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MILITARY STANDARD

PROCEDURE FOR DETERMINING NORMAL LOSS EXPECTANCIES FOR PETROLEUM LIQUIDS

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DEPARTMENT OF DEFENSE
Washington, DC 20301

Procedure for Determining Normal Loss Expectancies for Petroleum Liquids

MIL-STD-140B

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1. SCOPE

1.1 Purpose. The purpose of this standard is to provide a uniform procedure for determining, with reasonable accuracy, the normal loss expectancy of petroleum liquids, including crude oil, from bulk storage tanks and from transportation operations.

1.2 Application. The procedure for determining evaporation loss expectancies for volatile petroleum liquids is applicable at all domestic and oversea installations of the Department of Defense. Data tables are provided to translate theoretical considerations or mathematical expressions and observed experience into typical data of sufficient accuracy to permit valid evaluation of probable loss conditions for bulk storage. Overall experience data are offered which will serve as a basis for evaluating transportation losses of volatile petroleum liquids. However, this sample survey should not be utilized as a target for any particular facility. Each facility should be surveyed utilizing the guidance provided herein and a loss expectancy established for each tank or facility. These data can be used as a basis for obtaining needed modification, improvements or repairs when excessive losses occur. Bulk tankage losses can be controlled so as to not exceed the loss expectancies for volatile petroleum liquids. Losses resulting from leaking tanks, valves, lines, pilferage, or spillage are controllable and should be processed in accordance with applicable departmental instructions; data presented herein do not include nor reflect these losses. This standard will be implemented by each Department for the reporting and handling of losses during transportation, receipt, storage, and issue of petroleum liquids within the framework of its inventory control system.

2. REFERENCE DOCUMENTS

2.1 American Petroleum Institute bulletins. The following documents form a part of this standard to the extent specified herein:

(a) API Bull. 1623 - Recommended Good Practice for Bulk Liquid-Loss Control in Terminals and Depots.
(b) API Bull. 2512 - Tentative Methods of Measuring Evaporation Loss from Petroleum Tanks and Transportation Equipment.
(c) API Bull. 2513 - Evaporation Loss in the Petroleum Industry - Causes and Control.
(d) API Bull. 2514 - Evaporation Loss from Tank Cars, Tank Trucks, and Marine Vessels.
(e) API Bull. 2514A - Hydrocarbon Emissions from Marine Vessel Loading of Gasolines.

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(f) API Bull. 2515 - Use of Plastic Foam to Reduce Evaporation Loss.
(g) API Bull. 2516 - Evaporation Loss from Low-Pressure Tanks.
(h) API Bull. 2517 - Evaporation Loss from Floating-Roof Tanks.
(i) API Bull. 2518 - Evaporation Loss from Fixed-Roof Tanks.
(j) API Bull. 2519 - Use of Internal Floating Covers for Fixed-Roof Tanks to Reduce Evaporation Loss.
(k) API Bull. 2520 - Use of Variable-Vapor-Space Systems to Reduce Evaporation Loss.
(l) API Bull. 2521 - Use of Pressure-Vacuum Vent Valves for Atmospheric Pressure Tanks to Reduce Evaporation Loss.
(m) API Bull. 2522 - Comparative Methods for Evaluating Conservation Mechanisms for Evaporation Loss.
(n) ASTM D1250/IP 200/API 2540 - Petroleum Measurement Tables.

3. DEFINITIONS

3.1 Breathing loss. Loss associated with the thermal expansion and contraction within the vapor space resulting from the daily temperature cycle.

3.2 Working loss. Loss associated with a change of liquid level in the tank which includes the evaporation from the liquid surface into the vapor space above the liquid level after a rapid withdrawal of the liquid.

3.3 Reid vapor pressure (RVP). Designates the vapor pressure of a liquid fuel containing normally dissolved air. The RVP, measured at 100° F with a vapor-to-liquid ratio of 4 to 1, is used in normal laboratory testing of volatile liquid fuels.

3.4 True vapor pressure (TVP). Designates the vapor pressure of an air-free liquid at a specified temperature and a vapor-to-liquid ratio of 0. This expression denotes the true vapor pressure of the liquid in equilibrium with its vapor space and is used in evaporation loss calculations. True vapor pressure is determined from the RVP and is used in calculating the breathing losses described herein.

3.5 Outage. The height of the vapor space in fixed-roof tanks, including a correction for cone-roof volume. (One-third cone height for cones with same base diameter as tank).

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4. GENERAL REQUIREMENTS OR STATEMENTS

4.1 Petroleum liquid conservation. Accuracy in measuring, good maintenance procedures, efficient records, detailed inspections, and equipment modifications provide the principal control tools necessary for the achievement of maximum practical petroleum liquid conservation. Calculation of the loss expectancy for an operation provides a measure of installation efficiency in the control of the losses within the limits imposed by the condition and nature of the facilities. An actual loss in excess of the calculated loss expectancy or indicated experience factors will indicate that an abnormal loss has occurred or that some undetected error was made when the invoiced, received, and inventoried quantities were determined. In any event, all losses will be investigated without delay and an explanation and assessment of responsibility rendered to the satisfaction of the appropriate administrative or property officer. Survey actions, if indicated, will then be directed by the cognizant administrative or property officer.

4.1.1 Conservation type tanks. Certain conservation type tanks are finding increasingly greater application in the military services for motor and aviation fuels storage. Data are offered herein to serve as a basis for predicting standing storage or breathing losses in this type of tankage. The earliest and predominant conservation type tank is the floating roof tank. Breathing losses are caused primarily by the leakage of vapors between the outer seal ring of the roof and tank shell and may be expressed as barrels per foot diameter per year per pound of true vapor pressure.

4.2 Effect of temperature. For adequate stock control, it is necessary to compensate for temperature variation by adjusting all receipts, deliveries, and inventories to a uniform basis of 60° F (ASTM D1250/IP 200/API 2540, Petroleum Measurement Tables).

4.3 Loss prevention. The prevention of losses requires constant vigilance by all concerned, periodic reevaluation of loss expectancy, adherence to time-tested operating practices, good housekeeping, and acceptance of the principle that it is as important to account for petroleum liquid stocks as it is for cash. Basically, the program that should be undertaken by each cognizant activity consists of:

(a) Determining actual losses.
(b) Isolating these losses as to phase of operation.
(c) Initiating loss control methods wherever economically possible.

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5. DETAILED REQUIREMENTS AND STATEMENTS

5.1 Tank loss expectancies.

5.1.1 Storage tanks.

5.1.1.1 General statements. It is recognized that some losses are unavoidable, especially in the handling and storing of a volatile petroleum liquid. Stock losses can be controlled so as to not exceed the loss expectancies for any volatile petroleum liquid. Such losses are relatively negligible for nonvolatile petroleum liquids. Naturally, the maximum loss reduction varies for each individual case depending upon the volume handled, the rapidity of turnover, the prevailing temperature and the type and condition of tankage, meters, and equipment.

5.1.1.2 Effects of vapor pressure. The tendency toward evaporation losses is governed, to a great extent, by the vapor pressure of the fuel. the higher the vapor pressure, the greater the possibility of increased evaporation losses through breathing. Breathing is caused by periodic temperature and pressure variations resulting in alternate expulsion of the vapor air mixture and intake of atmospheric air.

5.1.1.3 Expressing vapor pressure. Two terms used to express vapor pressure are defined in 3.3 and 3.4.

5.1.1.4 Determining true vapor pressure. The true vapor pressure is taken from the vapor pressure chart (see Figure 1) using the Reid vapor pressure and the average liquid body temperature. The slope of ASTM distillation (plus loss) curve at the 10 percent point provides a criterion for this variation as illustrated in Figure 1. Crude oils vary widely in vapor pressure and in the slope of the ASTM distillation (plus loss) curve at the 10 percent point. In the absence of distillation data a slope of 5.0 can be assumed for crude oil. In many crudes, the slope is higher than 5.0 and is off the scale of Figure 1. In such cases, the true vapor pressure calculated from Figure 1 should be considered as a lower limit, and the actual value will be higher than the calculated value.

5.1.1.5 Evaporation losses in tankage. From the RVP and the ASTM distillation characteristics of a petroleum liquid which are available from laboratory tests, it is possible to determine the evaporation loss expectancies from fixed roof storage tanks. Evaporation losses are the most common type and may be divided into two categories described in 5.2 and 5.3.

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5.2 Breathing loss expectancies (fixed roof bulk tanks).

5.2.1 Loss determination. The chart of Figure 2 shall be used to determine the expected annual breathing loss of volatile petroleum products from a fixed cone roof tank in good physical condition. The true vapor pressure is taken from the vapor pressure chart (see Figure 1). The outage will vary during operations, but will be taken as the average from

5.2.2 Tank roof and shell paint. Evaporation loss data indicate that roof and shell paint types (colors) have a decided effect upon breathing losses. The breathing loss, as determined from Figure 2, includes the paint color/condition factor.

5.2.3 Tank condition. The breathing loss determined as above is based on a tank in good physical condition; i.e., gas-tight roof, gas-tight manhole and gaging hatch, tank equipped with pressure-vacuum vent, and roof painted white. Consequently, the poorer the physical condition of a tank and fittings, the higher the breathing loss. To include the physical condition factor, the calculated breathing loss is multiplied by the tank condition factor listed in Table I. The condition factor is based upon the degree of leakage of the tank roof and fitting. It is determined as the sum of all individual items which contribute to increased losses from the tank in question.

Table I. Tank Condition Factor

Condition	Factor
Base factor for:	
Gastight tank and fitting	1.0
Add for:	
Leaky float gage	0.1
Leaky gage hatch	0.2
Leaky manhole cover	0.3
Open vent	0.5
Open gage hatch	0.5
Leaky roof construction	0.5

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Example: A tank 48 feet in diameter has been calculated to have an annual breathing loss of 185 barrels (see 5.6 for example). Tank condition indicates an open vent, non-gastight gage hatch, and non-gastight float gage; thus, 185 x (1.0 + 0.5 + 0.2 + 0.1) = 333 barrels (breathing and condition loss). Tank condition loss = 333 - 185 = 148 barrels.

5.2.4 Economics of repair and maintenance. Table I may be used as a rough guide for justifying the cost of maintaining or repairing leaky roofs and fittings.

5.3 Working loss expectancies (fixed roof bulk tanks).

5.3.1 General statement. Working loss is applicable only to fixed roof tanks for the purpose of this standard. Working loss is a term used to describe the losses attending tank filling and emptying operations. Vapors expelled when a petroleum liquid is delivered to a tank are filling losses. Additional fuel evaporation into ullage space following tank dispensing operations is called emptying losses.

5.3.2 Working loss determination. The chart on Figure 3 shall be used for above ground fixed cone roof and underground bulk storage tanks to determine the expectant working loss of volatile petroleum liquids. The true vapor pressure is taken from the vapor pressure chart (see Figure 1) using the Reid vapor pressure and the average liquid body temperature. Throughput, as used in Figure 3, is the total additive volume of fluid pumped into the tank for the period under consideration.

5.4 Transportation loss expectancies.

5.4.1 General statement. Transportation loss is that loss sustained while bulk petroleum liquids are loaded into, transported by, and discharged from barges, tankers, tank cars, tank trucks, and pipelines.

5.4.2 Barges and tankers. Transporation loss expectancy data presented in Table II reflect losses to be expected in transportation of petroleum liquids from issuing tank at source to receiving tank at destination as determined by shore tank gages. Loss expectancies of crude oil may vary widely according to the volatility of the crude. When no other data is available, the loss is assumed to be the same as motor gasoline. Experience factors for each crude oil, if available, should be used in place of the factor shown in Table II.

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Table II. Transporation Loss Expectancies

Petroleum Liquid	Tanker Factor	Barge Factor
Avgas/Mogas	0.0085	0.0025
Jet Fuel, JP-4	0.0040	0.0020
Jet Fuel, JP-5 and JP-8	0.0010	NIL
Diesel Fuel	0.0035	NIL
Fuel Oil, Burner, Navy Special	0.0006	NIL
Crude Oil	0.0085	0.0025

5.4.3 Tank cars and tank trucks. Experience data indicates losses attributable to transportation by tank truck and tank car as determined by transportation equipment gages is negligible. No further consideration to these losses is given in this standard.

5.4.4 Pipelines. Loss expectancy factors due to pipeline transportation in commercial experience average 0.0005 to 0.001.

5.5 Expectant losses - other tanks.

5.5.1 General statement. Average yearly losses for tanks other than fixed roof types are as follows:

5.5.1.1 Floating roof, welded shell, single or double seal. Breathing loss is 0.49 barrels per foot diameter per pound of true vapor pressure. Working losses are low for floating roof tanks where there is no actual displacement of vapor during filling and emptying, and may be considered negligible for practical purposes. As an average, working losses for floating roof tanks, all types, equal 0.01 percent of throughput.

5.5.1.2 Other types of conservation tanks. Tanks equipped with floating pans under fixed roofs will be considered to present negligible losses for purposes of this standard.

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5.6 Sample calculation.

5.6.1 Conditions:

Product	AVGAS
Tank diameter	48 feet
Height	40 feet
Type	Fixed roof
Paint	Medium grey (shell and top)
Capacity	12,500 barrels
RVP	6.5 psi
Annual temperature (average)	46.5° F
Annual maximum temperature (average)	55.0° F
Annual minimum temperature (average)	37.7° F
Throughput	57,500 barrels
Annual inventory (average)	17.25 feet

5.6.2 Breathing loss. To obtain true vapor pressure (TVP) from Figure 1, use average tank fuel temperature. If this information is not available, use average atmospheric temperature, plus 5° F to approximate the product temperature. Step 1 - enter Figure 1 at 51° F (46.5° + 5°). Use RVP slope 2 at 6.5 psi and read off TVP = 2.6 psi.

Annual average temperature change = 17.3° F (55.0° - 37.7°).

The average outage is the average distance from the surface of the fuel to the top of the tank. The tank vapor space due to the conical roof must be included. This is 1/3h (height of cone). Standard slope of cone roof is 3/4 inch per foot of tank radius = 3/4 x 48/2 = h; 1/3h = 6 inches = 0.5 foot. Actual equivalent height of shell and cone 40 feet + 0.5 foot = 40.5 feet. Average outage = 40.5 feet - 17.25 feet = 23.25 feet. Step 2 - enter Figure 2 at 17.3° F (average atmospheric temperature change) proceed to 1.46 on paint factor; then to 23.25 feet on tank outage; then to 2.6 psi true vapor pressure; then 48 feet tank diameter; then to breathing loss scale-read 185 barrels/year loss for AVGAS.

5.6.3 Working loss. Step 3 - enter working loss chart (see Figure 3) at tank turnover (0-36 turnovers/year) then line up with 2.6 psia TVP. Aline 5750 barrels throughput through pivot line and read 4.4 barrels working loss or 44 barrels for 57,500 barrels, throughput.

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Total evaporation loss =

Breathing loss	185 barrels
Working loss	44 barrels
Breathing and working loss	229 barrels

Add, if applicable, tank condition loss as computed by method described in 5.2.3.

Permission has been granted by the American Petroleum Institute for their data and charts. Examples shown on Figures 2 and 3, this standard, differ from those in API Bull. 2518 and have not been checked by API. API makes no claim to their correctness.

Custodians:
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Navy - SH
Air Force - 68

Review activities:
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Navy - NM
DLA - PS

User activities:
Army - CE
Navy - AS, MC, YD

Preparing activity:
Army - ME

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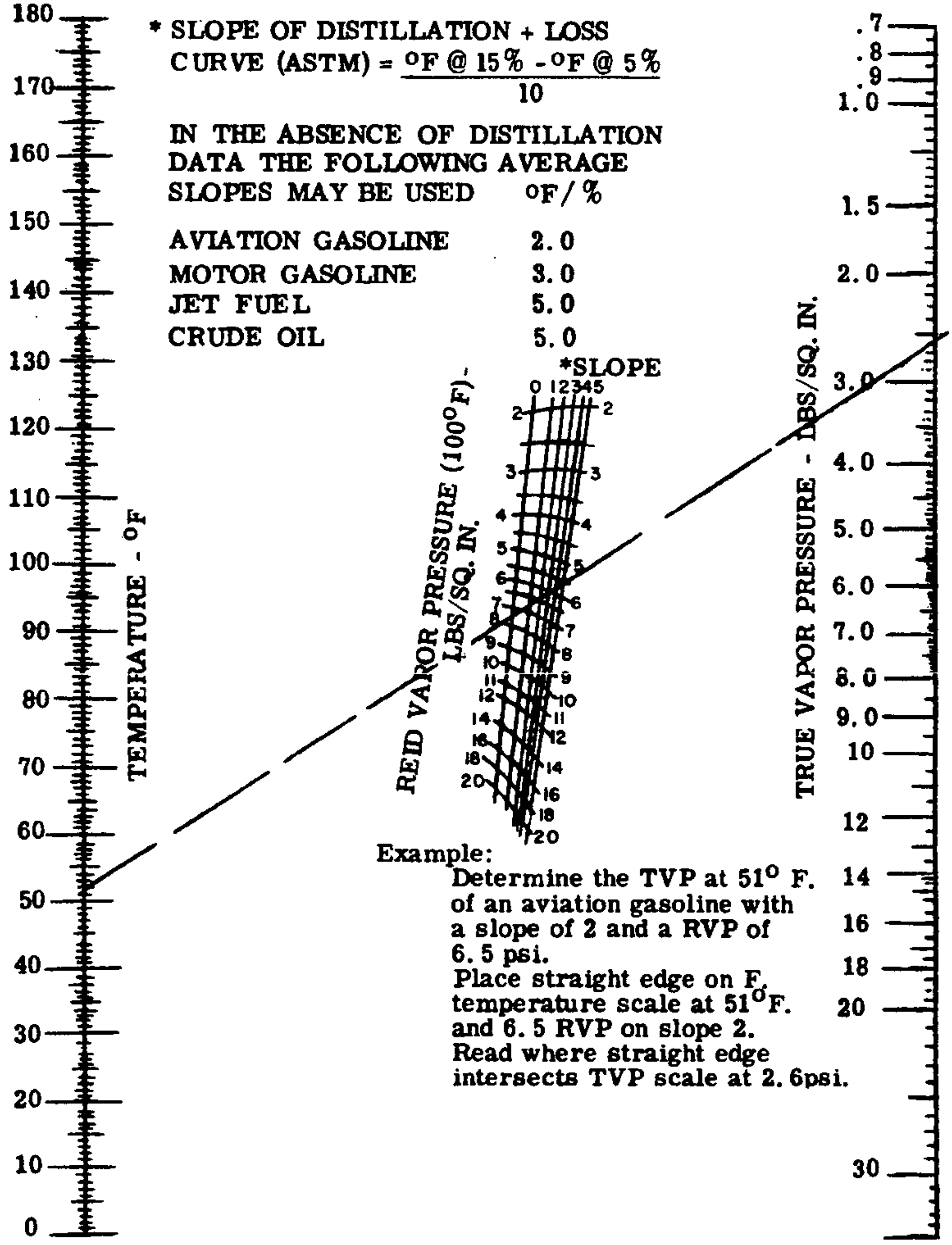

FIGURE 1. Vapor pressure of petroleum liquids.

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TANK COLOR		PAINT FACTOR, Fp	
ROOF	SHELL	PAINT IN GOOD COND.	PAINT IN POOR COND.
WHITE	WHITE	1.00	1.15
ALUM. (SPECULAR)	WHITE	1.04	1.18
WHITE	ALUM (SPECULAR)	1.16	1.24
ALUM. (SPECULAR)	ALUM (SPECULAR)	1.20	1.29
WHITE	ALUM. (DIFFUSE)	1.30	1.38
ALUM (DIFFUSE)	ALUM. (DIFFUSE)	1.39	1.46
WHITE	GRAY	1.30	1.38
LIGHT GRAY	LIGHT GRAY	1.33	—
MED. GRAY	MED. GRAY	1.46	—
OLIVE DRAB	OLIVE DRAB	1.76	—
BLACK	BLACK	1.83	—

EXAMPLE:

T = 17.3° F
F_P = 1.46
H = 23.25 FEET
P = 2.6 PSIA
D = 48 FEET
L_Y = 185 BARRELS PER YEAR

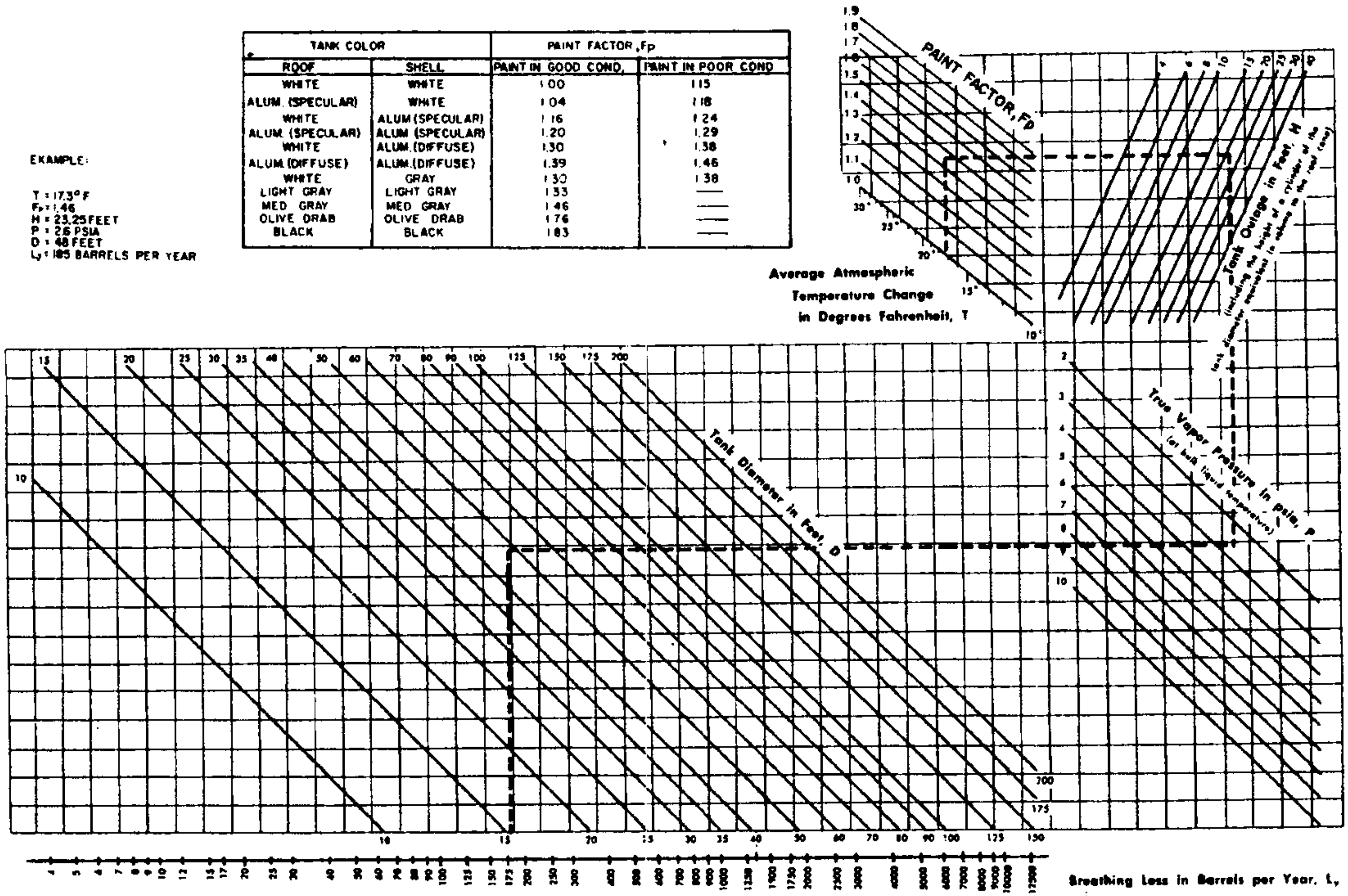

FIGURE 2. Breathing loss of petroleum liquids from fixed-roof tanks.

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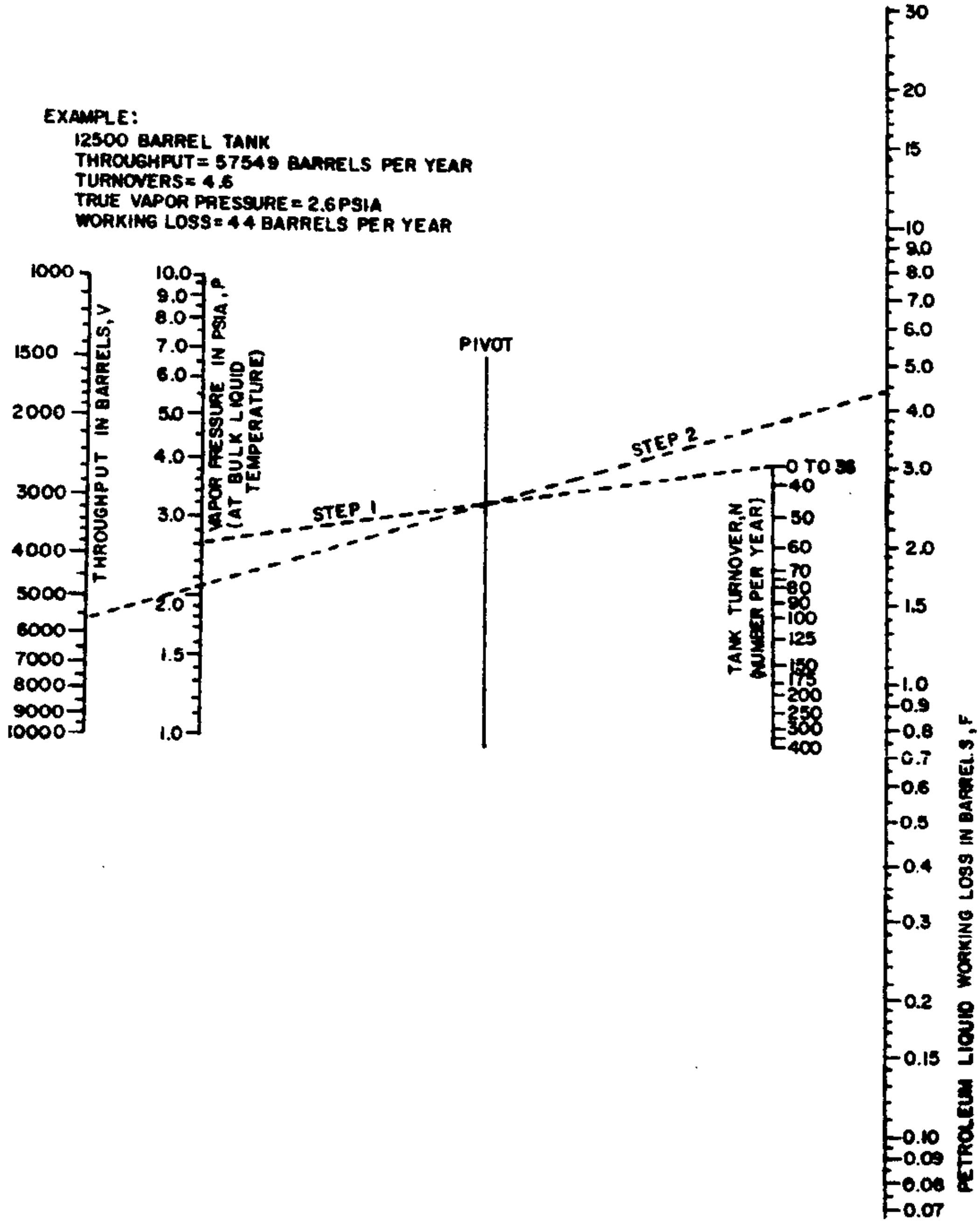

NOTE:
THE THROUGHPUT IS DIVIDED BY A NUMBER (1,10,100,1,000) TO BRING IT INTO THE RANGE OF THE SCALE. THE SCALE, MUST THEN BE MULTIPLIED BY THE SAME NUMBER.

FIGURE 3. Working loss of petroleum liquids from fixed-roof tanks.

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