Volumetric Shrinkage Resulting From Blending Volatile Hydrocarbons with Crude Oils

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American Petroleum Institute
1220 L Street, Northwest
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Measurement Coordination

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FOREWORD

The purpose of this bulletin is to present the best data currently available on the subject of volumetric changes resulting from blending volatile hydrocarbons (propane, butane, produced distillates, and natural gasolines) with crude oils.

Data contained herein correlate information made available to the Admixture Measurement Functional Group of the American Petroleum Institute's Committee on Crude Oil Measurements. (The functions of this group are now under the auspices of the Institute's Central Committee on Petroleum Measurement.) None of the experimental work was sponsored by the Admixture Measurement Functional Group. Although data were available to construct the included curves, the information is meager when considered in relation to the overall problem. The bulk of the data was obtained at concentrations at 20 percent or below. Therefore, users of the curves described herein should understand that they represent an average of data obtained with different materials at various conditions of temperature and pressure and by three basically different test methods.

Part I presents curves constructed from data made available by the following companies:

Atlantic Richfield Co.
Cities Service Pipe Line Co.
Humble Pipe Line Co.
Mobil Pipe Line Co.
Service Pipe Line Co.
Shell Pipe Line Corp.
Sun Oil Co.
Getty Oil Co.

Particular recognition is given to Service Pipe Line Company for authorizing Mr. W. E. Roads to devote time to the correlation of the data with the aid of the company's electronic computer.

Part II presents a generalized description of the three basic test methods and equipment used in obtaining the data from which the curves were calculated. Any of these three test methods is suitable for determining shrinkage when proper allowance is made for the test measurement accuracy of each method in relation to the mixture concentration desired.

The Appendix, "Tables for Predicting Volumetric Shrinkage," has been added to this edition. The first edition of this bulletin was published in 1962.

Further information is needed concerning volumetric changes resulting from petroleum admixtures. Companies which sponsor experimental work on this subject are urged to supply the data obtained to the director of the Division of Science and Technology, American Petroleum Institute.

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PART I—AVERAGE VOLUME CONTRACTION (SHRINKAGE) RESULTING FROM BLENDING OF PETROLEUM HYDROCARBONS

Introduction and Theory

In recent years, crude oil pipelines have been used for transporting an increasing amount of light products such as butane, natural gasoline, and high-gravity produced distillates. Because of the physical nature of the crude oil system and the widely dispersed receipt points of the light components, such products usually are blended into the crude oil stream. Such blending actually is encouraged to reduce losses by evaporation of the lighter components and to minimize pump suction difficulties.

As a part of the conservation effort of the pipeline industry, the causes of oil losses in transit are being investigated continuously. Such an investigation of the volume loss experienced in systems handling the light components blended into a common crude oil stream indicated that the losses did not result entirely from increased evaporation but were caused partly by a phenomenon associated with the blending of the lighter components and the heavier crude oil. That is, when a lighter product such as butane or natural gasoline is mixed with crude oil, the resulting volume is less than the sum of the individual component volumes. This loss or shrinkage is only an "apparent loss" on a volume basis for there is, of course, no loss of weight as a result of the mixing operation.

In the blending of petroleum components having different physical properties, volumetric shrinkage occurs because the components do not form ideal solutions. In an ideal solution, the total solution volume is equal to the sum of the volumes of the components. In order for a solution to approach ideality, the molecules of the materials blended together must be similar in size, shape, and properties. If the nature of the molecules of the components differs appreciably, then deviation from ideal behavior may be expected. This deviation may be either positive or negative; that is, the total volume may increase or decrease when the components are blended.

Glasstone [1a] states that if a solution of two or more components exhibits positive deviation from Raoult's law, the observed vapor pressure and volume would be greater than if the components had formed an ideal solution. This he attributes to the mean attractive forces between the molecules in the mixture being smaller than for the constituents separately.

Conversely, if a solution should exhibit negative deviation from Raoult's law, usually there is a decrease in vapor pressure and volume on mixing. This is attributed to the mean attractive forces between the molecules in the mixture being greater than for the constituents separately.

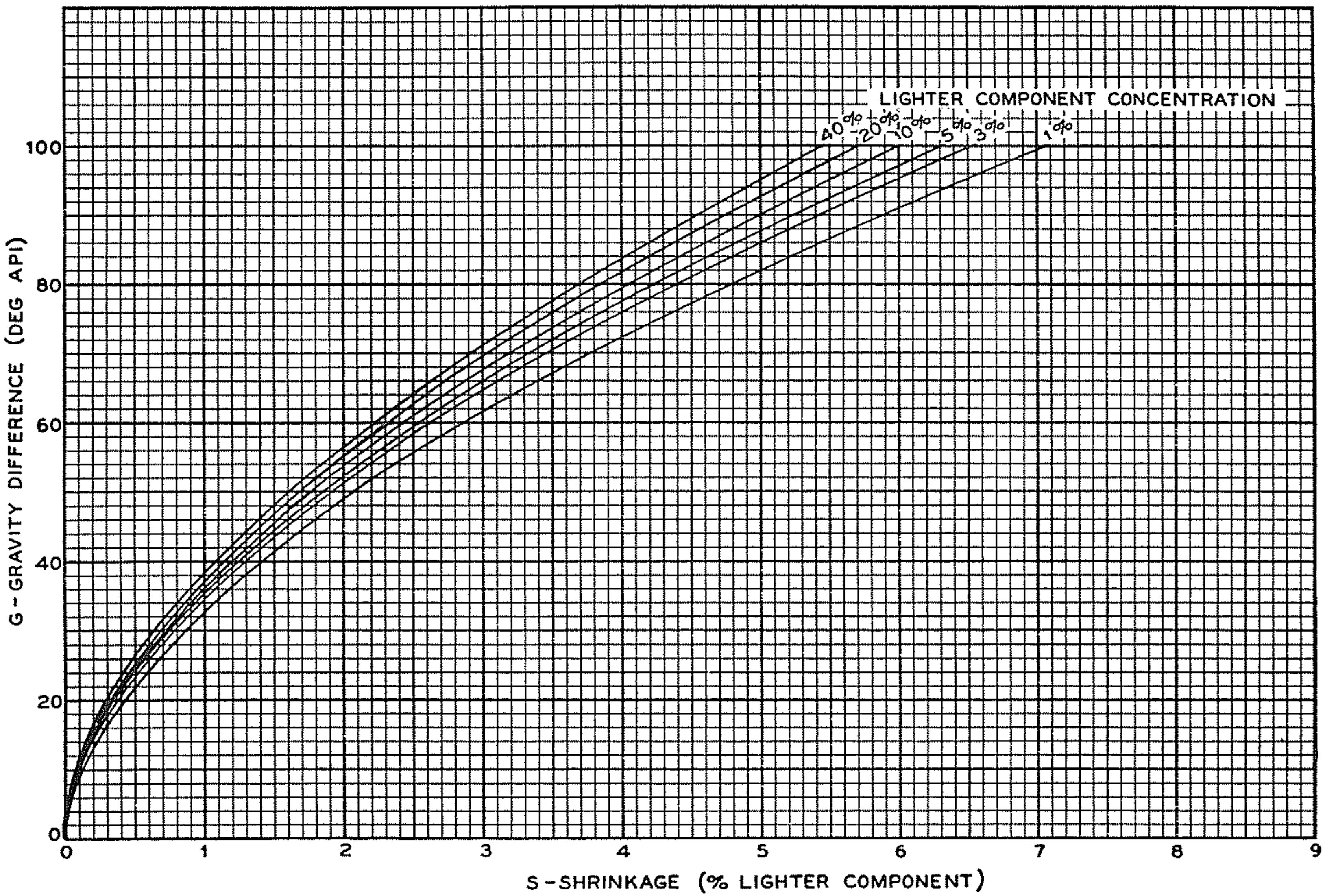
Inasmuch as petroleum components contain molecules of various sizes and weights, solutions of two separate components are seldom ideal. Consequently, it is to be expected there may be a change in volume associated with the mixing or blending of petroleum components of varying gravities and molecular structure.

All available test data covering blends of lighter and heavier petroleum components (e.g., butane with crude oil) indicate that the change in volume is negative in direction resulting in a shrinkage of the total volume.

Curves for Predicting Average Volume Shrinkage

The curves shown in Fig. 1 were constructed from data furnished by companies named in the Foreword in accordance with a correlation suggested to Interstate Oil Pipe Line Company [2] (presently Humble Pipe Line Company) by Dr. F. D. Rossini, of Carnegie Institute of Technology. Test data were obtained through methods described in Part II. All of the experimental work was not performed at the same pressures and temperatures. However, in view of the limited test results available, it was necessary to assume that the deviations in the test conditions and methods would not be great enough to prevent fitting of curves by statistical methods. Generally accepted methods of testing for correlation have shown that this assumption was justified for the average curves desired. Complete description of the correlation methods used and the computer program may be

[a] Refers to REFERENCES on p. 13.



NOTE: Factors equivalent to the percentage shrinkage are given in the Appendix tabulation.

FIG. 1—Curves for Estimating Volume Change When Blending Volatile Hydrocarbons with Crude Oil.

obtained from the Division of Science and Technology, American Petroleum Institute.

Users of the curves must remember that they represent average values for various combinations of crude oils and petroleum components. A specific crude oil blended with a specific petroleum component could result in shrinkage appreciably different from that shown on the curves. For this reason, if the exact shrinkage for a specific blend is required, then it is recommended that tests be conducted using the specific hydrocarbons to determine if the curves may be appropriately applied.

Example of Use of Curves for Predicting Shrinkage

Ninety-five thousand barrels of crude oil of 30.7 deg API gravity at 60 F are to be blended with 5,000 bbl of natural gasoline of 86.5 deg API gravity at 60 F. The resultant volume of the mixture may be obtained by reading the curve at the intersection of the gravity difference of 55.8 (obtained by the subtraction 86.5−30.7) and 5 percent of the lighter component. This value is found to be approximately 2.3 percent. This assumes that the volumetric reduction is applicable to the lighter component. Therefore, the volume of the mixture is equal to:

(0.023)(5,000) = 115 bbl shrinkage
5,000 − 115 = 4,885 bbl natural gasoline
4,885 + 95,000 = 99,885 bbl mixture

Effect of Temperature and Pressure on Volumetric Shrinkage

Limited tests have shown that pressure and temperature do affect the amount of volume shrinkage. However, sufficient data are not presently available to determine the magnitude of this effect. The limited data available indicate an increase in shrinkage with an increase in temperature and a decrease in shrinkage with an increase in pressure.

Calculation of Tables and Curves for Predicting Shrinkage

The "Tables for Predicting Volumetric Shrinkage," shown in the Appendix, were calculated using the following empirical formula derived from test data:

$$S = 0.0000214\, C^{-0.0704} G^{1.76}$$

Where:

S = shrinkage factor, as decimal fraction of lighter component volume.
C = concentration, in liquid volume percent of lighter component in mixture.
G = gravity difference, in degrees API.

The curves shown in Fig. 1 for various concentrations of lighter components were also calculated with the aid of the foregoing formula. (Note that shrinkage is expressed as a *decimal fraction* in the tables and in *percent* in Fig. 1.) This formula can be used with a high degree of confidence to calculate shrinkage at concentrations up to 21 percent of the lighter component, inasmuch as 460 data points were available in this range. Only 48 data points were available between 21-percent and 50-percent concentration. The formula is not valid at concentrations above 50 percent of the lighter component.

If the *volume reduction* is defined in terms of percent of the *total mixture volume* and plotted against percent concentrations of the lighter component, the volume reduction will be maximum in the vicinity of 50-percent concentration of the lighter component and will be zero at zero percent and 100 percent.

PART II—TEST METHODS FOR DETERMINING SHRINKAGE

Shrinkage Measurement Utilizing Modified P-V-T Apparatus

Description of Equipment: The equipment for this test consists of two pressure-volume cells and a calibrated mercury pump interconnected, as shown in Fig. 2, and placed in a constant-temperature water bath.

The temperature of the bath should be controlled within ±0.001 of 60 F (or other selected test temperature). A suggested method of controlling the temperature of the water bath is to combine a constant output refrigeration system with an extremely sensitive electrical heating system. The refrigeration system when operated alone should provide a bath temperature of approximately 58 F or approximately 2 F lower than the selected test temperature. Current to the resistance coils of the electrical heating system should be controlled by an electronic relay activated by a highly precise mercury-type thermoregulator. Temperatures should be read with a precision-grade thermometer or the equivalent.

This equipment, operating properly, should have little trouble in maintaining a constant bath temperature within the ±0.001 F.

All measurements should be made at a constant pressure of 100 psig (or other selected test pressure). The test pressure should exceed the vapor pressure of the most volatile component to prevent the formation of gases in the test system with resulting errors. It is suggested that a 200-psig test gage, with 1-psi divisions, be used. This gage should be calibrated to 0.1-psi accuracy by comparison with a deadweight tester. A hairline should be scribed on the gage face at the 100-psi point (or other selected test pressure) and all readings should be made at that point. The gage should be rechecked with the deadweight tester after each analysis.

Only compression-type fittings should be used to connect Valve 1 with Line D. This type of fitting has been found to reduce the possibility of errors resulting from trapped air or valve holdup.

Procedure During Preparation and Filling of Equipment for Shrinkage Test: For purposes of clarity in this procedure, the terms "heavier component" (i.e., crude oil) and "lighter component" (i.e., pentane, butane, etc.) are defined as follows: heavier component is the petroleum product contained in Cell A at the beginning of the test; lighter component is the petroleum product contained in Cell B, a portion of which is to be transferred into Cell A and mixed with the heavier component.

1. With Valve 1 removed and Valve 5 closed, pour approximately 400 ml of mercury into Cell A. Next, fill remainder of space in Cell A with a weighed quantity of the heavier component, approximately 1,100 ml. The volume of this heavier component is calculated by dividing its weight by its specific gravity. Replace and close Valve 1.

2. Before Cell B is connected to the apparatus, fill it with the lighter component to be tested. This lighter component floats on a layer of mercury in the cell. Filling the cell is accomplished by the technique normally used in subsurface sample analyses, whereby fluids are transferred under pressure from one container to another by displacement with mercury. At the end of the transfer, sufficient mercury is left in Cell B to maintain a seal above Valve 6 at all times. This prevents entrance of the lighter component into Valve 6 or Line F. With Valves 2 and 6 closed Cell B is then connected into the system shown in Fig. 2. Open Valves 3 and 4.

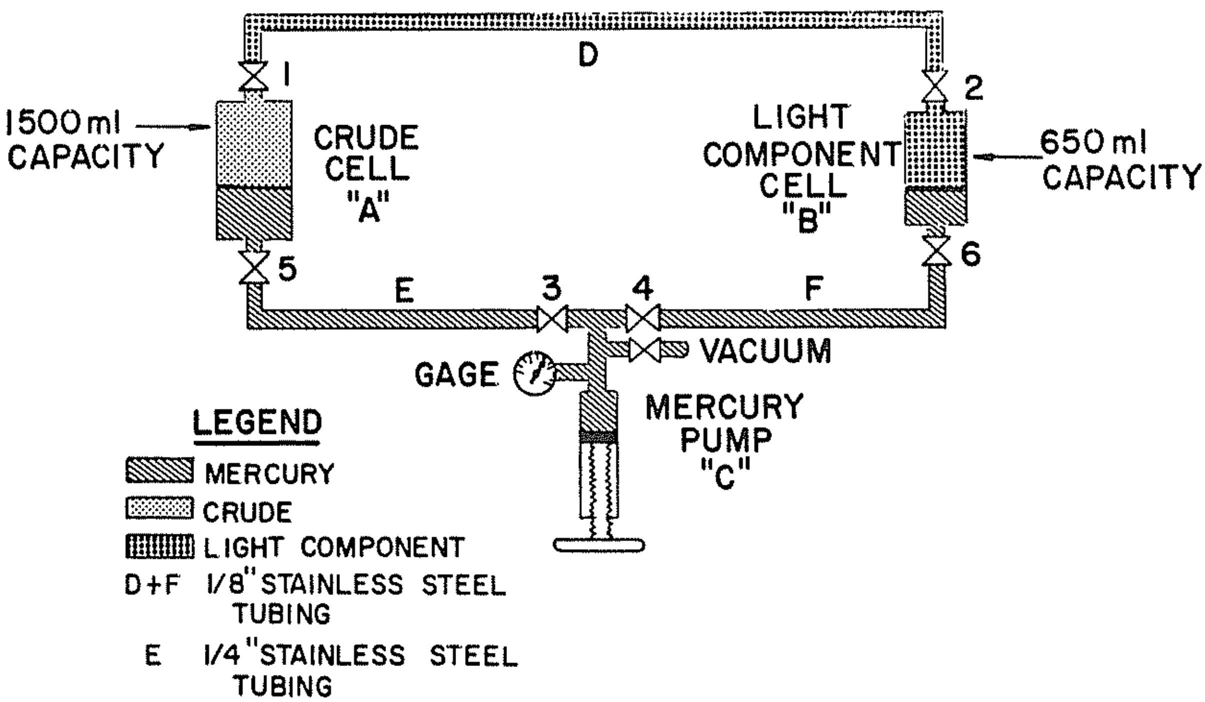


FIG. 2—Modified P-V-T Apparatus for Measuring Shrinkage of Petroleum Admixtures.

3. Evacuate lines between Mercury Pump C and closed Valves 5 and 6. Fill these evacuated lines with mercury by means of Mercury Pump C.

4. Open Valve 6. With Pump C inject sufficient mercury into Cell B to raise the cell pressure to 100 psig (or other selected base pressure) at bath temperature.

5. Open Valve 2. Slightly loosen the Line D connection at closed Valve 1. By mercury displacement at 100 psig, slowly purge the lighter component through Line D allowing trapped air and some lighter component to be vented at the loosened Line D connection at Valve 1. Tighten the loosened Line D connection and close Valve 4. Valves 2 and 6 are now left open.

6. Open valve 5 into Cell A. By mercury injection with Pump C, raise the pressure in Cell A to 100 psig (or other selected base pressure) at bath temperature.

7. Open Valve 4 so that the pump is connected to both Cells A and B with only Valve 1 closed. The system is now checked for leaks by allowing it to stand at constant 100-psig pressure for 1 hr or longer. Any leakage would cause a pressure drop in the constant-volume system and constant-temperature system.

8. After the system is proved to be free of leaks as described in the preceding step 7, the system constitutes a closed constant-volume unit consisting of Mercury Pump C, Cells A and B, and connecting valves and lines. In this system, maintained at constant temperature, only actual change in volume of fluids in the system will cause a change in pressure. Thus, any shrinkage occurring upon mixing of heavier and lighter components will be reflected in pressure drop. The volume of mercury which must be injected to prevent pressure drop during component mixing measures the amount of shrinkage which occurred.

Procedure During Shrinkage Test: At this point in the procedure, the valves should be positioned as follows:

1. Valves 2, 5, and 6 remain open and undisturbed throughout the remainder of the test.

2. Valves 3 and 4 hereafter are closed or are opened only to fixed positions. Thus, variations in volume of the system resulting from changes in valve positions are controlled. All volumetric measurements are made with Valve 1 closed, thus preventing further addition of lighter component to Cell A.

Determination of shrinkage occuring upon mixing heavier and lighter components requires that the lighter component be transferred from Cell B to Cell A which already contains heavier component. In Cell A, the two components are mixed. The resulting shrinkage is measured as the volume of mercury which must be injected into Cell A to maintain a pressure of 100 psig in the constant-temperature system. The procedure is as follows:

1. Close Valve 4 and record initial pump reading with Valve 3 open and Valve 1 closed. With Mercury Pump C, withdraw mercury from Cell A. Close Valve 3 and open Valve 4. Record reading of mercury pump at 100 psig. Open Valve 1 and displace a measured volume of lighter component into Cell A. Close Valve 1 and take another reading of the mercury pump at 100 psig. The difference in pump readings measures the volume of lighter component injected into Cell A.

2. Close Valve 4 and open Valve 3. Mix the contents of Cell A by repeatedly inverting the cell, meanwhile maintaining 100-psig pressure in the cell by addition of mercury with Pump C. When the pressure becomes a constant 100 psig at a definite pump position, regardless of continued agitation, no further shrinkage is occurring and the final pump reading is recorded. The shrinkage which has occurred is calculated as the volumetric difference between the initial pump reading (see preceding step 1) and the final 100-psig pump reading just obtained. This volumetric shrinkage is calculated to a percentage basis by dividing by the total volume of lighter component added and multiplying by 100.

Accuracy:

1. *Volume measurement:* Pump accuracy = 0.001 turns = 0.00129 ml.

2. *Temperature:* Temperature controlled at 60 F ± 0.001.

3. *Sample weight:* The heavier component is weighed into the pressure-volume cell with an accuracy of 0.1 g in approximately 1,000 g.

4. *Specific gravity:* The specific gravity of the heavier component should be measured on a precise balance to an accuracy of 0.0001. The specific gravity is used to convert the weight of the heavier component (see preceding Par. 3) to its equivalent volume.

The overall measurement accuracy—including mercury pump accuracy, temperature bath variation, sample weight accuracy, and the specific gravity accuracy—is 0.002 ml for a total test volume of approximately 1,200 ml.

Shrinkage Measurement Utilizing Visual Volumetric Apparatus

The apparatus in Fig. 3, operated at constant temperature, permits visual measurement of volumetric shrinkage resulting from the mixing of two dissimilar petroleum components. When properly calibrated, the equipment is designed to give experimental data for concentrations as low as 2½ percent by volume of the lighter component in a two-component system. Auxiliary equipment required is a Reid vapor pressure temperature bath, accurate to 0.1 F, and a pressure gage (usually 0 to 100 psi), accurate to 1 psi.

The overall measurement accuracy, including reading accuracy of the calibrated buret and temperature bath variation (assuming correct compressibility correction of the test liquids and equipment), is 0.036 ml for the smallest chamber combination (total test volume, 269 ml) and 0.051 ml for the largest chamber combination (total test volume, 626 ml), based on butane and a 40 deg API gravity crude oil mixture.

Procedure: The apparatus shown in Fig. 3 is assembled using the appropriate parts. Flasks, bulbs, and sight glass are interchanged to obtain different percentages of blends. Table 1 shows the combinations of flasks and bulbs used to obtain these various blend percentages.

To determine the shrinkage for a blend containing approximately 10 percent by volume of lighter components, use Flask 1 and Bulb 1 in the assembly. Force the heavier component via a vaportight line into the calibrated Flask 1 through Valve 1 until it is well above Valve 2. (*Note:* In order to minimize evaporation losses, the pressure in the apparatus should be higher than the vapor pressure of the components at the existing temperature.)

TABLE 1—Approximate Composition of Blends When Various Combinations of Bulbs and Flasks Are Used *

Flask No.	Bulb No.	Lighter Component (Percent by Volume)
1	None	2 to 4
2	None	5 to 7
1	1	10
1	3	15
1	4	20
1	1, 4	25
2	3	30
2	4	35
2	3, 2	45
2	2, 4	50

* Other combinations will result in different percentage blends.

After closing Valves 3 and 4, the apparatus is placed in the constant-temperature bath and Valve 2 is closed when the sample has reached test temperature (30 min). The excess heavier component is then drained from the apparatus at Valve 3. The lighter component is forced into the calibrated Bulb 1 through Valve 3 until the liquid level reaches Valve 4. The apparatus is then inverted, and the lighter component is forced out at Valve 4 by its own vapor pressure or by draining. The lighter component is again forced into Bulb 1 until the liquid level is near the center mark of the calibrated glass section. Valve 4 is then opened momentarily to allow the pressure in the upper chamber to reach the vapor pressure of the lighter component at the existing conditions. A small 0-psia to 100-psia gage, or one of appropriate range, is attached to Valve 4.

The apparatus is again placed in the constant-temperature bath until both the lighter and heavier components have reached test temperature (30 min). Valve 4 is opened slightly, and the vapor pressure (P_1) and liquid level, both the upper level and lower meniscus, are read and recorded. The meniscus is used when possible but the meniscus of some dark blends cannot be read. The difference between the upper level before and after blending will then represent the shrinkage. Liquid levels are estimated to the nearest 0.02 ml, and the true vapor pressure is estimated to the nearest 1 psia. The apparatus should not be removed from the constant-temperature bath. Valve 2, between the two components, is then opened completely. The apparatus is rocked gently to assure that no gas bubbles have been trapped, and the liquid level in the calibrated section is again estimated as described previously. (*Note:* For use with high-vapor-pressure components, it is necessary to determine the volumetric expansion of the equipment at various anticipated pressures and temperatures and to know the approximate compressibility characteristics of the components and blends.)

After reading and recording both the upper level and lower meniscus with Valve 2 open, the apparatus is removed from the bath, Valve 4 is closed, and the two components are mixed until a homogeneous blend results. This is done by alternately holding the apparatus upright and then in an inverted position and gently shaking. At least 15 to 20 cycles over a period of 10 to 15 min are required to obtain a homogeneous blend.

The apparatus is again returned to the constant-temperature bath until the blend has reached the test temperature. The volume and true vapor

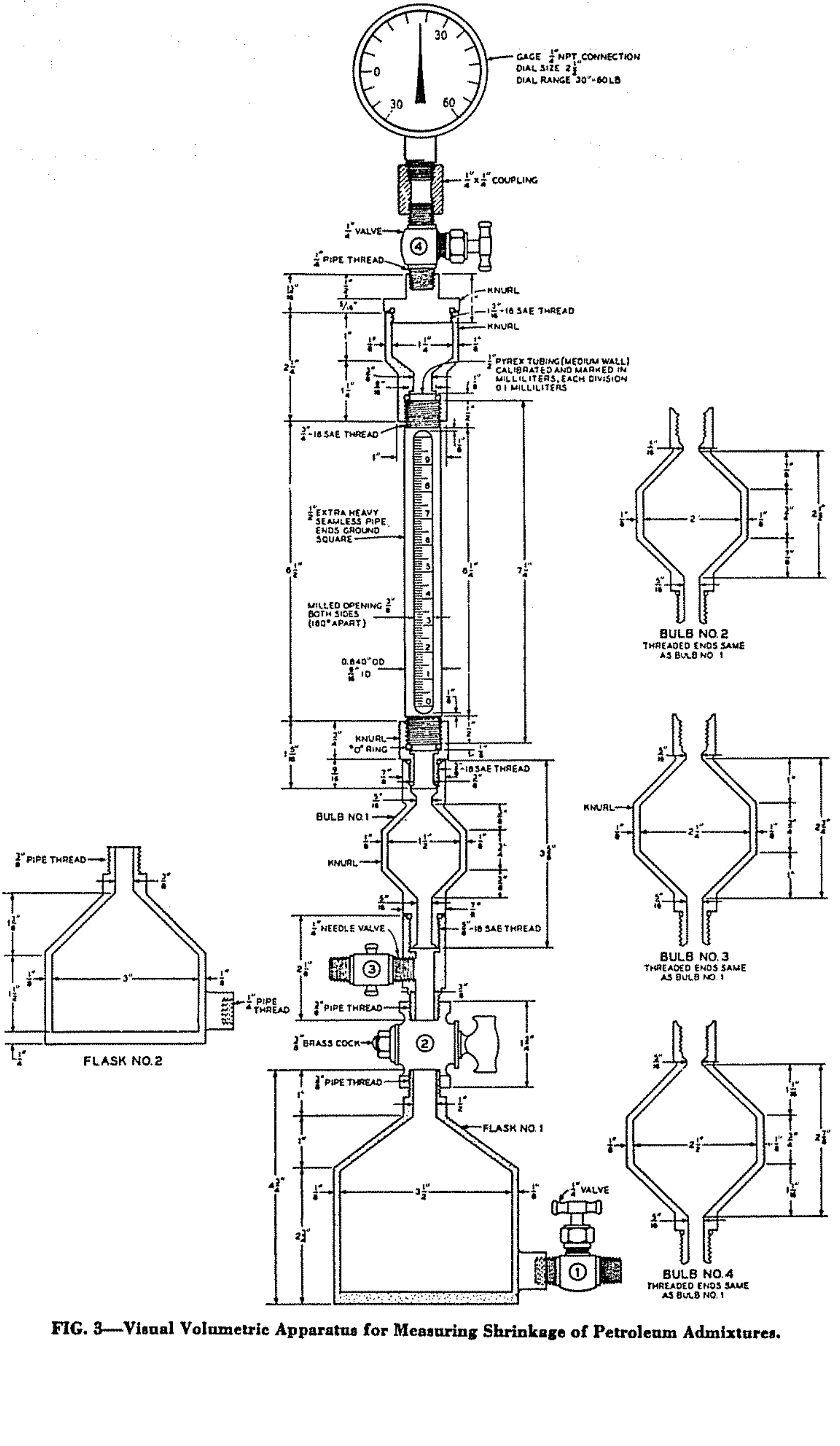


FIG. 3—Visual Volumetric Apparatus for Measuring Shrinkage of Petroleum Admixtures.

pressure (P_2) are read and recorded to the nearest 0.02 ml and 1 psia, respectively. The shrinkage is noted from the volumetric change resulting from the blend of the two components.

Calculation: The increase in volume resulting from the dissolved vapors is calculated and added to the determined volume decrease by use of Table 2 and the equation:

$$C=(F_1-F_2)S$$

Where:

C = volume correction, in milliliters.
F_1 = pressure factor for P_1.
F_2 = pressure factor for P_2.
S = vapor space, in milliliters.

The increase in volume, in milliliters, resulting from the lower pressure is determined from previously prepared tables, based on the expansion of the equipment and the compressibility of the components, and added to the determined volume decrease:

$$\text{Volume decrease as percent of total blend} = \frac{A}{H_v+L_v}(100)$$

Where:

A = corrected volume change on mixing, in milliliters.
H_v = corrected volume of the heavier component, in milliliters.
L_v = corrected volume of the lighter component, in milliliters.

This method can be used under field conditions by qualified technical personnel provided proper allowance is made for its range of accuracy and the conditions under which the data will be applied. The necessity of correct calibration of the test equipment and proper correction for the effects of compressibility is emphasized.

TABLE 2—Pressure Factors for Hydrocarbon Vapors

(Correction for Liquid Contained in Vapor Space)

(P) Pressure (Pounds per Square Inch Gage)	(P) Pressure (Pounds per Square Inch Absolute)	(F) Pressure Factor
	0	0.0000
	5	0.0015
	10	0.0030
0	15	0.0045
5	20	0.0060
10	25	0.0075
15	30	0.0090
20	35	0.0104
25	40	0.0118
30	45	0.0133
35	50	0.0148
45	60	0.0174
55	70	0.0209
65	80	0.0240
75	90	0.0270
85	100	0.0300
105	120	0.0363
125	140	0.0425
145	160	0.0490
165	180	0.0556
185	200	0.0620

Shrinkage Measurement Utilizing Specific Gravity Method

The shrinkage is determined for mixtures of two components by comparing the experimentally determined specific gravity of the mixtures with the theoretical specific gravities which the same components should have shown under conditions of ideal mixing. Tests using this method must be conducted under constant-temperature conditions. The crude oil or heavier component is poured into a glass-stoppered graduated cylinder. To this is added, from a buret, the measured volume of the lighter component. The buret must be extended beneath the surface of the heavier component to minimize evaporation loss. The graduated cylinder is stoppered and inverted repeatedly to insure mixing of the two components. Equilibrium temperature is determined with the aid of a thermometer. The gravity of both components and the resulting mixture is determined by the use of precise equipment such as hydrometers and pycnometers.

The theoretical specific gravity of each ensuing blend is calculated from the volume percent of each component and the specific gravity of the original samples. Comparison of the theoretical and experimentally determined gravity of the mixture is a measurement of the volume shrinkage.

Inasmuch as the technique and equipment used in this method preclude a high degree of accuracy, it should not be expected that the results will be as reliable as those from the two methods previously described. Temperature control of ±1 F and basic volumetric measurement accurate to approximately 0.4 percent make this procedure unsuitable for use when the proportion of the lighter component in a mixture is small. Data obtained by this method were among the first results which indicated the existence of shrinkage when petroleum components were mixed. Better control equipment and instrumentation would improve the procedure.

REFERENCES

[1] Samuel Glasstone, *Thermodynamics for Chemists*, 1st edn., D. Van Nostrand Co., Inc., New York (1947).

[2] H. M. Childress and M. B. Grove, "Volume Shrinkage Occurring in Blending Petroleum Products and Produced Distillates with Crude Oils," ASME meeting, New Orleans, La., Sept. 25-28 (1955); *Petrol. Eng.* **27** [13] D35-47 (1955).

APPENDIX

TABLES FOR PREDICTING VOLUMETRIC SHRINKAGE *

Gravity Difference (Degrees API)	Light-Product Concentration 1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
	FACTORS FOR COMPUTING VOLUMETRIC SHRINKAGE † (Decimal Fraction of Light-Product Volume)									
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
4	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
5	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
6	0.0005	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
7	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
8	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
9	0.0010	0.0010	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
10	0.0012	0.0012	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0010
11	0.0015	0.0014	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0012	0.0012
12	0.0017	0.0016	0.0016	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0014
13	0.0020	0.0019	0.0018	0.0018	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
14	0.0022	0.0021	0.0021	0.0020	0.0020	0.0020	0.0019	0.0019	0.0019	0.0019
15	0.0025	0.0024	0.0023	0.0023	0.0022	0.0022	0.0022	0.0022	0.0022	0.0021
16	0.0028	0.0027	0.0026	0.0026	0.0025	0.0025	0.0025	0.0024	0.0024	0.0024
17	0.0031	0.0030	0.0029	0.0028	0.0028	0.0028	0.0027	0.0027	0.0027	0.0027
18	0.0035	0.0033	0.0032	0.0031	0.0031	0.0031	0.0030	0.0030	0.0030	0.0029
19	0.0038	0.0036	0.0035	0.0035	0.0034	0.0034	0.0033	0.0032	0.0033	0.0032
20	0.0042	0.0040	0.0039	0.0038	0.0037	0.0037	0.0036	0.0036	0.0036	0.0035
21	0.0045	0.0043	0.0042	0.0041	0.0041	0.0040	0.0040	0.0039	0.0039	0.0039
22	0.0049	0.0047	0.0046	0.0045	0.0044	0.0043	0.0043	0.0043	0.0042	0.0042
23	0.0053	0.0051	0.0049	0.0048	0.0048	0.0047	0.0047	0.0046	0.0046	0.0045
24	0.0057	0.0055	0.0053	0.0052	0.0051	0.0051	0.0050	0.0050	0.0049	0.0049
25	0.0062	0.0059	0.0057	0.0056	0.0055	0.0054	0.0054	0.0053	0.0053	0.0053
26	0.0066	0.0063	0.0061	0.0060	0.0059	0.0058	0.0058	0.0057	0.0057	0.0056
27	0.0071	0.0067	0.0065	0.0064	0.0063	0.0062	0.0062	0.0061	0.0061	0.0060
28	0.0075	0.0072	0.0070	0.0068	0.0067	0.0066	0.0066	0.0065	0.0065	0.0064
29	0.0080	0.0076	0.0074	0.0073	0.0072	0.0071	0.0070	0.0069	0.0069	0.0068
30	0.0085	0.0081	0.0079	0.0077	0.0076	0.0075	0.0074	0.0074	0.0073	0.0072
31	0.0090	0.0086	0.0083	0.0082	0.0081	0.0080	0.0079	0.0078	0.0077	0.0077
32	0.0095	0.0091	0.0088	0.0087	0.0085	0.0084	0.0083	0.0082	0.0082	0.0081
33	0.0101	0.0096	0.0093	0.0091	0.0090	0.0089	0.0088	0.0087	0.0086	0.0086
34	0.0106	0.0101	0.0098	0.0096	0.0095	0.0094	0.0093	0.0092	0.0091	0.0090
35	0.0112	0.0106	0.0103	0.0101	0.0100	0.0098	0.0097	0.0096	0.0096	0.0095
36	0.0117	0.0112	0.0109	0.0106	0.0105	0.0103	0.0102	0.0101	0.0101	0.0100
37	0.0123	0.0117	0.0114	0.0112	0.0110	0.0109	0.0107	0.0106	0.0106	0.0105
38	0.0129	0.0123	0.0119	0.0117	0.0115	0.0114	0.0113	0.0111	0.0111	0.0110
39	0.0135	0.0129	0.0125	0.0123	0.0121	0.0119	0.0118	0.0117	0.0116	0.0115
40	0.0141	0.0135	0.0131	0.0128	0.0126	0.0125	0.0123	0.0122	0.0121	0.0120
41	0.0148	0.0141	0.0137	0.0134	0.0132	0.0130	0.0129	0.0127	0.0126	0.0125
42	0.0154	0.0147	0.0142	0.0140	0.0137	0.0136	0.0134	0.0133	0.0132	0.0131
43	0.0160	0.0153	0.0149	0.0146	0.0143	0.0141	0.0140	0.0139	0.0137	0.0136
44	0.0167	0.0159	0.0155	0.0152	0.0149	0.0147	0.0146	0.0144	0.0143	0.0142
45	0.0174	0.0166	0.0161	0.0158	0.0155	0.0153	0.0152	0.0150	0.0149	0.0148
46	0.0181	0.0172	0.0167	0.0164	0.0161	0.0159	0.0158	0.0156	0.0155	0.0154
47	0.0188	0.0179	0.0174	0.0170	0.0168	0.0165	0.0164	0.0162	0.0161	0.0160
48	0.0195	0.0185	0.0180	0.0177	0.0174	0.0172	0.0170	0.0168	0.0167	0.0166
49	0.0202	0.0192	0.0187	0.0183	0.0180	0.0178	0.0176	0.0174	0.0173	0.0172
50	0.0209	0.0199	0.0194	0.0190	0.0187	0.0184	0.0182	0.0181	0.0179	0.0178

* These tables were developed using the empirical formula shown on p. 7.
† Shrinkage volume = (factor) (light-product volume).

VOLUMETRIC SHRINKAGE TABLES *—*Continued*

Gravity Difference (Degrees API)	Light-Product Concentration 1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
	FACTORS FOR COMPUTING VOLUMETRIC SHRINKAGE † (Decimal Fraction of Light-Product Volume)									
50	0.0209	0.0199	0.0194	0.0190	0.0187	0.0184	0.0182	0.0181	0.0179	0.0178
51	0.0217	0.0206	0.0201	0.0196	0.0193	0.0191	0.0189	0.0187	0.0186	0.0184
52	0.0224	0.0213	0.0207	0.0203	0.0200	0.0198	0.0195	0.0194	0.0192	0.0191
53	0.0232	0.0221	0.0215	0.0210	0.0207	0.0204	0.0202	0.0200	0.0199	0.0197
54	0.0240	0.0228	0.0222	0.0217	0.0214	0.0211	0.0209	0.0207	0.0205	0.0204
55	0.0247	0.0236	0.0229	0.0224	0.0221	0.0218	0.0216	0.0214	0.0212	0.0210
56	0.0255	0.0243	0.0236	0.0232	0.0228	0.0225	0.0223	0.0221	0.0219	0.0217
57	0.0263	0.0251	0.0244	0.0239	0.0235	0.0232	0.0230	0.0228	0.0226	0.0224
58	0.0272	0.0259	0.0251	0.0246	0.0243	0.0239	0.0237	0.0235	0.0233	0.0231
59	0.0280	0.0267	0.0259	0.0254	0.0250	0.0247	0.0244	0.0242	0.0240	0.0238
60	0.0288	0.0275	0.0267	0.0262	0.0257	0.0254	0.0251	0.0249	0.0247	0.0245
61	0.0297	0.0283	0.0275	0.0269	0.0265	0.0262	0.0259	0.0256	0.0254	0.0252
62	0.0306	0.0291	0.0283	0.0277	0.0273	0.0269	0.0266	0.0264	0.0262	0.0260
63	0.0314	0.0299	0.0291	0.0285	0.0281	0.0277	0.0274	0.0271	0.0269	0.0267
64	0.0323	0.0308	0.0299	0.0293	0.0288	0.0285	0.0282	0.0279	0.0277	0.0275
65	0.0332	0.0316	0.0307	0.0301	0.0296	0.0293	0.0289	0.0287	0.0284	0.0282
66	0.0341	0.0325	0.0316	0.0309	0.0305	0.0301	0.0297	0.0295	0.0292	0.0290
67	0.0350	0.0334	0.0324	0.0318	0.0313	0.0309	0.0305	0.0303	0.0300	0.0298
68	0.0359	0.0342	0.0333	0.0326	0.0321	0.0317	0.0313	0.0310	0.0308	0.0306
69	0.0369	0.0351	0.0341	0.0335	0.0329	0.0325	0.0322	0.0319	0.0316	0.0314
70	0.0378	0.0360	0.0350	0.0343	0.0338	0.0333	0.0330	0.0327	0.0324	0.0322
71	0.0388	0.0369	0.0359	0.0352	0.0346	0.0342	0.0338	0.0335	0.0332	0.0330
72	0.0397	0.0379	0.0368	0.0361	0.0355	0.0350	0.0347	0.0343	0.0341	0.0338
73	0.0407	0.0388	0.0377	0.0369	0.0364	0.0359	0.0355	0.0352	0.0349	0.0346
74	0.0417	0.0397	0.0386	0.0378	0.0372	0.0368	0.0364	0.0360	0.0357	0.0355
75	0.0427	0.0407	0.0395	0.0387	0.0381	0.0376	0.0372	0.0369	0.0366	0.0363
76	0.0437	0.0416	0.0405	0.0397	0.0390	0.0385	0.0381	0.0378	0.0375	0.0372
77	0.0447	0.0426	0.0414	0.0406	0.0399	0.0394	0.0390	0.0386	0.0383	0.0380
78	0.0458	0.0436	0.0424	0.0415	0.0409	0.0403	0.0399	0.0395	0.0392	0.0389
79	0.0468	0.0446	0.0433	0.0424	0.0418	0.0413	0.0408	0.0404	0.0401	0.0398
80	0.0478	0.0456	0.0443	0.0434	0.0427	0.0422	0.0417	0.0413	0.0410	0.0407
81	0.0489	0.0466	0.0453	0.0444	0.0437	0.0431	0.0426	0.0422	0.0419	0.0416
82	0.0500	0.0476	0.0463	0.0453	0.0446	0.0440	0.0436	0.0432	0.0428	0.0425
83	0.0510	0.0486	0.0472	0.0463	0.0456	0.0450	0.0445	0.0441	0.0437	0.0434
84	0.0521	0.0497	0.0483	0.0473	0.0466	0.0460	0.0455	0.0450	0.0447	0.0443
85	0.0532	0.0507	0.0493	0.0483	0.0475	0.0469	0.0464	0.0460	0.0456	0.0453
86	0.0543	0.0518	0.0503	0.0493	0.0485	0.0479	0.0474	0.0469	0.0466	0.0462
87	0.0555	0.0528	0.0513	0.0503	0.0495	0.0489	0.0484	0.0479	0.0475	0.0472
88	0.0566	0.0539	0.0524	0.0513	0.0505	0.0499	0.0493	0.0489	0.0485	0.0481
89	0.0577	0.0550	0.0534	0.0524	0.0515	0.0509	0.0503	0.0499	0.0494	0.0491
90	0.0589	0.0561	0.0545	0.0534	0.0526	0.0519	0.0513	0.0509	0.0504	0.0501
91	0.0600	0.0572	0.0556	0.0544	0.0536	0.0529	0.0523	0.0518	0.0514	0.0510
92	0.0612	0.0583	0.0566	0.0555	0.0546	0.0539	0.0534	0.0529	0.0524	0.0520
93	0.0624	0.0594	0.0577	0.0566	0.0557	0.0550	0.0544	0.0539	0.0534	0.0530
94	0.0636	0.0605	0.0588	0.0576	0.0567	0.0560	0.0554	0.0549	0.0544	0.0540
95	0.0647	0.0617	0.0599	0.0587	0.0578	0.0571	0.0565	0.0559	0.0555	0.0551
96	0.0659	0.0628	0.0610	0.0598	0.0589	0.0581	0.0575	0.0570	0.0565	0.0561
97	0.0672	0.0640	0.0622	0.0609	0.0600	0.0592	0.0586	0.0580	0.0575	0.0571
98	0.0684	0.0651	0.0633	0.0620	0.0611	0.0603	0.0596	0.0591	0.0586	0.0582
99	0.0696	0.0663	0.0644	0.0631	0.0622	0.0614	0.0607	0.0601	0.0596	0.0592
100	0.0709	0.0675	0.0656	0.0643	0.0633	0.0625	0.0618	0.0612	0.0607	0.0603

* These tables were developed using the empirical formula shown on p. 7.
† Shrinkage volume = (factor) (light-product volume).

VOLUMETRIC SHRINKAGE TABLES *—*Continued*

Light-Product Concentration

FACTORS FOR COMPUTING VOLUMETRIC SHRINKAGE †

(Decimal Fraction of Light-Product Volume)

Gravity Difference (Degrees API)	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
4	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
5	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
6	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
7	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
8	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
9	0.0009	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
10	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
11	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
12	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
13	0.0017	0.0017	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016
14	0.0019	0.0019	0.0019	0.0019	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018
15	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0020	0.0020
16	0.0024	0.0024	0.0024	0.0024	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
17	0.0027	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0025	0.0025
18	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029	0.0028	0.0028	0.0028	0.0028
19	0.0032	0.0032	0.0032	0.0032	0.0032	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031
20	0.0035	0.0035	0.0035	0.0035	0.0035	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034
21	0.0039	0.0038	0.0038	0.0038	0.0038	0.0038	0.0037	0.0037	0.0037	0.0037	0.0037
22	0.0042	0.0042	0.0041	0.0041	0.0041	0.0041	0.0041	0.0040	0.0040	0.0040	0.0040
23	0.0045	0.0045	0.0045	0.0045	0.0044	0.0044	0.0044	0.0044	0.0044	0.0043	0.0043
24	0.0049	0.0049	0.0048	0.0048	0.0048	0.0048	0.0047	0.0047	0.0047	0.0047	0.0047
25	0.0053	0.0052	0.0052	0.0052	0.0051	0.0051	0.0051	0.0051	0.0050	0.0050	0.0050
26	0.0056	0.0056	0.0056	0.0055	0.0055	0.0055	0.0054	0.0054	0.0054	0.0054	0.0054
27	0.0060	0.0060	0.0059	0.0059	0.0059	0.0058	0.0058	0.0058	0.0058	0.0057	0.0057
28	0.0064	0.0064	0.0063	0.0063	0.0063	0.0062	0.0062	0.0062	0.0062	0.0061	0.0061
29	0.0068	0.0068	0.0067	0.0067	0.0067	0.0066	0.0066	0.0066	0.0065	0.0065	0.0065
30	0.0072	0.0072	0.0071	0.0071	0.0071	0.0070	0.0070	0.0070	0.0069	0.0069	0.0069
31	0.0077	0.0076	0.0076	0.0075	0.0075	0.0075	0.0074	0.0074	0.0074	0.0073	0.0073
32	0.0081	0.0081	0.0080	0.0080	0.0079	0.0079	0.0078	0.0078	0.0078	0.0078	0.0077
33	0.0086	0.0085	0.0085	0.0084	0.0084	0.0083	0.0083	0.0082	0.0082	0.0082	0.0082
34	0.0090	0.0090	0.0089	0.0089	0.0088	0.0088	0.0087	0.0087	0.0087	0.0086	0.0086
35	0.0095	0.0094	0.0094	0.0093	0.0093	0.0092	0.0092	0.0091	0.0091	0.0091	0.0090
36	0.0100	0.0099	0.0099	0.0098	0.0097	0.0097	0.0097	0.0096	0.0096	0.0095	0.0095
37	0.0105	0.0104	0.0103	0.0103	0.0102	0.0102	0.0101	0.0101	0.0100	0.0100	0.0100
38	0.0110	0.0109	0.0108	0.0108	0.0107	0.0107	0.0106	0.0106	0.0105	0.0105	0.0105
39	0.0115	0.0114	0.0113	0.0113	0.0112	0.0112	0.0111	0.0111	0.0110	0.0110	0.0109
40	0.0120	0.0119	0.0119	0.0118	0.0117	0.0117	0.0116	0.0116	0.0115	0.0115	0.0114
41	0.0125	0.0125	0.0124	0.0123	0.0123	0.0122	0.0121	0.0121	0.0120	0.0120	0.0119
42	0.0131	0.0130	0.0129	0.0129	0.0128	0.0127	0.0127	0.0126	0.0126	0.0125	0.0125
43	0.0136	0.0136	0.0135	0.0134	0.0133	0.0133	0.0132	0.0131	0.0131	0.0130	0.0130
44	0.0142	0.0141	0.0140	0.0139	0.0139	0.0138	0.0137	0.0137	0.0136	0.0136	0.0135
45	0.0148	0.0147	0.0146	0.0145	0.0144	0.0144	0.0143	0.0142	0.0142	0.0141	0.0141
46	0.0154	0.0153	0.0152	0.0151	0.0150	0.0149	0.0149	0.0148	0.0147	0.0147	0.0146
47	0.0160	0.0158	0.0158	0.0157	0.0156	0.0155	0.0154	0.0154	0.0153	0.0153	0.0152
48	0.0166	0.0164	0.0163	0.0163	0.0162	0.0161	0.0160	0.0160	0.0159	0.0158	0.0158
49	0.0172	0.0171	0.0170	0.0169	0.0168	0.0167	0.0166	0.0165	0.0165	0.0164	0.0164
50	0.0178	0.0177	0.0176	0.0175	0.0174	0.0173	0.0172	0.0171	0.0171	0.0170	0.0169

* These tables were developed using the empirical formula shown on p. 7.
† Shrinkage volume = (factor) (light-product volume).

VOLUMETRIC SHRINKAGE TABLES *—*Continued*

Gravity Difference (Degrees API)	Light-Product Concentration 10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%
	FACTORS FOR COMPUTING VOLUMETRIC SHRINKAGE † (Decimal Fraction of Light-Product Volume)										
50	0.0178	0.0177	0.0176	0.0175	0.0174	0.0173	0.0172	0.0171	0.0171	0.0170	0.0169
51	0.0184	0.0183	0.0182	0.0181	0.0180	0.0179	0.0178	0.0177	0.0177	0.0176	0.0175
52	0.0191	0.0189	0.0188	0.0187	0.0186	0.0185	0.0184	0.0184	0.0183	0.0182	0.0182
53	0.0197	0.0196	0.0195	0.0194	0.0193	0.0192	0.0191	0.0190	0.0189	0.0188	0.0188
54	0.0204	0.0202	0.0201	0.0200	0.0199	0.0198	0.0197	0.0196	0.0195	0.0195	0.0194
55	0.0210	0.0209	0.0208	0.0207	0.0205	0.0204	0.0204	0.0203	0.0202	0.0201	0.0200
56	0.0217	0.0216	0.0214	0.0213	0.0212	0.0211	0.0210	0.0209	0.0208	0.0208	0.0207
57	0.0224	0.0223	0.0221	0.0220	0.0219	0.0218	0.0217	0.0216	0.0215	0.0214	0.0213
58	0.0231	0.0229	0.0228	0.0227	0.0226	0.0225	0.0223	0.0223	0.0222	0.0221	0.0220
59	0.0238	0.0236	0.0235	0.0234	0.0233	0.0231	0.0230	0.0229	0.0228	0.0228	0.0227
60	0.0245	0.0244	0.0242	0.0241	0.0239	0.0238	0.0237	0.0236	0.0235	0.0234	0.0234
61	0.0252	0.0251	0.0249	0.0248	0.0247	0.0245	0.0244	0.0243	0.0242	0.0241	0.0240
62	0.0260	0.0258	0.0256	0.0255	0.0254	0.0252	0.0251	0.0250	0.0249	0.0248	0.0247
63	0.0267	0.0265	0.0264	0.0262	0.0261	0.0260	0.0259	0.0257	0.0256	0.0255	0.0254
64	0.0275	0.0273	0.0271	0.0270	0.0268	0.0267	0.0266	0.0265	0.0264	0.0263	0.0262
65	0.0282	0.0280	0.0279	0.0277	0.0276	0.0274	0.0273	0.0272	0.0271	0.0270	0.0269
66	0.0290	0.0288	0.0286	0.0285	0.0283	0.0282	0.0281	0.0279	0.0278	0.0277	0.0276
67	0.0298	0.0296	0.0294	0.0292	0.0291	0.0289	0.0288	0.0287	0.0286	0.0285	0.0284
68	0.0306	0.0304	0.0302	0.0300	0.0298	0.0297	0.0296	0.0294	0.0293	0.0292	0.0291
69	0.0314	0.0312	0.0310	0.0308	0.0306	0.0305	0.0303	0.0302	0.0301	0.0300	0.0299
70	0.0322	0.0319	0.0318	0.0316	0.0314	0.0313	0.0311	0.0310	0.0309	0.0307	0.0306
71	0.0330	0.0328	0.0326	0.0324	0.0322	0.0321	0.0319	0.0318	0.0316	0.0315	0.0314
72	0.0338	0.0336	0.0334	0.0332	0.0330	0.0328	0.0327	0.0326	0.0324	0.0323	0.0322
73	0.0346	0.0344	0.0342	0.0340	0.0338	0.0337	0.0335	0.0334	0.0332	0.0331	0.0330
74	0.0355	0.0352	0.0350	0.0348	0.0346	0.0345	0.0343	0.0342	0.0340	0.0339	0.0338
75	0.0363	0.0361	0.0359	0.0357	0.0355	0.0353	0.0351	0.0350	0.0348	0.0347	0.0346
76	0.0372	0.0369	0.0367	0.0365	0.0363	0.0361	0.0360	0.0358	0.0357	0.0355	0.0354
77	0.0380	0.0378	0.0376	0.0373	0.0371	0.0370	0.0368	0.0366	0.0365	0.0364	0.0362
78	0.0389	0.0387	0.0384	0.0382	0.0380	0.0378	0.0376	0.0375	0.0373	0.0372	0.0371
79	0.0398	0.0395	0.0393	0.0391	0.0389	0.0387	0.0385	0.0383	0.0382	0.0380	0.0379
80	0.0407	0.0404	0.0402	0.0399	0.0397	0.0395	0.0394	0.0392	0.0390	0.0389	0.0387
81	0.0416	0.0413	0.0411	0.0408	0.0406	0.0404	0.0402	0.0401	0.0399	0.0397	0.0396
82	0.0425	0.0422	0.0420	0.0417	0.0415	0.0413	0.0411	0.0409	0.0408	0.0406	0.0405
83	0.0434	0.0431	0.0429	0.0426	0.0424	0.0422	0.0420	0.0418	0.0417	0.0415	0.0413
84	0.0443	0.0440	0.0438	0.0435	0.0433	0.0431	0.0429	0.0427	0.0425	0.0424	0.0422
85	0.0453	0.0450	0.0447	0.0444	0.0442	0.0440	0.0438	0.0436	0.0434	0.0433	0.0431
86	0.0462	0.0459	0.0456	0.0454	0.0451	0.0449	0.0447	0.0445	0.0443	0.0442	0.0440
87	0.0472	0.0468	0.0466	0.0463	0.0461	0.0458	0.0456	0.0454	0.0452	0.0451	0.0449
88	0.0481	0.0478	0.0475	0.0472	0.0470	0.0468	0.0466	0.0464	0.0462	0.0460	0.0458
89	0.0491	0.0488	0.0485	0.0482	0.0479	0.0477	0.0475	0.0473	0.0471	0.0469	0.0467
90	0.0501	0.0497	0.0494	0.0491	0.0489	0.0486	0.0484	0.0482	0.0480	0.0478	0.0477
91	0.0510	0.0507	0.0504	0.0501	0.0498	0.0496	0.0494	0.0492	0.0490	0.0488	0.0486
92	0.0520	0.0517	0.0514	0.0511	0.0508	0.0506	0.0503	0.0501	0.0499	0.0497	0.0496
93	0.0530	0.0527	0.0524	0.0521	0.0518	0.0515	0.0513	0.0511	0.0509	0.0507	0.0505
94	0.0540	0.0537	0.0534	0.0531	0.0528	0.0525	0.0523	0.0521	0.0518	0.0517	0.0515
95	0.0551	0.0547	0.0544	0.0540	0.0538	0.0535	0.0533	0.0530	0.0528	0.0576	0.0524
96	0.0561	0.0557	0.0554	0.0551	0.0548	0.0545	0.0543	0.0540	0.0538	0.0536	0.0534
97	0.0571	0.0567	0.0564	0.0561	0.0558	0.0555	0.0553	0.0550	0.0548	0.0546	0.0544
98	0.0582	0.0578	0.0574	0.0571	0.0568	0.0565	0.0563	0.0560	0.0558	0.0556	0.0554
99	0.0592	0.0588	0.0584	0.0581	0.0578	0.0575	0.0573	0.0570	0.0568	0.0566	0.0564
100	0.0603	0.0599	0.0595	0.0592	0.0588	0.0586	0.0583	0.0580	0.0578	0.0576	0.0574

* These tables were developed using the empirical formula shown on p. 7.
† Shrinkage volume = (factor) (light-product volume).

VOLUMETRIC SHRINKAGE TABLES *—*Continued*

Light-Product Concentration

FACTORS FOR COMPUTING VOLUMETRIC SHRINKAGE †

(Decimal Fraction of Light-Product Volume)

Gravity Difference (Degrees API)	20%	21%	22%	23%	24%	25%	26%	27%	28%	29%	30%
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
4	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
5	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
6	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
7	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
8	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
9	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
10	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
11	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0011	0.0011
12	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0013	0.0013	0.0013	0.0013	0.0013
13	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0015	0.0015	0.0015	0.0015
14	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018
15	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
16	0.0023	0.0023	0.0023	0.0023	0.0023	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
17	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
18	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0027	0.0027	0.0027	0.0027
19	0.0031	0.0031	0.0031	0.0031	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030
20	0.0034	0.0034	0.0034	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033
21	0.0037	0.0037	0.0037	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036
22	0.0040	0.0040	0.0040	0.0040	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039	0.0039
23	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0042	0.0042	0.0042	0.0042	0.0042
24	0.0047	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0045	0.0045	0.0045
25	0.0050	0.0050	0.0050	0.0050	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049
26	0.0054	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0052	0.0052	0.0052	0.0052
27	0.0057	0.0057	0.0057	0.0057	0.0057	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056
28	0.0061	0.0061	0.0061	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0059	0.0059
29	0.0065	0.0065	0.0065	0.0064	0.0064	0.0064	0.0064	0.0064	0.0063	0.0063	0.0063
30	0.0069	0.0069	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0067	0.0067	0.0067
31	0.0073	0.0073	0.0073	0.0072	0.0072	0.0072	0.0072	0.0072	0.0071	0.0071	0.0071
32	0.0077	0.0077	0.0077	0.0076	0.0076	0.0076	0.0076	0.0076	0.0075	0.0075	0.0075
33	0.0082	0.0081	0.0081	0.0081	0.0081	0.0080	0.0080	0.0080	0.0080	0.0079	0.0079
34	0.0086	0.0086	0.0085	0.0085	0.0085	0.0085	0.0084	0.0084	0.0084	0.0084	0.0084
35	0.0090	0.0090	0.0090	0.0090	0.0089	0.0089	0.0089	0.0089	0.0088	0.0088	0.0088
36	0.0095	0.0095	0.0094	0.0094	0.0094	0.0094	0.0093	0.0093	0.0093	0.0093	0.0092
37	0.0100	0.0099	0.0099	0.0099	0.0098	0.0098	0.0098	0.0098	0.0097	0.0097	0.0097
38	0.0105	0.0104	0.0104	0.0104	0.0103	0.0103	0.0103	0.0102	0.0102	0.0102	0.0102
39	0.0109	0.0109	0.0109	0.0108	0.0108	0.0108	0.0107	0.0107	0.0107	0.0107	0.0106
40	0.0114	0.0114	0.0114	0.0113	0.0113	0.0113	0.0112	0.0112	0.0112	0.0111	0.0111
41	0.0119	0.0119	0.0119	0.0118	0.0118	0.0118	0.0117	0.0117	0.0117	0.0116	0.0116
42	0.0125	0.0124	0.0124	0.0123	0.0123	0.0123	0.0122	0.0122	0.0122	0.0121	0.0121
43	0.0130	0.0129	0.0129	0.0129	0.0128	0.0128	0.0128	0.0127	0.0127	0.0127	0.0126
44	0.0135	0.0135	0.0134	0.0134	0.0134	0.0133	0.0133	0.0132	0.0132	0.0132	0.0131
45	0.0141	0.0140	0.0140	0.0139	0.0139	0.0139	0.0138	0.0138	0.0137	0.0137	0.0137
46	0.0146	0.0146	0.0145	0.0145	0.0144	0.0144	0.0144	0.0143	0.0143	0.0143	0.0142
47	0.0152	0.0151	0.0151	0.0150	0.0150	0.0150	0.0149	0.0149	0.0148	0.0148	0.0148
48	0.0158	0.0157	0.0157	0.0156	0.0156	0.0155	0.0155	0.0154	0.0154	0.0154	0.0153
49	0.0164	0.0163	0.0162	0.0162	0.0161	0.0161	0.0161	0.0160	0.0160	0.0159	0.0159
50	0.0169	0.0169	0.0168	0.0168	0.0167	0.0167	0.0166	0.0166	0.0165	0.0165	0.0165

* These tables were developed using the empirical formula shown on p. 7.
† Shrinkage volume = (factor) (light-product volume).

VOLUMETRIC SHRINKAGE TABLES *—*Continued*

Gravity Difference (Degrees API)	20%	21%	22%	23%	24%	25%	26%	27%	28%	29%	30%
	Light-Product Concentration — FACTORS FOR COMPUTING VOLUMETRIC SHRINKAGE † (Decimal Fraction of Light-Product Volume)										
50	0.0169	0.0169	0.0168	0.0168	0.0167	0.0167	0.0166	0.0166	0.0165	0.0165	0.0165
51	0.0175	0.0175	0.0174	0.0174	0.0173	0.0173	0.0172	0.0172	0.0171	0.0171	0.0171
52	0.0182	0.0181	0.0180	0.0180	0.0179	0.0179	0.0178	0.0178	0.0177	0.0177	0.0176
53	0.0188	0.0187	0.0186	0.0186	0.0185	0.0185	0.0184	0.0184	0.0183	0.0183	0.0182
54	0.0194	0.0193	0.0193	0.0192	0.0192	0.0191	0.0190	0.0190	0.0189	0.0189	0.0189
55	0.0200	0.0200	0.0199	0.0198	0.0198	0.0197	0.0197	0.0196	0.0196	0.0195	0.0195
56	0.0207	0.0206	0.0205	0.0205	0.0204	0.0204	0.0203	0.0203	0.0202	0.0201	0.0201
57	0.0213	0.0213	0.0212	0.0211	0.0211	0.0210	0.0209	0.0209	0.0208	0.0208	0.0207
58	0.0220	0.0219	0.0219	0.0218	0.0217	0.0217	0.0216	0.0215	0.0215	0.0214	0.0214
59	0.0227	0.0226	0.0225	0.0225	0.0224	0.0223	0.0223	0.0222	0.0221	0.0221	0.0220
60	0.0234	0.0233	0.0232	0.0231	0.0231	0.0230	0.0229	0.0229	0.0228	0.0228	0.0227
61	0.0240	0.0240	0.0239	0.0238	0.0237	0.0237	0.0236	0.0235	0.0235	0.0234	0.0234
62	0.0247	0.0247	0.0246	0.0245	0.0244	0.0244	0.0243	0.0242	0.0242	0.0241	0.0240
63	0.0254	0.0254	0.0253	0.0252	0.0251	0.0251	0.0250	0.0249	0.0249	0.0248	0.0247
64	0.0262	0.0261	0.0260	0.0259	0.0258	0.0258	0.0257	0.0256	0.0256	0.0255	0.0254
65	0.0269	0.0268	0.0267	0.0266	0.0265	0.0265	0.0264	0.0263	0.0263	0.0262	0.0261
66	0.0276	0.0275	0.0274	0.0273	0.0273	0.0272	0.0271	0.0270	0.0270	0.0269	0.0268
67	0.0284	0.0283	0.0282	0.0281	0.0280	0.0279	0.0278	0.0278	0.0277	0.0276	0.0276
68	0.0291	0.0290	0.0289	0.0288	0.0287	0.0287	0.0286	0.0285	0.0284	0.0284	0.0283
69	0.0299	0.0298	0.0297	0.0296	0.0295	0.0294	0.0293	0.0292	0.0292	0.0291	0.0290
70	0.0306	0.0305	0.0304	0.0303	0.0302	0.0302	0.0301	0.0300	0.0299	0.0298	0.0298
71	0.0314	0.0313	0.0312	0.0311	0.0310	0.0309	0.0308	0.0308	0.0307	0.0306	0.0305
72	0.0322	0.0321	0.0320	0.0319	0.0318	0.0317	0.0316	0.0315	0.0314	0.0314	0.0313
73	0.0330	0.0329	0.0328	0.0327	0.0326	0.0325	0.0324	0.0323	0.0322	0.0321	0.0321
74	0.0338	0.0337	0.0336	0.0334	0.0333	0.0333	0.0332	0.0331	0.0330	0.0329	0.0328
75	0.0346	0.0345	0.0344	0.0342	0.0341	0.0340	0.0340	0.0339	0.0338	0.0337	0.0336
76	0.0354	0.0353	0.0352	0.0351	0.0350	0.0349	0.0348	0.0347	0.0346	0.0345	0.0344
77	0.0362	0.0361	0.0360	0.0359	0.0358	0.0357	0.0356	0.0355	0.0354	0.0353	0.0352
78	0.0371	0.0369	0.0368	0.0367	0.0366	0.0365	0.0364	0.0363	0.0362	0.0361	0.0360
79	0.0379	0.0378	0.0376	0.0375	0.0374	0.0373	0.0372	0.0371	0.0370	0.0369	0.0368
80	0.0387	0.0386	0.0385	0.0384	0.0383	0.0381	0.0380	0.0379	0.0378	0.0377	0.0377
81	0.0396	0.0395	0.0393	0.0392	0.0391	0.0390	0.0389	0.0388	0.0387	0.0386	0.0385
82	0.0405	0.0403	0.0402	0.0401	0.0400	0.0398	0.0397	0.0396	0.0395	0.0394	0.0393
83	0.0413	0.0412	0.0411	0.0409	0.0408	0.0407	0.0406	0.0405	0.0404	0.0403	0.0402
84	0.0422	0.0421	0.0419	0.0418	0.0417	0.0416	0.0415	0.0413	0.0412	0.0411	0.0410
85	0.0431	0.0430	0.0428	0.0427	0.0426	0.0424	0.0423	0.0422	0.0421	0.0420	0.0419
86	0.0440	0.0439	0.0437	0.0436	0.0434	0.0433	0.0432	0.0431	0.0430	0.0429	0.0428
87	0.0449	0.0448	0.0446	0.0445	0.0443	0.0442	0.0441	0.0440	0.0439	0.0438	0.0436
88	0.0458	0.0457	0.0455	0.0454	0.0452	0.0451	0.0450	0.0449	0.0448	0.0446	0.0445
89	0.0467	0.0466	0.0464	0.0463	0.0461	0.0460	0.0459	0.0458	0.0457	0.0455	0.0454
90	0.0477	0.0475	0.0474	0.0472	0.0471	0.0469	0.0468	0.0467	0.0466	0.0464	0.0463
91	0.0486	0.0484	0.0483	0.0481	0.0480	0.0479	0.0477	0.0476	0.0475	0.0474	0.0472
92	0.0496	0.0494	0.0492	0.0491	0.0489	0.0488	0.0486	0.0485	0.0484	0.0483	0.0482
93	0.0505	0.0503	0.0502	0.0500	0.0499	0.0497	0.0496	0.0495	0.0493	0.0492	0.0491
94	0.0515	0.0513	0.0511	0.0510	0.0508	0.0507	0.0505	0.0504	0.0503	0.0501	0.0500
95	0.0524	0.0523	0.0521	0.0519	0.0518	0.0516	0.0515	0.0513	0.0512	0.0511	0.0510
96	0.0534	0.0532	0.0531	0.0529	0.0527	0.0526	0.0524	0.0523	0.0522	0.0520	0.0519
97	0.0544	0.0542	0.0540	0.0539	0.0537	0.0535	0.0534	0.0533	0.0531	0.0530	0.0529
98	0.0554	0.0552	0.0550	0.0548	0.0547	0.0545	0.0544	0.0542	0.0541	0.0540	0.0538
99	0.0564	0.0562	0.0560	0.0558	0.0557	0.0555	0.0553	0.0552	0.0551	0.0549	0.0548
100	0.0574	0.0572	0.0570	0.0568	0.0567	0.0565	0.0563	0.0562	0.0560	0.0559	0.0558

* These tables were developed using the empirical formula shown on p. 7.
† Shrinkage volume = (factor) (light-product volume).

VOLUMETRIC SHRINKAGE TABLES *—*Continued*

Difference Gravity (Degrees API)	Light-Product Concentration 30%	31%	32%	33%	34%	35%	36%	37%	38%	39%	40%
	FACTORS FOR COMPUTING VOLUMETRIC SHRINKAGE † (Decimal Fraction of Light-Product Volume)										
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
4	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
5	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
6	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
7	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
8	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
9	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
10	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0009
11	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
12	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
13	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015
14	0.0018	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
15	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0019	0.0019	0.0019	0.0019
16	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
17	0.0025	0.0025	0.0025	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024
18	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027
19	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0029	0.0029	0.0029
20	0.0033	0.0033	0.0033	0.0033	0.0033	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032
21	0.0036	0.0036	0.0036	0.0036	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035
22	0.0039	0.0039	0.0039	0.0039	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038
23	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0041	0.0041	0.0041	0.0041	0.0041
24	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0044	0.0044
25	0.0049	0.0049	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048
26	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0051	0.0051	0.0051	0.0051	0.0051
27	0.0056	0.0056	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055
28	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0058	0.0058	0.0058	0.0058
29	0.0063	0.0063	0.0063	0.0063	0.0063	0.0062	0.0062	0.0062	0.0062	0.0062	0.0062
30	0.0067	0.0067	0.0067	0.0067	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066
31	0.0071	0.0071	0.0071	0.0071	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070
32	0.0075	0.0075	0.0075	0.0075	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074
33	0.0079	0.0079	0.0079	0.0079	0.0079	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078
34	0.0084	0.0083	0.0083	0.0083	0.0083	0.0083	0.0082	0.0082	0.0082	0.0082	0.0082
35	0.0088	0.0088	0.0088	0.0087	0.0087	0.0087	0.0087	0.0087	0.0086	0.0086	0.0086
36	0.0092	0.0092	0.0092	0.0092	0.0092	0.0091	0.0091	0.0091	0.0091	0.0091	0.0091
37	0.0097	0.0097	0.0096	0.0096	0.0096	0.0096	0.0096	0.0096	0.0095	0.0095	0.0095
38	0.0102	0.0101	0.0101	0.0101	0.0101	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
39	0.0106	0.0106	0.0106	0.0106	0.0105	0.0105	0.0105	0.0105	0.0105	0.0104	0.0104
40	0.0111	0.0111	0.0111	0.0110	0.0110	0.0110	0.0110	0.0110	0.0109	0.0109	0.0109
41	0.0116	0.0116	0.0116	0.0115	0.0115	0.0115	0.0115	0.0114	0.0114	0.0114	0.0114
42	0.0121	0.0121	0.0121	0.0120	0.0120	0.0120	0.0120	0.0119	0.0119	0.0119	0.0119
43	0.0126	0.0126	0.0126	0.0125	0.0125	0.0125	0.0125	0.0124	0.0174	0.0124	0.0124
44	0.0131	0.0131	0.0131	0.0131	0.0130	0.0130	0.0130	0.0130	0.0129	0.0129	0.0129
45	0.0137	0.0136	0.0136	0.0136	0.0136	0.0135	0.0135	0.0135	0.0135	0.0134	0.0134
46	0.0142	0.0142	0.0142	0.0141	0.0141	0.0141	0.0140	0.0140	0.0140	0.0140	0.0139
47	0.0148	0.0147	0.0147	0.0147	0.0146	0.0146	0.0146	0.0146	0.0145	0.0145	0.0145
48	0.0153	0.0153	0.0153	0.0152	0.0152	0.0152	0.0151	0.0151	0.0151	0.0150	0.0150
49	0.0159	0.0159	0.0158	0.0158	0.0158	0.0157	0.0157	0.0157	0.0156	0.0156	0.0156
50	0.0165	0.0164	0.0164	0.0164	0.0163	0.0163	0.0163	0.0162	0.0162	0.0162	0.0161

* These tables were developed using the empirical formula shown on p. 7.
† Shrinkage volume = (factor) (light-product volume).

VOLUMETRIC SHRINKAGE TABLES *—*Continued*

Gravity Difference (Degrees API)	Light-Product Concentration										
	30%	31%	32%	33%	34%	35%	36%	37%	38%	39%	40%
	FACTORS FOR COMPUTING VOLUMETRIC SHRINKAGE † (Decimal Fraction of Light-Product Volume)										
50	0.0165	0.0164	0.0164	0.0164	0.0163	0.0163	0.0163	0.0162	0.0162	0.0162	0.0161
51	0.0171	0.0170	0.0170	0.0169	0.0169	0.0169	0.0168	0.0168	0.0168	0.0167	0.0167
52	0.0176	0.0176	0.0176	0.0175	0.0175	0.0175	0.0174	0.0174	0.0174	0.0173	0.0173
53	0.0182	0.0182	0.0182	0.0181	0.0181	0.0181	0.0180	0.0180	0.0179	0.0179	0.0179
54	0.0189	0.0188	0.0188	0.0187	0.0187	0.0187	0.0186	0.0186	0.0185	0.0185	0.0185
55	0.0195	0.0194	0.0194	0.0193	0.0193	0.0193	0.0192	0.0192	0.0192	0.0191	0.0191
56	0.0201	0.0201	0.0200	0.0200	0.0199	0.0199	0.0198	0.0198	0.0198	0.0197	0.0197
57	0.0207	0.0207	0.0206	0.0206	0.0206	0.0205	0.0205	0.0204	0.0204	0.0204	0.0203
58	0.0214	0.0213	0.0213	0.0212	0.0212	0.0212	0.0211	0.0211	0.0210	0.0210	0.0210
59	0.0220	0.0220	0.0219	0.0219	0.0218	0.0218	0.0218	0.0217	0.0217	0.0216	0.0216
60	0.0227	0.0226	0.0226	0.0225	0.0225	0.0225	0.0224	0.0224	0.0223	0.0223	0.0222
61	0.0234	0.0233	0.0233	0.0232	0.0232	0.0231	0.0231	0.0230	0.0230	0.0229	0.0229
62	0.0240	0.0240	0.0239	0.0239	0.0238	0.0238	0.0237	0.0237	0.0236	0.0236	0.0236
63	0.0247	0.0247	0.0246	0.0246	0.0245	0.0245	0.0244	0.0244	0.0243	0.0243	0.0242
64	0.0254	0.0254	0.0253	0.0253	0.0252	0.0252	0.0251	0.0251	0.0250	0.0250	0.0249
65	0.0261	0.0261	0.0260	0.0260	0.0259	0.0258	0.0258	0.0257	0.0257	0.0257	0.0256
66	0.0268	0.0268	0.0267	0.0267	0.0266	0.0266	0.0265	0.0264	0.0264	0.0264	0.0263
67	0.0276	0.0275	0.0274	0.0274	0.0273	0.0273	0.0272	0.0272	0.0271	0.0271	0.0270
68	0.0283	0.0282	0.0282	0.0281	0.0280	0.0280	0.0279	0.0279	0.0278	0.0278	0.0277
69	0.0290	0.0290	0.0289	0.0288	0.0288	0.0287	0.0287	0.0286	0.0285	0.0285	0.0284
70	0.0298	0.0297	0.0296	0.0296	0.0295	0.0294	0.0294	0.0293	0.0293	0.0292	0.0292
71	0.0305	0.0305	0.0304	0.0303	0.0303	0.0302	0.0301	0.0301	0.0300	0.0300	0.0299
72	0.0313	0.0312	0.0311	0.0311	0.0310	0.0309	0.0309	0.0308	0.0308	0.0307	0.0307
73	0.0321	0.0320	0.0319	0.0318	0.0318	0.0317	0.0316	0.0316	0.0315	0.0315	0.0314
74	0.0328	0.0328	0.0327	0.0326	0.0325	0.0325	0.0324	0.0323	0.0323	0.0322	0.0322
75	0.0336	0.0335	0.0335	0.0334	0.0333	0.0333	0.0332	0.0331	0.0331	0.0330	0.0329
76	0.0344	0.0343	0.0343	0.0342	0.0341	0.0340	0.0340	0.0339	0.0338	0.0338	0.0337
77	0.0352	0.0351	0.0350	0.0350	0.0349	0.0348	0.0348	0.0347	0.0346	0.0346	0.0345
78	0.0360	0.0359	0.0359	0.0358	0.0357	0.0356	0.0356	0.0355	0.0354	0.0354	0.0353
79	0.0368	0.0367	0.0367	0.0366	0.0365	0.0364	0.0364	0.0363	0.0362	0.0362	0.0361
80	0.0377	0.0376	0.0375	0.0374	0.0373	0.0373	0.0372	0.0371	0.0370	0.0370	0.0369
81	0.0385	0.0384	0.0383	0.0382	0.0382	0.0381	0.0380	0.0379	0.0379	0.0378	0.0377
82	0.0393	0.0392	0.0392	0.0391	0.0390	0.0389	0.0388	0.0388	0.0387	0.0386	0.0385
83	0.0402	0.0401	0.0400	0.0399	0.0398	0.0397	0.0397	0.0396	0.0395	0.0394	0.0394
84	0.0410	0.0409	0.0408	0.0408	0.0407	0.0406	0.0405	0.0404	0.0404	0.0403	0.0402
85	0.0419	0.0418	0.0417	0.0416	0.0415	0.0414	0.0414	0.0413	0.0412	0.0411	0.0411
86	0.0428	0.0427	0.0426	0.0425	0.0424	0.0423	0.0422	0.0421	0.0421	0.0420	0.0419
87	0.0436	0.0435	0.0435	0.0434	0.0433	0.0432	0.0431	0.0430	0.0429	0.0429	0.0428
88	0.0445	0.0444	0.0443	0.0442	0.0441	0.0441	0.0440	0.0439	0.0438	0.0437	0.0436
89	0.0454	0.0453	0.0452	0.0451	0.0450	0.0449	0.0449	0.0448	0.0447	0.0446	0.0445
90	0.0463	0.0462	0.0461	0.0460	0.0459	0.0458	0.0457	0.0457	0.0456	0.0455	0.0454
91	0.0472	0.0471	0.0470	0.0469	0.0468	0.0467	0.0466	0.0466	0.0465	0.0464	0.0463
92	0.0482	0.0480	0.0479	0.0478	0.0477	0.0476	0.0475	0.0475	0.0474	0.0473	0.0472
93	0.0491	0.0490	0.0489	0.0488	0.0487	0.0486	0.0485	0.0484	0.0483	0.0482	0.0481
94	0.0500	0.0499	0.0498	0.0497	0.0496	0.0495	0.0494	0.0493	0.0492	0.0491	0.0490
95	0.0510	0.0508	0.0507	0.0506	0.0505	0.0504	0.0503	0.0502	0.0501	0.0500	0.0499
96	0.0519	0.0518	0.0517	0.0516	0.0515	0.0513	0.0512	0.0511	0.0510	0.0510	0.0509
97	0.0529	0.0527	0.0526	0.0525	0.0524	0.0523	0.0522	0.0521	0.0520	0.0519	0.0518
98	0.0538	0.0537	0.0536	0.0535	0.0534	0.0532	0.0531	0.0530	0.0529	0.0528	0.0527
99	0.0548	0.0547	0.0545	0.0544	0.0543	0.0542	0.0541	0.0540	0.0539	0.0538	0.0537
100	0.0558	0.0556	0.0555	0.0554	0.0553	0.0552	0.0551	0.0550	0.0549	0.0548	0.0547

* These tables were developed using the empirical formula shown on p. 7.
† Shrinkage volume = (factor) (light-product volume).