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ON

EVAPORATION LOSS FROM TANK CARS, TANK TRUCKS, AND MARINE VESSELS

Prepared by the Evaporation Loss Committee of the American Petroleum Institute

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ABSTRACT

The Evaporation Loss Committee * of the American Petroleum Institute developed evaporation-loss correlations for tank cars, tank trucks, and marine vessels from loss data submitted by several oil companies. These correlations apply to crude oil and products with true vapor pressures up to approximately 9 psia.

Unloading and loading losses from tank cars and trucks can be estimated within 25 per cent when per cent saturation of the vapor space is known. Exhibit I shows how these losses vary with stock vapor pressure and loading method. For example, losses from handling a 9.0-psia RVP gasoline at 80 F would be: splash-loading loss, 0.23 per cent; subsurface-loading loss, 0.07 per cent; and unloading loss, 0.06 per cent. Although transit-loss data were not supplied, such loss usually is considered negligible for hauls of less than two days.

Correlations for unloading and loading losses from marine vessels are based on meager data and are less reliable. For a 9.0-psia RVP gasoline at 80 F, unloading loss is indicated to be approximately 0.05 per cent, and loading loss probably would not exceed 0.05 per cent. Transit loss usually is sufficient to be measured and, for the example gasoline, is indicated to be approximately 0.07 per cent for a one-week voyage.

More test data are needed to further verify unloading and loading losses from marine vessels and transit losses from tank cars, tank trucks, and marine vessels.

* The 1959 membership of the API Evaporation Loss Committee is recorded in Appendix VII of this bulletin, as well as the membership of its three subcommittees.

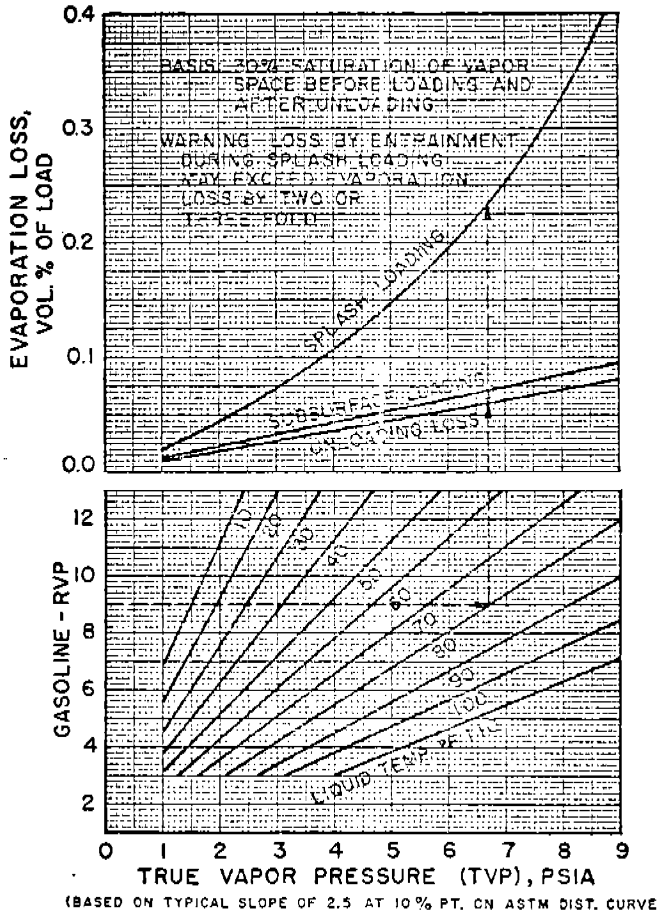

EXHIBIT I—Gasoline Correlation for Tank Cars and Tank Trucks.

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EVAPORATION LOSS FROM TANK CARS, TANK TRUCKS, AND MARINE VESSELS

INTRODUCTION

The Evaporation Loss Committee of the American Petroleum Institute has developed general correlations for estimating evaporation loss from transportation vehicles. These correlations apply to crude oil and products with true vapor pressures up to approximately 9 psia. Whereas loss correlations for storage tanks usually give the average loss for a year, those for transportation vehicles must give loss for each phase of the transportation cycle. Thus, three different losses were considered: unloading, loading, and transit.

Unloading loss is the volume of stock that evaporates into the air drawn into the compartment during unloading, even though this vapor is not expelled until the compartment is reloaded. This vapor, existing in the compartment before loading, will hereafter be referred to as the *existent vapor*.

Loading loss is the volume of stock that evaporates as the compartment is being filled; loss of the existent vapor is not included.

Transit loss is the breathing loss that occurs between points of receipt and delivery.

Evaporation that occurs in the shipping tank during withdrawal, that is, occurring between the opening and closing gages on the tank, is called *withdrawal loss*. Because this loss does not occur from the transportation vehicle, it is beyond the scope of this bulletin. However, it may affect the final correlations, depending upon the test method used, and is considered only to that extent.

Tank-car and tank-truck shipments, each shipment usually is less than 250 bbl, normally require only a short period of time to load and unload. Subsurface loading is the common filling method, but splash loading is still used in some areas. The storage compartments are seldom freed from hydrocarbon vapor between shipments, and this vapor retards evaporation during loading. Data on transit loss are not reported; however, such loss for the usual short haul (less than two days) is thought to be too small to be measured by present test methods.

Tankers and barges, large-capacity carriers, may require a day or more for loading and unloading. The fill pipes are integral parts of the carriers and permit loading with a minimum of splashing. The storage compartments sometimes are freed from hydrocarbon vapor after unloading. Under such a condition, maximum evaporation loss occurs during loading. Because voyages frequently last one week or more, the transit loss usually can be measured.

TESTING METHODS

The data used in developing correlations for evaporation loss from tank cars, tank trucks, and marine vessels were obtained by several different methods. Basically, the test methods fall into three general categories: stock-property change (vapor-pressure change and density change), vapor analysis via the air-balance technique, and direct measurement of loss via repeated transfer. To properly evaluate the data, the characteristics of each test method must be recognized and accounted for.

The property-change methods were used to measure loading loss and transit loss. The measured loading loss should be corrected for withdrawal loss if the shipping tank was a fixed-roof container. Such loss for large marine-type loadings has been estimated to be approximately 0.007 per cent per psia of true vapor pressure (TVP).* These methods cannot detect the loss of whole stock, such as occurs with entrainment during splash loading. Any loss beyond the equivalent of complete saturation of the expelled vapor would indicate an error in the test method. Transit loss as measured by the property-change methods does not need any correction.

The vapor-analysis method via the air-balance technique was used to measure only loading loss. Samples of compartment vapors before loading and of expelled vapors during loading were collected in evacuated sample containers. Analyses were made with the mass spectrometer. Theoretically, these data do not need any corrections.

Repeated-transfer techniques were used to measure loading loss plus unloading loss. Stock was transferred repeatedly between compartments until a measurable loss occurred.† The loss was determined by the weight of stock added to fill to the original level, by a change in weight of total contents, or by the difference in meter readings. Compartment vapors were not analyzed during these tests; thus a precise split between loading loss and unloading loss cannot be given. However, because such tests usually are done rapidly, unloading probably resulted in only 10 per cent saturation of the vapor space. When used to measure splash-loading loss, any loss by entrainment would be included and the indicated evaporation loss would tend to be high.

* Test No. 2 in Appendix VI is the basis for this estimate. Correction of this magnitude applied to other marine-loading tests tend to substantiate this value.

† The experiments were designed to eliminate loss by leakage at fittings and pump glands.

TANK CARS AND TANK TRUCKS

Most evaporation losses from tank cars and tank trucks occur during loading and unloading. The loading rates used in the subsurface- and splash-loading tests reported here were low by modern present-day standards but no other data were available. Its effect on loading loss, however, is apparently minor. The saturation condition of the vapor space before loading is a major controlling factor. Because this condition results from the unloading operation, the unloading-loss correlation will be developed first.

Unloading Loss

In this bulletin, estimation of unloading loss is confined to the amount of hydrocarbon which evaporates into the air drawn in during a complete withdrawal of stock from a compartment. Evaporation caused by split deliveries is considered under "Transit Loss." Thus, the unloading loss is simply the hydrocarbon vapor in the vapor space. An analysis of the vapor, air included, will not regularly be available for calculation of the volume of equivalent liquid. However, the loss can be estimated knowing the TVP of the stock, the slope at the 10-per-cent point of the ASTM distillation curve, and the per cent saturation of the vapor space following unloading. Per cent saturation is relatively constant for a given pattern of unloading. For typical motor gasolines, the volume of hydrocarbon vapor which will occupy 1 gal as a liquid will vary between 28.8 cu ft and 30.7 cu ft. Fig. 1 shows a theoretically derived chart for estimating unloading loss. Liquid volume loss as a per cent of the liquid load withdrawn is plotted as a function of TVP and per cent saturation. This chart is based on an average gasoline-vapor composition in which 29.9 cu ft of vapor will occupy 1 gal as a liquid.

Fig. 1 can be expressed in the following form:

Unloading loss, per cent by volume

$$= \frac{(\text{per cent saturation})(\text{TVP},^{*}\ \text{psia})}{(29.9)(7.48)(14.7)}$$

(29.9 = vol. occup. by 1 gal at 520°R and TVP = 14.7 PSIA)

Unloading loss, per cent by volume

$$= \frac{(S)(\text{TVP}^{*})}{3{,}300} \qquad (1)$$

Per cent saturation (S)

$$= \frac{(14.7)(\text{mole per cent hydrocarbon in vapor})}{(\text{TVP},^{*}\ \text{psia})} \qquad (2)$$

Thus, when the TVP and average saturation of the vapor space are known, the unloading loss for gasoline can be estimated with a probable error of less than ±10 per cent.

This correlation can also be used to estimate unloading loss from crude oil but the answer will be less accurate than for gasoline. Lower accuracy stems from two factors: 1, the vapor volume equivalent for crude-oil vapors varies over a wider range—from 26.7 cu ft to 32.0 cu ft; and, 2, conversion of RVP † to TVP is less accurate.

Per cent saturation of the vapor space following unloading can sometimes be estimated. Unloading in one rapid delivery minimizes evaporation and results in a low per cent saturation. Unloading in several steps may result in 100 per cent saturation, particularly if significant liquid remains. Data reported on seven returning gasoline trucks, all emptied in one-stop deliveries, showed vapor concentrations to range from 10 to 45 per cent saturated for an average value of approximately 30 per cent. Vapor analyses on seven empty, crude-oil tank cars showed an average vapor concentration equal to 20 per cent saturation. When the pattern of operation is not known, an analysis of the vapor space should be obtained because the upper possible limit of saturation is 100 per cent.

Loading Loss

The method used for loading has the greatest influence on rate of loss. The industry has long recognized that subsurface or submerged loading incurs the smallest loss. The use of a long spout or fixed pipe with tight connections permits delivery to the bottom of the compartment without splashing. Direct bottom loading achieves the same effect. Splash loading causes much greater loss than subsurface loading. The stock is discharged into the upper part of the compartment through a short spout, which never dips below the surface. The free fall promotes evaporation and even results in the expulsion of liquid droplets; this entrainment loss, by definition, is not an evaporation loss. Such loss is not amenable to correlation and is not considered.

Subsurface-Loading Loss

In subsurface loading, rapid evaporation occurs until the tip of the loading pipe is adequately covered to give

* TVP is obtained from appropriate RVP-TVP chart in Appendix I.

† Reid vapor pressure.

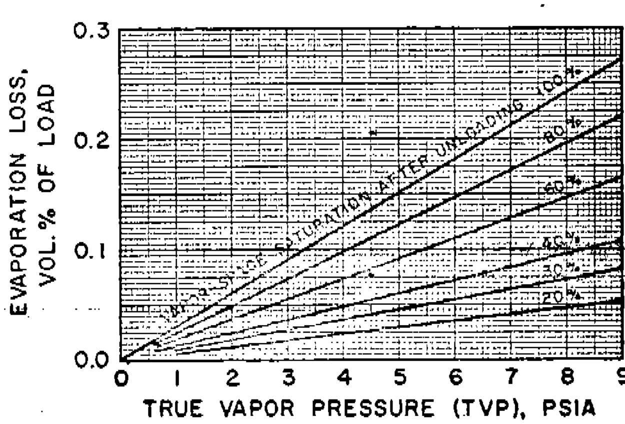


FIG. 1—Unloading-Loss Correlation for Tank Cars and Tank Trucks (Gasoline and Crude Oil).

a relatively calm surface. For maximum benefit the vapor-tight loading pipe should be within a few inches of the bottom. This ideal situation is not easily obtained because the many different-shaped tank cars and trucks impose some practical design limitations on loading facilities. In fact, about half the data used to develop the correlation for subsurface-loading loss were obtained from tests in which the loading pipe was between 12 in. and 14 in. from the bottom.

The degree of saturation in the vapor space affects the loading loss. At zero per cent saturation, loss is at a maximum, whereas between 95 and 100 per cent saturation loss is nil. The existent vapor is the unloading loss from the previous operation.

Six sets of gasoline-loss data from five companies, ranging between 3.3 psia and 8.0 psia TVP at the gasoline temperatures, were used to establish the correlation. Thirty-five separate tests, based on five different techniques of loss measurement, were made (see Table 1). The concentration of hydrocarbon in the vapor space before loading ranged from 0 to 45 per cent saturated; the average was approximately 20 per cent. Detailed test results, including the environmental conditions, are listed in Appendix II.

The data may be interpreted to fall within three families as shown in Fig. 2. Each family is related to the method used for measurement of evaporation loss. The center family nearly represents an average of the three.

The scatter of data within each family permits assuming only a straight-line proportionality between per cent loss and TVP; each line may be reasonably extrapolated to zero loss at zero TVP. The indicated scatter of data, ranging from ±30 per cent to ±70 per cent is most reasonable. The ±30 per cent scatter occurring at the highest level of loss and the ±70 per cent scatter occurring at the lowest level indicate about the same absolute degree of deviation. At 6.0 psia TVP the deviation is ±0.03 per cent of the volume loaded (±40 per cent scatter); this deviation allows for differences of hydrocarbon-vapor concentration in compartments before loading, extent of splashing before

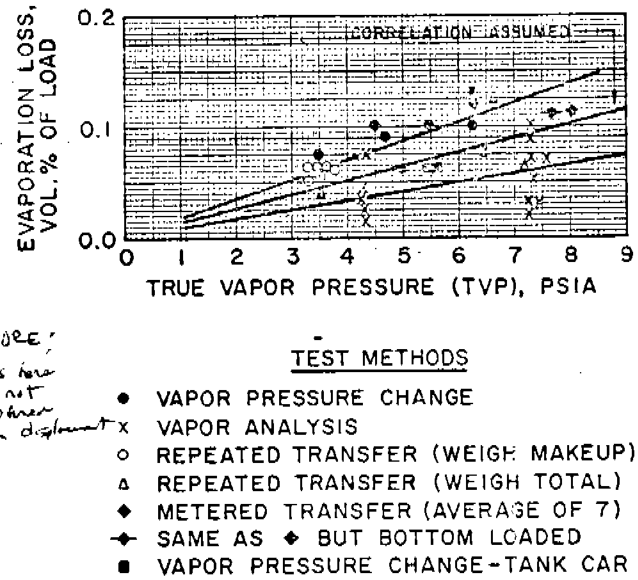


FIG. 2—Loss from Subsurface Loading of Gasoline (Tank Trucks).

the loading spout is submerged, and variation in loading rates.

After adjustments are made for peculiarities of test methods, the center family best represents loss in the 35 tests. The data points for the repeated-transfer tests, representing both loading and unloading losses, fall in the center family when corrected by an amount equal to 10 per cent saturation of the vapors before loading. The top family of data, obtained by the vapor-pressure-change method, lies above the center family by an amount roughly equal to withdrawal loss from the shipper's tank (0.005 per cent per psia TVP vs. 0.007 per cent per psia TVP). The bottom family of data, obtained by vapor-analysis method, appears to be low.

The line for the center family of data is defined as zero per cent loss at zero psia TVP and 0.10 per cent loss at 8.0 psia TVP. This line assumes 20 per cent

TABLE 1—Techniques of Loss Measurement and Loading Conditions (Subsurface-Loading Loss)

Test Methods	Number of Data Points	Spout Location (Inches from Bottom)	Filling Rate (Gallons per Minute)	Probable Accuracy of Experimental Measurement, ± Per Cent of Load
Vapor-pressure change	10	<12, 12	70 to 265	0.040
Vapor analysis	13	12, 24	200 to 800	0.02, 0.025
Repeated transfer (weigh makeup)[a]	6	4	65	0.005
Repeated transfer (weigh total)[b]	4	0,[d] 1	150	0.006
Metered transfer (average of 7)[c]	2	3,[e] 18	380	0.020
Total	35			

[a] Loss measured by weighing stock added to fill to original level.
[b] Loss measured by change in total weight.
[c] Loss measured by difference in meter readings.
[d] End of spout immersed at all times.
[e] Enters through bottom, deflected horizontally.

saturation of the existent vapors, the average of the test data. Loss is calculated as:

$$\text{Loss, per cent by volume} = \frac{(40 \text{ per cent incremental saturation})(TVP)}{3{,}300} \qquad (3)$$

Equation (3) states: with the existent vapor 20 per cent saturated, the net evaporation or loading loss is enough to cause a 40 per cent increment of saturation of a vapor volume as large as the gasoline delivery. This equation holds for a condition where the degree of saturation of existent vapors is 20 per cent, which is the average of that found in the tests. For a different degree of saturation, loading loss would be different. When the existent vapor is 100 per cent saturated, incremental saturation during loading must be zero. Thus, with these two reference points and straight-line proportionality, incremental saturation can be determined for other degrees of per cent saturation before loading. The proportionality data are shown in Table 2.

The liquid loss, in per cent by volume, from subsurface loading is given by equation (4).

$$\text{Loss, per cent by volume} = \frac{(\text{per cent incremental saturation})(TVP)}{3{,}300} \qquad (4)$$

Equation (4) is plotted in Fig. 3, based on incremental saturations listed.

Although loss rate is probably sensitive to spout location and loading rate, a correlation is not apparent. Nozzle velocity may be an important correlating variable but such data are not available.

Tests to measure subsurface-loading loss from crude oil were conducted by one company. Data from nine tests on West Texas crude oil and on blends containing 5 per cent of 20-psia natural gasoline are listed in Appendix III. Fig. 4 indicates that the loss rate is approximately 75 per cent of the gasoline rate. This lower loss rate is reasonable because a crude oil having the same TVP as a gasoline becomes deficient in the more volatile components more rapidly. Because the difference in loss rates is relatively small and difficult to measure, the

TABLE 2—Incremental Per Cent Saturation During Loading (Subsurface-Loading Loss)

Per Cent Saturation Before Loading	Incremental Per Cent Saturation During Loading
0	50
10	45
20 [a]	40 [a]
30	35
40	30
50	25
60	20
70	15
80	10
90	5
100 [b]	0 [b]

[a] Average of the test data.
[b] By theory.

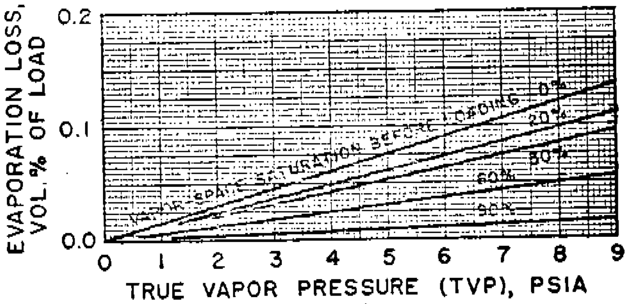


FIG. 3—Subsurface-Loading-Loss Correlation for Tank Cars and Tank Trucks (Gasoline and Crude Oil).

subsurface-loading-loss correlation for gasoline should also be used for crude oil. The TVP for crude oil should be determined from Fig. "B" in Appendix I.

Accurate use of the correlation depends upon a knowledge of saturation (or hydrocarbon content) of the vapor space before loading. The subsurface-loading loss estimated from Fig. 3 should deviate no more than ±25 per cent from actual value ninety per cent of the time. However, when the saturation before loading is assumed to be 30 per cent, subsurface-loading loss may deviate as much as ±50 per cent. Because the level of loss in subsurface loading is low, this accuracy usually is adequate. The loss correlation is based on the simplified case of a vehicle in which the vapor space before loading contains gasoline or crude-oil vapor which evaporated from a liquid similar to the new load of gasoline or crude oil.

The loss correlation does not apply to operations in which the existent vapor is chemically dissimilar to the stock being loaded. For example, for conditions of equal TVP and per cent saturation, an existent vapor of pure hexane and air would retard evaporation less than would a vapor from gasoline. The correlation breaks down, theoretically, with different gasolines. Two gasolines of equal RVP, one pressurized with butane and the other with propane, will give vapors of widely different compositions. Such combinations are beyond the scope of this bulletin.

To estimate the subsurface-loading loss, the per cent

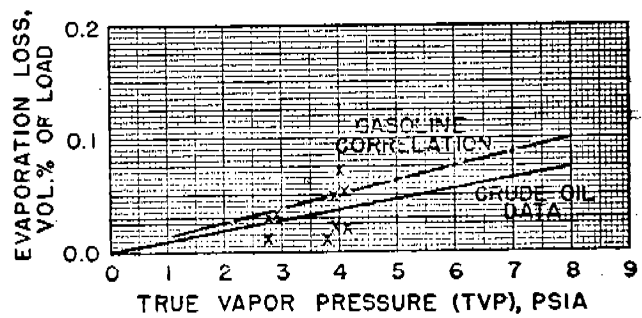


FIG. 4—Loss from Subsurface Loading of Crude Oil (Tank Cars).

TABLE 3—Techniques of Loss Measurement and Loading Conditions (Splash-Loading Loss)

Test Methods	Number of Data Points	Spout Location (Inches Below Hatch)	Filling Rate (Gallons per Minute)	Probable Accuracy of Experimental Measurement, ± Per Cent of Load
Vapor-pressure change	25	1, 6 to 12	70 to 372	0.040
Vapor analysis	2	... [d]	200	0.025
Repeated transfer (weigh makeup)[a]	4	6	65	0.013
Repeated transfer (weigh total)[b]	6	0 to 5	150	0.006
Metered transfer (average of 6)[c]	1	4	384	0.020
Total	38			

[a] Loss measured by weighing stock added to fill to original level.
[b] Loss measured by change in total weight.
[c] Loss measured by difference in meter readings.
[d] Not reported but nozzle end not immersed.

saturation must be determined by analysis or assumed.* From the saturation data, the unloading loss and loading loss can be estimated. For example, if the existent vapor is 30 per cent saturated and 6.0 psia TVP, the unloading loss, from Fig. 1, is 0.055 per cent and the subsurface-loading loss for 6.0 psia TVP, from Fig. 3, is 0.065 per cent.

Failure to correct per cent saturation of existent vapors for differences between unloading and loading conditions results in a wrong estimate. An example shows the procedure for making this correction. However, a relatively small residual error will still exist in cases where the temperature of the vapor space is different from the temperature of the liquid being loaded.

PROBLEM: Determine loss from unloading a 10-psia RVP (slope of ASTM distillation curve at 10 per cent evaporated equals 2.5) gasoline at 50 F when the vapor space of the empty compartment is at 30 per cent saturation. Also, determine loss from loading a 10-psia RVP gasoline at 70 F into the same compartment.

SOLUTION: Three figures are used to solve the problem. RVP is converted to TVP by Fig. "A" in Appendix I. Unloading loss is estimated by use of Fig. 1. Loading loss is estimated by use of Fig. 1 and Fig. 3.

1. *Unloading loss:* First, from Fig. "A" in Appendix I, convert 10 psia RVP to TVP at 50 F, 4.3 psia. Then locate 4.3 psia on Fig. 1 and move vertically to the 30 per cent saturation line. The unloading loss is 0.04 per cent.

2. *Loading loss:* First, correct vapor-space per cent saturation to loading conditions. TVP at loading conditions from Fig. "A" in Appendix I is 6.3 psia. Locate 6.3 psia TVP on Fig. 1 and move vertically to 0.04 per cent loss and read the new per cent saturation (corrected to loading conditions), 20 per cent. On Fig. 3, locate 6.3 psia TVP and move vertically to the 20 per cent saturation line. The correct subsurface-loading loss is 0.075 per cent. The uncorrected loss would have been 0.065 per cent.

* Limited data indicate that in normal operation vapor from gasoline compartments is 30 per cent saturated and vapor from crude-oil compartments is 20 per cent saturated.

The same procedure should be used for estimating loss from similar stocks having different RVP.

Splash-Loading Loss

In splash loading, stock free falls into the compartment during the entire operation. Vapor leaving the compartment flows countercurrent to the falling stream and becomes almost completely saturated regardless of saturation in the existent vapor.

The many variables in splash-loading loss limits the correlation to operations with a short spout—outlet from 0 in. to 12 in. below hatch. One-third of the data were obtained from tests in which the spout was less than 6 in. below the hatch. Faulty design or poorly conducted operations can result in entrainment loss, which may be two or three times greater than the evaporation loss. The use of funnels with splash loading can cause inspiration of air and markedly increase evaporation loss and chances for entrainment. Such operations are excluded from the correlation.

Five sets of gasoline-loss data from four companies, ranging between 3.7 psia and 7.7 psia TVP at gasoline temperatures, were used to establish the correlation. Thirty-eight separate tests, based on five different techniques of loss measurement were made (see Table 3). Existent vapor ranged from 0 to 45 per cent saturated before loading; the average was approximately 20 per cent. Detailed test data, including environmental conditions are listed in Appendix IV.

Fig. 5 shows much scatter among the 38 data points; however, they may be interpreted to follow a curvature. The dashed line, the maximum evaporation loss theoretically possible, assumes zero per cent saturated vapor before loading and 100 per cent saturation of the total vapor leaving the tank. Four data points determined by the vapor-pressure-change method are too high and are excluded from the correlation. Some of the data points from the repeated-transfer tests could be high because of liquid entrainment. The remaining scatter could have resulted from differences in loading rate, degree of saturation in the compartment before loading, and elevation and angle of the loading spout.

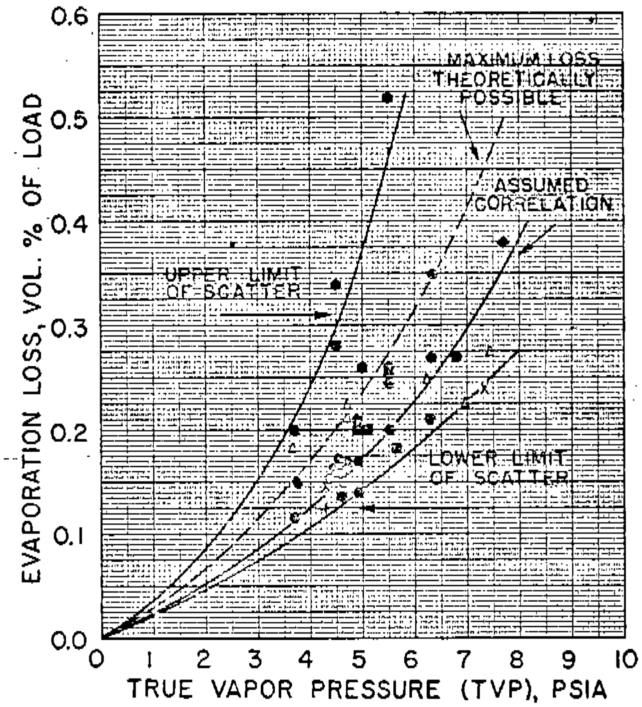


FIG. 5—Loss from Splash Loading of Gasoline (Tank Trucks).

Because the expelled vapor from a splash-loading operation is nearly 100 per cent saturated, the correlation equation should resemble the air-balance formula. Allowing for 95 per cent saturation of the expelled vapor, the equation would be:

$$\text{Loss, per cent by volume} = \frac{100}{(7.48)(29.9)}\left[\frac{14.7-(0.01)(\text{per cent saturation of existent vapor})(\text{TVP})}{14.7-(0.01)(95\text{ per cent saturation of expelled vapor})(\text{TVP})}-1\right] \quad (5)$$

Equation (5) appears to fit the test data. With all scatter allowed for, an "assumed correlation" was drawn through the data points. When the repeated transfer data are corrected for 10 per cent saturation before loading, they fall close to this line. The assumed correlation curve passes through zero loss at zero TVP and 0.23 per cent loss at 6.0 psia TVP. With existent vapor at 20 per cent saturation and expelled vapor at 95 per cent saturation, the air-balance formula satisfies the test data. Therefore:

$$\text{Loss, per cent by volume} = 0.45\left[\frac{14.7-(0.01)(20)(6.0)}{14.7-(0.01)(95)(6.0)}-1\right] = 0.23 \text{ per cent} \quad (6)$$

For the entire range of per cent saturation of existent vapors (0 to 95 per cent), equation (5) should be satisfactory for splash-loading evaporation loss. When existent vapor is between 95 and 100 per cent saturation, evaporation loss is negligible. The correlation equation is plotted in Fig. 6.

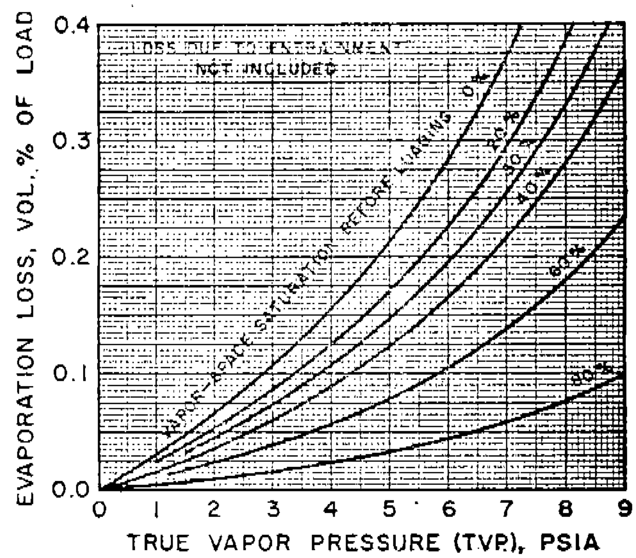


FIG. 6—Splash-Loading-Loss Correlation for Tank Cars and Tank Trucks (Gasoline and Crude Oil).

Eighteen tests on splash loading of crude oil * were conducted by one company at two locations. The air-balance technique was used for all tests. Detailed data are listed in Appendix V.

Fig. 7 shows that the two sets of data form similar curves, neither of which is satisfactory. Curve **A** is far too high because it indicates an impossible degree of super saturation of the vapor. Curve **B** seems too low. Although the two sets of data cannot be reconciled with available information, an intermediate value is more nearly correct. The logical compromise is to use the gasoline-loss correlation shown in Fig. 6; also, the RVP-TVP relationship for crude oil, Fig. "B" in Appendix I, should be used.

Accurate use of the splash-loading correlation, Fig. 6, depends upon knowing the saturation of the vapor space before loading. When it is known, loss (exclusive of any entrainment) can be estimated with a deviation not more than ±10 per cent, ninety per cent of the time. If saturation of the existent vapor is assumed to be 30 per cent, predicted loss would not deviate more than ±35 per cent.

Splash-loading loss may be estimated in the same manner as described under "Subsurface-Loading Loss";

* West Texas crude oil and blends containing 5 per cent of 20-psia natural gasoline.

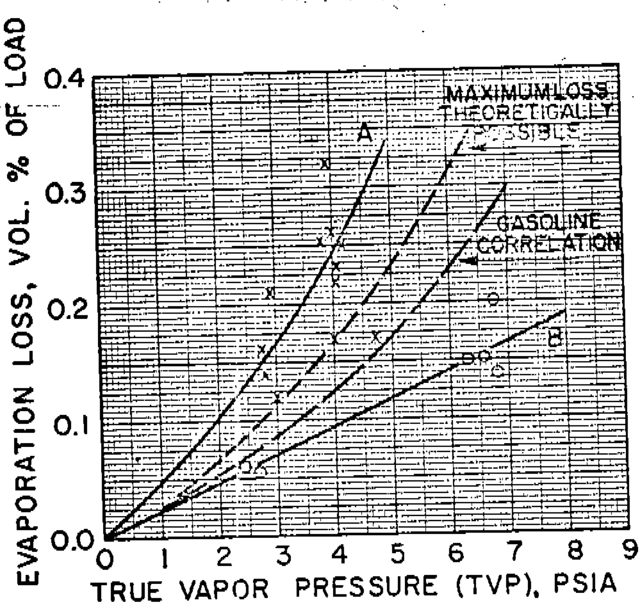


FIG. 7—Loss from Splash Loading of Crude Oil (Tank Cars).

however, the correlation chart for splash loading (Fig. 6) should be used.

Transit Loss

Data for evaporation loss from tank cars and trucks in transit were not reported.

Because travel time is usually short, less than two days, the transit loss for a one-stop delivery is probably too small to measure. However, a distinction should not be drawn between transit loss from tank cars and trucks and that from marine vessels. To make a rough estimate of such loss, refer to the paragraph on transit loss under "Marine Vessels." The estimated loss should be time-corrected on a prorated basis.

Sometimes the transit loss might be large, such as when the load is split between two or more stops. A relatively large vapor space is created by the first-stop delivery. The vapor expands and contracts because of temperature changes. Loss is accentuated because the vapor is nearly 100 per cent saturated. Also, changes in atmospheric and solar heat may cause rather large fluctuations in TVP, which add to the expansion and contraction effects. Loss from this type operation cannot be correlated.

MARINE VESSELS

Evaporation loss from marine vessels usually occurs during all phases of the transportation cycle. However, tankers and barges can be designed to minimize evaporation loss. This requires that vents operate effectively at maximum permissible pressure settings, and that stripper pumps drain the last traces of liquid from the storage compartments. The fill pipes should be integral parts of the carriers and should be arranged so as to minimize splashing.

Unloading Loss

Data are not available for unloading loss from tankers and barges. Because of the size of cargoes and the time required to unload, loss could be approximately the same as the analogous shore-tank withdrawal loss—0.007 per cent per psia TVP. For split deliveries from one compartment, the loss might equal 100 per cent saturation of the vapor space (approximately 0.03 per cent per psia TVP).

Loading Loss

Data from eight tests on loading gasoline, at TVP ranging between 4.9 psia and 9.0 psia, were supplied by three companies. Three different test methods were used: density change, vapor-pressure change, and vapor metering * (see Table 4).

* The expelled vapor is measured by means of an orifice meter. With the compartment free of hydrocarbon vapor before loading, the difference between the volume of vapor expelled and the volume of stock received should be the hydrocarbon vapor expelled. The shore-tank withdrawal loss is not involved. This method is described in detail in *API Bull. 2512: Tentative Methods of Measuring Evaporation Loss from Petroleum Tanks and Transportation Equipment.*

TABLE 4—Loading-Loss Data for Tankers and Barges

Test No.	Vessel	Volume Tested (Thousands of Barrels)	Test Method	TVP	Total Loss (Per Cent by Volume)	Type of Tank Filled From	Loading Loss (Per Cent by Volume)
1	Barge	11	Density	9.0	0.06	Floating roof	0.06
2	Ship	70	Density	8.0	0.12	Fixed roof	0.06
3	Ship	80	Vapor pressure	7.6	0.12	Fixed roof	0.063
4	Barges (4)	80	Vapor pressure	5.4	0.08	Tanker	0.042
5	Ship	10	Vapor pressure	4.9	0.07	Fixed roof	0.036
6	Ship	9	Vapor meter	6.7	0.015	...	0.015
7	Ship	9	Vapor meter	6.7	0.016	...	0.016
8	Ship	9	Vapor meter	7.0	0.008	...	0.008

TABLE 5—Transit-Loss Data for Tankers and Barges

Test No.	Vessel	Volume Tested (Thousands of Barrels)	Days	Test Method	TVP	Transit Loss (Per Cent of Load)	Per Cent per TVP per Week
1	Ship	80	9	Vapor pressure	6.8	0.07	0.008
2	Ship	10	23	Vapor pressure	4.9	0.06	0.0037
3	Barge	11	6	Density	8.6	0.11	0.015
4	Ship	33	6	Density	7.1	0.08	0.013

Per cent saturation of the vapor spaces was zero in four tests and unreported in four tests. However, circumstances suggest that per cent saturation was probably zero in two of these tests. Detailed data are listed in Appendix VI.

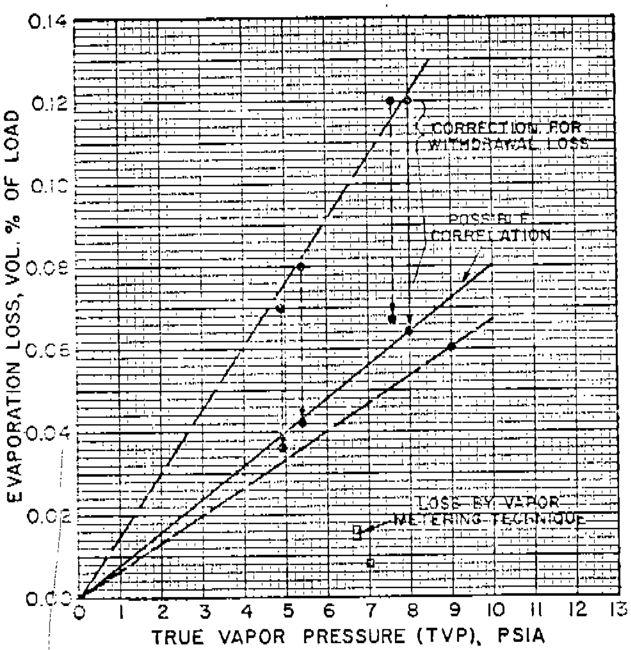


FIG. 8—Loss from Loading Tankers and Barges.

The eight data points are plotted in Fig. 8. One data point obtained by the density-change method did not need correction for withdrawal loss because the shore tank was equipped with a floating roof. When the vapor-pressure-change data points are corrected for a withdrawal loss, a relatively good line is obtained:

$$\text{Loading loss, per cent by volume} = 0.008(\text{TVP}) \quad (7)$$

However, the data obtained by the vapor-metering method show a much lower loss: 0.001 to 0.002 per cent per psia TVP. The possible correlation given in equation (7) would apply to ships which are relatively vapor free. The loss would be lower for ships having significant existent vapor.

Before a firm correlation can be established, more experimental data are required on loading loss from tankers and barges.

Transit Loss

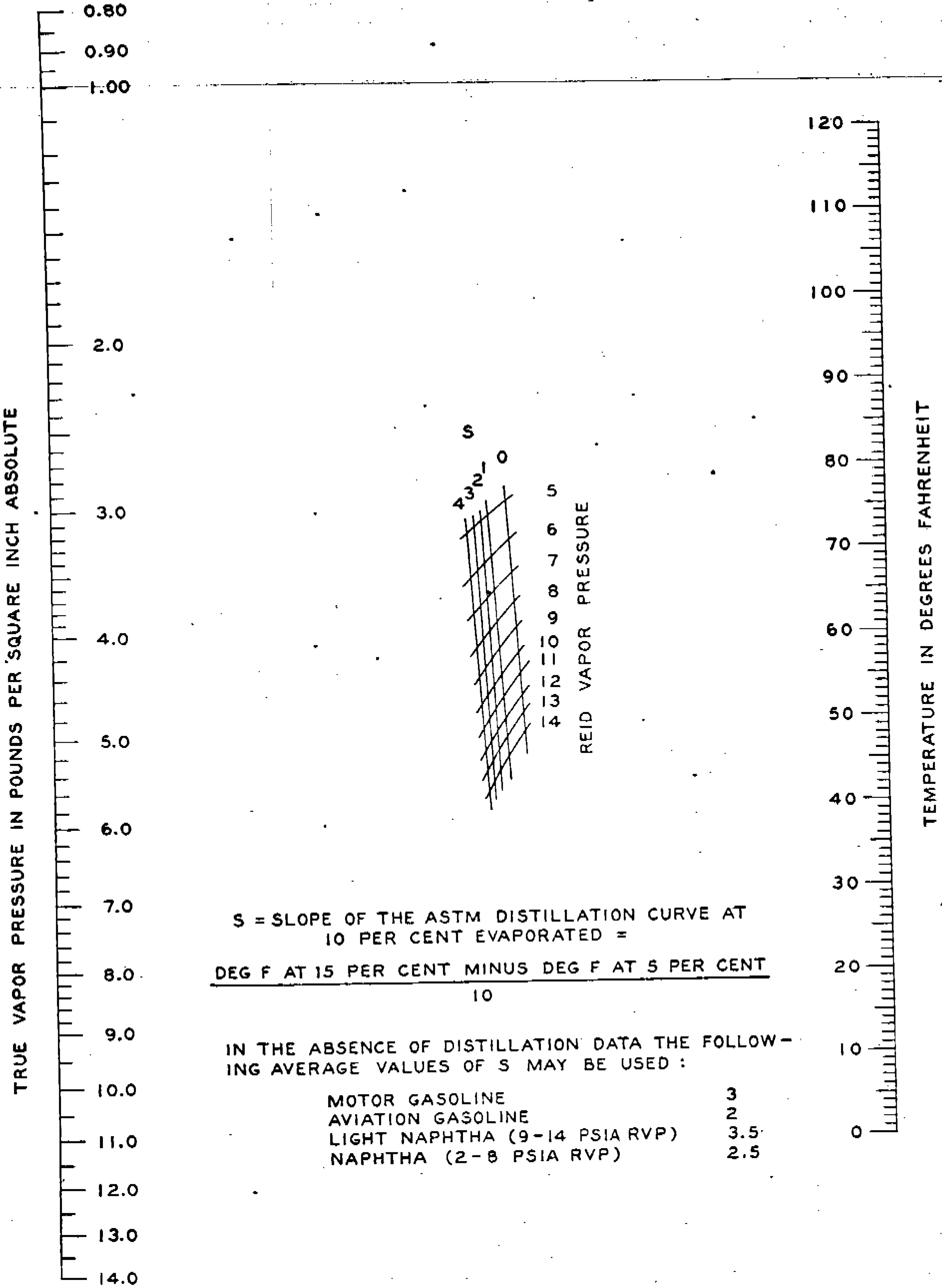
A limited amount of data received on marine transit loss are included for orientation purposes. Four test results were reported by three companies (see Table 5). Except for Test No. 2, the data show that the transit loss was approximately 0.01 per cent per psia TVP for a one-week voyage.

CONCLUSION

The present correlations for estimating evaporation losses from tank cars and trucks are distinct improvements over older information. The unloading- and loading-loss correlations are reliable yardsticks for the normal, well-conducted operations. Refinement, which might be attained with more test data, would probably be of little added value. Entrainment loss, the result of faulty design or poorly conducted operations, cannot be satisfactorily correlated. Transit-loss data were not reported, and although such loss is assumed to be negligible for short, one-stop deliveries, supporting test data would be reassuring. For split deliveries, transit loss might be significant, but, here again, no data are available.

The loss correlations for marine vessels are not supported by enough data to be accepted as final. Unloading loss, for lack of any data, is assumed to be equal to shore-tank withdrawal loss; this conclusion should be confirmed. The loading-loss correlation shows the need for further test work, especially to determine the reliability of the vapor-metering method. Transit loss is significant, but several more data points are needed to substantiate the indicated loss rate.

APPENDIX I—VAPOR-PRESSURE CHARTS



Source: Nomograph drawn from data of the National Bureau of Standards.

FIG. A—Vapor Pressures of Gasolines and Finished Petroleum Products.

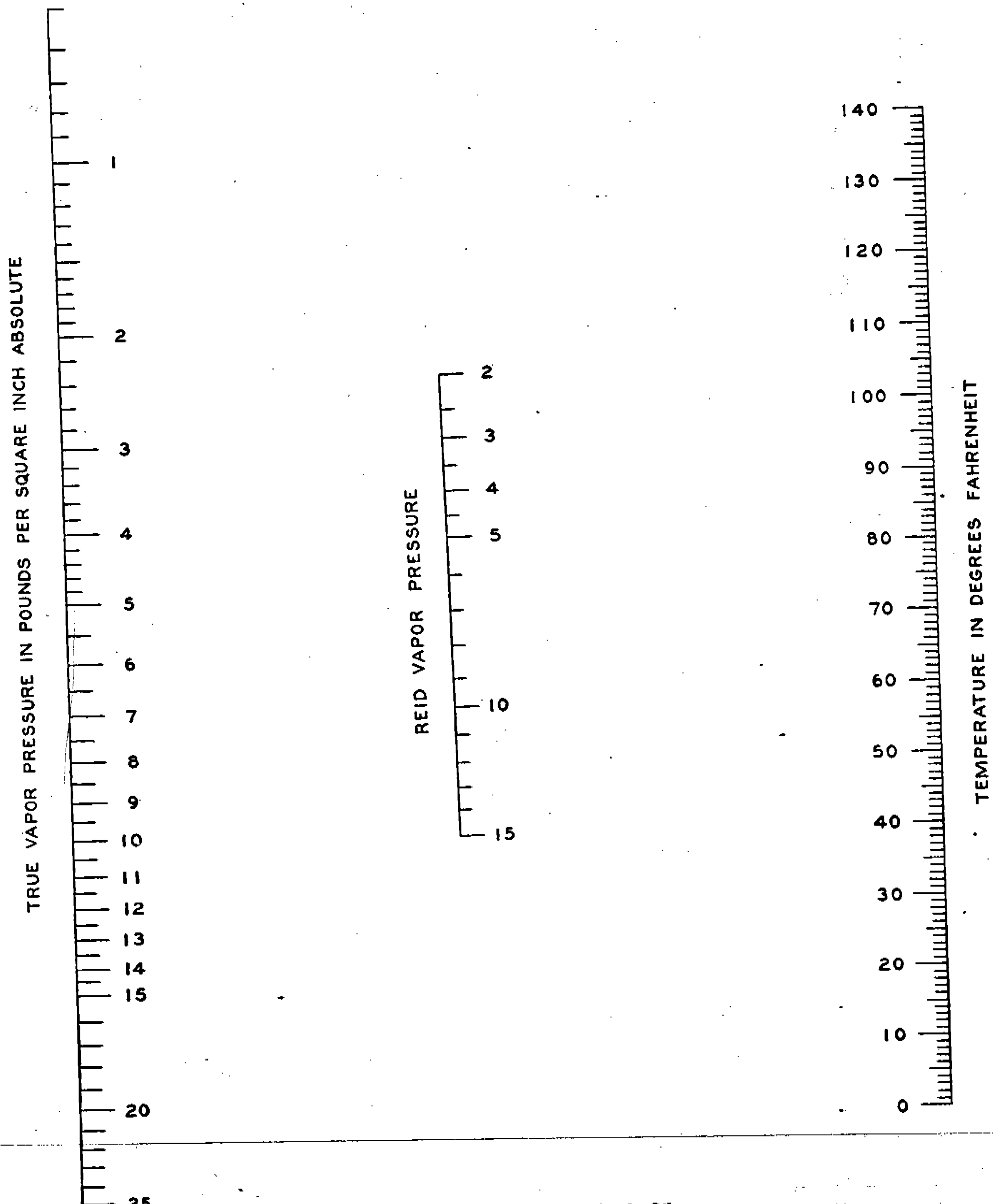


FIG. B—Vapor Pressures of Crude Oil.

APPENDIX II—SUBSURFACE-LOADING-LOSS TESTS FOR TANK CARS AND TANK TRUCKS (GASOLINE)

Test No.	Geographical Location	Daily Mean Temperature (Deg F)	Month	Weather Condition	Loading Conditions: Spout Location (Inches from Bottom)	Vapor Saturation (Per Cent)	Stock: Deg F	Stock: RVP	Stock: TVP	Fill Rate (Gallons per Minute)	Load (Gallons)	Loss (Per Cent)	Test Method
1	Quincy, Mass.	20	Mar.	—	Very bottom	[b]	35	11.0	3.5	—	—	0.07	Vapor-pressure change
2	Quincy, Mass.	84	July	—	Very bottom	[b]	70	10.0	6.3	—	400	0.13	Vapor-pressure change
3	Quincy, Mass.	84	July	—	Very bottom	[b]	70	10.0	6.3	—	315	0.12	Vapor-pressure change
4	Quincy, Mass.	84	July	—	Very bottom	[b]	70	10.0	6.3	—	2,800	0.10	Vapor-pressure change
5	Buffalo, N. Y.	—	Nov.	—	—	[b]	59	10.5	5.5	71	—	0.10	Vapor-pressure change
6	Buffalo, N. Y.	—	Nov.	—	—	[b]	54	10.5	5.0	89	—	0.06	Vapor-pressure change
7	Buffalo, N. Y.	—	Nov.	—	—	[b]	51	10.5	4.7	265	—	0.09	Vapor-pressure change
8	Buffalo, N. Y.	—	Mar.	—	—	[b]	40	12.5	4.5	200	—	0.10	Vapor-pressure change
9	Mt. Vernon, N. Y.	—	Apr.	—	—	[b]	62	10.3	5.5	156	—	0.06	Vapor-pressure change
10	Boston, Mass.	—	July	—	12	—	70	9.1	5.6	—	8,000	0.06	Vapor-pressure change
11	Cleveland, Ohio	46	Mar.	Cloudy	24	0	43	11.6	4.3	750	1,400	0.072	Vapor analysis [c]
12	Cleveland, Ohio	46	Mar.	Cloudy	24	0	43	11.6	4.3	750	610	0.044	Vapor analysis [c]
13	Cleveland, Ohio	46	Mar.	Cloudy	24	0	43	11.6	4.3	200	1,220	0.022	Vapor analysis [c]
14	Cleveland, Ohio	46	Mar.	Cloudy	24	10.6	43	11.6	4.3	200	1,220	0.014	Vapor analysis [c]
15	Cleveland, Ohio	46	Mar.	Cloudy	24	0	43	11.6	4.3	200	610	0.032	Vapor analysis [c]
16	Cleveland, Ohio	87	Aug.	Cloudy	24	0	81	9.6	7.3	800	1,400	0.050	Vapor analysis [c]
17	Cleveland, Ohio	87	Aug.	Cloudy	24	10.3	81	9.6	7.3	800	1,400	0.020	Vapor analysis [c]
18	Cleveland, Ohio	87	Aug.	Cloudy	24	0	81	9.6	7.3	800	610	0.100	Vapor analysis [c]
19	Cleveland, Ohio	87	Aug.	Cloudy	24	0	81	9.6	7.3	200	1,220	0.030	Vapor analysis [c]
20	Cleveland, Ohio	87	Aug.	Cloudy	24	0	81	9.6	7.3	200	610	0.070	Vapor analysis [c]
21	Cleveland, Ohio	87	Aug.	Cloudy	24	0	81	9.6	7.3	200	505	0.030	Vapor analysis [c]
22	Torrance, Calif.	—	—	—	12	[b]	82	9.5	7.3	450	—	0.09	Vapor analysis [d]
23	Torrance, Calif.	—	—	—	12	[b]	86	9.0	7.6	450	—	0.07	Vapor analysis [d]
24	Emeryville, Calif.	—	May	—	4	—	—	—	3.3	65	—	0.065	Repeated transfer [e]
25	Emeryville, Calif.	—	May	—	4	—	—	—	3.4	65	—	0.065	Repeated transfer [e]
26	Emeryville, Calif.	—	May	—	4	—	—	—	3.5	65	—	0.065	Repeated transfer [e]
27	Emeryville, Calif.	—	May	—	4	—	—	—	3.3	65	—	0.050	Repeated transfer [e]
28	Emeryville, Calif.	—	May	—	4	—	—	—	3.5	65	—	0.055	Repeated transfer [e]
29	Emeryville, Calif.	—	May	—	4	—	—	—	3.8	65	—	0.060	Repeated transfer [e]
30	East Coast	—	July	—	Immersed	—	—	—	3.5	150	150	0.040	Repeated transfer [f]
31	East Coast	—	July	—	Immersed	—	—	—	7.0	150	150	0.065	Repeated transfer [f]
32	East Coast	—	Aug.	—	Immersed	—	—	—	6.5	150	150	0.075	Repeated transfer [f]
33	East Coast	—	Aug.	—	1	—	—	—	6.6	150	150	0.126	Repeated transfer [f]
34	Buffalo, N. Y.	—	Aug.	—	18	—	76	—	8.0	360 avg	739	0.11	Metered transfer [g]
35	Buffalo, N. Y.	—	Aug.	—	About 3 [a]	—	74	—	7.8	415 avg	739	0.11	Metered transfer [g]

[a] Deflected bottom loading.
[b] Independently indicated 24 to 45 per cent saturated.
[c] Vapor-analysis method via air-balance technique. Vapor samples collected in evacuated bombs and analyzed by mass spectrometer.
[d] Vapor-analysis method via air-balance technique; average of three loading tests.
[e] Ten repeated transfers per test. Loss measured by weighing stock added to fill compartment to original level.
[f] Ten repeated transfers per test. Loss measured by loss in total weight.
[g] Average of 6 to 8 metered transfers into a calibrated tank. Tank calibrated with kerosine up to a marker in the Seraphim neck. Each transfer was a new batch of gasoline; thus loss per batch was not magnified.

APPENDIX III—SUBSURFACE-LOADING-LOSS TESTS FOR TANK CARS (CRUDE OIL)

Test No.	Geographical Location	Daily Mean Temperature (Deg F)	Month	Weather Condition	Loading Conditions: Vapor Saturation (Per Cent)	Loading Conditions: Stock Deg F	Loading Conditions: Stock RVP	Loading Conditions: Stock TVP	Loading Conditions: Fill Rate (Gallons per Minute)	Loading Conditions: Load (Gallons)	Loss (Per Cent)	Test Method
1	Midland, Texas	63	Feb.	Clear	8.9	56	5.5	2.8	181	10,100	0.03	Vapor analysis [a, b]
2	Midland, Texas	63	Feb.	Cloudy	2.6	55	5.5	2.8	176	8,104	0.01	Vapor analysis [a, b]
3	Midland, Texas	63	Feb.	Clear	2.5	58	5.5	2.9	171	6,475	0.03	Vapor analysis [a, b]
4	Midland, Texas	63	Feb.	Cloudy	3.5	48	7.5	3.8	217	10,203	0.01	Vapor analysis [a, b]
5	Midland, Texas	63	Feb.	Cloudy	5.7	49	7.5	3.9	240	8,126	0.02	Vapor analysis [a, b]
6	Midland, Texas	63	Feb.	Cloudy	0	50	7.5	4.0	195	9,912	0.05	Vapor analysis [a, b]
7	Midland, Texas	63	Feb.	Clear	19.5	51	7.5	4.0	160	6,374	0.05	Vapor analysis [a, b]
8	Midland, Texas	63	Feb.	Night	4.8	51	7.5	4.0	200	7,975	0.07	Vapor analysis [a, b]
9	Midland, Texas	63	Feb.	Night	10.4	52	7.5	4.1	203	10,175	0.02	Vapor analysis [a, b]

[a] Vapor-analysis method via air-balance technique. Vapor samples aspirated from dome of tank car. Air content determined by Orsat analysis.
[b] Insufficient information to determine extent of interaction between oxygen (O_2) and hydrogen sulfide (H_2S) and the error resulting therefrom.

APPENDIX IV—SPLASH-LOADING-LOSS TESTS FOR TANK CARS AND TANK TRUCKS (GASOLINE)

Test No.	Geographical Location	Daily Mean Temperature (Deg F)	Month	Weather Condition	Loading Conditions: Spout Location (Inches Below Hatch)	Vapor Saturation (Per Cent)	Stock: Deg F	Stock: RVP	Stock: TVP	Fill Rate (Gallons per Minute)	Load (Gallons)	Loss (Per Cent)	Test Method
1	Quincy, Mass.	84	July	—	6 to 12	b	70	10.0	6.3	—	250	0.35	Vapor-pressure change
2	Quincy, Mass.	84	July	—	6 to 12	b	70	10.0	6.3	—	400	0.27	Vapor-pressure change
3	Quincy, Mass.	84	July	—	6 to 12	b	70	10.0	6.3	—	2,200	0.21	Vapor-pressure change
4	Glenwood, N. Y.	—	Oct.	—	6 to 12	b	78	9.5	6.8	210	—	0.27	Vapor-pressure change
5	Buffalo, N. Y.	—	Nov.	—	6 to 12	b	59	10.5	5.5	70	—	0.20	Vapor-pressure change
6	Buffalo, N. Y.	—	Nov.	—	6 to 12	b	53	10.5	4.9	157	—	0.14	Vapor-pressure change
7	Buffalo, N. Y.	—	Nov.	—	6 to 12	b	54	10.5	5.0	89	—	0.26	Vapor-pressure change
8	Buffalo, N. Y.	—	Nov.	—	6 to 12	b	53	10.5	4.9	188	—	0.17	Vapor-pressure change
9	Buffalo, N.Y.	—	Nov.	—	6 to 12	b	51	10.5	4.7	269	—	0.17	Vapor-pressure change
10	Buffalo, N. Y.	—	Nov.	—	6 to 12	b	53	10.5	4.9	372	—	0.21	Vapor-pressure change
11	Buffalo, N. Y.	—	Mar.	—	6 to 12	b	40	12.5	4.5	200	—	0.34	Vapor-pressure change
12	Buffalo, N. Y.	—	Mar.	—	6 to 12	b	40	12.5	4.5	200	—	0.28	Vapor-pressure change
13	Mt. Vernon, N. Y.	—	Apr.	—	6 to 12	b	62	10.3	5.5	146	—	0.25	Vapor-pressure change
14	Mt. Vernon, N. Y.	—	Apr.	—	6 to 12	b	62	10.3	5.5	139	—	0.25	Vapor-pressure change
15	Mt. Vernon, N. Y.	—	Apr.	—	6 to 12	b	62	10.3	5.5	136	—	0.26	Vapor-pressure change
16	Mt. Vernon, N. Y.	—	Apr.	—	6 to 12	b	62	10.3	5.5	95	—	0.52	Vapor-pressure change
17	Mt. Vernon, N. Y.	—	Nov.	—	6 to 12	b	47	9.2	3.7	—	—	0.12	Vapor-pressure change
18	Mt. Vernon, N. Y.	—	Nov.	—	6 to 12	b	48	9.2	3.7	—	—	0.15	Vapor-pressure change
19	Mt. Vernon, N. Y.	—	Nov.	—	6 to 12	b	48	9.2	3.7	—	—	0.20	Vapor-pressure change
20	Brooklyn, N. Y.	—	Mar.	—	6 to 12	b	46	11.5	4.6	—	—	0.14	Vapor-pressure change
21	Brooklyn, N. Y.	—	Mar.	—	6 to 12	b	46	11.5	4.6	—	—	0.17	Vapor-pressure change
22	Brooklyn, N. Y.	—	Mar.	—	6 to 12	b	46	11.5	4.6	—	—	0.17	Vapor-pressure change
23	Boston, Mass.	65	Aug.	—	1	—	69	8.4	5.0	—	8,000	0.20	Vapor-pressure change
24	Boston, Mass.	65	Aug.	—	1	—	69	8.4	5.0	—	8,000	0.20	Vapor-pressure change
25	Boston, Mass.	68	July	—	1	—	70	9.1	5.6	—	8,000	0.18	Vapor-pressure change
26	Cleveland, Ohio	46	Mar.	—	a	0	43	11.6	4.3	200	1,020	0.144	Vapor analysis c
27	Cleveland, Ohio	87	Aug.	—	a	0	81	9.6	7.3	200	335	0.238	Vapor analysis c
28	Emeryville, Calif.	—	May	—	6	—	—	—	4.2	65	—	0.145	Repeated transfers d
29	Emeryville, Calif.	—	May	—	6	—	—	—	4.4	65	—	0.155	Repeated transfers d
30	Emeryville, Calif.	—	May	—	6	—	—	—	4.4	65	—	0.145	Repeated transfers d
31	Emeryville, Calif.	—	May	—	6	—	—	—	4.5	65	—	0.160	Repeated transfers d
32	East Coast	—	July	—	0	—	—	—	7.4	150	150	0.275	Repeated transfers e
33	East Coast	—	July	—	0	—	—	—	4.7	150	150	0.222	Repeated transfers e
34	East Coast	—	July	—	0	—	—	—	3.6	150	150	0.182	Repeated transfers e
35	East Coast	—	July	—	0	—	—	—	4.7	150	150	0.215	Repeated transfers e
36	East Coast	—	July	—	1	—	—	—	6.2	150	150	0.255	Repeated transfers e
37	East Coast	—	July	—	5	—	—	—	6.9	150	150	0.222	Repeated transfers e
38	Buffalo, N. Y.	—	Aug.	—	About 4	—	—	—	7.7	290 to 530	739	0.378	Metered transfers f

a Nozzle end not immersed.
b Independently indicated 24 to 45 per cent saturated.
c Vapor-analysis method via air-balance technique. Vapor samples collected in evacuated bombs and analyzed by mass spectrometer.
d Three repeated transfers per test. Loss measured by weighing stock added to fill compartment to original level.
e Ten repeated transfers per test. Loss measured by loss in total weight.
f Average of 6 metered transfers into a calibrated tank. Tank calibrated with kerosine up to a marker in the Seraphim neck. Each transfer was a new batch of gasoline; thus loss per batch was not magnified.

APPENDIX V—SPLASH-LOADING-LOSS TESTS FOR TANK CARS (CRUDE OIL)

Test No.	Geographical Location	Daily Mean Temperature (Deg F)	Month	Loading Conditions: Weather Condition	Spout Location (Inches Below Hatch)	Vapor Saturation (Per Cent)	Stock: Deg F.	Stock: RVP	Stock: TVP	Fill Rate (Gallons per Minute)	Load (Gallons)	Loss (Per Cent)	Test Method
1	Midland, Texas	63	Feb.	Clear	—	5.0	56	5.5	2.8	176	8,097	0.14	Vapor analysis [b, c]
2	Midland, Texas	63	Feb.	Cloudy	—	113.0 [a]	55	5.5	2.8	215	10,214	0.16	Vapor analysis [b, c]
3	Midland, Texas	63	Feb.	Clear	—	61.3	60	5.5	3.0	203	8,106	0.12	Vapor analysis [b, c]
4	Midland, Texas	63	Feb.	Clear	—	14.2	58	5.5	2.9	206	10,073	0.21	Vapor analysis [b, c]
5	Midland, Texas	63	Feb.	Cloudy	—	13.6	48	7.5	3.8	196	8,213	0.25	Vapor analysis [b, c]
6	Midland, Texas	63	Feb.	Cloudy	—	3.4	49	7.5	3.9	280	10,090	0.32	Vapor analysis [b, c]
7	Midland, Texas	63	Feb.	Cloudy	—	26.5	50	7.5	4.0	172	8,078	0.23	Vapor analysis [b, c]
8	Midland, Texas	63	Feb.	Cloudy	—	19.5	51	7.5	4.0	148	8,106	0.26	Vapor analysis [b, c]
9	Midland, Texas	63	Feb.	Clear	—	15.0	59	7.5	4.7	300	8,063	0.17	Vapor analysis [b, c]
10	Midland, Texas	63	Feb.	Cloudy	—	18.4	51	7.5	4.0	256	10,205	0.22	Vapor analysis [b, c]
11	Midland, Texas	63	Feb.	Night	—	15.1	52	7.5	4.1	188	8,155	0.25	Vapor analysis [b, c]
12	Midland, Texas	63	Feb.	Night	—	12.1	51	7.5	4.0	271	8,105	0.17	Vapor analysis [b, c]
13	Jefferson, Texas	79	June	Clear	—	11.2	80	7.2	6.3	168	8.081	0.15	Vapor analysis [b, c]
14	Jefferson, Texas	79	June	Clear	—	22.6	84	7.2	6.8	137	8,192	0.14	Vapor analysis [b, c]
15	Jefferson, Texas	79	June	Clear	—	24.2	83	7.2	6.7	172	8,237	0.20	Vapor analysis [b, c]
16	Jefferson, Texas	79	June	Clear	—	31.0	81	7.2	6.4	142	10,214	0.15	Vapor analysis [b, c]
17	Jefferson, Texas	79	June	Clear	—	30.0	92	2.7	2.5	—	8,077	0.06	Vapor analysis [b, c]
18	Jefferson, Texas	79	June	Clear	—	0	92	2.7	2.5	153	8,128	0.06	Vapor analysis [b, c]

[a] Theoretically could not exceed 100 per cent.
[b] Vapor-analysis method via air-balance technique. Vapor samples aspirated from dome of car; air content determined by Orsat analysis.
[c] Insufficient information to determine extent of interaction between oxygen (O_2) and hydrogen sulfide (H_2S) and the error resulting therefrom.

APPENDIX VI—LOADING-LOSS TESTS FOR TANKERS AND BARGES (GASOLINE)

Test No.	Vessel	Geographical Location	Month	Loading Conditions: Vapor Saturation (Per Cent)	Stock: Deg F	Stock: RVP	Stock: TVP	Fill Rate (Barrels per Hour)	Load (Barrels)	Loss (Per Cent)	Type of Tank Filled From	Test Method
1	Barge	Baton Rouge, La.	July	—	93	9.4	9.0	—	11,000	0.06 [c]	Floating roof	Density change
2	Ship	Baytown, Texas	June	[a]	92	8.4	8.0	5,800	70,000	0.12 [d]	Fixed roof	Density change
3	Ship	Beaumont, Texas	July	—	90	8.8	7.6	8,000	80,000	0.12	Fixed roof	Vapor-pressure change
4	Barges (4)	New York Harbor	July	—	72	8.6	5.4	—	80,000	0.08	Tanker	Vapor-pressure change
5	Ship	Terminal Island, Calif.	Jan.	—	55	10.3	4.9	—	9,866	0.07	Fixed roof	Vapor-pressure change
6	Ship	California	May	0.7 [b]	76	9.6	6.7	6,758	9,150	0.015 [e]	—	Vapor analysis [e]
7	Ship	California	May	[b]	76	9.6	6.7	6,758	—	0.016 [e]	—	Vapor analysis [e]
8	Ship	California	May	[b]	76	10.1	7.0	5,326	—	0.008 [e]	—	Vapor analysis [e]

[a] Sixty per cent of compartment volume subjected to gas-freeing before loading.
[b] Compartment subjected to gas-freeing before loading.
[c] Does not include shore-tank withdrawal loss.
[d] Shore-tank withdrawal loss (by density method) indicated to be 0.06 per cent of load.
[e] Loss by vapor-analysis method. Loss equals volume of expelled vapor (by orifice meter) less displaced volume of compartment.

APPENDIX VII—COMMITTEE MEMBERSHIP

Committee on Evaporation Loss (1959)

Officers

J. H. McClintock (*Chairman*)	Esso Research and Engineering Co.	Linden, N. J.
E. L. Hoffman (*Vice Chairman*)	Socony Mobil Oil Co., Inc.	New York, N. Y.
E. O. Mattocks (*Secretary*)	American Petroleum Institute	New York, N. Y.

Members

J. H. Brown	Tidewater Oil Co.	New York, N. Y.
S. H. Dowdell	The British American Oil Co., Ltd.	Toronto, Ont., Canada
D. E. Hanson	Sinclair Refining Co.	New York, N. Y.
H. M. Hart	Standard Oil Co. (Indiana)	Whiting, Ind.
Francis Horton	Texaco Inc.	New York, N. Y.
F. P. Irwin	Imperial Oil Limited	Toronto, Ont., Canada
A. W. Jasek	Humble Pipe Line Co.	Houston, Texas
O. W. Johnson	Standard Oil Co. of California	San Francisco, Calif.
E. P. Kropp	The Standard Oil Co. (Ohio)	Cleveland, Ohio
R. T. Mapston	Richfield Oil Corp.	Wilmington, Calif.
H. S. Mount	Sun Oil Co.	Philadelphia, Pa.
K. G. Oswald	The Pure Oil Co.	Chicago, Ill.
H. C. Packard	Shell Oil Co.	New York, N. Y.
H. E. Simonson	Phillips Petroleum Co.	Bartlesville, Okla.
A. B. Stevens	General Petroleum Corp.	Torrance, Calif.
E. F. Wagner	The Atlantic Refining Co.	Philadelphia, Pa.

Subcommittee I—Methods of Testing (1959)

Officer

O. W. Johnson (*Chairman*)	Standard Oil Co. of California	San Francisco, Calif.

Members

J. A. Arnold	The Standard Oil Co. (Ohio)	Cleveland, Ohio
J. M. Dempster	The Standard Oil Co. (Ohio)	Cleveland, Ohio
D. Ray Miley	Sun Oil Co.	Toledo, Ohio
George Rezanka	Sinclair Refining Co.	East Chicago, Ind.

Associate Member

L. V. Larsen	Chicago Bridge and Iron Co.	New York, N.Y.

Subcommittee II—Correlations (1959)

Officers

A. B. Stevens (*Chairman*)	General Petroleum Corp.	Torrance, Calif.
E. P. Kropp (*Vice Chairman*)	The Standard Oil Co. (Ohio)	Cleveland, Ohio

Members

P. D. Baker	The Carter Oil Co.	Tulsa, Okla.
S. H. Dowdell	The British American Oil Co., Ltd.	Toronto, Ont., Canada
Otto Gerbes	Humble Oil and Refining Co.	Baytown, Texas
D. E. Hanson	Sinclair Refining Co.	New York, N. Y.
A. W. Jasek	Humble Pipe Line Co.	Houston, Texas
O. W. Johnson	Standard Oil Co. of California	San Francisco, Calif.
R. W. Martz	Esso Standard Oil Co.	New York, N. Y.
H. S. Mount	Sun Oil Co.	Philadelphia, Pa.
H. E. Simonson	Phillips Petroleum Co.	Bartlesville, Okla.
E. F. Wagner	The Atlantic Refining Co.	Philadelphia, Pa.

Subcommittee II—(Continued)

Associate Members

A. A. Lummio	Graver Tank and Manufacturing Co.	East Chicago, Ind.
T. D. Mueller	Graver Tank and Manufacturing Co.	East Chicago, Ind.
N. A. Pierson	General American Transportation Corp.	Los Angeles, Calif.
J. C. Thompson	General American Transportation Corp.	New York, N. Y.
I. L. Wissmiller	Chicago Bridge and Iron Co.	Chicago, Ill.

Subcommittee III—Field Test Program Development (1959)

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Editorial Advisor (1959)

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API EVAPORATION LOSS BULLETINS

API Bulletin 2512: Tentative Methods of Measuring Evaporation Loss from Petroleum Tanks and Transportation Equipment (1957)	$2.00
API Bulletin 2513: Evaporation Loss in the Petroleum Industry—Causes and Control (1959)	$1.50
API Bulletin 2514: Evaporation Loss from Tank Cars, Tank Trucks, and Marine Vessels (1959)	$1.00
API Bulletin 2515: Use of Plastic Foam to Reduce Evaporation Loss 1961)	$1.00
API Bulletin 2516: Evaporation Loss from Low-Pressure Tanks (1962)	$1.00
API Bulletin 2517: Evaporation Loss from Floating-Roof Tanks (1962)	$1.00
API Bulletin 2518: Evaporation Loss from Fixed-Roof Tanks (1962)	$1.00
API Bulletin 2519: Use of Internal Floating Covers for Fixed-Roof Tanks to Reduce Evaporation Loss (1962)	$1.00
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