

Measurement and Calibration of Tank Cars

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FOREWORD

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Suggested revisions are invited and should be submitted to the director of the Measurement Coordination Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.



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Standard Method for
MEASUREMENT AND CALIBRATION OF TANK CARS¹



API Standard: 2554

ASTM Designation: D 1409 - 65

ADOPTED, 1965.^{2,3}

This standard of the American Petroleum Institute issued under the fixed designation API 2554 is also a standard of the American Society for Testing and Materials issued under the fixed designation D 1409; 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 procedures for calibrating tank cars. It is presented in two parts: Part I (Sections 2 to 21) outlines procedures for nonpressure-type tank cars; Part II (Sections 22 to 31) outlines procedures for pressure-type tank cars.

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 2555—ASTM D 1406: *Liquid Calibration of Tanks*

PART I. PROCEDURE FOR CALIBRATING NONPRESSURE TANK CARS

General

2. (a) The volume capacity of tank cars shall be determined in one of the three followings ways:

(1) By filling the tank with a quantity of water measured by discharge from calibrated tank or tanks (water gage plant procedure).

(2) By filling the tank with water and

weighing the car before and after filling (water-weighing procedure).

(3) By computing the volume from external measurements of the tank and deducting for the thickness of walls, laps, etc. ("strapping" procedure).

(b) Since 1951 the volume of all new tank cars should have been determined by the water gage plant procedure.

(c) With reference to the use of the three different procedures for calibration, it has been realized that there should be some further clarification with regard to the relation of these three procedures. This has been expressed as follows:

(1) The water gage plant procedure is recommended as the most accurate.

(2) Where facilities are not available for the use of the water gage plant procedure, an acceptable alternative is the water-weighing procedure used for all types of tank cars, and the strapping procedure used for only nonpressure or non-insulated tank cars.

(d) The calibration procedures outlined herein require that the interior surface of the tank be clean and free from any foreign substance such as the residue of commodities adhering to the bottom and sides of the tank—dirt, rust, and the like. Examination and inspection of a tank car may indicate the need for thorough cleaning if the correct established capacity is to be assured.

(e) Tank cars modified or damaged to the extent that the capacity is changed should be recalibrated; and the new capacity should be reported in accordance with instructions in *Freight Tariff No. 300*, latest issue and supplements thereto, issued under ICC authority for United States, Canadian, and Mexican railroads.

WATER GAGE PLANT PROCEDURE

Design and Construction of Gage Plants

3. (a) The gage plant (see Fig. 1) shall consist of one or more elevated tanks

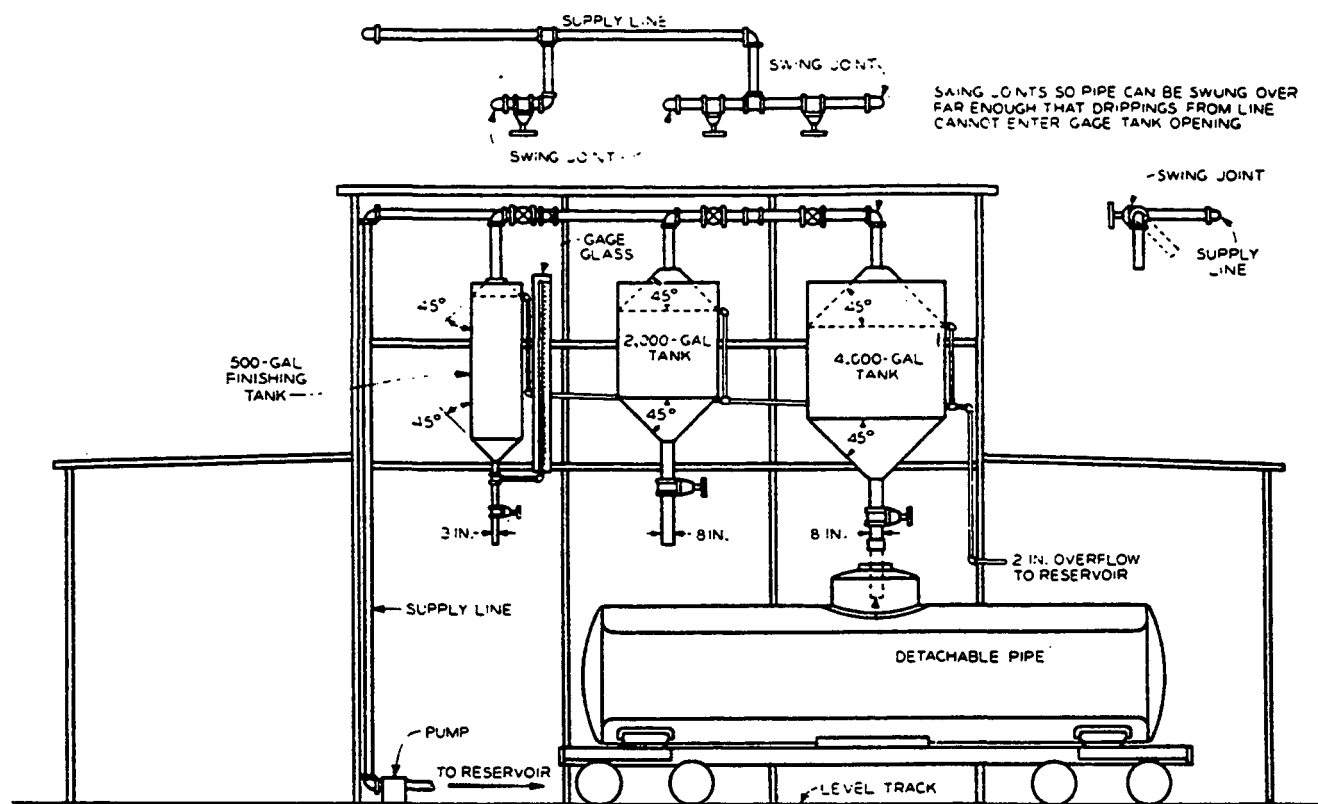
¹ Under the standardization procedures of the API and the ASTM, this standard is under the jurisdiction of the API Central Committee on Petroleum Measurement and the ASTM Committee D-2 on Petroleum Products and Lubricants.

² The API method was adopted as API Standard 2554 in October, 1965.

Prior to their present publication, the API methods of test were issued as API Code 1201 and API Code 1202. API Code 1201 was issued as tentative in July, 1948; it was revised and reissued in January, 1957 as API Standard 1201. API Code 1202 was issued as tentative in December, 1951; it was revised and reissued in February, 1960 as API Standard 1202.

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

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NOTE.—Any and all delivery pipes to the car must have a slope of not less than 2 in. per foot to insure proper and rapid drainage. It is preferred to have a direct discharge pipe from the finishing tank to the car. However, the discharge pipes may be manifolded to avoid movement of car during casing.

FIG. 1.—TYPICAL LAYOUT OF WATER GAGE PLANT

of convenient size, and shall be used for water gaging tank car tanks. In addition to the main tank or tanks, there shall be a finishing tank equipped with an external gage glass throughout its length and so connected that the water level in the glass shall conform to the water level in the tank. This finishing tank shall be of small diameter so that accurate readings are obtained when small quantities of water are withdrawn.

(b) The gage tanks shall have conical bottoms and tops—preferably inclined at an angle of 45 deg or greater from the horizontal—and shall be provided with drawoff valves at the bottom and suitable connections at the top for filling with water. The connections for filling the tank shall be provided with swing joints so that they may be moved away from the opening at the top of the tank. The water in the tank will then be completely separated from its source of supply. All connections shall be so placed that the

water on the tank side of the valve will drain completely.

(c) The openings at the top of the gage tanks (which shall be just large enough to permit entrance for inspection of the tanks) shall be circular or elliptical in shape, have true and absolutely level edges, or be equipped with V-notches, so that, when filled to overflowing, the tanks shall necessarily contain a definite volume.

(d) The water shall be conveyed by gravity from the gage tanks to the car tank. The piping between the valve of the gage tank and the dome opening of the car tank shall be as short and direct as possible, and shall be inclined at an angle that will promote rapid and complete drainage.

(e) During gaging operations the gage tanks and the tank car tanks shall be housed to protect them from the sun and rain.

(f) A section of level track—preferably laid on concrete—on which a car may re-

main undisturbed for any desired length of time shall pass directly under or at the side of the gage tanks. The gage tanks shall be at such a height that water from them will drain directly into the car tank to be gaged. Suitable apparatus shall be installed to raise the water into the gage tanks.

(g) When desired, gage tanks may be equipped with suitable connections for filling from the bottom, in which case the valves in the supply line leading to the gage tanks shall be doubled and the nipples between the valves shall be equipped with a drain cock or bleeder. To ascertain that no water is leaking into or out of the supply line, the drain cock or bleeder shall be opened after the tank has been filled. When the gage tank is filled from the bottom, a downspout shall also be used which reaches to within a few inches of the bottom of the car tank to be gaged, so that the outlet is under the surface of the water after the first few

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seconds of filling. The piping between the valve of the gage tank and the end of the downspout shall be as short and direct as possible, and shall be inclined at an angle which will promote rapid and complete drainage.

CALIBRATION OF WATER GAGE PLANTS

Primary Measures

4. (a) As it is of the utmost importance that great care be exercised to obtain accurate capacities, the calibration of gage plants shall be done by men thoroughly versed in the theory and practice of such work. A small error is greatly multiplied in the final result, for the result is based upon the number of times a measure of small capacity (the exact capacity of which is known) can be filled from the gage tanks. This is determined by the use of a measure of 5- or 10-gal nominal capacity (hereinafter referred to as the "principal primary measure") which is made of such material or protected in such manner that it cannot easily be dented by accident and its capacity thereby changed. The measure shall be constructed in such a manner that it will drain readily toward a mouth at the top drawn into a small diameter. The measure shall be fitted with a cover so that it will hold and deliver, within very narrow limits, the same amount of water time after time. This shall be accomplished by grinding or machining the top of the measure at the mouth and sliding a glass disk over the opening. The fit shall be such that, when the disk is held in place tightly and the measure is tipped, water will not leak from the measure unless the glass is slid off the opening. Also, the fit shall be such that a definite amount of water is always held under the glass when the measure stands in an upright position. The measure shall be provided with a pouring spout, so that its contents may be transferred to another vessel without the loss of a drop.

(b) Another procedure for calibration is to employ a measure constructed with a narrow mouth, using a needle gage to determine the height of the liquid in the measure. The top of the measure shall be machined or ground off, if necessary, to insure accuracy.

(c) In all cases the capacities of primary measures used shall be certified by

the U.S. Bureau of Standards, Washington, D.C. The certificates shall show the capacity, based on the number of gallons or milliliters the measure *holds or delivers* at 60 F after draining for 30 sec.

(d) All measures larger than primary shall be calibrated either by filling from or by emptying into the primary measures. In the former case, the primary measures shall be calibrated *to deliver*; in the latter case, they shall be calibrated either *to hold* or *to deliver*. If calibrated *to hold*, they shall be wiped dry with a cloth *each time used*; if calibrated *to deliver*, the measures shall be cleaned out frequently to remove any dirt or oil.

Intermediate Measures

5. (a) For the calibration of gage tanks, a cylindrical measure shall be used. This measure shall be of intermediate capacity of approximately 50 to 500 gal (hereinafter referred to as the "intermediate measure"). It shall have cone-shaped ends, terminating in a small neck at each end (see Fig. 2), it shall be equipped

with a drawoff valve at the bottom, and it shall be provided with an overflow at the top. If the tank is of such construction that it cannot be inspected for accumulation of foreign matter, it shall be recalibrated frequently.

(b) When calibrating the intermediate measure, level it accurately; fill it with water; and then drain it, allowing 2 min for this operation; and close the valve. Fill the principal primary measure, taking approximately 2 min for the operation and using a soft flexible connection which may be inserted into the measure in such a way that, while filling, the end will be below the surface of the water. After the primary measure has been filled, remove hose, make up outage, and strike the measure gently with the flat of the hand around the sides and the top to release any bubbles. Slide the glass disk, *ground side down*, over the opening, observing whether or not any bubbles are visible through the glass. If so, slide the glass back part way, and with a small sponge add more water until no bubble can be

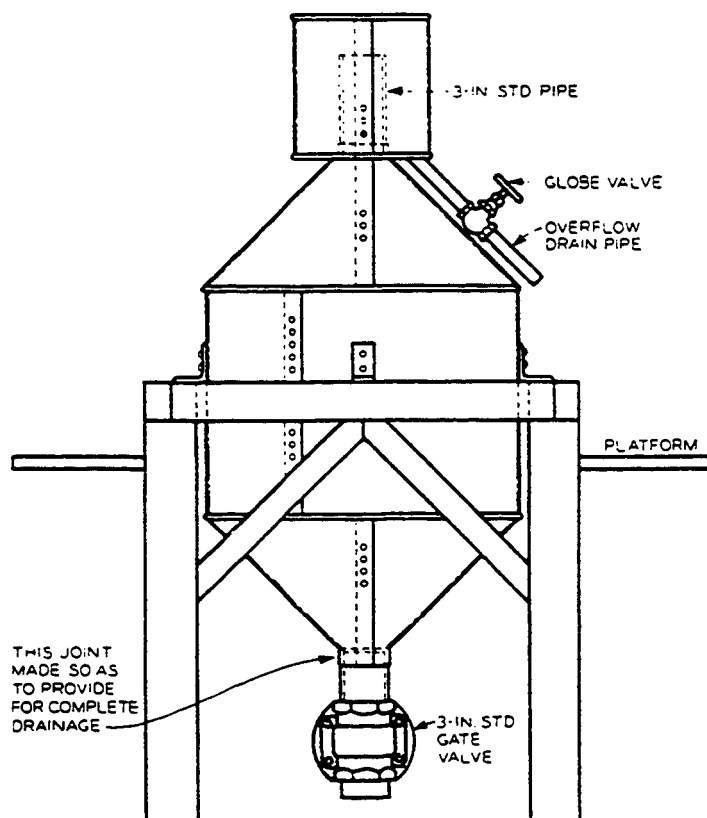


FIG. 2.—TYPICAL INTERMEDIATE MEASURE WITH SUPPORT.

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seen. Hold the glass firmly in place, fully covering the opening, and with a small sponge take out all the water in the pouring lip. Thereupon, have an assistant carefully raise the measure to the proper position for pouring into the intermediate measure. The operator shall hold the glass firmly over the opening and, as the measure is being tilted to pour, he shall slide the disk off. While the contents of the principal primary measure are being poured into the intermediate measure, care shall be taken so that the primary measure is not allowed to rest against the intermediate measure—the primary measure shall be entirely supported in the hands of the assistant so as to avoid denting. It shall be emptied very slowly into the intermediate measure to avoid entrapping air, and shall be allowed to drain for 30 sec after each emptying.

(c) After the principal primary measure has been emptied into the intermediate measure a sufficient number of times so that the intermediate measure will not again hold the full contents of the primary measure, the shortage shall be made up by pouring an additional amount from one or more of the smaller containers, the capacity of which has been certified by the U.S. Bureau of Standards.

(d) After the intermediate measure has been filled with the aid of the smaller containers, total the number of milliliters in the small amounts which have been added; then divide by 3,785, the number of milliliters in the U.S. standard gallon. This quantity, added to the quantity poured in by means of the principal primary measure, gives the total capacity. The temperature of the water used must approximate 60 F; if a temperature change occurs during calibration, appropriate correction should be made.

(e) A delivery pipette is convenient for the removal of any excess liquid when a desired mark on a small container or graduate is overrun.

(f) If a primary measure with needle gage is used, the intermediate measure shall first be filled with water to the predetermined point; then the water shall be drained slowly into the principal primary measure to a point where the liquid just touches the needle gage. If this procedure is employed, the principal primary measure shall be calibrated preferably to *hold* rather than to *deliver*. If surplus water is drained into the principal pri-

mary measure, it shall be removed with a pipette—the accumulations of surplus liquid being measured after the intermediate measure has been drained. The quantity so measured shall be added to that measured in the principal primary measure.

(g) For the purpose of obtaining constant results, as well as for the purpose of ascertaining the average of calibrations used in determining the capacity of the gage tanks, the intermediate measure shall be calibrated at least three times—more, if necessary.

(h) When calibrating intermediate measures or gage tanks, the work shall be discontinued if the atmospheric conditions cause “sweating” or condensation on the outside or inside of the vessels being calibrated.

(i) After the exact capacity of the intermediate measure has been determined, the measure shall be placed under the measuring tank to be calibrated and carefully leveled. It is expedient to fasten to the sides of the measure lugs which can be made to rest on a stout wooden support or table of such height that the valves underneath the measure can be conveniently handled.

Procedure for Calibrating Gage Tanks

6. (a) A plug or reducer, of such design that no water can be entrapped in it, shall be connected to the outlet of the gage tank below its valve, the plug being tapped for approximately a 1-in. pipe. The operator shall then make certain that the inside of the tank to be gaged is clean and free from rust. Thereupon the discharge valve on the gage tank shall be closed, the supply valves opened, and the tank filled with water. It is important that water used for calibration be clean and clear. If the water is used repeatedly, it is well to treat it with a rust inhibitor. The valves of the gage tank shall then be examined to make certain that they are in good condition and that they do not leak. If a leak is found, the valves shall be repaired before proceeding.

(b) The 1-in. pipe shall then be screwed into the plug at the bottom of the tank; it shall be run down to a 1-in. valve which is placed in such a position that the operator can readily examine the inside of the intermediate measure and at the same time, by means of this valve, regulate the flow of the water into the

top of the measure. To insure tightness and ease of operation, the 1-in. valve shall be tested before it is applied. The valve should close tightly without effort. To bring the operator to the proper height for conveniently inspecting the water in the intermediate measure, a platform shall be built around the measure.

(c) The piping having been installed and the gage tank having been filled with water, the intermediate measure shall be carefully examined to see that the interior is perfectly clean. It shall then be filled and emptied to wet the interior surfaces and allowed to drain for at least 2 min, whereupon the discharge valve at the bottom shall be closed. This “drainage period,” once having been determined, shall be used at all times in connection with the operation of the gage plant.

(d) The gage tank shall then be inspected to see that it is filled to overflowing and that no more water can be added.

(e) The large valve of the gage tank shall next be opened *slowly*. If opened too quickly, an air bubble large enough to carry considerable water over the edge of the top of the tank may result. The supply pipe to the intermediate measure is thus filled from the gage tank. The supply valve shall then be opened and the intermediate measure filled. Care should be taken to see that no leakage occurs from the discharge valve at the bottom. The flow to the intermediate measure shall be regulated by the 1-in. valve—the water flowing very slowly as the level approaches the top. It is possible to regulate the valve in such a manner that but little more water will be released than the amount actually required to fill the intermediate measure. If too much water is released, the excess will, of course, be caught in the overflow and eventually measured.

(f) After the intermediate measure has been filled with water, it shall be allowed to settle 2 min to allow air to escape. Shortage due to settling shall be made up, the measure being filled to gage or overflowing. The intermediate measure shall then be emptied and drained for at least 2 min. This procedure shall be repeated, and a tally shall be kept of the number of times it is possible to fill the intermediate measure from the gage tank. When the gage tank is empty, the last intermediate measure may be partially filled—all water from the gage tank having been drained

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into the intermediate measure. The water in the overflow shall also be drained and poured into the intermediate measure. The intermediate measure shall then be filled with water (but not from the gage tank) by means of the principal primary measure and graduates. The gallonage added by means of the principal primary measure and graduates, not having come from the gage tank, shall be subtracted from the capacity of the intermediate measure; the difference, added to the gallonage obtained by the number of times the intermediate measure is filled, shall determine the capacity of the gage tank. The gage tank shall be calibrated at least three times, or as many additional times as shall be necessary to secure uniform results. The average of these results shall be the capacity used when gaging tank cars.

(g) All the gage tanks of the gage plant, including the small finishing tank, shall be calibrated by the foregoing procedure.

Procedure for Calibrating Finishing Tanks

7. (a) The finishing tank shall then be calibrated to show the number of gallons that it holds at any height. This tank shall be equipped with an external gage glass, behind which a suitable gage board shall be placed in a vertical position and securely fastened to prevent shifting. In order accurately to read the gage board, the use of a carpenter's small try-square is recommended; thus the line of vision will be in the same horizontal plane as the bottom of the meniscus. First to be marked on the gage board shall be the height of the water in the gage glass when the tank is full. The finishing tank shall be equipped with a plug with a 1-in. pipe and a 1-in. valve (the same as in the case of the calibration of the gage tank). A number of gallons of water shall be withdrawn into the principal primary measure, and the height again marked on the board. This procedure shall be repeated—the height of the water in the gage glass being marked on the board each time the same quantity of water is withdrawn—until the entire length of the tank has been calibrated. Before this calibration is started, the finishing tank shall be full; likewise, the pipe leading from the tank to the 1-in. valve (by which the operator regulates the flow of water) shall be full. Furthermore, if the principal primary measure does not hold the required gallonage, cor-

rection shall be made by means of a 25-ml measure, in order that the same gallonage will be withdrawn each time.

(b) Inasmuch as considerable time is consumed in calibrating the tank—due to the fact that definitely prescribed quantities are drawn off—the temperature of the water in the gage glass, especially in warm weather, may vary considerably with the temperature of the water in the main body of the finishing tank. These temperatures, therefore, shall be carefully checked. If the temperature of the water in the gage glass is higher or lower than that in the finishing tank, in order to equalize the temperature and to prevent errors in marking, water from the main body of the finishing tank shall be poured into the gage glass to displace the water in the glass. No new water shall be added to the finishing tank for this purpose; it is sufficient that a circulation of water in the gage glass shall be effected.

(c) When the operator is satisfied that the marks on the gage board are properly placed, the marks shall be deepened and the number of gallons of outage in the tank that each mark represents shall be stencilled on the board. Preferably, the scale on the gage board should be in gallons, rather than in inches. Closer readings can be made by interpolation and by the use of the try-square. With the gallonage of the principal primary measure definitely established on the board, the filling tank shall be refilled and the water shall be drained off in single gallons. The board shall be calibrated to show the height of the water in the finishing tank for each gallon. This can be done rather quickly, since the 5- or 10-gal marks are on the board; and the liquid level may be adjusted, if necessary, at each of these marks to avoid any cumulative error.

Check Gage Plant

8. After the gage plant has been calibrated, as outlined in Sections 4 to 7, it should be checked, if possible, by tank cars which have been gaged at other gaging plants whose accuracy has been established.

Procedure for Calibrating Single-Compartment Tank Car Tanks

9. (a) In hot weather tank car tanks shall be cooled by spraying the outside with water before gaging.

(b) The capacity of the car to be gaged shall be determined as it stands on a level track. Before gaging commences, it is important that the gage track be checked to ascertain that it is level.

(c) The inside of the tank shall be examined for the purpose of removing any foreign substances, such as dirt, rust, etc. The outlet valve shall be thoroughly cleaned and put in good condition. All measuring tanks shall be examined to make certain that they are perfectly clean. A check shall be made to ascertain that the scale behind the gage glass on the finishing tank is tight and in its proper position. The gagers shall make certain that the water used is clean. When measuring tanks become nearly empty, they shall be watched for sediment. If any sediment is present, the water shall be stirred thoroughly to carry it away. The operator shall examine all valves on the measuring tanks to see that none are leaking. If any of the valves leak, they shall be repaired or renewed.

(d) Each gage tank shall be separately drained into the car tank, 5 min being allowed for draining after the tanks have become empty.

(e) When water is first emptied into the car tank, the outlet valve shall be examined; if it leaks more than 20 drops per minute, the water shall be drained from the car tank and the valve repaired before proceeding. A pail shall be placed under the valve in such a position that it will catch any leakage. Throughout the operation the outlet valve shall be watched carefully to see that leakage does not become excessive. If preferred, the valve cap may be screwed on (a tight gasket being used). However, if this is done, the outlet leg should be filled with water and the valve closed. Any surplus water left in the car from this operation should be removed by wiping.

(f) Repeat the filling and emptying of measuring tanks until the car tank is nearly full. In order to avoid error or duplication in tallying the number of measuring tanks emptied into the car tank, a record shall be made immediately after the valve from the measuring tank has been closed. When the car tank is nearly full, gaging shall be completed by the use

⁴ This same procedure is applicable to multiple-compartment tank cars by considering each compartment individually as a single-compartment tank.

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of the finishing tank. A straightedge shall be fastened across the manway opening in the shell of the car tank so that it is level with the inside of the shell at its highest point. When the water begins to trickle over the center of the straightedge, the tank is full.

(g) The finishing tank shall be completely filled each time, rather than filled to a point that is marked on the gage board.

(h) The last 100 gal shall not be permitted to run into the car tank faster than at the rate of 10 gpm.

(i) Just before the car tank becomes full, any leakage from the outlet valve shall be poured back into the tank, inasmuch as this water has already been measured.

(j) After the car tank has been filled, allow 15 min for settling to displace the air and fill to the top of straightedge if outage shows, care being taken to include any water that may have leaked from the outlet valve. The capacity of the tank shell shall be determined by taking the total number of gallons which have been emptied from the measuring tanks into the car tank, plus the final reading of the gage on the finishing tank.

(k) The capacity of the dome shall then be determined by the use of the finishing tank.

(l) Throughout tank car tank gaging operations, the gager shall make all important readings personally and check, as far as possible, all other readings. He shall take every possible precaution to insure accurate results, and shall impress upon his assistants the importance of avoiding haste which may result in inaccuracies.

ENTIRE OUTAGE TABLE

General

10. To provide an entire outage table, one car of each class shall be water gaged to show the volume held for each $\frac{1}{2}$ -in. increment from the bottom to the top of the tank. This work shall be done with extreme accuracy; and the table obtained, by the procedure discussed in Section 2, shall be used in determining the outage table for the class of cars represented by the tank gaged.

Procedure for Obtaining Outage Table

11. (a) Tank must be thoroughly cleaned inside.

(b) Tank to be gaged must be placed in the shelter of the gage plant after making sure that track is level, both for length and width of car. The location at which the car is placed within the gage plant shall be such that the water from the finishing tank shall drain directly into the tank to be gaged.

(c) The tank shall be leveled by means of wedges under the side bearings so that the bottom sheet on the inside of the tank is level longitudinally. The tank shall be leveled laterally by adjusting wedges at the side bearings so that the bob of a plumb line, when suspended from the center of the dome ring, rests on the longitudinal centerline of the bottom sheet.

(d) Unscrew the standard valve cap from the tank and replace with a cap having a $\frac{3}{4}$ -in. union connection.

(e) Apply a bracket to the running board on which to support a gage glass and apply an adjustable connection to join the $\frac{3}{4}$ -in. union on the valve cap to the bottom of the gage glass.

(f) Plumb the gage glass and clamp bracket solidly so that gage glass is supported in the plumb position.

(g) Fill the outlet nozzle and piping until the water reaches the top of the bottom sheet on the inside of the tank.

(h) Apply a steel scale to bracket adjacent to gage glass, locating the zero point on the scale at the level of the bottom of meniscus of the water in the glass at the top of the bottom sheet level.

(i) The steel scale shall be clamped securely in position to prevent any change in its position relative to the gage glass.

(j) Do not gage tanks on windy days nor in freezing weather.

(k) Use only clean water at a temperature as near 60 F as practicable.

(l) When gaging operations have started, they shall be continued until the entire tank has been gaged. If gaging continues longer than one day, the water shall be emptied from the tank each night and refilled the next day to the level where gaging was discontinued the night before.

(m) Fill the finishing tank in the gage plant with water and allow it to settle 5 min to free the water from air and make up the outage, if any. Allow enough water to pass from the finishing tank to the car tank to raise the water level in the gage glass to within a fraction of the first $\frac{1}{2}$ in.,

and close the gage tank valve. Allow the water to settle and become calm, after which add additional small quantities until the first $\frac{1}{2}$ in. is reached. Allow the water to settle and become calm.

(n) Check to see that the water in the gage glass is exactly on the $\frac{1}{2}$ -in. mark on the scale.

NOTE 2.—Important: Take each reading in gage glass with the eye on the level of the bottom of the water curve on meniscus.

(o) Read the glass on the finishing gage tank and record the gallonage conveyed to the car tank for the first $\frac{1}{2}$ in.

(p) Repeat the operation for the second $\frac{1}{2}$ in., third $\frac{1}{2}$ in., etc.

(q) When nearing the top of the tank, apply a straightedge to the highest point on the inside of the tank shell.

(r) The last reading is to be taken when the water is at the top of the straightedge and is about to trickle over.

(s) Measure the inside of the tank with the scale and check with reading on the glass.

(t) Draw off the water in the outside gage glass occasionally, and pour it back into the tank. Keep the outside gage glass shaded from the sun to maintain the same temperature in the glass as in the tank. Also be sure that water in the gage glass of the finishing tank is circulated from time to time so that the temperature of the water in the glass is the same as the temperature of the water in the gage tank.

(u) After the water is emptied from the car tank, the car tank must again be leveled; if it is found that the level of the tank has changed during the gaging operation, the tank shall be leveled again and regaged.

WATER-WEIGHING PROCEDURE

General

12. Scales must be sensitive in order to respond quickly and accurately to small changes in weight. They should be checked at regular periods and, if necessary, they should be adjusted to meet check weights. The car weight must also be carefully checked and verified at three stages: (1) empty (dry); (2) tank shell filled with water; and (3) tank shell, including dome, filled with water.

MEASUREMENT AND CALIBRATION OF TANK CARS (API 2554 - ASTM D 1409)

Definitions

13. (a) *Tare Weight* is the weight of tank underframe and trucks (i.e., weight of car with empty, dry tank).

(b) *Gross Weight* is the combined weight of the underframe and trucks and the tank and dome filled with water.

(c) *Gross Weight, Tank Shell Full*, is the weight of the car with the tank shell—but not including the dome—filled with water.

(d) *Net Weights* are the difference between gross weights and tare weight. Please note that the term "net weights" is used because two different "gross weights" are possible [see Paragraphs (b) and (c)].

(e) *Corrected Net Weights* are net weights adjusted to density at 60 F, using the correction factor from Table VIII (Appendix).

Procedure

14. (a) Examine the inside of the tank shell for the purpose of removing any foreign substance, such as dirt, rust, etc., then weigh the car with the tank empty. This is the tare weight. (Wedges, if used to steady the car when filled, should also be used on empty weight to insure that net weight includes only the water in the tank.)

(b) After the tare weight is established, fill the tank shell with water. The last 100 gal shall be at a slow flow rate, not exceeding 10 gpm. Then allow the car to stand for 15 min to permit settling and escape of air in water. Following this, water should be added to bring the level to the inside of the top of the tank shell. The car shall then be weighed and the weight recorded. This is the gross weight, tank shell full.

(c) Following the weighing of the car with the tank shell full of water: (1) when the safety valve is on top of the dome, fill with water to the inside top of the dome; or (2) when the safety valve is on the side of the dome, fill to the top of the safety valve opening. This is the gross weight.

(d) Take the temperature of the water at approximately the vertical center of the tank.

NOTE 3.—For details relative to procedures, equipment and inspection, and testing of equipment, see *API Standard 2543*—

ASTM D 1086: Measuring the Temperature of Petroleum and Petroleum Products.

(e) Obtain the net weights by subtracting the tare weight from the gross weights. Multiply net weight by correction factor to obtain corrected net weight for water at 60 F. The weight of one gallon of water in air at 60 F is equal to 8.328247 lb, established by the U. S. Bureau of Standards. Corrected net weight divided by 8.328247 equals gallons capacity for the tank shell or for the tank and dome. The dome capacity can be determined by deducting the calculated capacity of the tank shell from the calculated capacity of the tank and dome.

CALIBRATING SINGLE-COMPARTMENT TANK CAR TANKS BY EXTERNAL STRAPPING PROCEDURE

Equipment

15. (a) *Tape Calibration*.—The standard tape for calibrating tank-measuring (working) tapes shall be identified with a Report of Calibration at 68 F by the National Bureau of Standards attesting to the standard tape accuracy within 0.001 ft (approximately $\frac{1}{4}$ in.) per 100 ft of length. The Report of Calibration for a standard tape shall include these factors and/or formulas necessary to correct the tape length for use:

(1) At 60 F.

(2) Under tension differing from that used in calibration.

(3) Under conditions of sag in an unsupported tape.

NOTE 4.—The National Bureau of Standards provides for standard tapes (NBS "reference" tapes) only a Report of Calibration at 68 F when the tape is completely supported in a horizontal position and subject to horizontal tension as prescribed in *National Bureau of Standards Test Fee Schedule 202.404—Steel Tapes*. The additional data indicated in Section 15(a), Items (1), (2), and (3), are included in the NBS Report of Calibration only when requested by the applicant and to the extent specifically requested.

(b) *Steel Rulers*:

(1) The rulers used in making measurements, except for plate thicknesses, shall be of steel and of such thickness as to insure that they will not bend in ordinary

use. The rulers shall be graduated in feet, and in tenths and hundredths of a foot.

(2) Plate thicknesses shall be measured with a suitable depth gage having graduations to $\frac{1}{64}$ in. (0.0013 ft).

(c) *Straightedge*:

(1) The straightedge used in making measurements at the heads of tanks shall be of wood or other suitable material of sufficient width and thickness to maintain a substantially straight edge when held flat in a horizontal position and supported only at its ends. The length of the straightedge should be at least 12 in. greater than the diameter of the tank on which it is to be used. A small notch shall be cut in the middle of the straightedge so that the rivet in the head of the tank will not hold the straightedge away from the spherical plate.

(2) A straightedge provided with a pair of sliding blocks or wedges, which can be used in conjunction with graduated scales on the straightedge, may be used to estimate the radius of the outside surface of the spherical head. A procedure for graduating the straightedge is illustrated in Fig. 3. Data for graduating a straightedge equipped with blocks having a projection of 0.400 ft are presented in Table I.

Measuring Procedure

16. (a) All readings except thicknesses shall be made to the nearest 0.005 ft; thickness measurements shall be made to the nearest $\frac{1}{64}$ in. (0.0013 ft).

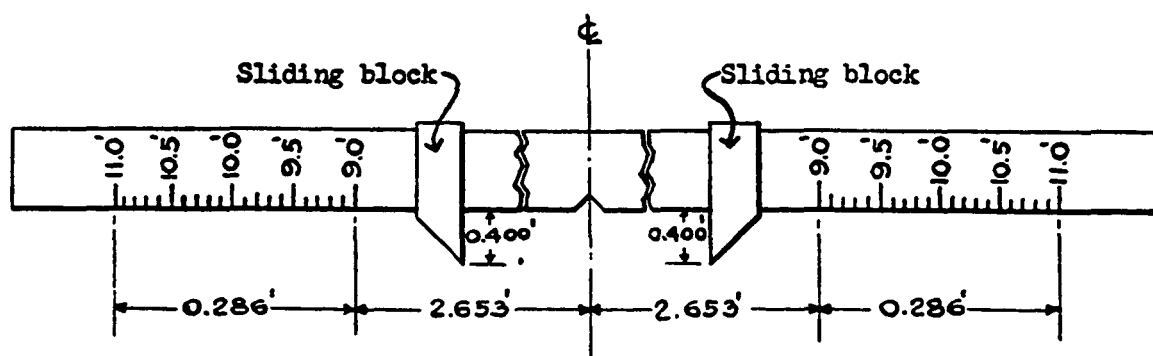
(b) Determine the average overall circumference of the main cylinder (dimension C_m):

(1) If the tank is constructed of a bottom sheet and two longitudinal top sheets, at least four measurements of the circumference shall be made on each tank. When only four are made, they shall be taken as nearly as possible at $\frac{1}{4}$, $\frac{3}{4}$, $\frac{5}{4}$, and $\frac{7}{4}$ points of the length of the tank.

TABLE I.—GRADUATIONS FOR STRAIGHTEDGE.

Distance to Graduation, ft	Head Radius Graduation, ft	Distance to Graduation, ft	Head Radius Graduation, ft
2.653	9.0	2.80	10.0
2.668	9.1	2.814	10.1
2.683	9.2	2.828	10.2
2.698	9.3	2.843	10.3
2.713	9.4	2.857	10.4
2.728	9.5	2.871	10.5
2.742	9.6	2.884	10.6
2.757	9.7	2.898	10.7
2.771	9.8	2.812	10.8
2.786	9.9	2.926	10.9

MEASUREMENT AND CALIBRATION OF TANK CARS (API 2554 - ASTM D 1409)



NOTE.—Table I gives data for graduating a straightedge equipped with blocks having a projection of 0.400 ft.

FIG. 3.—STRAIGHTEDGE WITH SLIDES AND GRADUATIONS FOR ESTIMATING RADIUS OF TANK HEADS.

(2) If the tank is constructed of a bottom sheet and several top rings, or of a number of complete rings, at least one circumference shall be determined for each ring. If only one circumference is determined, it shall be measured as nearly as possible to the middle of each ring. If two are taken, they shall be made as nearly as possible at the $\frac{1}{2}$ and $\frac{3}{2}$ points of each ring.

(3) Since a circumference cannot be measured at the middle of the ring where the dome is located, at least one measurement on each side of the dome shall be made of that ring.

(c) Establish reference points X at ends of main cylinder:

(1) After determining the width of the circumferential lap between the main cylinder and the head cylinder (rivet row spacing plus twice the width of the calking edge), mark in clear and unmistakable manner four reference points, two at each end of the car on opposite sides as shown in Fig. 4.

(d) Determine average length of main cylinder (dimension L_m):

(1) If the tank is constructed of a bottom sheet and two longitudinal top sheets, measure the distances between reference points X on both sides of the tank. The average of these measurements shall be taken as the length of the main cylinder.

(2) If the tank is constructed of a bottom sheet and several top rings or a number of complete rings, reference points shall be established along both sides of the tank on the outside of the overlapped rings opposite the calking edges of the

underlapped rings (see Fig. 4). After these points are established, the net inside widths of the several rings shall be measured. The sum of these partial lengths of the main cylinder must be equal to the overall length as measured between the reference points X at the heads of the car.

(e) Determine the average overall projection of each head from the reference points X (dimensions P_a and P_b):

(1) With a suitable straightedge held against the center of the head, and two rulers held perpendicular to its edge and opposite the reference points, measure the overall projection of the head (length of head cylinder, plus depth of head, plus thickness of head); see Fig. 4.

NOTE 5.—The straightedge should be held so that it is tangent to the tank head at its center.

(f) Determine the outside radius of each tank head (dimensions R_a and R_b):

(1) The tank head radius may be ascertained by measuring—with the straightedge perpendicular to the axis of the tank—the distance to the tank head from the inside of the straightedge at two points on the straightedge equidistant from the tank center. Report the average of the depth measurements as outside depth of arc, and the distance between the two points on straightedge as chord at that depth. From these measurements, outside radius of head may be computed.

NOTE 6.—These measurements should be checked with the straightedge in an approximately horizontal position and in an approximately vertical position, plus a mea-

surement at approximately 45 deg on either side of the vertical, taking care not to measure at points where tank head may be dented. The average of the depths so measured shall be reported. To avoid the knuckle curvature of the head, these measurements shall not be taken nearer than 1 ft from the edge of the head.

(2) The tank head radius may also be ascertained by use of a straightedge equipped with sliding blocks, as illustrated in Fig. 3.

NOTE 7.—The head at the end of the car, where the hand brake wheel is located, shall be designated as head $B-B$ for "brake."

(g) Determine theoretical length of each head cylinder (dimensions L_a and L_b):

(1) With profile board (Fig. 5) held against the knuckle of the tank opposite reference point X , measure the distance between point T on the profile board and reference point X on the tank. This measurement shall be made on both sides of each head cylinder and the average reported as length of the head cylinder.

NOTE 8.—Procedure to be used in constructing a profile board is illustrated in Fig. 5.

(h) Determine the average external circumference of the dome (dimension C_d):

(1) Measure the external circumference of the dome at a point midway between the top of the main cylinder and the top of the dome.

(i) Determine height of dome above top of main cylinder (dimension H_d).