Methods of Sampling Tank Cars at Destination and a Proposed Method Which Overcomes the Geometric Error[1]

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OIL technologists and refiners recognize that one of the most baffling problems which has confronted the trade and which is hardly closer to a completely satisfactory solution today than it was 20 years ago, is the accurate evaluation by usual laboratory methods of a tank car load of crude vegetable oil on the tracks at destination—before unloading. While admittedly many of the testing methods still in use lack the degree of precision which might be desired in some cases, the real nub of the problem is in taking a truly representative sample from the tankcar when it contains foots or settlings. (In instances where the buyer is going to unload the car regardless of its analysis, accurate sampling becomes much simplified, as in the case of taking the loading sample, where suitable bleeder and cup composite methods apply.)

In the special but important case of drawing samples from loaded tank cars containing foots, large sampling errors may result from the use of methods which, while intended to provide a roughly proportional composite of the various depth sections crossing the vertical diameter of the car, are nevertheless stated in such terms that the inclusion of the precise amount of foots in the sample, proportional to the amount in the car, does not result except by accident. Furthermore, considerable errors may occur when dependence is placed upon the well known method of taking a core along the tank car's vertical diameter to the bottom. This has been called the geometric error, and it follows mathematically from the difference in the relationship between small fractions of the diameter to the total diameter on the one hand, (representing foots' depth and hence amount in a vertical core sample), and the corresponding relationship between the actual weight or volume of foots to the total weight or volume of the tank car's contents. This is indicated by the data in Table I.

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It is the purpose of this paper to show why all of the published methods give erroneous samples in the special case under consideration, to show the magnitude of errors and the degrees of misrepresentation of oil quality in test results run on such incorrect samples, and then to present in detail a method which overcomes the difficulties and provides, when properly applied, samples which afford correct evaluation of oil quality within the usual limits of error inherent in the testing methods generally applied.

TABLE I

Depth (of Foots Stratum) as % of Diameter	Corresponding Volume as % of Total Volume	% of Bottom Stratum Taken in Full Core Sample (4)	Ratio: % of Foots in Core Sample/True % Foots	Equivalent Inches Depth in 84" Diam. Tankcar
0.3	0.031	0.30	10.0	0.25
0.5	0.06	0.5	8.3	0.42
1	0.18	1.0	5.6	0.84
2	0.48	2.0	4.2	1.68
5	1.9	5.0	2.6	4.2
10	5.2	10.0	1.9	8.4
30	25	30	1.2	25
50	50	50	1.0	42

Cognizance is taken of this problem by some trade associations by designating that the loading sample shall be official when drawn under certain specified conditions. It is conceded that even a core sample taken promptly after loading a tank car is substantially representative, except perhaps in the unusual case when the oil may contain an appreciable amount of coarse meal which may settle very rapidly, believed to be a rare occurrence nowadays.

It has been observed that among some people who do not understand this tank car destination sampling problem it is considered adequate coverage of the car's content to draw "takes" from the top, middle, and bottom of the tank car, then mix these three portions for the sample. To show the fallaciousness and danger of this procedure the following figures are given for some tests on tank cars of raw linseed oil

TABLE II

ASSUMPTIONS: Foots Condition:			A	B	C
(I)—Depth of Foots			1"	3"	6"
(II)—True per cent of foots in bottom stratum, by volume (for 84" diam. tankcar)			0.23	1.13	3.17
(III)—A.S.T.M. foots test on footy bottom stratum: (Based on actual tests)			30.0	30.0	20.0
(IV)—Per cent A.S.T.M. foots test on oil overlying the bottom stratum, per cent (A representative value)			0.6	0.6	0.6
Nature of Sample		Proportion of Foots Stratum in Sample: Ratio	Proportion of Foots Stratum in Sample: Percentage	A.S.T.M. Foots Tests[b]: A	A.S.T.M. Foots Tests[b]: B	A.S.T.M. Foots Tests[b]: C
(1)	Test result on a true sample	True	see (II)	0.67%	0.94%	1.2%
(2)	Composite of equal portions—top, middle, and bottom	1:2[a] or	33.3	10.4	10.4	7.1
(3a)	These would conform to A.S.T.M. method for tung oil	1:7	12.5	4.3*	4.3*	3.0*
(3b)	Ditto	2:6	25.0	.....	.....	5.5
(4a)	These would conform to method given in Fed. Spec. TT-O-369, but method would be correctly applied only in cases indicated with * symbol	1:39	2.5	1.36*	1.36	1.08
(4b)	Ditto	2:38	5.0	2.07	2.07*	1.57
(4c)	Ditto	3:37	7.5	.....	2.8	2.05*
(4d)	Ditto	4:36	10.0	.....	.....	2.54

* These are the values, for a given method, 3 or 4, that would result if the "takes" from the tank car were equally spaced up the vertical diameter starting on the very bottom. The other values shown are what might obtain if the sampler should make an uneven distribution of his "takes" getting more or less than the "theoretical" number for a given method from the bottom stratum.

[a] Parts foots stratum to parts upper oil.

[b] Indicated A.S.T.M. foots test in per cent, based on lines III and IV above, on composite samples containing amounts of foots stratum component in ratios and percentages shown in the two columns at left, i.e., on samples as they would be taken by the methods indicated.

containing various amounts of foots, these being given in terms of A.S.T.M. heated acetone foots test, a highly empirical one giving the volume per cent of "foots" which separate under certain conditions in the presence of acetone and aqueous acid-calcium chloride.

Moreover, since much of the moisture in a raw oil is associated with the mucilaginous matter comprising the foots (and indeed may be largely responsible for the precipitation of the foots), it is apparent that the moisture content of the false sample would also be greatly exaggerated. It is little wonder in view of the relationships brought out in Table II that processors and other shippers of crude vegetable oils are leery of test results made on tank car samples at destination before unloading.

It is possible, however, by taking into full account the principal factor involved in the problem, to draw samples which are truly representative for all practical purposes from footy oil in tank cars. Before introducing the proposed method, it is appropriate to discuss briefly some general principles concerned and to give the significant features of several other commonly-used methods, and note their shortcomings.

Clear—or Foots-Free Oil. When a tank car's content is free from foots and it may be assumed that the oil in the car was drawn from a large storage tank, it really does not make much difference what method of sampling is used since, as a result of the mixing which occurs on filling the car and in transit, the oil in every part of the car must be substantially the same as the oil in every other part. This, of course, covers the case of refined oil samples, and a core sample taken through the center to the bottom may be considered entirely satisfactory.

It may also be considered for practical purposes that when foots are present, all of the oil above and outside of the area where the foots occur is reasonably uniform and that part, at least, may be considered as in the same category as the above, i.e., the problem of getting the foots blended back with the main body of oil in the correct proportion is so much more important, that minor variations within the main body of the top oil itself shrink into near insignificance by comparison.

It is pertinent to consider the manner in which foots accumulate at the bottom of tank cars, especially with reference to composition variations, vertically, within the foots stratum. While data are not available on this, general experience and observation enable one to classify crude vegetable oil foots somewhat as follows: 1. Mealy foots, may result from inadequate settling or filtration. If these are accompanied by the usual gum-type of foots (largely phosphatides), then the over-all foots stratum will itself be stratified, with the meal on the bottom. Fortunately, the presence of appreciable meal is rare in crude vegetable oil shipments, though formerly this was not the case. 2. Except when accompanied by severe chilling, raw linseed oil deposits extremely "soft" foots which readily flow with the associated oil. The foots stratum in this case usually has a sharp interface with the foots-free oil above it. The character of the foots which may be deposited in crude soybean oil depends upon a number of factors, principally the type of oil. 3. Disregarding the possible occurrence of meal, expeller oil commonly deposits what the trade calls "sludge" ("the solid residue which cannot be pumped and squeegeed from the car . . .") (0) when any foots at all are formed. It is practically certain that sludge is overlaid by soft foots except after a long settlement period. The case of sludge is treated further below. 4. Non-degummed crude extracted soybean oil uniformly deposits a stratum of soft foots. Except during very cold weather or after a very long settling period (much longer than encountered during delivery of a tank car), these foots readily flow out of the car with the main load of oil and of course are embodied in the loading sample.

It may be stated at this point that the method proposed here was intended to apply specifically to linseed oil, and it is only on such that it has been applied so far by this writer. The sampling of crude soybean oil shipments is adequately covered in trading rules where the loading sample is declared official when such is provided by the shipper. The same is true in the case of crude cottonseed and peanut oils under the N.C.P.A. rules. Depending upon whether it can be established that a detectable interface or boundary occurs between foots and foots-free oil, the proposed method will be applicable to other types. However, as an industrial oil, linseed oil is usually traded under A.S.T.M. Standard Specifications, or in accordance with agreements between individual buyers and sellers, or without reference to any rules or agreements—in which case disputes when they occur are settled by negotiation between buyer and seller. There thus occur many occasions where the buyer of such oil may desire to obtain a true sample from a tank car on his tracks before unloading. Let us, now, examine the various methods which are available to him and which are used no doubt with many variations. These are to be considered from the standpoint of raw linseed oil, which becoming chilled in transit during the winter, can be expected to deposit some foots at times regardless of how well it may have been processed. These foots may deposit when the oil is of such quality as to be well within all of the accepted specifications governing the type.

American Society for Testing Materials

The author has been unable to find any method in the A.S.T.M. Standard Specifications for sampling of linseed oil, which is rather surprising, in view of the importance of this oil and considering the facts about it just mentioned.

For Tung Oil (1). "The total sample shall be not less than one gallon per tank car, and shall be a composite of numerous small samples of not more than one pint each, taken from the top, bottom, and intermediate points by means of a glass or metal container with removable stopper or top." There is thus permitted a minimum of eight portions.

Federal Specifications TT-O-369 (2, 3)

This method is word for word exactly the same as the A.S.T.M. method for tung oil with this important difference: that it specifies a minimum sample size of five gallons. Thus, with the maximum size portion comprising each "take" again given as one pint, this fixes a minimum of 40 portions to be withdrawn. While it would appear that too much leeway is left deciding the distribution of the points where the various "takes" are made, there seems no question but that if evenly distributed over the cross-

section of the tank car according to the intent of the method, (but an occurrence which in practice would be quite unlikely), the amount of foots in the sample would approximate in a general way the amount in the entire load. Assuming a uniform foots stratum, if two "takes" were composed of foots and 40 portions were taken altogether, then the sample would contain 5% of the bottom portion, by volume. If only one "take" comprised all foots, they would be 2½%. It is apparent that the amount of foots in the sample will depend upon the number of portions drawn at or near the bottom, and the method is thus woefully vague in not specifying the use of some particular kind of bomb sampler which affords control over the depth at which it opens, i.e., within narrow limits—and also in not further specifying some particular spacing as to the distribution of the sampling points, at least near the bottom where the foots occur. Reference is made again to Table II showing how samples taken by this method compare on analysis with the corresponding true samples.

Discussion of Table II

Sample condition (2) shows how grossly a mild foots condition is exaggerated by a sample composed of equal parts of top, middle, and bottom portions. However, the A.S.T.M. method wherein one of eight "takes" is from the foots stratum also badly downgrades the oil. In the case where only forty equal portions are drawn, (Fed. Spec. TT-O-369), even when only one of these is from the bottom stratum, we find that even the best sample, in the case of conditions A and B, still downgrades the oil somewhat, throwing the heated acetone foots value well over the 1.0% A.S.T.M. specification maximum, and if 2 portions are drawn from or near the bottom, as might easily occur in B or C, the oil becomes seriously downgraded.

It is apparent that this method was intended to be a proportional method, in effect, and that it assumes that the sampler has no knowledge of conditions in the bottom of the tank car. Clearly, however, it would not be possible to get a representative sample by the Federal Method unless the foots depth were known and unless that knowledge were used in a precise manner in drawing the various portions. Also it would not be possible to get a representative sample in any of the cases cited if as few as forty equal portions were drawn, even though only one of these was drawn from the foots stratum. It is apparent that to be accurately applied, a series of portions should be drawn at equal small intervals from the bottom upwards, at least in the foots stratum—then on the basis of the findings revealed by these, the total number of portions to be drawn from upper oil could then be determined. Yet the method does not specify the use of any apparatus affording the determination of such spacing; and stated as it is, it becomes a matter of accident whenever a sample drawn contains precisely the correct amount of foots. Given a knowledge of the foots depth, this method could be restated to specify the number of "takes" to draw for any particular depth of foots; and it was just this consideration which led to the development of the proportional foots method presented here.

In view of this criticism of the Federal Specifications method, consider with how much more force it also applies to the A.S.T.M. tung oil method; for under the latter, assuming that the sampler follows the minimum (easiest, less time-consuming!) condition, a sample containing one bottom "take" would then contain 12½% of foots whereas if the foots layer were no more than three inches deep, it would be present in the entire tankcar (84" diam.) only to the extent of a maximum of 1.15% of foots. In an instance where a foots layer may be 10 inches deep, the corresponding percentage would still be only 6.8%. Yet, if two "takes" out of the eight minimum required under the A.S.T.M. method happened to be drawn from the foots layer, the foots would then occur in the sample to the extent of 25%, thus badly down-grading that oil.

American Oil Chemists' Society Method C 1-41 (4)

The guiding principle which forms the basis of the present paper is mentioned as follows:

> "3. Settled material in which the water and solid impurities are likely to be concentrated at the bottom is difficult to sample and reconstitute in proportional quantities. The contour of the tank must be taken into account. If the bottom of the tank is smaller than the middle or top, or vice versa, a core sample is not adequate. To overcome this, the number of portions from each section (e.g. each 1-foot level) should be regulated in reverse order to the cubical capacity of each section. For example, if the bottom 1-foot section is one-fourth of the middle 1-foot section, then one 1-foot sectional sample should be drawn from the bottom level and four 1-foot sectional samples from the middle section. These portions are then composited into one sample and mixed."

Note, however, that while this covers the principle of proportional compositing in a general way, it does not develop the idea with respect to locating precisely the depth of a foots level, then calculating precisely the amount of foots to be incorporated in the final composite sample. Moreover, although this important principle is emphasized, it is not applied in any specific method for obtaining tankcar samples. Only one of the three methods (4) given is applicable to the important case of sampling tank cars at destination before unloading. Two of these methods, which are in common use for taking loading samples, are also applicable at destination for sampling during unloading. These are a) Petcock or Bleeder Method and b) the Multiple Grab composite, sometimes called the Dipper Method. The method given for loaded tankcars c) is well known in the edible oil trade and needs no description beyond stating that it takes a vertical core through the center of the tankcar to within ¼ in. of the bottom and hence results in downgrading the oil being sampled insofar as its grade is affected by the content of foots, which is practically always the case when they are present (see Table I). As already mentioned, this objection is overcome in practice by designating the loading sample as official; and this method is rightly considered satisfactory for loading samples.

Proportional Core Samplers. One or more devices analogous to the A.O.C.S. core sampler have been proposed whereby in one operation a core could be drawn from a tankcar so that the portions which entered the sampler at the various levels were in the correct proportions. One such, known as the Gnaedinger Sampler, is described in reference 4. Apparently this device was successful although, as well as can be judged by its picture, it would not afford a close enough "resolution" of the foots stratum when any depth less than two or three inches was present. It

seems to have been designed largely for use on refined oils or relatively non-footy oils—at least not specifically to include precisely the correct amount of foots in the sample when the volume present might be relatively small.

A sampler operating on exactly the same principle was designed and built at Ralston-Purina Company some years ago, but due to its weight and certain mechanical difficulties its development was abandoned.

The Proportional Foots Method—Proposed. The method given below suddenly grew out of the commercial necessity during the war to evaluate some dozens of raw linseed oil shipments from Canada. Most of these tank cars contained foots strata ranging to 10 in. or more in depth, and accordingly we had absolutely no confidence in the results obtained by any of the available official methods—without unloading the tank cars, an action which was made contingent upon the contents meeting specifications. Using the proportional foots method, samples were obtained which satisfied us as to the oil's quality, and these were subsequently confirmed after unloading the oil. Unfortunately, careful records were not kept to afford experimental proof of the validity of the method and of the invalidity of the published methods in this particular circumstance. However, Table II provides a mathematical demonstration of the latter. In this actual experience just cited, the proportional foots method actually worked and afforded a smooth transaction of the business; whereas neither the author, nor his business associates outside of the laboratory, nor the commercial chemist retained to draw the samples, were willing to base the evaluation of this oil's quality on samples drawn by the published methods.

The basis of the table given in the method was a combination of three different sources dealing with the same principle, in effect showing percentage of volume in terms of percentage of diameter for horizontal cylindrical tanks. One of these was a formula given in "Handbook of Chemistry and Physics"; another, a chart shown in "Chemical Engineering Nomographs" by Davis, p. 219; and the third, tables in "Chemical Engineers' Handbook" by Perry.

Proportional Foots Method

Scope: Applicable to linseed oil when the foots are not firm or frozen, and to other oils in which the settlings are not too firm to flow.

A. *Apparatus*

1. A weighted container of about one gallon capacity (such as a dairy cream pail or oil can) which may be lowered through the oil and allowed to fill at any depth not nearer than one foot from the bottom. The handle should be fitted with a chain or stout cord and an opening in the cover must be sufficiently small to prevent intake of more than about one-sixth of the capacity before the container attains the desired depth. A 1½-in. diameter hole is about right.
2. Bacon bomb sampler with extension pin, or equivalent spacing rods—half pint size preferred—or Krouse oil thief.
3. 5-gallon pail for top and middle oil composite portion.
4. 8-oz. wide mouth bottles, one or more for each portion drawn from different levels within the foots layer.
5. A 500-ml. graduated cylinder, or 16-oz. graduate.
6. A 100-ml. graduate cylinder, or 4-oz. graduate.

B. *Other Requirements.* The sampler should supply the following information and sample components.

1. Size of the tank car in gallons capacity, alternately, the diameter.
2. Depth of the foots layer in inches.
3. A 3-gallon composite of oil drawn from the upper and middle parts of the tank car.
4. One or more separate portions drawn from within the foots layer, depending upon the depth of the layer, in accordance with case 3 below.

C. *Procedure*

Establish the depth of the foots either by using a Bacon bomb sampler, taking successive portions at depths varying by one-inch intervals, or by using a glass core sampler (Krouse oil theif, or equivalent) taking a core of the bottom 12" or 24". Care should be used in lowering the sampler into the tank car bottom not to spring the closure by contact with a coil pipe several inches above the bottom. This can be avoided by locating an exact spot on the rim of the dome opening by a few trial soundings (with the sampler locked shut) until a point is found where it is known that the sampler will not be tripped by contact with a coil pipe on being lowered from that point. After determining the condition of the bottom portion of the car's content, draw a proportional composite by the method below which is most appropriate.

Case 1. No Foots Present

(a) Combine equal parts of extreme top and bottom portions and then mix one part of this blend with six parts of a center composite made as follows: With the large sampler, take a portion from within the center section, allowing the sampler to fill while being raised and lowered, but without having the opening remain nearer than one foot from the bottom, or from the top surface, (except during the initial immersion in the latter case).
(b) Alternately, any equivalent method, such as with a core trier, which takes some oil from different depths, as in (a).

Case 2. Uniform Foots Stratum (as when it may be largely water)

If an examination of the bottom core sample (by means appropriate for establishing this information) indicates the foots stratum to be practically of uniform composition from the very bottom upward, the bomb sampler is set to take a portion at its center point, or directly off the bottom if the foots depth is no greater than 2". Take 3 gallons of oil from various depths (except near the bottom) and mostly from the middle, as in case 1 (a). Composite with the appropriate amount of foots as found in the following table. (See D below.)

Tank car capacity, gallons	4,000	6,000	8,000	10,000	12,000
Inside diameter, inches	59	72 long 77 short	77	86	96

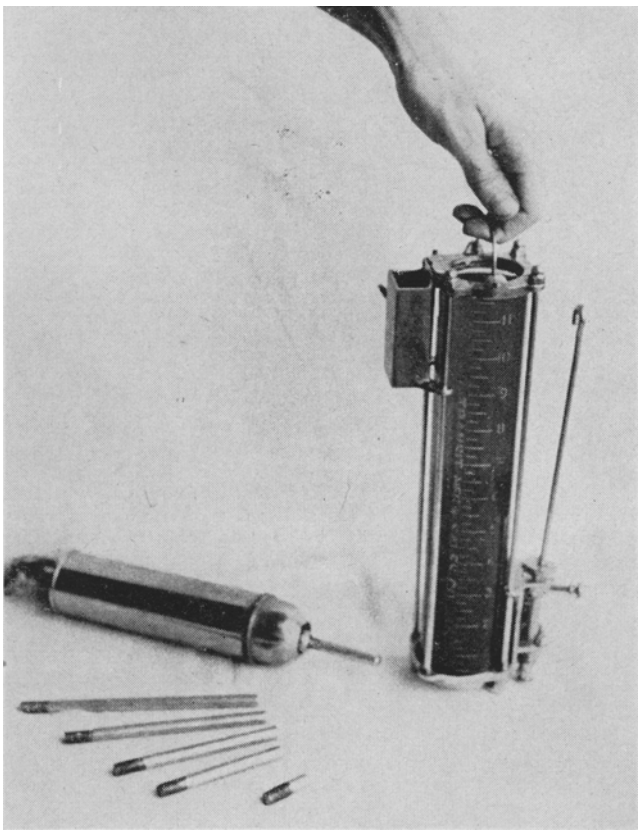
Foots Depth % of Diameter	Foots to Add to 3 Gal. Upper Oil		% Foots in Car by Volume
	ml.	*or fl. oz.*	
0.5	7	¼	0.06
1.0	21	¾	0.18
1.5	37	1¼	0.32
2.0	55	1¾	0.48
2.5	78	2¾	0.68
3.0	103	3½	0.90
3.5	127	4¼	1.10
4.0	156	5¼	1.35
4.5	185	6¼	1.60
5.0	220	7½	1.90
5.5	250	8½	2.15
6.0	286	9¾	2.45
6.5	322	11	2.75
7.0	364	12¼	3.10
7.5	400	13½	3.40
8.0	437	14¾	3.70
8.5	486	16½	4.10
9.0	530	18	4.45
9.5	574	19½	4.80
10.0	625	21	5.20
10.5	676	22¾	5.60
11.0	727	24½	6.00
11.5	792	26¾	6.50
12.0	856	29	7.00

Case 3. Non-Uniform Foots (also to be used when uniformity is in doubt)

Make composite of portions taken from within the foots stratum itself according to the following scheme, then mix this foots composite with the main non-footy upper

oil according to the indicated proportion given under Case 2. (See D below.)

If total foots depth is:	Take from within foot layer @	Composite in proportions:
More than 8″	Near top, at center and bottom	2 parts top 2 parts center 1 part bottom
4 to 8″	Near top and near bottom	2 parts top 1 part bottom
2 to 4″	Center	Then follow case 2
Less than 2″	Bottom	Then follow case 2



Left: Bacon Bomb Sampler with graduated series of spacer rods for filling sampler at various precisely-determined distances above bottom of tank.

Right: Krouse Oil Thief containing core of bottom foots stratum and of non-footy overlaying oil. Bottom-closing trigger rod is extendable to close sampler at various pre-set levels for cases when foots stratum may exceed depth of cylinder. Bottom may be closed at any depth by pulling auxiliary line attached to trigger rod. Note provision for lowering sampler on end of long wooden stick, to be clamped in socket at upper left. As shown, sampler contains core indicating top of foots stratum at 6¾″ depth.

D. *Compositing the Final Sample.* The determination of the correct proportion in which to blend the footy oil with the upper oil should be done in the laboratory or under the direct supervision of the laboratory, as follows:

1. Referring to the table, find the diameter of the tank car opposite its capacity in gallons (to the nearest thousand).
2. Take the depth of the foots layer reported and figure this, to the nearest quarter per cent, as a per cent of the total diameter.
3. Referring to table (interpolating if necessary) find the equivalent percentage of foots in the tank car by volume and the correct proportion in which to combine the sample drawn from the foots layer with the upper-middle oil composite. This applies to any composite of two (or three) separate portions drawn from within the foots layer at different depths therein.
4. The composite foots portion is measured in the graduated cylinder and after emptying into the larger portion of upper oil the remaining foots adhering to the walls of the cylinder are then rinsed from same with a suitable quantity of the upper oil, but without changing the proportion.
5. After combining the foots portion and the main oil, the sample is thoroughly stirred until the foots have been uniformly distributed. It is then subdivided into several identical portions (usually three, of about ¾ gal. each) in appropriate containers and marked as may be designated by trading rules or regulations governing the transaction represented.

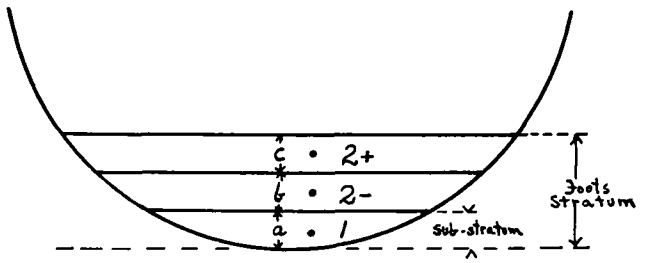
Application to Soybean Oil. It might be mentioned that this method should be applicable to crude soybean oil even when a tankcar of same may contain several inches of stiff sludge on the bottom; for in this case this sludge will not flow into the bomb or core types of samplers, just as it will not flow into the outlet pipe when the tank car is unloaded. Thus, in this case, the sample does reasonably well represent the oil that can be unloaded, and the matter of sludge is covered independently by a trading rule not concerned with the sample. Although a stiff phosphatide or mealy deposit would not flow into either the Krouse or the Bacon bomb samplers, it is considered that this material might seal off the opening in the Bacon sampler, preventing the inflow of bottom oil; and it is probably not sufficiently resistant to spring the closing cap on the Krouse sampler. Both of these difficulties can be overcome by drilling and tapping the ends of the release pins on both samplers so that a flat plate about 3 in. across could be fastened horizontally on the ends of these pins with thumbscrews, affording a sort of snowshoe effect on the sludge, thus causing the samplers to operate on contact with the sludge surface as though the latter were the tank car bottom. This plate should be oriented on the Krouse sampler so as not to impede the free flow of oil into the cylinder.

Notes on Bomb and Glass Core Samplers. The Bacon bomb sampler, made in 4-, 8-, and 16-oz. sizes, is available in a model having an extendable pin, graduated in inches, which may be set to trip the sampler at any depth from ⅜″ of the bottom up to about 12″ or more. The regular model, without this feature, can easily be adapted to do this, as follows: Drill and tap into the end of the opening pin on the bottom a hole into which may be screwed various lengths of metal rods (¼ or ⅜″ diam. are suitable). From a piece of such rod, short lengths are cut so that when threaded for about ¼″ on one end and screwed into the end of the tripping pin, the sampler can be made to open (by contact of the pin against the bottom) at any desired depth above the bottom, up to two or more feet if necessary. Generally a kit containing rods affording sample "takes" at one-inch intervals up to about 10 inches is adequate. (See photo.)

Locating the top of the foots stratum, however, is far more easily done, i.e., may be accomplished in one operation, by using a glass bottom-core sampler, of which a suitable example is known as the Krouse Oil Thief.* This device cuts off within one inch of the bottom, may be set to close on contact at any distance up to several inches off the bottom; or it may be closed by pulling an auxiliary cord. The depth

* Obtainable from W. H. Curtin Company, Houston, Texas, Nos. 16740A and 16740B in one-foot and two foot sizes.

of the foots stratum may be plainly seen through the glass wall and read on the engraved scale thereon, as shown in the photograph.



Substrata Thickness (a=b=c)	Total Foots Depth (a+b+c)	Volume Ratios c/a	b/a	a/a
2"	6"	2.3	1.8	1
3	9	2.3	1.8	1
4	12	2.2	1.8	1
6	18	2.2	1.8	1

Cross Section of the Lower Part of Tank Car Containing Foots. Geometrical basis for the proportions specified in Case 3 of the proportional foots method. Thus, within the rather extreme limits indicated, (which should cover all cases encountered in practice), and for all practical purposes, the ratio of the volumes of the top third, based on depth, and of the middle third of any foots stratum, to the volume of the bottom third, is substantially two-to-one.

Technique. If the proportional foots method appears to be rather complicated, it is really simple and logical to a technically-trained person though it may seem difficult to the average workman. Tankcar sampling, however, should always be under the close supervision of the laboratory, when price settlements or claims are concerned; and where there is indicated a method of sampling which may require unusual care in application as compared with the usual ones, if it cannot be applied under the direct supervision of a laboratory man or someone thoroughly familiar with the principle involved, then the workman who does use it unobserved should be qualified by thorough instruction.

On the other hand, what this method may lose in being somewhat complicated in principle, from the workman's point of view, it more than makes up by being less time-consuming; and once the idea of the right proportion has been mastered it should be more easily applied, especially when we consider that it requires drawing only a few portions from the tankcar, as compared with the federal specifications method's minimum of 40 withdrawals.

Summary

The general problem of taking a representative sample from a tank car containing foots is discussed, and the shortcomings of various methods in wide use are noted. A new method based upon a clear recognition of the difficulties involved and the application of simple geometry to the problem has been proposed.

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He is grateful also to Charles V. Bacon, inventor of the Bacon Bomb Sampler, for corroborating the basic points made in this paper when it was presented at the 1948 Fall Meeting of the Society in New York. Since Dr. Bacon has applied these principles (and probably others also have), no claim of originality for the basic concept is made.

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Flavor Reversion in Hydrogenated Soybean Oil.* I. The Effect of Double-Degumming. II. The Effect of Unsaponifiable Matter

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THE results of research work in this field fall into two general groups with respect to the cause of flavor reversion. One group considers materials other than pure triglycerides to be the offending factors whereas the other places the responsibility on the triglycerides proper. This apparent contradiction is largely due to the ambiguous use of the term "soybean oil flavor reversion" and particularly to the failure to make proper distinction between the flavor found in soybean oils held at moderate temperatures (20-60°C.) and the entirely different flavor and odor developed by heating hydrogenated soybean oils to the elevated temperatures required for culinary purposes.

The different methods used to develop the two types of reversion as well as the lack of uniformity in panel evaluations add to the confusion and have made it virtually impossible to compare the results of various workers. As has been pointed out repeatedly in the literature (1, 2, 13, 14), the use of the term "flavor reversion" is unfortunate since these flavors are not the same as the original ones. This is particularly true of the heated flavor of soybean oils hydrogenated to shortening consistency since this strong-peculiar-lasting taste is in no way reminiscent of natural soybean oil.

Soybean oil reversion is usually referred to in terms of flavor. We have found, however, that the flavor developed in hydrogenated soybean oils at elevated temperatures is characterized by a similar distinct odor; and in the panel evaluations to be discussed later participants have used the flavor and/or

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