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Method for Liquid Calibration of Tanks

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Method for Liquid Calibration of Tanks

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FOREWORD

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Standard Method for

LIQUID CALIBRATION OF TANKS [1]

API Standard: 2555

ASTM Designation: D 1406 – 65

ADOPTED, 1965.[2, 3]

This standard of the American Petroleum Institute issued under the fixed designation API 2555 is also a standard of the American Society for Testing and Materials issued under the fixed designation D 1406; the final number indicates the year of original adoption as standard, or, in the case of revision, the year of last revision.

This method was adopted as a joint API-ASTM standard in 1965.

Scope

1. This standard describes the procedure for calibrating tanks, or portions of tanks, larger than a barrel or drum by introducing or withdrawing measured quantities of liquid.

NOTE 1.—Other calibration standards are:

API Standard 2550—ASTM D 1220: Measurement and Calibration of Upright Cylindrical Tanks

API Standard 2551—ASTM D 1410: Measurement and Calibration of Horizontal Tanks

API Standard 2552—ASTM D 1408: Measurement and Calibration of Spheres and Spheroids

API Standard 2553—ASTM D 1407: Measurement and Calibration of Barges

API Standard 2554—ASTM D 1409: Measurement and Calibration of Tank Cars

General

2. Liquid calibration is a means of determining incremental volumes and capacities of tanks or other containers by transfer of known quantities of liquid to or from a vessel. This standard outlines the steps required for accurately determining the incremental values required in preparing tables for tanks of any design or shape except meter prover systems.

Applications

3. Liquid calibration may be accomplished by volumetric or gravimetric means. The standard used depends on individual circumstances and equipment available.

Discussion of Procedure

4. (*a*) The procedure selected for liquid calibration depends on such conditions as the degree of accuracy required, the type and size of tank to be calibrated, and the equipment available to do the job. The purpose of this discussion is to aid the prospective user in selecting a procedure which is consistent with the degree of accuracy desired. Generally it is desirable to select a procedure which will accomplish the job in the shortest period of time in order to eliminate the effect of temperature changes on the liquid volume.

(*b*) A portable volumetric tank can best be used in calibrating small tanks with a capacity in the range of 50 to 500 bbl. This procedure generally provides the highest degree of accuracy, but it is rather time-consuming when used to calibrate large tanks. Portable positive displacement metering units have been used to good advantage to check volumes of liquid delivered from lease tanks.

(*c*) When large tanks are to be calibrated, it is more practical to use the positive displacement meter procedure.

(*d*) When stationary service tanks are available, the stationary tank calibration procedure may be suitable.

(*e*) It is preferable that the diameter of the service tank be smaller than the diameter of the tank to be calibrated in order to provide a higher degree of accuracy. The stationary service tank to be used as a calibrating tank should be strapped according to the critical measurements procedure, or the volume should be determined by use of a prover tank or a master meter.

(*f*) If the available liquid is viscous and has a tendency to adhere to the walls of the tank, it is preferable to use the liquid-weighing procedure. The weighed liquid should be delivered into the tank that is to be calibrated. When the weighing proce-

[1] Under the standardization procedures of the API and the ASTM, this standard is under the jurisdiction of the API Central Committee on Petroleum Measurement and the ASTM Committee D-2 on Petroleum Products and Lubricants.

[2] The API method was adopted as API Standard 2555 in October, 1965.

Prior to their present publication, the API methods of test were issued in December, 1929 as API Code 25. API Code 25 was reissued in 1930, 1931, 1933, 1935, 1940, and 1948. The material was revised and reissued in September, 1955 as API Standard 2501, and the second edition was issued in July, 1961.

[3] Revised and adopted as standard June, 1965, by action of the ASTM at the Annual Meeting and confirming letter ballot.

Prior to adoption as ASTM standard, this method was published as tentative in 1956.

dure is used, the calibrating liquid should be relatively free of BS&W (basic sediment and water).

(*g*) Tanks should have been filled at least once with a liquid as heavy as the liquid to be stored.

Equipment

5. General equipment requirements are as follows:

(*a*) Supply of liquid, preferably nonvolatile and of the same or near the same specific gravity as the product to be stored in the tank.

(*b*) Gaging equipment—gage line, tank thermometer, etc. This equipment should be used in accordance with the procedures discussed in: *API Standard 2543—ASTM D 1086: Measuring the Temperature of Petroleum and Petroleum Products; API Standard 2544—ASTM D 287: Test for API Gravity of Crude Petroleum and Petroleum Products; API Standard 2545—ASTM D 1085: Gaging Petroleum and Petroleum Products; API Standard 2546—ASTM D 270: Sampling Petroleum and Petroleum Products;* and *API Standard 1101: Measurement of Petroleum Liquid Hydrocarbons by Positive Displacement Meter.*

(*c*) Suitable forms for recording data.

(*d*) When using the portable tank calibration procedure, one or more tanks. The size and number of tanks required are determined by the size of the tank to be calibrated. These calibrating tanks must be calibrated to deliver by use of the National Bureau of Standards standard test measure as outlined in API Standard 1101.

(*e*) When using the positive displacement meter procedure, the meters selected should be of the proper size. The meters should be non-temperature-compensated, and they should be equipped with continuous correction-type calibrators rather than impulse-type calibrators. Generally the equipment required will include: meter prover tanks; air eliminators; strainers; pumps; pressure regulators; pressure gages; in-line thermometers, preferably of the recording type; quick-acting valves; and related pipe fittings. Meter installation should be in accordance with the latest edition of API Standard 1101.

PROCEDURES

General

6. (*a*) The size of increments will be determined by the size of the deadwood, the change in the shape of the tank, or the tank zone to be calibrated.

(*b*) All hose and pipe connections should be tight. Arrangement should be made to eliminate the possibility of air or vapor locks when piping is installed. Piping must be tightly packed with calibrating liquid before the test is started and remain packed throughout the calibration.

(*c*) If a pump is used to transfer the liquid, caution should be observed to insure that the liquid level in the delivering tank will not be lowered to a point which will allow air to enter the system. The pump and its suction piping should be of appropriate size to avoid pulling a vacuum on the system.

(*d*) If a meter is used, care should be exercised to avoid pulling vapor or air through the meter. (The meter will register vapor or air as liquid.)

(*e*) If the calibration is to be used to prepare a tank table, the job should be started and completed without interruption, where possible. If the calibration is interrupted and the liquid level in either tank is changed due to temperature effects, the calibration operation may be resumed after applying the proper correction to the volume of each tank before continuing the operation. Applicable correction factors for the liquid used will be found in Table I of the Appendix of this standard and in unabridged Table 6 of *API Standard 2540—ASTM D 1250: ASTM-IP Petroleum Measurement Tables.*

(*f*) Better results can be obtained when the ambient and liquid temperatures are about the same.

(*g*) It is desirable to carry out the calibration as rapidly as possible so that temperature change will be small.

(*h*) Accurate temperature determinations must be made of all volumes measured. The number of temperature determinations required for any volume which is being measured depends on the quantity of liquid and the shape and size of the vessel containing the liquid. The temperature used for the calibration must be the average of all temperatures taken if more than one temperature determination is made. Normally, one temperature determination in the center of the liquid volume will suffice for vessels of less than 100-gal capacity. Two temperatures usually will be required on vessels of a capacity between 100 and 500 gal, taken at the middle of the upper and lower halves of the liquid volumes. Three temperature determinations usually will be required on vessels of more than 500-gal capacity taken at the midpoint of the upper, middle, and lower third portions of the liquid. If the height of the column of liquid representing 500 gal or more is less than 2 ft, one temperature determination at the midpoint will suffice. If the height of the column of liquid is greater than 2 ft and less than 3 ft, two temperature determinations should be taken. If the height of the liquid column is greater than 3 ft, three temperature determinations should be taken. Thermometers with divisions no greater than 0.5 F shall be used and temperatures should be read and recorded to the nearest 0.1 F. Whether gaged or metered, volumes at a determined temperature when delivered into a tank must be adjusted to the temperature of the liquid measured in the tank that is being calibrated (see Table II, Appendix).

(*i*) Atmospheric temperature and general weather conditions, such as wind and rain, should be recorded at the time the test is run.

(*j*) Suggested minimum stops that should be made by any of the procedures used are as follows:

(*1*) When liquid first hits hand gaging point. (Where the tank has a downward cone bottom, two gaging or striking points may be used.)

(*2*) When tank bottom is completely covered.

(*3*) At lower and upper limits of all deadwood.

(*4*) When float gage floats freely, adjustment should be made with handline gage.

(*5*) At bottom edge and fully floating position of a floating roof, plus a sufficient number of intermediate stops to establish incremental values desired.

(*6*) Every 3 or 6 in. up cylindrical portion of tank.

(*7*) At top of each ring.

(*k*) The following readings should be taken at each stop:

(*1*) Handline gage of liquid in receiving tank.

(*2*) Tank liquid temperature of receiving tank.

(*3*) Meter reading or gage on delivery tank.

(*4*) Meter temperature or temperature on delivery tank.

(*5*) Automatic float gage, which has been set when it first starts to float.

(*l*) Handline gages should be read to nearest 1/16 in. (0.01 or 0.005 ft by mutual agreement), temperatures to nearest 0.1 F, and meter to 0.01 gal or 0.001 bbl.

Portable Tank Calibration Procedure

7. (*a*) The calibration tank, or tanks, should be located as near as possible to the tank to be calibrated and set in a level position. All piping should be checked and tested before calibration is started, to insure a positive delivery from tank to tank. Lines should drain completely. A drainage time, as recommended by the National Bureau of Standards, shall be used when the calibrating tanks are certified and shall be followed throughout the calibrating procedure. This time period is established by waiting until the liquid stops pouring and begins to drip from the end of the pipe. The liquid should be allowed to drip for the same period of elapsed time after each run, as outlined in API Standard 1101. The temperatures of the tank being calibrated and the calibration tank should be taken before and after each fill, and volume adjustment for change in temperature should be made (see Table II, Appendix).

(*b*) When liquid is to be introduced into the tank to be calibrated, the calibration tank, or tanks, should be full of liquid. The tank to be calibrated must be empty between the levels to be calibrated. The quick-acting valve on the calibrating tank, or tanks, should be opened and the liquid allowed to flow until the tank is empty. The run or fill number, the amount of fill, and the temperature should be entered on a record, report, or data sheet. The gage and the temperature of the receiving tank should be recorded at intervals necessary to determine incremental volumes required for making the tank table. This information should be recorded on one data sheet if possible. A telephone circuit should be provided and all data recorded by one operator. The condition of fill of the piping system shall be the same at start and stop of each measurement, either completely full or completely empty.

Positive Displacement Meter Procedure

8. (*a*) The metering unit may be mounted on a trailer, skid platform, truck, or the like and located as near as possible to the tank to be calibrated. It should be installed on a firm footing in a level position. Connections, whether hose or piping, should be installed so that air traps will be eliminated. The system should then be purged of all air in the lines. The chosen operating pressure should be adjusted by means of the pressure regulator; the meter should be proved under simulated operating conditions of pressure, rate, and temperature. It is important that the meter be in good mechanical condition and that it be adjusted for correct clearance of its parts.

(*b*) The meter must be proved on the same liquid to be used in the calibration of the tank or on a liquid of similar properties. The meter may be proved in an appropriately sized prover, or it may be proved against a master meter of known accuracy (see API Standard 1101 for meter-proving procedure). The meter factor obtained should be the average of two or more consecutive provings which check within 0.02 per cent.

(*c*) The meter should be proved just prior to its use for tank calibration. By mutual agreement the meter may be reproved during or after completion of tank calibration runs in order to reconfirm meter accuracy.

(*d*) If the meter is reproved during or after the calibration, the meter factors from such subsequent provings should be averaged with the previous factor and applied to the volumes determined between the meter provings.

(*e*) The flow of the liquid to or from the vessel to be calibrated should be started at predetermined points. These points are determined by the type of tank to be calibrated, distribution of deadwood, size and shape of the zone to be calibrated, and so forth. At each stop, a meter reading, average temperature of liquid delivered by meter, tank gaging, and tank temperatures must be determined as outlined in API Standard 2543—ASTM D 1086; API Standard 2544—ASTM D 287; API Standard 2545—ASTM D 1085; and API Standard 2546—ASTM D 270. Volume adjustments for change in temperature also should be made (see Table II, Appendix). An appropriate form should be used to record the data. A communication channel should be provided if needed and all data should be recorded by one person.

Stationary Tank Calibration Method

9. (*a*) A stationary calibration tank whose capacity has been determined by the critical measurements procedure of strapping should be located adjacent or close to the tank to be calibrated. The diameter of the tank should be smaller, never larger, than the tank to be calibrated.

(*b*) The lines should be purged of all air prior to starting calibration. A pump of size and design suitable to the operation may be used to transfer the liquid between the tanks. However, when a pump is used, care should be exercised to prevent air entering the system. Water is the preferred medium for calibration; however, a nonvolatile product ranging between kerosine and No. 3 heating oil may be used.

(*c*) After the connecting lines have been filled, each tank shall be accurately gaged and tank temperatures shall be taken and recorded in accordance with API Standard 2543—ASTM D 1086; API Standard 2544—ASTM D 287; API Standard 2545—ASTM D 1085; and API Standard 2546—ASTM D 270. The liquid should then be transferred between the tanks. The size of the increments shall be determined by the tank construction, location of deadwood, and so forth. After each delivery, fill, or run, both tanks must be gaged and the temperatures determined and recorded.

(*d*) When a tank is being calibrated either by withdrawing into or filling from test measures, the volumes determined in the test measures must be adjusted by a temperature factor to the temperature of the liquid in the tank if the temperature in the test measure is different from the temperature of the liquid in the tank.

Liquid-Weighing Procedure

10. Weighing of liquids delivered into or withdrawn from a vessel requires accuracy unobtainable at most tank locations. Where this method is preferred or is advisable, instructions for weighing may be obtained from API Standard 1101.

Example

11. (*a*) Following is an example of the adjustments which are required for calibrating a tank by withdrawal of liquid from the tank to be calibrated and measuring the volume of the increment withdrawn by a positive displacement meter or by a smaller measuring tank of known volume.

(*b*) The correction factors used in adjusting the volume of withdrawals to the starting temperature are shown in Table I

(Appendix), when water is the calibrating medium. These correction factors apply only when the procedure is by withdrawal of liquid from the tank to be calibrated.

(*c*) In order to establish the volume of an increment of 1 ft on a particular tank, when the temperature of the volume measured in the test tank is 2 F higher than the temperature of the water before the withdrawal is made, the adjustment is as follows: The opening gage of the tank to be calibrated is 39 ft and the closing gage is 38 ft. The temperature of the water before the withdrawal is found to be 65 F. The volume of the water withdrawn between the 39- and 38-ft gages was indicated to be 100 bbl, by measuring the tank at a temperature of 67 F. The factor for this adjustment, obtained from Table I (Appendix), for a 2 F temperature rise, is 0.99978. Therefore, the volume of the increment between 39 and 38 ft is 99.978 bbl.

(*d*) Correction factors for adjusting the volume to the starting temperature when a temperature drop occurs are also shown in Table I (Appendix).

APPENDIX

TABLE I.—VOLUMETRIC CORRECTION FACTORS FOR WATER WITHDRAWN FROM PROVER TANK TO TEST MEASURE.

TABLE II.—LIQUID TEMPERATURE CHANGE CONSIDERATIONS IN TANK CALIBRATION BY METER OR TANK TO TANK.

TABLE I.—VOLUMETRIC CORRECTION FACTORS FOR WATER WITHDRAWN FROM PROVER TANK TO TEST MEASURE.

Temperature in Measure Lower than in Prover by Degrees Fahrenheit

(Multiply Measured Volume by Correction Factor to Give Volume at Prover Temperature)

Temperature of Water in Prover, °F	10	9	8	7	6	5	4	3	2	1	Temperature of Water in Prover, °F
35								0.99991	0.99995	0.99998	35
36							0.99989	0.99993	0.99996	0.99998	36
37						0.99988	0.99991	0.99994	0.99997	0.99999	37
38					0.99987	0.99991	0.99994	0.99996	0.99998	0.99999	38
39				0.99987	0.99990	0.99993	0.99996	0.99997	0.99999	1.00000	39
40			0.99987	0.99990	0.99993	0.99996	0.99998	0.99999	1.00000	1.00000	40
41		0.99988	0.99991	0.99994	0.99996	0.99998	1.00000	1.00000	1.00001	1.00001	41
42	0.99989	0.99992	0.99995	0.99998	0.99999	1.00001	1.00002	1.00002	1.00002	1.00001	42
43	0.99994	0.99997	0.99999	1.00001	1.00002	1.00003	1.00004	1.00003	1.00003	1.00002	43
44	0.99999	1.00001	1.00003	1.00004	1.00005	1.00006	1.00005	1.00005	1.00004	1.00002	44
45	1.00004	1.00006	1.00007	1.00008	1.00008	1.00008	1.00007	1.00006	1.00005	1.00003	45
46	1.00009	1.00010	1.00011	1.00011	1.00011	1.00010	1.00009	1.00008	1.00005	1.00003	46
47	1.00013	1.00014	1.00014	1.00014	1.00014	1.00013	1.00011	1.00009	1.00006	1.00003	47
48	1.00018	1.00018	1.00018	1.00017	1.00016	1.00015	1.00013	1.00010	1.00007	1.00004	48
49	1.00023	1.00022	1.00022	1.00021	1.00019	1.00017	1.00014	1.00011	1.00008	1.00004	49
50	1.00027	1.00026	1.00025	1.00024	1.00022	1.00019	1.00016	1.00013	1.00009	1.00005	50
51	1.00032	1.00030	1.00029	1.00027	1.00024	1.00021	1.00018	1.00014	1.00010	1.00005	51
52	1.00036	1.00034	1.00032	1.00030	1.00027	1.00023	1.00020	1.00015	1.00011	1.00006	52
53	1.00040	1.00038	1.00036	1.00033	1.00029	1.00025	1.00021	1.00017	1.00011	1.00006	53
54	1.00044	1.00042	1.00039	1.00036	1.00032	1.00027	1.00023	1.00018	1.00012	1.00006	54
55	1.00049	1.00046	1.00042	1.00038	1.00034	1.00029	1.00024	1.00019	1.00013	1.00007	55
56	1.00053	1.00049	1.00046	1.00041	1.00037	1.00031	1.00026	1.00020	1.00014	1.00007	56
57	1.00057	1.00053	1.00049	1.00044	1.00039	1.00033	1.00028	1.00021	1.00015	1.00007	57
58	1.00061	1.00057	1.00052	1.00047	1.00041	1.00035	1.00029	1.00022	1.00015	1.00008	58
59	1.00065	1.00060	1.00055	1.00049	1.00044	1.00037	1.00031	1.00023	1.00016	1.00008	59
60	1.00069	1.00064	1.00058	1.00052	1.00046	1.00039	1.00032	1.00025	1.00017	1.00009	60
61	1.00072	1.00067	1.99961	1.00055	1.00048	1.00041	1.00034	1.00026	1.00017	1.00009	61
62	1.00076	1.00070	1.00064	1.00057	1.00050	1.00043	1.00035	1.00027	1.00018	1.00009	62
63	1.00080	1.00074	1.00067	1.00060	1.00052	1.00045	1.00036	1.00028	1.00019	1.00010	63
64	1.00084	1.00077	1.00070	1.00062	1.00055	1.00046	1.00038	1.00029	1.00020	1.00010	64
65	1.00087	1.00080	1.00073	1.00065	1.00057	1.00048	1.00039	1.00030	1.00020	1.00010	65
66	1.00091	1.00083	1.00076	1.00067	1.00059	1.00050	1.00041	1.00031	1.00021	1.00011	66
67	1.00094	1.00087	1.00078	1.00070	1.00061	1.00052	1.00042	1.00032	1.00022	1.00011	67
68	1.00098	1.00090	1.00081	1.00072	1.00063	1.00053	1.00043	1.00033	1.00022	1.00011	68
69	1.00101	1.00093	1.00084	1.00075	1.00065	1.00055	1.00045	1.00034	1.00023	1.00012	69
70	1.00105	1.00096	1.00087	1.00077	1.00067	1.00057	1.00046	1.00035	1.00024	1.00012	70
71	1.00108	1.00099	1.00089	1.00079	1.00069	1.00058	1.00047	1.00036	1.00024	1.00012	71
72	1.00112	1.00102	1.00092	1.00082	1.00071	1.00060	1.00049	1.00037	1.00025	1.00013	72
73	1.00115	1.00105	1.00095	1.00084	1.00073	1.00062	1.00050	1.00038	1.00026	1.00013	73
74	1.00118	1.00108	1.00097	1.00086	1.00075	1.00063	1.00051	1.00039	1.00026	1.00013	74
75	1.00121	1.00111	1.00100	1.00088	1.00077	1.00065	1.00052	1.00040	1.00027	1.00014	75
76	1.00125	1.00114	1.00102	1.00091	1.00079	1.00066	1.00054	1.00041	1.00027	1.00014	76
77	1.00128	1.00116	1.00105	1.00093	1.00080	1.00068	1.00055	1.00042	1.00028	1.00014	77
78	1.00131	1.00119	1.00107	1.00095	1.00082	1.00069	1.00056	1.00042	1.00029	1.00014	78
79	1.00134	1.00122	1.00110	1.00097	1.00084	1.00071	1.00057	1.00043	1.00029	1.00015	79
80	1.00137	1.00125	1.00112	1.00099	1.00086	1.00072	1.00058	1.00044	1.00030	1.00015	80
81	1.00140	1.00127	1.00114	1.00101	1.00088	1.00074	1.00060	1.00045	1.00030	1.00015	81
82	1.00143	1.00130	1.00117	1.00103	1.00089	1.00075	1.00061	1.00046	1.00031	1.00016	82
83	1.00146	1.00133	1.00119	1.00105	1.00091	1.00077	1.00062	1.00047	1.00031	1.00016	83
84	1.00149	1.00135	1.00121	1.00107	1.00093	1.00078	1.00063	1.00048	1.00032	1.00016	84
85	1.00152	1.00138	1.00124	1.00109	1.00095	1.00079	1.00064	1.00049	1.00033	1.00016	85
86	1.00155	1.00140	1.00126	1.00111	1.00096	1.00081	1.00065	1.00049	1.00033	1.00017	86
87	1.00157	1.00143	1.00128	1.00113	1.00098	1.00082	1.00066	1.00050	1.00034	1.00017	87
88	1.00160	1.00146	1.00130	1.00115	1.00100	1.00084	1.00067	1.00051	1.00034	1.00017	88
89	1.00163	1.00148	1.00133	1.00117	1.00101	1.00085	1.00069	1.00052	1.00035	1.00018	89
90	1.00166	1.00151	1.00135	1.00119	1.00103	1.00086	1.00070	1.00053	1.00035	1.00018	90

Derived from Tilton and Taylor, NBS Journal of Research, 18, 205 (1937).

TABLE I (*Continued*)

Temperature in Measure Higher than in Prover by Degrees Fahrenheit

(Multiply Measured Volume by Correction Factor to Give Volume at Prover Temperature)

Temperature of Water in Prover, °F	1	2	3	4	5	6	7	8	9	10	Temperature of Water in Prover, °F
35	1.00002	1.00003	1.00004	1.00004	1.00004	1.00004	1.00002	1.00001	0.99999	0.99996	35
36	1.00001	1.00002	1.00003	1.00002	1.00002	1.00001	0.99999	0.99997	0.99994	0.99991	36
37	1.00001	1.00001	1.00001	1.00000	0.99999	0.99998	0.99996	0.99993	0.99990	0.99987	37
38	1.00000	1.00000	1.00000	0.99998	0.99997	0.99995	0.99992	0.99989	0.99986	0.99982	38
39	1.00000	0.99999	0.99998	0.99996	0.99994	0.99992	0.99989	0.99986	0.99982	0.99977	39
40	0.99999	0.99998	0.99997	0.99995	0.99992	0.99989	0.99986	0.99982	0.99978	0.99973	40
41	0.99999	0.99997	0.99995	0.99993	0.99990	0.99986	0.99983	0.99978	0.99974	0.99968	41
42	0.99998	0.99996	0.99994	0.99991	0.99987	0.99984	0.99979	0.99975	0.99970	0.99964	42
43	0.99998	0.99995	0.99992	0.99989	0.99985	0.99981	0.99976	0.99971	0.99966	0.99960	43
44	0.99997	0.99995	0.99991	0.99987	0.99983	0.99978	0.99973	0.99968	0.99962	0.99956	44
45	0.99997	0.99994	0.99990	0.99986	0.99981	0.99976	0.99970	0.99964	0.99958	0.99951	45
46	0.99997	0.99993	0.99989	0.99984	0.99979	0.99973	0.99967	0.99961	0.99954	0.99947	46
47	0.99996	0.99992	0.99987	0.99982	0.99977	0.99971	0.99964	0.99958	0.99951	0.99943	47
48	0.99996	0.99991	0.99986	0.99980	0.99975	0.99968	0.99962	0.99954	0.99947	0.99939	48
49	0.99995	0.99990	0.99985	0.99979	0.99973	0.99966	0.99959	0.99951	0.99943	0.99935	49
50	0.99995	0.99989	0.99984	0.99977	0.99971	0.99963	0.99956	0.99948	0.99940	0.99931	50
51	0.99994	0.99989	0.99982	0.99976	0.99969	0.99961	0.00053	0.99945	0.99936	0.99928	51
52	0.99994	0.99988	0.99981	0.99974	0.99967	0.99959	0.99951	0.99942	0.99933	0.99924	52
53	0.99994	0.99987	0.99980	0.99972	0.99965	0.99956	0.99948	0.99939	0.99930	0.99920	53
54	0.99993	0.99986	0.99979	0.99971	0.99963	0.99954	0.99945	0.99936	0.99926	0.99916	54
55	0.99993	0.99985	0.99978	0.99969	0.99961	0.99952	0.99943	0.99933	0.99923	0.99913	55
56	0.99993	0.99985	0.99977	0.99968	0.99959	0.99950	0.99940	0.99930	0.99920	0.99909	56
57	0.99992	0.99984	0.99975	0.99966	0.99957	0.99948	0.99938	0.99927	0.99917	0.99906	57
58	0.99992	0.99983	0.99974	0.99965	0.99955	0.99945	0.99935	0.99924	0.99913	0.99902	58
59	0.99991	0.99983	0.99973	0.99964	0.99954	0.99943	0.99933	0.99922	0.99910	0.99899	59
60	0.99991	0.99982	0.99972	0.99962	0.99952	0.99941	0.99930	0.99919	0.99907	0.99895	60
61	0.99991	0.99981	0.99971	0.99961	0.99950	0.99939	0.99928	0.99916	0.99904	0.99892	61
62	0.99990	0.99980	0.99970	0.99959	0.99948	0.99937	0.99925	0.99913	0.99901	0.99889	62
63	0.99990	0.99980	0.99969	0.99958	0.99947	0.99935	0.99923	0.99911	0.99898	0.99885	63
64	0.99990	0.99979	0.99968	0.99957	0.99945	0.99933	0.99921	0.99908	0.99895	0.99882	64
65	0.99989	0.99978	0.99967	0.99955	0.99943	0.99931	0.99918	0.99906	0.99892	0.99879	65
66	0.99989	0.99978	0.99966	0.99954	0.99942	0.99929	0.99916	0.99903	0.99889	0.99876	66
67	0.99989	0.99977	0.99965	0.99953	0.99940	0.99927	0.99914	0.99900	0.99887	0.99872	67
68	0.99988	0.99976	0.99964	0.99951	0.99939	0.99925	0.99912	0.99898	0.99884	0.99869	68
69	0.99988	0.99976	0.99963	0.99950	0.99937	0.99923	0.99910	0.99895	0.99881	0.99866	69
70	0.99988	0.99975	0.99962	0.99949	0.99935	0.99922	0.99907	0.99893	0.99878	0.99863	70
71	0.99987	0.99974	0.99961	0.99948	0.99934	0.99920	0.99905	0.99891	0.99876	0.99860	71
72	0.99987	0.99974	0.99960	0.99946	0.99932	0.99918	0.99903	0.99888	0.99873	0.99857	72
73	0.99987	0.99973	0.99959	0.99945	0.99931	0.99916	0.99901	0.99886	0.99870	0.99854	73
74	0.99986	0.99973	0.99958	0.99944	0.99929	0.99914	0.99899	0.99883	0.99868	0.99851	74
75	0.99986	0.99972	0.99958	0.99943	0.99928	0.99913	0.99897	0.99881	0.99865	0.99848	75
76	0.99986	0.99971	0.99957	0.99942	0.99926	0.99911	0.99895	0.99879	0.99862	0.99846	76
77	0.99986	0.99971	0.99956	0.99940	0.99925	0.99909	0.99893	0.99876	0.99860	0.99843	77
78	0.99985	0.99970	0.99955	0.99939	0.99923	0.99907	0.99891	0.99874	0.99857	0.99840	78
79	0.99985	0.99970	0.99954	0.99938	0.99922	0.99906	0.99889	0.99872	0.99855	0.99837	79
80	0.99985	0.99969	0.99953	0.99937	0.99921	0.99904	0.99887	0.99870	0.99852	0.99834	80
81	0.99984	0.99969	0.99952	0.99936	0.99919	0.99902	0.99885	0.99867	0.99850	0.99832	81
82	0.99984	0.99968	0.99952	0.99935	0.99918	0.99901	0.99883	0.99865	0.99847	0.99829	82
83	0.99984	0.99967	0.99951	0.99934	0.99916	0.99899	0.99881	0.99863	0.99845	0.99826	83
84	0.99984	0.99967	0.99950	0.99933	0.99915	0.99897	0.99879	0.99861	0.99842	0.99824	84
85	0.99983	0.99966	0.99949	0.99932	0.99914	0.99896	0.99877	0.99859	0.99840	0.99821	85
86	0.99983	0.99966	0.99948	0.99930	0.99912	0.99894	0.99876	0.99857	0.99838	0.99818	86
87	0.99983	0.99965	0.99947	0.99929	0.99911	0.99892	0.99874	0.99855	0.99835	0.99816	87
88	0.99982	0.99965	0.99947	0.99928	0.99910	0.99891	0.99872	0.99853	0.99833	0.99813	88
89	0.99982	0.99964	0.99946	0.99927	0.99908	0.99889	0.99870	0.99850	0.99831	0.99811	89
90	0.99982	0.99964	0.99945	0.99926	0.99907	0.99888	0.99868	0.99848	0.99828	0.99808	90

TABLE II.—LIQUID TEMPERATURE CHANGE CONSIDERATIONS IN TANK CALIBRATION BY METER OR TANK TO TANK.[a]

1	2	3		4	5	6	7	8	9	10 [b]
Meter Run No.	Meter Registry	Tank Gage (Ft)	Tank Gage (In.)	Corrected for Meter Calibration Factor of 0.9997	Temperature Meter	Temperature Tank	Degrees Difference Between Tank and Meter	Temperature Coefficient Adjustment	Final Adjustment on Meter Registry (Columns 4 × 8)	Accumulated Gallons at End of Each Run
1	22,059	1	0	22,052	64.5	62.5	−2	0.99900	22,030	22,030
2	21,993	2	0	21,986	64.0	63.0	−1	0.99950	21,975	44,011
3	22,047	3	0	22,040	64.1	63.6	−0.5	0.99975	22,035	66,059
4	18,548	4	0	18,542	64.0	64.0	...	1.00000	18,542	84,614
5	20,000	5	0	19,994	63.5	64.0	+0.5	1.00025	19,999	104,613
				104,614					104,581	

Difference of 104,613 −104,581 = 32 or 0.31 per cent due to additional temperature correction

Check on Accumulated Gallonage

Check Run No.	Column 4	Column 5	Final Tank Temperature	Difference	Correction Factor	Checks
5	19,994	63.5	64.0	+0.5	1.00025	19,999
4	18,542	64.0	64.0	+0.0	1.00000	18,542
3	22,040	64.1	64.0	−0.1	0.99995	22,039
2	21,986	64.0	64.0	+0.0	1.00000	21,986
1	22,052	64.5	64.0	−0.5	0.99975	22,047
	104,614					104,613 [c]

[a] Calculations made using 44 API gravity and ASTM-IP Table 6.

[b] Explanation of Column 10, "Accumulated Gallons at End of Each Run":

Run No. 1 = 22,030 at 62.5 F (Column 9).

Run No. 2 = 22,030 at 62.5 F (Column 9) + 21,975 at 63.0 F (2nd run, Column 9) = 22,030 expanded by + 0.5 F to 63.0 F by a factor of 1.00025 or 22,036 at 63.0 F + 21,975 at 63.0 F = 44,011 at 63.0 F.

Run No. 3 = 44,011 at 63.0 F + 22,035 at 63.6 F (3rd run, Column 9) = 44,011 expanded by 0.6 F to 63.6 F by a factor of 1.0003 or 44,024 at 63.6 F + 22,035 at 63.6 F = 66,059 at 63.6 F.

Run No. 4 = 66,059 at 63.6 F + 18,542 at 64.0 F (4th run, Column 9) = 66,059 expanded by 0.4 F by a factor of 1.0002 or 66,072 at 64.0 F + 18,542 at 64.0 F = 84,614 at 64.0 F.

Run No. 5 = 84,614 at 64.0 F + 19,999 at 64.0 F (5th run, Column 9) = 104,613 at 64.0 F.

Formulary approach to Column 10:

If the data are coded as follows:

Column 9	*Column 6*
$F_1 = 22{,}030$	$T_1 = 62.5$
$F_2 = 21{,}975$	$T_2 = 63.0$
$F_3 = 22{,}035$	$T_3 = 63.6$
$F_4 = 18{,}542$	$T_4 = 64.0$
$F_5 = 19{,}999$	$T_5 = 64.0$

Then the accumulated gallons at the end of each run, A_1, A_2, etc., as shown in Column 10, will be:

$$A_1 = F_1 = 22{,}030$$
$$A_2 = A_1[1.0000 + (T_2 - T_1)(0.0005)] + F_2 = 44{,}011$$
$$A_3 = A_2[1.0000 + (T_3 - T_2)(0.0005)] + F_3 = 66{,}059$$
$$A_4 = A_3[1.0000 + (T_4 - T_3)(0.0005)] + F_4 = 84{,}614$$
$$A_5 = A_4[1.0000 + (T_5 - T_4)(0.0005)] + F_5 = 104{,}613$$

[c] Checks with amount obtained incrementally, Column 10.

Order No. 852-25550

1-1700 — 9/66 — 4M
1-1700 — 1/80 — 5C
1-1700 — 12/80 — 5C
1-1700 — 5/81 — 1M
1-1700 — 1/82 — 5C
1-1700 — 2/83 — 1M
1-1700 — 6/84 — 5C
1-1700 — 8/85 — 5C
1-1700 — 9/87 — 1C
1-1700 — 12/87 — 3C
1-1700—2/89—1.75C(5A)
1-1700 — 8/89 — 3C(2A)
1-1700— 9/90 — 3.5C(5D) U

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005