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Manual of Petroleum Measurement Standards

Chapter 3—Tank Gauging

Section 2—Standard Practice for Gauging Petroleum and Petroleum Products in Tank Cars

SECOND EDITION, XXXX

Introduction

This standard provides a uniform method for measuring liquids and liquefied gases in tank cars by liquid level measurement. Measurement of both vapor space and liquid level are described.

Significance and Use

Volumes based on liquid level measurements in tank cars are used for commercial purposes and to indicate compliance with regulations regarding weight and volume. The procedures in this standard are intended to reduce variability in the results of measurement and sampling operations when comparing loading terminal data to unloading terminal data.

Safety and Health Considerations

Caution: All applicable safety and health procedures should be consulted. Considerations should include, but are not limited to, potential electrostatic and other fire and explosion hazards, potential personnel exposure (for example, exposure limits, hazard communication, training, associated protective clothing and equipment requirements, and work practices), and potential explosive and toxic hazards associated with a tank car's atmosphere. The physical characteristics of the commodity and existing operational conditions should be evaluated, and applicable international, federal, state, and local regulations should be observed. Safety procedures designated by the employer and other concerned parties should also be observed. The Association of American Railroads Manual of Standard Recommended Practices and API publications provide additional safety information and should be consulted.

Caution: Petroleum vapors and associated substances may also involve potential toxicity, including hydrogen sulfide vapors from "sour" crude. Petroleum vapors with high concentrations of hydrogen sulfide may cause unconsciousness or death. During and after the opening of the manway, one should stand so that vapor inhalation is minimized. Harmful vapors or oxygen deficiency cannot be detected safely by smell, visual inspection, or judgment. Appropriate precautions should be used for protection against toxic vapors or oxygen deficiency. Procedures should be developed to provide for appropriate exposure monitoring, personal protective equipment, and emergency rescue precautions. When necessary, suitable respirator protection should be worn prior to entering the gauge site and during the gauging procedure.

Physical Characteristics and Fire Considerations

Caution: Personnel involved with the handling of petroleum-related substances (and other chemical materials) should be familiar with their physical and chemical characteristics—including the potential for fire, explosion, and reactivity—and appropriate emergency procedures, as well as potential toxicity and health hazards. They should comply with individual company safe operating practices and local, state, and federal regulations. Personnel should be alert to avoid potential sources of ignition; they should keep containers of materials closed when not in use.

Chapter 3—Tank Gauging

SECTION 2—STANDARD PRACTICE FOR GAUGING PETROLEUM AND PETROLEUM PRODUCTS IN TANK CARS

1. Scope

Tank car contents may be measured by three methods: railroad scale weighing, metering, and liquid level measurement. This standard describes only the equipment for and the procedures of the liquid level method of measurement.

When tank cars can be opened for manual measurements, gauge tapes and bobs may be used to measure the level of liquid contents. When tank cars cannot be opened for gauging contents, closed-system measurement equipment must be used for gauging. This standard describes gauging and temperature measurement equipment used in both open and closed measurement systems.

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2. Normative References

There are no reference documents that are indispensable for the application of this document.

3. Terms and Definitions

3.1. Terms and Definitions

For the purposes of this document the following terms and definitions apply. Terms of more general use may be found in the API *MPMS* Chapter 1—Online Terms and Definitions Database.

3.1.1.
capacity table
Table showing the liquid volume capacities, on an innage or ullage (outage) basis, and the corresponding vapor space capacities, in a tank, tank car or vessel compartment, at various liquid levels, which are measured at the reference gauge point: from the datum up to the liquid surface level for innage gauges; or, from the reference gauge point down to the liquid surface level for ullage (outage) gauges. ~~A capacity table (also, tank capacity table, calibration table) is a table showing the tank car capacities or volumes for various liquid levels measured at the reference gauge point.~~

3.1.2.
dome tank cars
Non-pressure tank cars with an expansion trunk (dome) at the top center of the tank car to provide space for expansion of the liquid in the car. The manway opening is on the dome.

3.1.3.
domeless tank cars
Tank cars with the manway opening attached directly to the top of the tank car shell.

NOTE See Figure 1.

3.1.4.
interior lining
The surface coating applied to the interior of a tank car shell to prevent contents from contacting the metal shell. Linings may be damaged if gauging equipment is not used carefully. The thickness of the lining is included in the calculation of the tank's capacity table. If a lining is removed, replaced, or added at a later date by the car's owner, the capacity table should be recalculated.

3.1.5.
magnetic float gauging device ~~(also, magnetic float gauge)~~
Consists of a float with an interior magnet that moves up and down a hollow tube (sealed to the outside) as the liquid level changes. Another magnet is attached to the bottom of a graduated gauge rod located in the hollow tube and accessible from the outside. When the gauge rod is manually pulled up until the two magnets link, the liquid level's outage may be read off the rod. An outage offset may have to be calculated if the gauge's reference relative density (specific gravity) is different from that of the product to be measured, or if the temperature of the liquid differs substantially from the temperature at which the gauge is calibrated.~~is a gauging device fitted to a tank car to permit measuring the liquid level in the car without opening the car to the atmosphere. The device consists of two magnets: one fitted inside a float and one affixed to a graduated gauge rod or tape. When the two magnets link, the gauge is read at the reference gauge point.~~

3.1.6.
markers
In domeless tank cars, usually at the level where the car is filled to 98 percent of capacity; however, they are occasionally at other levels. Markers are not accurate measurement devices. Markers are not recommended for custody transfer measurements.~~are metal liquid-level indicators installed in domeless tank cars, usually at the level where the car is filled to 98 percent of capacity; however, they are occasionally at other levels. Markers are not accurate measurement devices. Markers are not recommended for custody transfer measurements.~~

3.1.7.
reference gauge point

The point from which all liquid level measurements shall be taken: (a) as determined at the time of the tank calibration and as reflected by the tank capacity table; or, (b) as modified in keeping with guidelines in API *MPMS* Chapters 2 and 3, and for which either adjustment calculations shall be made or a new tank capacity table issued reflecting the new location of the reference gauge point.~~(tank cars): When the tank car can be opened for liquid level measurement, the reference gauge point is at the top edge of the manway opening at the longitudinal centerline of the tank car at the point on the manway circumference closest to the midpoint of the tank car. Tank cars that cannot be opened for liquid level measurement are equipped with built-in measurement equipment. The reference gauge point in these tank cars should be established by the manufacturer of the measurement equipment.~~

3.1.8.
slip tube
A graduated hollow rod fitted into a gas-tight housing, the lower end of which is open to the cargo's contents and the upper end is fitted with a valve.~~Slip-tube gauging devices measure the level of pressurized liquid in a tank car. They consist of a graduated hollow gauge rod fitted into a gas-tight housing. The lower end of the rod is open, and the upper end is fitted with a valve. When the lower end contacts liquid in a tank car, a small amount of the liquid is expelled from the valve at the upper end by pressure inside the tank car.~~

3.1.9.
stenciled load limit
~~is t~~The number painted onto the sides of a tank car indicating the maximum legal weight of its contents.

3.1.10.
stenciled empty weight ~~(light weight, tare) is~~
~~t~~The number painted onto the sides of a tank car indicating the empty weight of the car.

3.1.11.
tank car capacity ~~(stenciled capacity) is~~
~~t~~The number painted onto the ends or sides of a tank car indicating its "shell~~-~~ full" capacity. Verification may be necessary.

3.1.12.
tank car shell full
The number painted onto the ends or sides of a tank car indicating the maximum amount of water the shell can contain at 60 °F. For funnel flow cars, the shell-full point is at the center of the car (there will be air pockets on both sides where the liquid cannot reach). Pressure cars, which are horizontal cylinders, will include the manway volume.

3.1.13.
thermometer well for tank cars
~~Thermometer well (thermowell) is a~~A metal tube, sealed at the bottom, which extends into tank cars requiring closed loading/unloading. The thermowell is filled with a heat-transferring liquid of low volatility and freeze point (usually ethylene glycol) which transmits the temperature of the tank car contents to a thermometer or thermoprobe lowered into the thermowell. ~~metal tube, sealed at the bottom, that extends into tank cars requiring closed loading or unloading. The thermowell is filled with a heat-transferring liquid of low volatility and freeze point (usually, ethylene glycol) that transmits the temperature of the tank car contents to a thermometer lowered into the thermowell.~~

4. Measurement Equipment

Only measurement equipment that yields results that are reproducible and traceable to NIST standards (or equivalent national standards) and for which calibration records are available ~~should~~ shall be used to

measure liquid levels for custody transfer purposes.

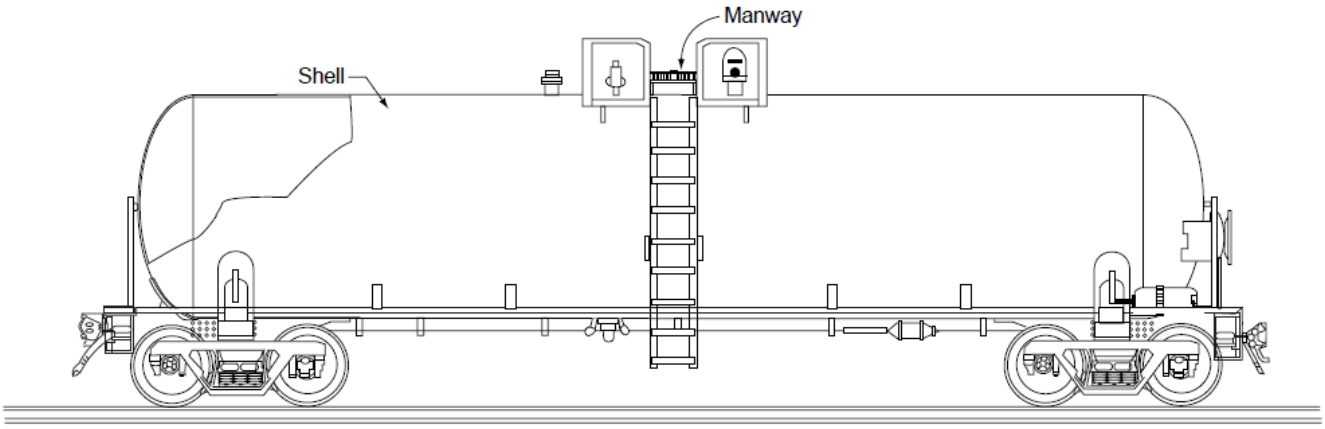

Figure 1—Non-Pressure Tank Car

4.1. LIQUID-LEVEL MEASUREMENT EQUIPMENT

4.1.1. Custody Transfer

Gauge tape and bobs, either manual or electronic, are recommended to measure the liquid level of tank car contents for custody transfer purposes when the tank car can be safely opened for gauging. [API *MPMS* Chapters 3.1A and 17.2 describe manual measurement equipment in detail.] Other measurement equipment of equivalent accuracy may be used if it meets the criteria defined in 3.2.8.

Other measurement equipment of equivalent accuracy may be used if it meets the criteria defined in Section 4 3.2.8. New equipment or technology shall demonstrate compliance with applicable API standards.

4.1.2. Inventory

The liquid level in tank cars may also be gauged with properly functioning equipment built into the tank car. Built- in equipment includes slip tubes , and magnetic float gauges, and other measurement devices. These devices may be used for custody transfer purposes if they comply with requirement in Section 43.2.8. and the procedures Procedures for using them are described in Section 53.2.9.

NOTE Note: Since the location of markers is often approximate, markers are not recommended for custody transfer liquid level measurement. The primary purpose of markers in tank cars is to provide a convenient reference mark to prevent overloading a tank car by volume.

4.2. TEMPERATURE MEASUREMENT EQUIPMENT

To quantify tank car volumes to a standard temperature, the observed temperature of the contents of each car have tomust be measured. Either mercury-glassliquid-in-glass thermometers or portable electronic thermometers may be used. Temperature measurement equipment may be lowered directly into the liquid of tank cars that can be opened. The temperature of the liquid in a closed tank car has tomust be measured in a thermowell. Refer toSee API *MPMS* Chapters 7.1 and 7.32.

5. Liquid-Level Measurement Procedures

Liquid-level measurements in tank cars may be used to determine either the liquid volume or the vapor volume in the measured tank car. Vapor volume is determined by measuring the liquid level, referencing the tank car's capacity table to obtain the liquid volume, then deducting the liquid volume from the stenciled tank car capacity (or the manufacturer's published tank car capacity) to obtain the vapor volume.

Before gauging, the exterior of the tank car should be visually checked for any indication of leaking. The surface of the tank car contents should be calm while gauging. Liquid-level measurements should be read to the resolution of the strapping tablenearest 1/4 inch (7 mm). Two consecutive identical readings of all

gauges are required to assure the absence of motion of the liquid in the tank car during gauging (see Figure 1).

Reference gauge heights ~~must~~ always have to be verified when using outage level measurement. Depending on the design of tank car and/or format of tank car capacity tables, one or more of the following measurements or data points could~~may~~ also be required for reference height verification:~~The liquid outage level, measured from the reference gauge point, must always be measured. Depending on the format of tank car capacity tables, one or more of the following measurements may also be required~~:

a. The height of the manway from upper edge to lower edge.

b. The distance from the inside top of the shell to the upper edge of the manway.

c. The distance from the inside bottom of the shell to the centerline edge of the manway (reference gauge height).

d. The distance from the inside bottom of the shell to the shell-full liquid level.

Measurements a, b, c, and d above should be recorded on the tank car capacity table. ~~so that they need to be measured only once~~.

NOTE ~~Note:~~ The lining of rail tank cars is easily damaged by the pointed end of innage bobs. Care should~~must~~ be exercised to lower innage bobs gently onto the bottom of the tank car.

5.1. GAUGE TAPE AND BOB PROCEDURE

Procedures for measuring liquid levels using gauge tapes and bobs are described in API *MPMS* Chapter 3.1A.

5.2. PORTABLE MEASUREMENT UNIT PROCEDURE

Portable measurement units (electronic tape and bob assemblies) are designed to be used in conjunction with specially designed measurement access valves that limit the escape of vapors during measurement of liquid levels. The use of these devices is acceptable if they meet the requirements of Section 4~~3.2.8~~; however, they are not in common use for measuring liquid levels in rail tank cars. Procedures for measuring liquid levels using electronic gauge tapes and bobs are described in API *MPMS* Chapter 17.

5.3. SLIP-TUBE GAUGING PROCEDURE

Slip tubes have been phased out due to emission concerns. Please refer to manufacturer recommendations for other gauging techniques and calculations as these are not included in the scope this standard. ~~Slip-tube gauging devices measure the level of pressurized liquid in a closed system (see Figures 2a and 2b). The manufacturer's instructions for location of the reference gauge point, use of the equipment, and safe operation must be followed. When all protective devices are released, the slip-tube should slide into its sleeve. As the tube is lowered and the bottom of the tube reaches the liquid surface, liquid is forced by the tank pressure out of the upper end of the tube. The appearance of liquid indicates that the surface of the liquid has been contacted. Using the graduations on the tube, read the liquid level to the nearest 1⁄4 inch at the reference gauge point specified by the manufacturer.~~

5.4. MAGNETIC GAUGING PROCEDURE (ROD TYPE)

Rod-type magnetic gauging devices consist of two parts:
(a) a movable gauge rod with a magnet at the bottom of the rod and (b) a float-magnet assembly that floats on the surface of any liquid in the tank. (See Figure 2~~3~~.)

Magnetic gauging equipment is fitted to a tank car according to the density of one product. The level of the float on the liquid surface can change with any change in the density of the product being measured. The manufacturer of the equipment should label the magnetic gauge rods with the design density of the float to facilitate ease of data collection.

NOTE ~~Note:~~ If gauge rods need to be replaced, consult the tank car owner for replacement.

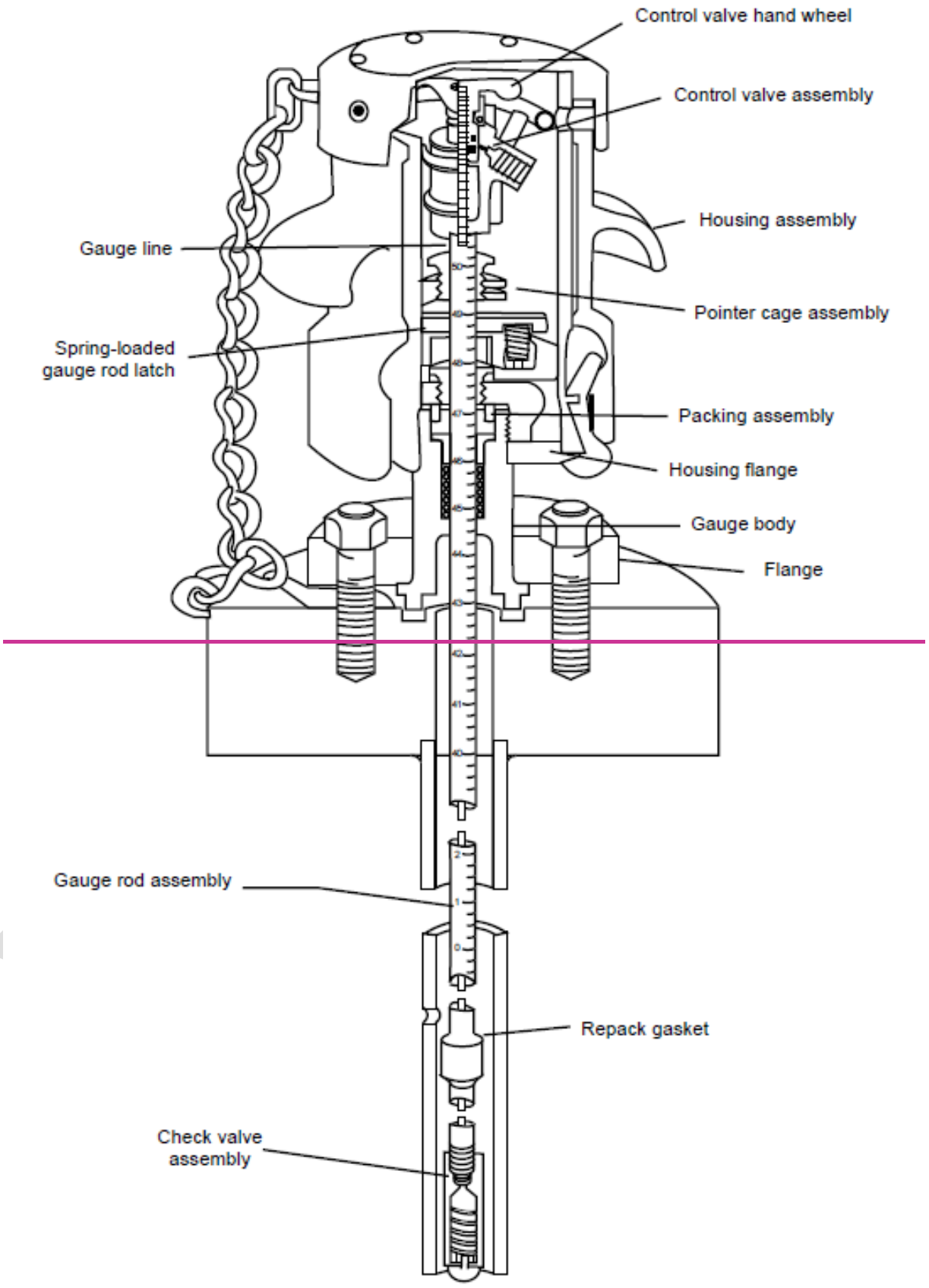

Figure 2a—Slip-Tube Gauging Device Assembly With Quick-Release Cover for Compressed Gas Cars

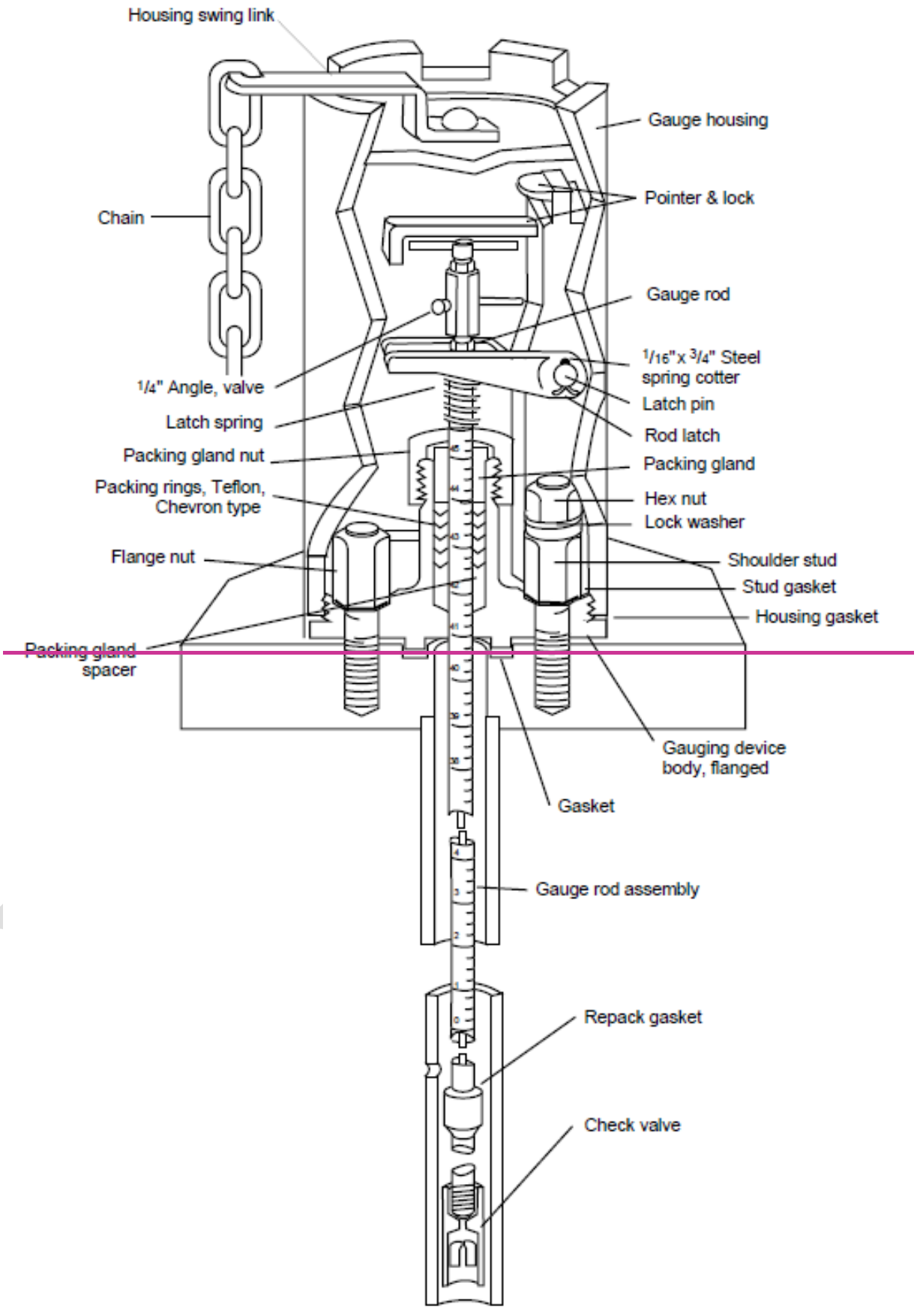

Figure 2a—Slip-Tube Gauging Device Assembly for Compressed Gas

~~Cars~~

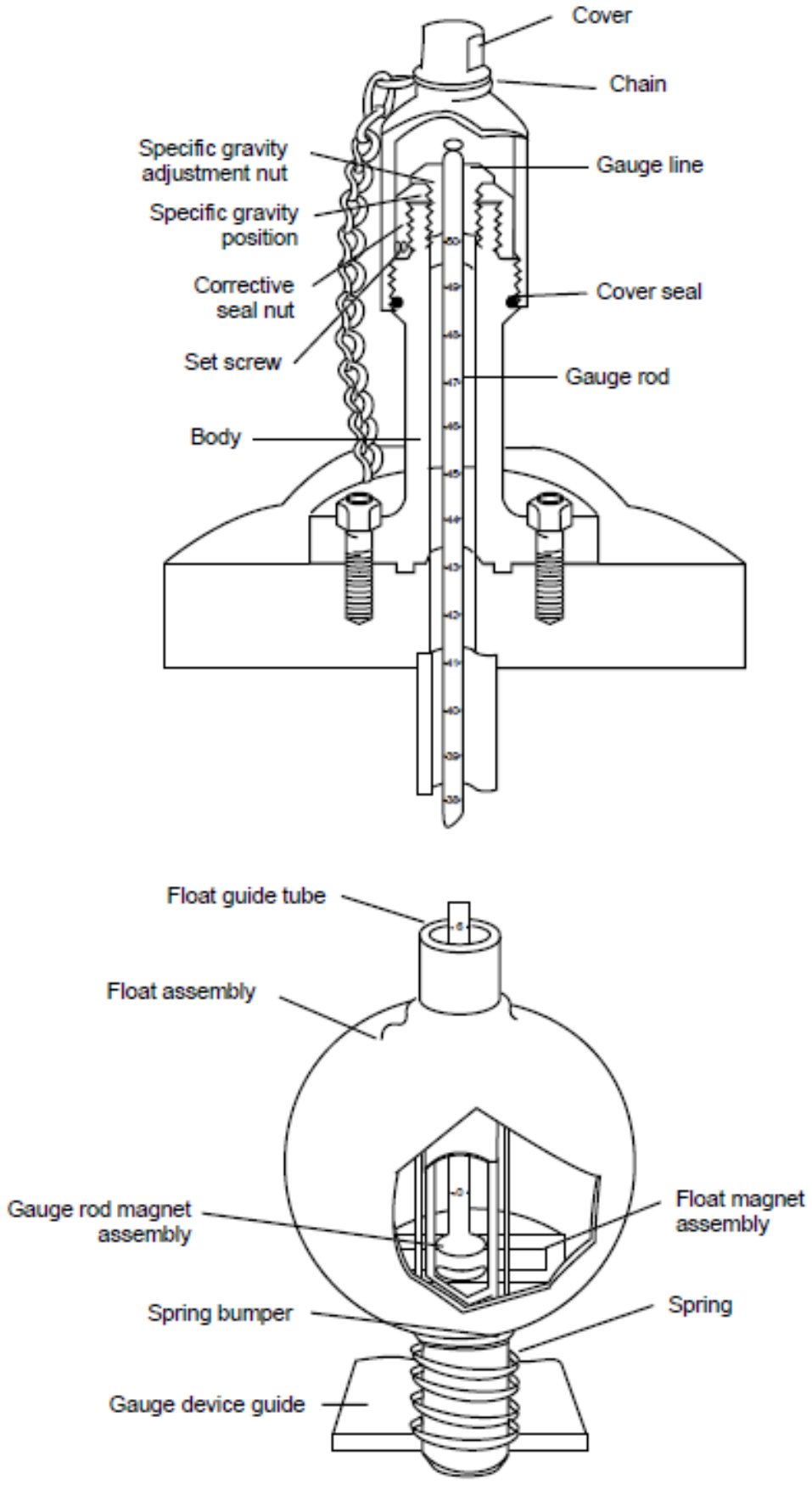

Figure 2~~3~~—Rod-Type Magnetic Gauging Device

To use the rod-type magnetic gauging system, remove the protective cover and pull up on the gauge rod until the rod magnet links with the float magnet (you will feel the linking). Read the outage gauge at the top of the specific gravity adjustment bushing. Read levels as indicated in Section 53.2.9.

~~Note: Magnetic gauging equipment is fitted to a tank car according to the density of one product. The level of the float on the liquid surface will change with any change in the density of the product being measured. The manufacturer of the equipment should be consulted for advice on possible application of a density correction to the gauge.~~

5.5. MAGNETIC GAUGING PROCEDURE (TAPE TYPE)

The tape-type magnetic gauging device uses a graduated tape in place of the rod in 5.43.2.9.4. Otherwise, the principle of operation is the same. ~~(~~See Figure 34.~~)~~

Open the protective cover. Rotate the handwheel until magnetic linkage is felt, then read the outage gauge through the window at the top of the device. Read levels as indicated in Section 53.2.9.

NOTE ~~Note:~~ Magnetic gauging equipment is fitted to a tank car according to the density of one product. The level of the float on the liquid surface will change with any change in the density of the product being measured. The manufacturer of the equipment should be consulted for advice on the possible application of a density correction to the gauge.

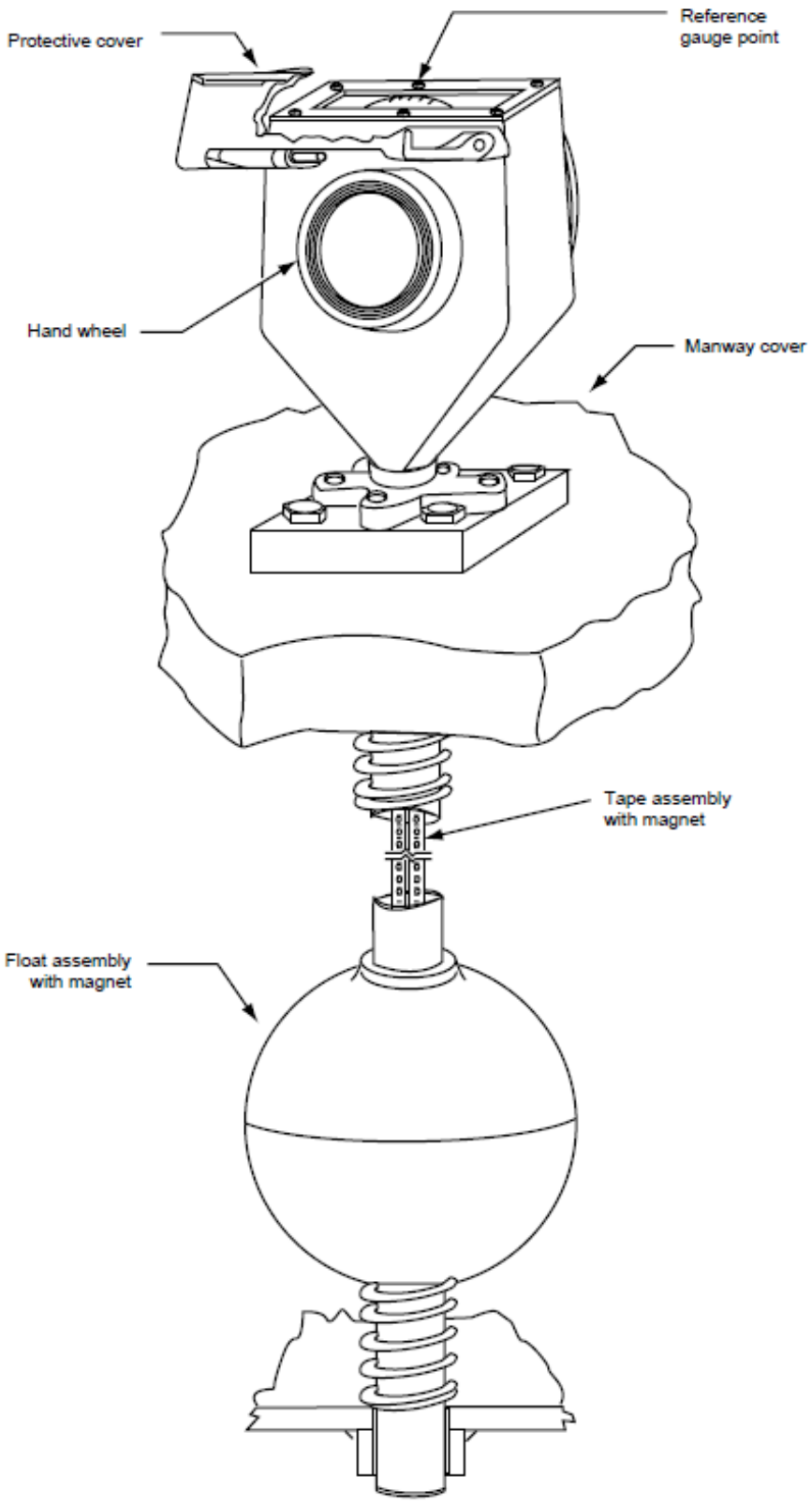

Figure 3—Tape-Type Magnetic Gauging Device

6. Temperature Measurement Procedure

Either ~~L~~liquid-in-glass ~~mercury-glass~~ thermometers or portable electronic thermometers (PET's) may be used to measure the temperature of tank car contents. Due to the long immersion time required for ~~L~~liquid-in-glass~~mercury-glass~~ thermometers in high-temperature liquids, PET's are recommended for these materials.

Follow the procedures recommended in API *MPMS* Chapters 7.1 and 7.~~3~~2.

7. Sampling

Tank cars may be sampled using techniques appropriate for the nature and volume of the contents of the tank car. See API *MPMS* Chapter 8.1.

8. Reading Tank Car Capacity Tables

Tank car capacity tables should be available prior to gauging to determine the type and extent of measurement necessary (see Section 5~~3.2.9~~). Tank car calibration tables are usually presented in one of six formats:

a. Tables based on innage gauges, indicating liquid gallons.
b. Tables based on innage gauges, indicating vapor gallons.
c. Tables based on outage gauges taken at the reference gauge point, indicating liquid gallons.
d. Tables based on outage gauges taken at the reference gauge point, indicating vapor gallons.
e. Tables based on outage gauges taken at the shell-full point, indicating liquid gallons.
f. Tables based on outage gauges taken at the shell-full point, indicating vapor gallons.

See ~~the~~ Annex A for examples of typical rail tank car capacity table formats.

9. Reporting

All measurements and volumes should be reported on a tank car gauging report that includes the following information:

a. Tank car number and DOT number.
b. Stenciled volume.
c. Date, time, and location of gauging.
d. Loading or unloading.
e. Outage or innage gauge and reference point.
f. Gauge readings, temperature (and pressure if applicable).
g. Gauging equipment used
NOTE ~~(~~If magnetic, the design density used for calibration~~)~~.
~~g.~~h. Whether or not the tank car is insulated.

ANNEX A
Informative
TYPICAL RAIL TANK CAR CAPACITY TABLES

No Dome **Outage Table No. 7200**

Inches	Gallons	Inches	Gallons	Inches	Gallons	Inches	Gallons	Inches	Gallons	Inches	Gallons
0[a]	10	0	502	40	3,791	80	8,890	97	10,342		
1/4	2		540	41	3,921	81	8,997		10,355		
1/2	5	11	579	42	4,052	82	9,102		10,368		
3/4	10		619	43	4,184	83	9,204		10,381		
1	16	12	660	44	4,316		9,255	98	10,393		
1/4	22		701	45	4,449	84	9,305		10,405		
1/2	29	13	743	46	4,582		9,354		10,417		
3/4									10,428		
2	44	14	830	48	4,848		9,451	99	10,439		
1/4	53		874	49	4,982	86	9,498		10,450		
1/2	62	15	920	50	5,116		9,545		10,460		
3/4	72		965	51	5,250	87	9,591		10,469		
3	82	16	1,012	52	5,387		9,637	100	10,478		
1/4	92		1,059	53	5,521	88	9,681		10,487		
1/2	103	17	1,107	54	5,654		9,725		10,495		
3/4	115		1,156	55	5,788	89	9,769		10,503		
4	126	18	1,205	56	5,921		9,811	101	10,509		
1/4	139		1,254	57	6,054	90	9,853		10,516		
1/2	151	19	1,304	58	6,187		9,894		10,521		
3/4	164		1,355	59	6,319	91	9,934		10,526		
5	177	20	1,407	60	6,451		9,973	102	10,529		
1/4	191	21	1,511	61	6,582	92	10,012		10,531		
1/2	204	22	1,617	62	6,712		10,049				
3/4	219	23	1,726	63	6,842		10,068				
6	233	24	1,836	64	6,972	93	10,086				
1/4	248	25	1,948	65	7,100		10,104				
1/2	263	26	2,062	66	7,228		10,122				
3/4	278	27	2,177	67	7,355		10,139				
7	294	28	2,294	68	7,480	94	10,156				
1/4	310	29	2,412	69	7,605		10,173				
1/2	326	30	2,532	70	7,729		10,190				
3/4	342	31	2,653	71	7,852		10,206				
8	359	32	2,776	72	7,973	95	10,223				
1/4	376	33	2,899	73	8,093		10,238				
1/2	393	34	3,024	74	8,212		10,254				
3/4	411	35	3,149	75	8,329		10,269				
9	429	36	3,276	76	8,444	96	10,284				
1/4	447	37	3,403	77	8,558		10,299			102 1/2	10,531
1/2	465	38	3,532	78	8,671		10,314			Empty	
3/4	483	39	3,661	79	8,781		10,328				

[a]Zero inches represents manway nozzle capacity.
[b]Represents shell capacity plus manway capacity.

Figure A1—Typical Rail Tank Car Capacity Tables

Gallons per Inch in Manway 1.10 Outage Table No. 7201

Inches	Gallons	Inches	Gallons	Inches	Gallons	Inches	Gallons	Inches	Gallons	Inches	Gallons
0	14	10	487	20	1,289	30	2,210	40	3,129	50	3,921
¼	16		505		1,311		2,234		3,151		3,938
½	19		522		1,333		2,257		3,173		3,954
¾	24		540		1,356		2,281		3,194		3,971
1	29	11	558	21	1,378	31	2,304	41	3,216	51	3,987
¼	35		576		1,400		2,328		3,238		4,003
½	42		594		1,423		2,351		3,259		4,019
¾	49		613		1,445		2,375		3,281		4,034
2	57	12	631	22	1,468	32	2,398	42	3,302	52	4,050
¼	66		650		1,491		2,421		3,323		4,065
½	75		669		1,513		2,445		3,344		4,080
¾	84		688		1,536		2,468		3,365		4,094
3	93	13	707	23	1,559	33	2,492	43	3,386	53	4,109
¼	104		726		1,582		2,515		3,407		4,123
½	114		745		1,605		2,538		3,428		4,137
¾	125		765		1,628		2,561		3,448		4,150
4	136	14	784	24	1,651	34	2,585	44	3,469	54	4,164
¼	148		804		1,674		2,608		3,489		4,190
½	160		824		1,697		2,631		3,510	55	4,214
¾	172		844		1,720		2,654		3,530		4,238
5	184	15	864	25	1,743	35	2,677	45	3,550	56	4,260
¼	197		885		1,766		2,700		3,570		4,280
½	210		905		1,789		2,723		3,589	57	4,299
¾	224		926		1,813		2,746		3,609		4,317
6	237	16	946	26	1,836	36	2,769	46	3,629	58	4,332
¼	251		967		1,859		2,792		3,648		4,345
½	265		988		1,882		2,815		3,667	59	4,355
¾	280		1,009		1,906		2,838		3,686		
7	294	17	1,030	27	1,929	37	2,861	47	3,705		
¼	309		1,051		1,952		2,883		3,724		
½	324		1,072		1,976		2,906		3,743		
¾	340		1,093		1,999		2,929		3,761		
8	355	18	1,115	28	2,023	38	2,951	48	3,780		
¼	371		1,136		2,046		2,974		3,798		
½	387		1,158		2,070		2,996		3,816		
¾	403		1,179		2,093		3,018		3,834		
9	420	19	1,201	29	2,117	39	3,041	49	3,852		
¼	436		1,223		2,140		3,063		3,869	59½[b]	4,360
½	453		1,245		2,163		3,085		3,887	Empty	
¾	470		1,267		2,187		3,017		3,904		

[a]Zero inches represents manway nozzle capacity.
[b]Represents shell capacity plus manway capacity.

Figure A1—Typical Rail Tank Car Capacity Tables (Continued)

Bibliography

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[5] API *MPMS* Chapter 17 (all sections), *Marine Measurement*

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