	4.3	4.4	.6
.8	3.7	3.8	3.9	4.0	4.1	4.3	4.5	4.6	.8
5.0	3.9	4.0	4.1	4.2	4.3	4.5	4.7	4.8	5.0
.2	4.1	4.2	4.3	4.4	4.5	4.7	4.9	5.0	.2
.4	4.2	4.3	4.4	4.5	4.6	4.8	5.0	5.2	.4
.6	4.3	4.5	4.6	4.7	4.8	5.0	5.2	5.3	.6
.8	4.5	4.6	4.7	4.8	4.9	5.1	5.3	5.5	.8
6.0	4.6	4.8	4.9	5.0	5.1	5.3	5.5	5.7	6.0

TABLE III.

For directly finding the obscuration in sweetened gin and all other obscured spirits from the extract-gravity at 60° F.

Extract-gravity at 60° F.	APPARENT STRENGTH BY HYDROMETER.										Extract-gravity at 60° F.	
	O. P. 60	O. P. 40	O. P. 20	Proof.	U. P. 10	U. P. 20	U. P. 30	U. P. 40	U. P. 50	U. P. 60		U. P. 70
	Obscuration in proof-degrees.											
1001	0.5	0.6	0.7	0.8	0.8	0.9	1.1	1.2	1.4	1.6	1.7	1001
1002	0.9	1.2	1.3	1.5	1.6	1.8	2.1	2.3	2.8	3.1	3.3	1002
1003	1.4	1.8	2.0	2.2	2.4	2.7	3.0	3.4	4.1	4.6	4.8	1003
1004	1.9	2.4	2.7	2.9	3.2	3.5	3.9	4.5	5.3	5.9	6.3	1004
1005	2.4	3.0	3.3	3.6	3.9	4.3	4.8	5.6	6.5	7.2	7.8	1005
1006	2.8	3.6	3.9	4.3	4.6	5.1	5.7	6.6	7.7	8.5	9.2	1006
1007	3.3	4.0	4.5	5.0	5.4	5.9	6.6	7.6	8.8	9.8	10.5	1007
1008	...	4.5	5.0	5.7	6.1	6.7	7.4	8.5	9.9	11.0	11.9	1008
1009	...	5.0	5.6	6.4	6.8	7.4	8.2	9.4	10.9	12.2	13.3	1009
1010	...	5.5	6.2	7.0	7.5	8.1	9.1	10.3	11.8	13.5	...	1010
1011	...	6.0	6.8	7.6	8.2	8.9	9.9	11.2	12.8	...	...	1011
1012	...	...	7.4	8.2	8.9	9.7	10.7	12.1	13.8	...	...	1012
1013	...	...	8.0	8.9	9.6	10.3	11.5	13.1	...	...	...	1013
1014	...	...	...	9.6	10.2	11.1	12.3	14.1	...	...	...	1014
1015	...	...	...	10.2	10.8	11.8	13.1	...	...	...	...	1015
1016	...	...	...	10.8	11.5	12.5	13.9	...	...	...	...	1016
1017	...	...	...	11.4	12.2	13.1	...	...	...	...	...	1017
1018	...	...	...	12.0	12.8	13.8	...	...	...	...	...	1018
1019	...	...	...	12.5	...	...	...	...	...	...	...	1019

NOTES ON TABLES I, II AND III.

Use of Table I.

(1) To find the true content at 60° F. of a 1,000-grain pyknometer examined at temperatures 70°—100° F.

Example.—The pyknometer is found to contain 995.00 grains of distilled water at 93° F.

According to the table this represents $995.00 + 4.26 = 999.26$ grains at 60° F. The content is thus $(1000 - 999.26) = 0.74$ grains too small, and a portion of the lower end of the stopper must accordingly be removed by careful grinding, until the content is 1,000 grains.

(2) To convert the weight of an aqueous extract weighed at temperatures 70°—100° F., to gravity at 60° F., by adding the grains and decimals of a grain, found in the table.

Example.—Temperature 89° F.

Weight of aqueous extract in 1,000-grain pyknometer at 89° F. = 998.33 grains.
Correction from table = 3.57 "

Extract-gravity at 60° F. = 1001.90 "

Use of Tables II and III.

(3) To find the obscuration in proof-degrees. Table I gives this by inspection, Table II may require interpolation.

Examples.—

(a) Apparent strength 30° U. P.

Extract-gravity at 60° F. = 1001.90

Obscuration by table = 2.0 proof-degrees.

(b) Apparent strength 29° U. P.

Extract-gravity at 60° F. = 1013.3

Obscuration by Table III by interpolation = 11.6 proof-degrees.

The figure 11.6 is found as follows:—

Look up in the table the correction for each of the extract-gravities nearest to the one found (1013.3) at each of the strengths nearest to that given (29° U. P.) and arrange them thus:—

	20° U. P.	30° U. P.	
For 1,013	10.3	11.5	Diff. = 1.2
„ 1,014	11.1	12.3	Diff. = 1.2

The number $29 = 20 + \frac{9}{10}$ of the difference between 30 and 20.

So the correction at 1,013 for 29° U. P. is proportional, namely—

$$10.3 + \frac{9}{10} \text{ of the difference between } 11.5 \text{ and } 10.3 \\ = 10.3 + (0.9 \times 1.2) = 10.3 + 1.08 = 11.4 \quad (3)$$

By the same reasoning, the correction at 1,014 for 29° U. P. is—

$$11.1 + \frac{9}{10} \text{ of the difference between } 12.3 \text{ and } 11.1 \\ = 11.1 + (0.9 \times 1.2) = 11.1 + 1.08 = 12.2 \quad (4)$$

The given extract-gravity, however, is 1,013.3 which is $1,013 + \frac{3}{10}$ of the difference between 1,014 and 1,013.

The corrections for 29° U. P. have just been found, viz., (3) and (4).

So the correction at 1,013.3 for 29° U. P. is—

$$11.4 + \frac{3}{10} \text{ of the difference between } 12.2 \text{ and } 11.4 \\ = 11.4 + (0.3 \times 0.8) \\ = 11.4 + 0.2 = 11.6, \text{ as stated.}$$

II.—Report on the existing laboratory accommodation and equipment at Calcutta, Madras and Bombay.

In December 1910 I was deputed to visit the Customs Laboratories at Calcutta and Bombay and the Board's Laboratory at Madras to demonstrate Colonel Bedford's method of obscuration and also the English method in preparation for the cold weather tests.

I was requested to report to the Director, Central Excise Laboratory, as to the suitability of these laboratories for use as Testing Stations for combined Customs and Excise work. This report is now presented here.

Calcutta Customs Laboratory.—The room at present occupied is in my judgment small and crowded and poorly lighted. The water supply is inadequate and badly arranged consisting of a tank half-way up on wall, filled by hand labour, and only distributed to the distilling bench. The arrangements for washing apparatus are wasteful and inconvenient. The stock of apparatus provided is very limited. According to present orders these defects will be entirely removed. A more suitable room is in contemplation and the apparatus from the Central Excise Laboratory is to be placed in it.

Bombay Customs Laboratory.—The site of the laboratory is bad as it is on the ground floor with heavy traffic immediately outside, resulting in the entry of much dust and dirt and at times a most distracting amount of noise. A more suitable upper room was indicated as a possible alternative later. The water and gas supply are ample and well arranged. The present stock of apparatus is excellent and the provision of new or special apparatus is fully arranged for.

The Board's Laboratory, Madras.—This is a fully equipped laboratory with every desired convenience in the way of plant, apparatus and full provision for maintaining it. The natural lighting is not particularly good and the immediate neighbourhood of important Record Office causes anxiety to the officer in charge, as a fire once started might have disastrous results. A specially built laboratory away from other buildings is proposed. Chemical work of any description is adequately provided for. The officer in charge has four assistants, the senior being a well-trained graduate in chemistry of the Madras University.

R. L. JENKS,

Officer in charge, Central Excise Laboratory.

KASAUJI ;

The 15th September 1911.

III.—Table for correcting the weight of spirit found at temperatures 61° F.—100° F. to real gravities at 60° F.

USE OF TABLE.

This table is to permit of the weighing of spirits in a pyknometer at air-temperatures and thus avoid the troubles of dilatation and dew formation which occur at 60° F. in tropical climates. A pyknometer holding strictly 1,000 grains at 60° F. is used (for adjustment of such, see Obscuration Report, Notes to Tables I, II and III). This is filled in the ordinary manner, the temperature of the spirit at the time of filling being carefully observed. It is then weighed on the balance. The vertical column in the table to which the actual weight of the spirit is nearest is followed down to a line corresponding to the temperature of filling. The figure found at this point is added to the actual weight and the result is the true weight, supposing the spirit had been cooled to 60° F. and weighed at that temperature. This quantity, by moving of the decimal point, becomes at once the gravity at 60° F. of the spirit, the value of which in spirit terms (degrees proof or per cent. by volume) is found from any recognised Alcohol Tables. The Alcohol Tables most commonly used are those printed for the Collector of Customs, Calcutta, in 1889, for the use of the Appraisers' Department. These are in fact Otto Hehner's Tables published in the Analyst, Vol. V. Certain irregularities have been discovered here in them. The British Government is about to publish official revised Alcohol Tables by which gravities obtained by the use of this present table should then be interpreted.

Weight in grains of the spirit at temperatures 61°—100°F.

Fahr.	830	840	850	860	870	880	890	900	905	910	915	Fahr.
61°	0.50	0.49	0.45	0.42	0.39	0.36	0.48	0.47	0.45	0.44	0.44	61°
62	1.00	0.99	0.95	0.92	0.89	0.86	0.96	0.94	0.91	0.88	0.87	62
63	1.50	1.48	1.44	1.41	1.38	1.35	1.45	1.40	1.36	1.32	1.30	63
64	2.00	1.97	1.93	1.90	1.87	1.84	1.93	1.88	1.82	1.76	1.74	64
65	2.50	2.47	2.43	2.40	2.37	2.34	2.31	2.26	2.23	2.20	2.17	65
66	2.98	2.94	2.90	2.86	2.82	2.78	2.75	2.70	2.66	2.63	2.59	66
67	3.47	3.43	3.38	3.33	3.28	3.23	3.19	3.15	3.10	3.05	3.01	67
68	3.95	3.90	3.84	3.78	3.72	3.66	3.63	3.58	3.53	3.49	3.44	68
69	4.44	4.38	4.31	4.24	4.17	4.10	4.07	4.02	3.97	3.91	3.86	69
70	4.93	4.86	4.78	4.71	4.64	4.58	4.51	4.45	4.40	4.36	4.30	70
71	5.39	5.32	5.24	5.16	5.08	5.03	4.94	4.88	4.83	4.78	4.71	71
72	5.85	5.79	5.71	5.63	5.55	5.48	5.39	5.32	5.25	5.21	5.13	72
73	6.31	6.24	6.16	6.10	6.02	5.93	5.82	5.75	5.68	5.63	5.55	73
74	6.77	6.73	6.65	6.57	6.49	6.38	6.26	6.18	6.10	6.05	5.97	74
75	7.23	7.19	7.12	7.03	6.93	6.83	6.70	6.60	6.53	6.47	6.39	75
76	7.70	7.66	7.59	7.49	7.38	7.27	7.13	7.03	6.95	6.90	6.80	76
77	8.17	8.12	8.05	7.94	7.82	7.71	7.57	7.45	7.39	7.32	7.22	77
78	8.64	8.59	8.52	8.40	8.27	8.15	8.01	7.88	7.81	7.74	7.64	78
79	9.11	9.05	8.98	8.85	8.72	8.59	8.45	8.32	8.25	8.16	8.06	79
80	9.58	9.52	9.45	9.31	9.17	9.02	8.88	8.72	8.67	8.58	8.48	80
81	10.05	9.99	9.91	9.77	9.62	9.47	9.32	9.17	9.11	9.01	8.90	81
82	10.52	10.45	10.36	10.21	10.05	9.90	9.76	9.61	9.55	9.44	9.33	82
83	10.99	10.91	10.81	10.66	10.49	10.33	10.20	10.06	9.99	9.88	9.75	83
84	11.46	11.37	11.26	11.10	10.92	10.76	10.64	10.50	10.43	10.31	10.18	84
85	11.93	11.84	11.73	11.57	11.39	11.23	11.08	10.95	10.87	10.75	10.61	85
86	12.42	12.32	12.20	12.03	11.84	11.67	11.53	11.38	11.30	11.18	11.03	86
87	12.91	12.80	12.67	12.49	12.29	12.11	11.96	11.82	11.73	11.61	11.45	87
88	13.40	13.28	13.14	12.95	12.74	12.55	12.39	12.25	12.16	12.05	11.87	88
89	13.88	13.74	13.59	13.39	13.17	12.99	12.83	12.69	12.59	12.47	12.29	89
90	14.36	14.21	14.05	13.83	13.60	13.42	13.28	13.13	13.03	12.91	12.72	90
91	14.82	14.67	14.51	14.30	14.07	13.87	13.72	13.55	13.45	13.32	13.12	91
92	15.28	15.13	14.96	14.75	14.52	14.32	14.17	13.98	13.87	13.74	13.53	92
93	15.74	15.59	15.42	15.21	14.98	14.77	14.60	14.41	14.29	14.16	13.95	93
94	16.20	16.05	15.87	15.66	15.43	15.22	15.04	14.84	14.71	14.57	14.36	94
95	16.67	16.52	16.34	16.13	15.89	15.66	15.47	15.27	15.13	14.98	14.77	95
96	17.15	16.99	16.79	16.57	16.32	16.10	15.90	15.70	15.57	15.40	15.19	96
97	17.63	17.46	17.25	17.02	16.76	16.54	16.34	16.14	16.00	15.83	15.61	97
98	18.11	17.93	17.71	17.47	17.20	16.98	16.78	16.58	16.43	16.27	16.03	98
99	18.59	18.40	18.17	17.92	17.64	17.42	17.22	17.01	16.87	16.70	16.45	99
100	19.07	18.88	18.64	18.39	18.11	17.87	17.67	17.45	17.30	17.12	16.87	100
Fahr.	830	840	850	860	870	880	890	900	905	910	915	Fahr.

Fahr.	920	922	924	926	928	930	931	932	933	934	935	Fahr.
61°	0.43	0.42	0.42	0.41	0.41	0.41	0.40	0.40	0.40	0.40	0.40	61°
62	0.86	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.80	0.79	0.79	62
63	1.29	1.27	1.26	0.25	1.23	1.22	1.21	1.21	1.20	1.19	1.18	63
64	1.72	1.70	1.68	1.66	1.64	1.62	1.61	1.61	1.60	1.59	1.58	64
65	2.13	2.11	2.10	2.08	2.05	2.03	2.02	2.01	2.00	1.99	1.98	65
66	2.55	2.53	2.51	2.50	2.47	2.44	2.43	2.42	2.41	2.39	2.38	66
67	2.97	2.95	2.93	2.91	2.88	2.85	2.84	2.83	2.81	2.80	2.79	67
68	3.39	3.37	3.34	3.32	3.29	3.26	3.25	3.23	3.22	3.20	3.19	68
69	3.81	3.79	3.76	3.73	3.70	3.67	3.66	3.64	3.62	3.60	3.59	69
70	4.23	4.21	4.18	4.14	4.11	4.07	4.04	4.02	4.00	3.98	3.95	70
71	4.64	4.62	4.58	4.55	4.51	4.46	4.43	4.41	4.40	4.37	4.34	71
72	5.05	5.03	4.99	4.96	4.91	4.85	4.83	4.81	4.79	4.76	4.73	72
73	5.47	5.44	5.40	5.36	5.31	5.25	5.23	5.20	5.18	5.14	5.11	73
74	5.88	5.85	5.81	5.77	5.71	5.64	5.62	5.59	5.56	5.52	5.50	74
75	6.29	6.26	6.22	6.17	6.11	6.04	6.02	5.99	5.95	5.91	5.88	75
76	6.70	6.67	6.63	6.56	6.50	6.44	6.39	6.36	6.32	6.28	6.26	76
77	7.12	7.08	7.02	6.96	6.88	6.83	6.77	6.73	6.69	6.65	6.65	77
78	7.53	7.49	7.43	7.35	7.27	7.23	7.15	7.12	7.07	7.02	7.02	78
79	7.94	7.90	7.82	7.75	7.66	7.62	7.54	7.49	7.44	7.40	7.41	79
80	8.35	8.31	8.23	8.14	8.05	7.97	7.91	7.87	7.82	7.78	7.72	80
81	8.76	8.71	8.62	8.53	8.45	8.38	8.29	8.24	8.20	8.15	8.14	81
82	9.18	9.11	9.02	8.93	8.83	8.76	8.68	8.62	8.58	8.52	8.50	82
83	9.59	9.52	9.42	9.32	9.22	9.14	9.06	9.00	8.95	8.90	8.86	83
84	10.01	9.92	9.82	9.72	9.61	9.51	9.44	9.38	9.33	9.27	9.21	84
85	10.42	10.32	10.22	10.11	10.00	9.88	9.82	9.76	9.70	9.63	9.57	85
86	10.83	10.73	10.63	10.52	10.40	10.27	10.22	10.16	10.08	10.00	9.95	86
87	11.25	11.15	11.04	10.92	10.80	10.67	10.60	10.53	10.46	10.40	10.33	87
88	11.67	11.56	11.46	11.33	11.20	11.06	11.00	10.93	10.85	10.77	10.70	88
89	12.09	11.97	11.86	11.73	11.60	11.46	11.38	11.31	11.23	11.16	11.08	89
90	12.50	12.39	12.27	12.14	12.00	11.85	11.78	11.70	11.62	11.53	11.46	90
91	12.90	12.78	12.66	12.53	12.38	12.23	12.15	12.07	11.99	11.90	11.82	91
92	13.29	13.18	13.06	12.92	12.77	12.62	12.52	12.44	12.36	12.27	12.18	92
93	13.70	13.58	13.44	13.31	13.16	13.00	12.90	12.81	12.74	12.64	12.55	93
94	14.10	13.97	13.84	13.70	13.54	13.37	13.28	13.19	13.11	13.01	12.92	94
95	14.50	14.37	14.23	14.09	13.92	13.74	13.65	13.57	13.48	13.38	13.28	95
96	14.90	14.77	14.63	14.47	14.30	14.11	14.02	13.93	13.84	13.74	13.64	96
97	15.31	15.18	15.03	14.87	14.70	14.49	14.40	14.30	14.20	14.10	13.99	97
98	15.72	15.58	15.43	15.25	15.08	14.87	14.77	14.67	14.58	14.46	14.35	98
99	16.13	15.99	15.83	15.64	15.48	15.25	15.15	15.04	14.94	14.82	14.70	99
100	16.54	16.40	16.23	16.04	15.86	15.63	15.51	15.41	15.30	15.20	15.06	100
Fahr.	920	922	924	926	928	930	931	932	933	934	935	Fahr.

Weight in grains of the spirit at temperatures 61°—100°F.

Fahr.	936	937	938	939	940	941	942	943	944	945	946	Fahr.
61°	0.39	0.39	0.39	0.39	0.39	0.38	0.38	0.38	0.38	0.38	0.37	61°
62	0.78	0.78	0.78	0.77	0.77	0.77	0.76	0.76	0.75	0.74	0.73	62
63	1.18	1.17	1.17	1.16	1.16	1.15	1.14	1.14	1.13	1.12	1.11	63
64	1.57	1.56	1.55	1.55	1.54	1.53	1.52	1.52	1.51	1.49	1.47	64
65	1.97	1.95	1.94	1.93	1.93	1.92	1.91	1.90	1.88	1.86	1.84	65
66	2.37	2.35	2.33	2.32	2.31	2.30	2.29	2.28	2.26	2.23	2.20	66
67	2.77	2.75	2.73	2.71	2.69	2.68	2.66	2.65	2.62	2.60	2.57	67
68	3.17	3.15	3.13	3.10	3.07	3.06	3.04	3.03	3.00	2.97	2.94	68
69	3.57	3.51	3.51	3.48	3.45	3.43	3.42	3.40	3.37	3.34	3.31	69
70	3.92	3.90	3.88	3.84	3.84	3.82	3.80	3.78	3.74	3.71	3.67	70
71	4.30	4.30	4.26	4.22	4.22	4.20	4.18	4.15	4.10	4.06	4.02	71
72	4.70	4.68	4.65	4.61	4.61	4.57	4.55	4.52	4.47	4.43	4.38	72
73	5.08	5.06	5.01	4.98	4.99	4.96	4.93	4.90	4.86	4.80	4.76	73
74	5.47	5.43	5.40	5.35	5.38	5.34	5.30	5.27	5.22	5.16	5.13	74
75	5.85	5.81	5.78	5.73	5.76	5.72	5.68	5.63	5.59	5.51	5.47	75
76	6.22	6.17	6.13	6.08	6.12	6.07	6.02	5.97	5.93	5.85	5.79	76
77	6.58	6.54	6.48	6.44	6.46	6.42	6.36	6.31	6.26	6.19	6.13	77
78	6.95	6.90	6.85	6.80	6.80	6.77	6.71	6.65	6.61	6.53	6.45	78
79	7.32	7.26	7.21	7.15	7.16	7.13	7.06	6.99	6.95	6.87	6.79	79
80	7.68	7.62	7.57	7.51	7.50	7.47	7.42	7.34	7.30	7.21	7.12	80
81	8.04	7.98	7.92	7.88	7.86	7.83	7.75	7.67	7.62	7.53	7.43	81
82	8.41	8.35	8.30	8.24	8.23	8.17	8.09	8.00	7.91	7.85	7.74	82
83	8.77	8.71	8.66	8.60	8.60	8.51	8.42	8.34	8.27	8.18	8.07	83
84	9.14	9.08	9.02	8.95	8.96	8.86	8.77	8.68	8.59	8.50	8.39	84
85	9.51	9.44	9.38	9.31	9.31	9.20	9.11	9.01	8.92	8.82	8.70	85
86	9.88	9.81	9.74	9.67	9.64	9.53	9.43	9.33	9.22	9.13	8.99	86
87	10.26	10.18	10.11	10.03	9.99	9.88	9.77	9.67	9.56	9.47	9.29	87
88	10.62	10.55	10.46	10.40	10.32	10.22	10.12	10.00	9.88	9.77	9.58	88
89	11.00	10.91	10.84	10.76	10.68	10.56	10.46	10.32	10.21	10.08	9.89	89
90	11.37	11.28	11.20	11.11	11.02	10.91	10.80	10.65	10.52	10.40	10.29	90
91	11.72	11.64	11.54	11.46	11.36	11.24	11.14	10.98	10.86	10.72	10.53	91
92	12.10	12.00	11.90	11.81	11.70	11.58	11.47	11.32	11.20	11.06	10.87	92
93	12.45	12.34	12.25	12.16	12.04	11.92	11.81	11.65	11.54	11.39	11.21	93
94	12.81	12.70	12.60	12.52	12.38	12.25	12.13	11.99	11.86	11.73	11.57	94
95	13.17	13.06	12.96	12.86	12.72	12.58	12.46	12.32	12.20	12.07	11.91	95
96	13.52	13.40	13.31	13.20	13.06	12.91	12.80	12.65	12.52	12.38	12.21	96
97	13.87	13.75	13.65	13.54	13.40	13.25	13.12	12.98	12.83	12.69	12.62	97
98	14.22	14.10	14.00	13.88	13.73	13.58	13.45	13.30	13.16	13.01	12.84	98
99	14.57	14.45	14.33	14.22	14.07	13.91	13.78	13.62	13.46	13.31	13.14	99
100	14.92	14.80	14.69	14.55	14.37	14.20	14.09	13.94	13.77	13.60	13.44	100
Fahr.	936	937	938	939	940	941	942	943	944	945	946	Fahr.

Fahr.	947	948	949	950	951	952	953	954	955	956	957	Fahr.
61°	0.36	0.36	0.36	0.35	0.35	0.34	0.34	0.33	0.32	0.32	0.31	61°
62	0.72	0.72	0.72	0.70	0.70	0.69	0.68	0.67	0.66	0.64	0.63	62
63	1.09	1.08	1.08	1.06	1.04	1.03	1.02	1.00	0.98	0.96	0.94	63
64	1.46	1.44	1.43	1.42	1.39	1.37	1.36	1.34	1.31	1.28	1.26	64
65	1.82	1.80	1.79	1.77	1.74	1.71	1.69	1.67	1.63	1.60	1.57	65
66	2.18	2.15	2.13	2.12	2.09	2.05	2.03	1.99	1.95	1.92	1.88	66
67	2.55	2.52	2.50	2.48	2.44	2.39	2.36	2.31	2.27	2.24	2.20	67
68	2.91	2.88	2.86	2.83	2.78	2.73	2.70	2.65	2.59	2.56	2.50	68
69	3.28	3.24	3.21	3.18	3.12	3.07	3.04	2.97	2.91	2.88	2.82	69
70	3.64	3.61	3.58	3.53	3.48	3.42	3.37	3.31	3.26	3.20	3.13	70
71	3.98	3.94	3.91	3.85	3.80	3.74	3.67	3.61	3.55	3.49	3.42	71
72	4.33	4.28	4.25	4.19	4.14	4.07	3.99	3.92	3.86	3.78	3.71	72
73	4.68	4.63	4.59	4.52	4.47	4.40	4.31	4.23	4.15	4.07	3.98	73
74	5.04	4.97	4.94	4.86	4.80	4.71	4.62	4.54	4.45	4.37	4.27	74
75	5.39	5.33	5.28	5.20	5.12	5.04	4.94	4.85	4.76	4.67	4.57	75
76	5.71	5.65	5.60	5.52	5.44	5.36	5.26	5.17	5.07	4.96	4.91	76
77	6.06	5.98	5.93	5.84	5.75	5.66	5.56	5.43	5.37	5.25	5.18	77
78	6.38	6.30	6.25	6.16	6.07	5.97	5.87	5.68	5.65	5.46	5.46	78
79	6.73	6.65	6.58	6.49	6.40	6.29	6.19	5.96	5.98	5.85	5.73	79
80	7.06	6.98	6.90	6.80	6.71	6.60	6.50	6.40	6.28	6.16	6.01	80
81	7.37	7.28	7.20	7.10	6.99	6.89	6.78	6.54	6.56	6.43	6.29	81
82	7.67	7.57	7.49	7.39	7.28	7.17	7.07	6.86	6.84	6.70	6.55	82
83	7.98	7.88	7.79	7.69	7.56	7.46	7.34	7.17	7.12	6.96	6.83	83
84	8.29	8.18	8.10	7.99	7.84	7.74	7.62	7.49	7.40	7.24	7.10	84
85	8.60	8.50	8.38	8.28	8.14	8.03	7.91	7.79	7.67	7.50	7.37	85
86	8.91	8.80	8.69	8.58	8.42	8.31	8.19	8.07	7.94	7.77	7.65	86
87	9.21	9.10	8.99	8.88	8.73	8.61	8.48	8.34	8.21	8.05	7.94	87
88	9.52	9.39	9.29	9.19	9.02	8.90	8.77	8.63	8.50	8.34	8.22	88
89	9.84	9.70	9.60	9.49	9.31	9.19	9.05	8.91	8.77	8.62	8.50	89
90	10.14	10.00	9.90	9.75	9.60	9.49	9.34	9.20	9.04	8.90	8.78	90
91	10.46	10.31	10.21	10.09	9.90	9.78	9.62	9.47	9.32	9.15	9.02	91
92	10.78	10.64	10.52	10.39	10.20	10.07	9.90	9.75	9.58	9.40	9.26	92
93	11.11	10.97	10.84	10.69	10.50	10.36	10.18	10.02	9.85	9.64	9.50	93
94	11.45	11.31	11.16	11.00	10.81	10.64	10.45	10.30	10.12	9.89	9.73	94
95	11.79	11.60	11.48	11.30	11.12	10.92	10.73	10.55	10.38	10.14	9.97	95
96	12.07	11.90	11.74	11.58	11.40	11.20	11.00	10.80	10.61	10.38	10.19	96
97	12.38	12.21	12.02	11.85	11.67	11.47	11.26	11.06	10.86	10.66	10.43	97
98	12.68	12.51	12.31	12.13	11.94	11.75	11.51	11.31	11.10	10.89	10.66	98
99	12.98	12.81	12.60	12.42	12.23	12.03	11.78	11.57	11.35	11.14	10.88	99
100	13.27	13.10	12.90	12.70	12.50	12.29	12.05	11.83	11.60	11.39	11.13	100
Fahr.	947	948	949	950	951	952	953	954	955	956	957	Fahr.

Weight in grains of the spirit at temperatures 61°—100°F.

Fahr.	958	959	960	961	962	963	964	965	966	967	968	Fahr.
61°	0.30	0.30	0.29	0.28	0.28	0.27	0.26	0.26	0.25	0.24	0.24	61°
62	0.61	0.60	0.59	0.56	0.55	0.55	0.53	0.52	0.50	0.48	0.47	62
63	0.92	0.90	0.88	0.85	0.83	0.82	0.80	0.78	0.75	0.72	0.70	63
64	1.23	1.20	1.18	1.13	1.11	1.10	1.06	1.03	1.00	0.96	0.94	64
65	1.52	1.50	1.47	1.42	1.39	1.37	1.32	1.29	1.24	1.21	1.18	65
66	1.84	1.80	1.76	1.71	1.67	1.64	1.59	1.55	1.50	1.45	1.40	66
67	2.15	2.10	2.05	2.00	1.95	1.91	1.85	1.79	1.74	1.69	1.63	67
68	2.45	2.40	2.34	2.29	2.23	2.18	2.12	2.05	1.99	1.93	1.85	68
69	2.76	2.70	2.64	2.58	2.52	2.45	2.38	2.31	2.24	2.17	2.08	69
70	3.07	3.00	2.93	2.87	2.79	2.71	2.64	2.57	2.49	2.40	2.31	70
71	3.35	3.28	3.20	3.12	3.03	2.96	2.89	2.79	2.69	2.60	2.52	71
72	3.63	3.56	3.46	3.37	3.27	3.20	3.12	3.02	2.92	2.84	2.74	72
73	3.91	3.83	3.73	3.63	3.53	3.44	3.36	3.25	3.14	3.06	2.96	73
74	4.20	4.10	3.99	3.89	3.77	3.68	3.58	3.47	3.36	3.27	3.18	74
75	4.48	4.38	4.25	4.14	4.03	3.93	3.83	3.72	3.60	3.50	3.40	75
76	4.76	4.65	4.51	4.41	4.28	4.18	4.06	3.95	3.82	3.72	3.61	76
77	5.04	4.93	4.79	4.66	4.55	4.44	4.31	4.19	4.05	3.94	3.82	77
78	5.34	5.23	5.06	4.93	4.80	4.69	4.54	4.43	4.27	4.16	4.03	78
79	5.62	5.49	5.34	5.21	5.07	4.95	4.79	4.67	4.51	4.38	4.25	79
80	5.90	5.77	5.62	5.48	5.33	5.20	5.03	4.90	4.73	4.60	4.46	80
81	6.16	6.04	5.89	5.74	5.58	5.43	5.27	5.13	4.96	4.81	4.67	81
82	6.42	6.29	6.14	5.98	5.82	5.67	5.51	5.37	5.19	5.04	4.87	82
83	6.68	6.56	6.41	6.24	6.07	5.91	5.76	5.60	5.42	5.25	5.08	83
84	6.94	6.83	6.67	6.50	6.33	6.16	6.01	5.84	5.67	5.49	5.29	84
85	7.21	7.09	6.94	6.76	6.58	6.40	6.25	6.07	5.90	5.70	5.50	85
86	7.48	7.34	7.19	7.01	6.83	6.65	6.48	6.31	6.11	5.90	5.71	86
87	7.78	7.62	7.46	7.28	7.09	6.89	6.70	6.53	6.33	6.10	5.90	87
88	8.06	7.89	7.72	7.54	7.35	7.15	6.93	6.75	6.53	6.30	6.10	88
89	8.34	8.17	7.99	7.80	7.61	7.39	7.16	6.97	6.74	6.50	6.30	89
90	8.60	8.43	8.25	8.05	7.87	7.63	7.40	7.20	6.95	6.71	6.50	90
91	8.83	8.64	8.45	8.25	8.06	7.82	7.58	7.40	7.16	6.92	6.72	91
92	9.06	8.86	8.67	8.45	8.28	8.02	7.78	7.60	7.35	7.13	6.91	92
93	9.29	9.09	8.87	8.66	8.46	8.22	7.97	7.80	7.55	7.33	7.11	93
94	9.52	9.31	9.09	8.87	8.66	8.41	8.16	8.00	7.75	7.55	7.31	94
95	9.74	9.52	9.30	9.08	8.86	8.61	8.38	8.20	7.96	7.74	7.52	95
96	9.96	9.74	9.51	9.29	9.07	9.82	8.58	8.41	8.17	7.94	7.72	96
97	10.19	9.97	9.73	9.50	9.29	9.04	8.81	8.61	8.37	8.14	7.91	97
98	10.41	10.18	9.95	9.72	9.50	9.26	9.02	8.81	8.58	8.33	8.11	98
99	10.64	10.41	10.17	9.92	9.71	9.47	9.24	9.02	8.78	8.52	8.30	99
100	10.88	10.64	10.40	10.13	9.93	9.68	9.43	9.21	8.98	8.72	8.50	100
Fahr.	958	959	960	961	962	963	964	965	966	967	968	Fahr.

Weight in grains of the spirit at temperatures 61°—100° F.

Fahr.	980	981	982	983	984	985	990	995	1000	Fahr.
61°	0.12	0.12	0.11	0.11	0.10	0.10	0.09	0.08	0.08	61°
62	0.24	0.24	0.22	0.21	0.21	0.20	0.18	0.16	0.16	62
63	0.37	0.35	0.33	0.32	0.31	0.30	0.26	0.25	0.24	63
64	0.50	0.47	0.44	0.43	0.42	0.40	0.35	0.33	0.32	64
65	0.62	0.58	0.55	0.52	0.51	0.50	0.44	0.41	0.40	65
66	0.73	0.71	0.68	0.65	0.63	0.62	0.55	0.51	0.50	66
67	0.87	0.84	0.81	0.78	0.75	0.73	0.66	0.61	0.60	67
68	1.00	0.97	0.94	0.91	0.87	0.85	0.77	0.71	0.70	68
69	1.14	1.10	1.07	1.04	0.99	0.97	0.88	0.81	0.80	69
70	1.29	1.24	1.20	1.17	1.12	1.08	0.98	0.91	0.90	70
71	1.45	1.40	1.36	1.32	1.26	1.22	1.10	1.03	1.02	71
72	1.62	1.56	1.51	1.47	1.41	1.36	1.23	1.15	1.14	72
73	1.76	1.69	1.65	1.60	1.55	1.51	1.35	1.27	1.27	73
74	1.92	1.84	1.79	1.74	1.69	1.65	1.48	1.40	1.38	74
75	2.08	1.99	1.94	1.88	1.83	1.79	1.60	1.52	1.51	75
76	2.22	2.13	2.07	2.01	1.95	1.91	1.74	1.66	1.64	76
77	2.37	2.28	2.21	2.16	2.09	2.05	1.87	1.79	1.78	77
78	2.51	2.42	2.35	2.30	2.23	2.18	2.01	1.93	1.92	78
79	2.66	2.57	2.50	2.44	2.37	2.32	2.14	2.06	2.06	79
80	2.81	2.71	2.63	2.58	2.50	2.46	2.27	2.20	2.20	80
81	2.97	2.89	2.79	2.75	2.67	2.60	2.42	2.35	2.36	81
82	3.13	3.03	2.94	2.89	2.81	2.75	2.56	2.49	2.51	82
83	3.28	3.20	3.10	3.03	2.96	2.89	2.71	2.64	2.67	83
84	3.47	3.35	3.27	3.19	3.12	3.04	2.85	2.78	2.82	84
85	3.64	3.52	3.42	3.33	3.27	3.19	3.00	2.94	2.95	85
86	3.82	3.70	3.59	3.49	3.43	3.35	3.17	3.09	3.14	86
87	4.00	3.87	3.76	3.67	3.60	3.52	3.32	3.25	3.29	87
88	4.18	4.05	3.94	3.84	3.77	3.68	3.49	3.41	3.43	88
89	4.35	4.22	4.12	4.04	3.94	3.85	3.64	3.57	3.57	89
90	4.51	4.40	4.30	4.20	4.10	4.02	3.80	3.72	3.71	90
91	4.67	4.56	4.46	4.37	4.26	4.19	3.98	3.88	3.88	91
92	4.83	4.73	4.62	4.53	4.42	4.36	4.14	4.06	4.06	92
93	4.99	4.87	4.78	4.70	4.60	4.53	4.32	4.23	4.23	93
94	5.15	5.02	4.94	4.86	4.76	4.70	4.48	4.41	4.42	94
95	5.30	5.18	5.09	5.00	4.92	4.87	4.66	4.59	4.59	95
96	5.47	5.36	5.28	5.20	5.11	5.04	4.83	4.78	4.78	96
97	5.64	5.53	5.45	5.36	5.28	5.22	5.01	4.96	4.96	97
98	5.81	5.70	5.62	5.53	5.45	5.39	5.19	5.13	5.15	98
99	5.98	5.87	5.78	5.70	5.62	5.57	5.38	5.32	5.33	99
100	6.14	6.03	5.96	5.88	5.80	5.73	5.57	5.50	5.51	100
Fahr.	980	981	982	983	984	985	990	995	1000	Fahr.

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