Tank Car Gauging Instructions

General Service Tank Cars without Magnetic Gauging Devices

This Service Bulletin provides a basic guide to some of the more common gauging methods for general service tank cars. Accurate gauging of tank cars is critical to optimize the tank car loading capacity, comply with minimum federal outage requirements, facilitate freight rate calculations, and prepare and verify customer invoices. A knowledge of the fundamental terms is required for all personnel involved in the gauging of tank cars.

Shell Full Capacity

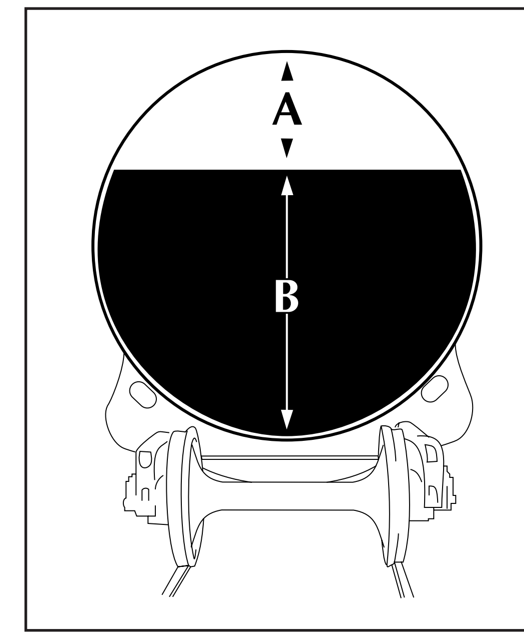
The amount of product in a tank car when the tank shell is completely filled.

Shell Innage

The depth of the product in the tank car measured from the bottom of the tank up to the liquid level of the product, dimension B.

Shell Outage

The unfilled portion of the tank car measured from the inside top of the tank shell down to the level of the product, dimension A.



All tank cars that operate and carry hazardous materials and/or operate in interchange service are required by federal regulations to have a minimum outage at the time of loading. The minimum outage requirements provide for thermal expansion of the product during normal operations. The minimum outage is defined in the Code of Federal Regulation - CFR 49-173.24b. For most liquids, the minimum outage is 1% at a reference temperature of 115° F for non-insulated tank cars and 105° F for insulated tank cars.

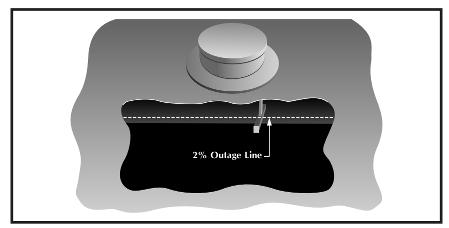
TC3

Outage Reference Points

Loading tank cars to the maximum allowable level is facilitated by a variety of marking or gauging devices, the most common being the 2% outage marker. In some cases, the minimum outage for a given product may be greater than the 2% minimum specified for the tank. These are some of the factors that can affect the minimum outage requirements for a given product:

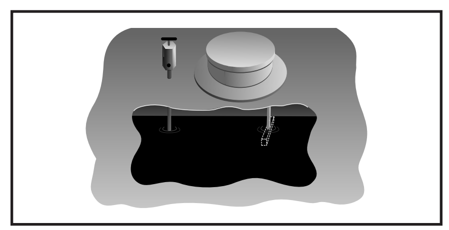
1. The rate of expansion can vary with different products. Therefore, it is necessary to calculate the minimum outage of each product, based on the requirements defined in CFR 49-173.24b.
2. The specific gravity for the product may require a greater minimum outage so that the gross weight rail limit is not exceeded.
3. If the accuracy of the outage marker is in question, contact the owner or builder of the tank car for assistance.

DOT-111A tank cars provide for expansion in the tank and manway area. These cars are generally equipped with an inverted T-shape outage marker indicating 2% outage. The top of the horizontal T-bar is the reference point for the 2% outage.



Gage Marker

In some cases, general service tank cars can be found equipped with a tell-tale device which, when set at the same level as the outage marker, squirts liquid when the loading level is reached. Due to environmental concerns, these devices are not permitted for use with many commodities and are generally not considered acceptable for use.


Tell-Tale Pipe

Methods of Gauging

Several methods are currently used to determine the amount of product in a tank car:

1. Scale Weighing — When a railroad scale is available, the weight of the lading can be determined by subtracting the car's lightweight from the loaded scale weight. The lightweight is determined by an additional weighing, or the lightweight stencilled on the car below its reporting marks may be used. A volume measurement is obtained by dividing the weight measurement by the product's weight per gallon and using the appropriate temperature correction factor.

B. Long Pole Method —
Pole Measurement Is Shell Innage

1. Using An Innage Table — Read the innage in gallons to the right of the shell innage measurement in the gauge table.

Example

Shell innage measurement = 82 1/2 in.

From Table No. 557, 82 1/2 in. corresponds to the measured volume of **9,923 gal.**

2. Using An Outage Table — Subtract the shell innage measurement from the measurement at the end of the outage table. The resulting measurement and corresponding reading in the table reflect the car's shell outage. Subtract the gallons of outage from the stencilled capacity to obtain the measured volume.

Example

Shell innage measurement	= 70 3/4 in.
Stencilled capacity of car	= 11,173 gal.

Measurement at end of outage table	85 in.
Less shell innage measurement	-70 3/4 in.
Equals a shell outage of	14 1/4 in.

From Table No. 558, an outage of 14 1/4 in. corresponds to 1,208 gals. of outage.

Stencilled capacity of car	11,173 gal.
Less shell outage	-1,208 gal.
Equals measured volume	**9,965** gal.

Notes

1. Always be sure that the gauge table being used is the correct one for the car being gauged.
2. If the stencilled capacity of the car is illegible, the gauge table shell full capacity figure may be used as an approximation.
3. Care must be taken when gauging cars with sloping bottoms, dual diameter tanks or interior heater coils, because the gallons per inch of the diameters of these tanks do not present symmetrical volumes per inch of tank diameter in the gauge tables. Therefore, it is necessary to determine the volume of lading in the tank using the gauge table, whether innage or outage type, assigned to the car.
4. When volume comparisons are made, measured gallons must be converted to gross gallons at 60°F, or other comparable basis, using the appropriate temperature and specific gravity information.

Volume Conversion Using Gauge Tables

The innage and outage measurements made with gauge poles can be readily converted into the volume of product in gallons by using gauge tables. Procedures for making this conversion are given below for both the short and long pole methods. Examples given are based on information contained in sample ARL gauge tables No. 557 and No. 558 on the back cover.

A. Short Pole Method —
Pole Measurement Is Shell Outage

1. Using An Outage Table — Read the outage in gallons to the right of the shell outage measurement. Subtract this volume from the actual stencilled capacity of the tank car.

Example

Shell outage measurement	=	6 1/4 in.
Stencilled capacity of car	=	11,173 gal.
Outage Table No. 558		

From Table No. 558, 6 1/4 in. corresponds to 356 gallons.

Stencilled capacity of car	11,173 gal.
Less shell outage	-356 gals.
Equals measured volume	**10,817** gals.

2. Using An Innage Table — Subtract the shell outage measurement from the measurement at the end of the gauge table. The resulting measurement and corresponding gallonage is the car's shell innage.

Example

Shell outage measurement	= 10 1/4 in.
Innage Table No. 557	
Measurement at end of innage table	86 1/4 in.
Less shell outage measurement	-10 1/4 in.
Equals a shell innage of	76 in.

The measured volume in gallonage corresponding to an innage of 76 inches in Table No. 557 - **9,411 gallons.**

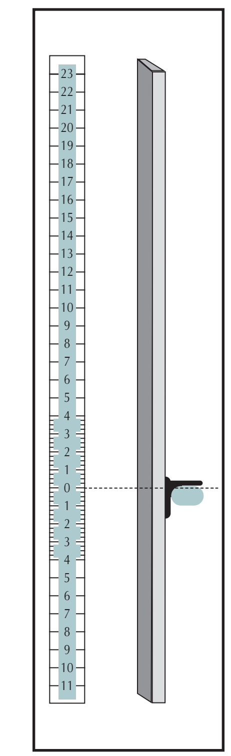
2. Metering — The amount of product can be determined by loading or unloading through a metering system. This is the recommended method for gauging slope-bottom tank cars.

3. Liquid Level Measurement — In this method, the product level in the tank is measured manually by using a gauge pole. A gauge table is used to convert this measurement into a volume measurement. This method lacks accuracy when used with slope-bottom tank cars.

Using Gauge Poles and Gauge Tables

Two methods employing gauge poles can be used to calculate the amount of lading in a tank car by measuring the product level. When using either of these methods, care should be taken to see that the tank car is on a level track. Instructions for each, and for the corresponding use of gauge tables, are given on the following pages.

Short Pole Method



This method employs a short pole gauge stick to measure a car's shell outage. Knowing this dimension, it is possible to calculate the volume of innage gallons in the tank using either the outage or innage tables assigned to the particular car.

The recommended short pole is 36 inches long and graduated in 1/8 inch divisions, with the "0" mark 12 inches from one end. A metal angle is attached to the pole at a point 3/8 inches above the "0" mark to allow for the nominal shell thickness, so that all measurements start from the underside of the tank shell.

Positioning and Reading the Short Pole

Positioning and reading the short pole to gauge the contents of a car will vary depending upon the type of car being gauged. In each case, however, the objective is the same - to measure the distance from the underside of the top of the tank shell to the level of product in the car; i.e., the shell outage measurement. Keeping this objective in mind simplifies understanding the following typical positionings of the short pole.

DOT-111A Cars — Compute the manway nozzle height in the same manner described above for the dome height. Insert the short pole straight down into the tank, resting the angle on the gauge marker (Figure 1). Measure the total outage from the top of the manway nozzle; that is, take a reading at the top of the nozzle, withdraw the pole and take a reading at the point where the liquid cuts the pole. The distance between the two readings is the total outage measurement. Finally, compute the shell outage by subtracting the manway nozzle height from the total outage measurement.

An alternate and preferred method is to position the pole so that the "0" mark coincides with the inside top of the tank shell. The reading taken at the point where the liquid cuts the pole is the shell outage measurement.

Long Pole Method

This method employs a long pole gauge stick to measure a car's shell innage. Knowing this dimension, it is possible to compute the volume of innage gallons in the tank using either the innage or outage tables assigned to the particular car.

The recommended long pole is 10 feet long and graduated in 1/8 inch divisions. The long pole is primarily used for measuring the amount of sediment or liquid in the lower part of the tank. It is also, however, an effective tool for gauging the contents of a fully loaded tank car.

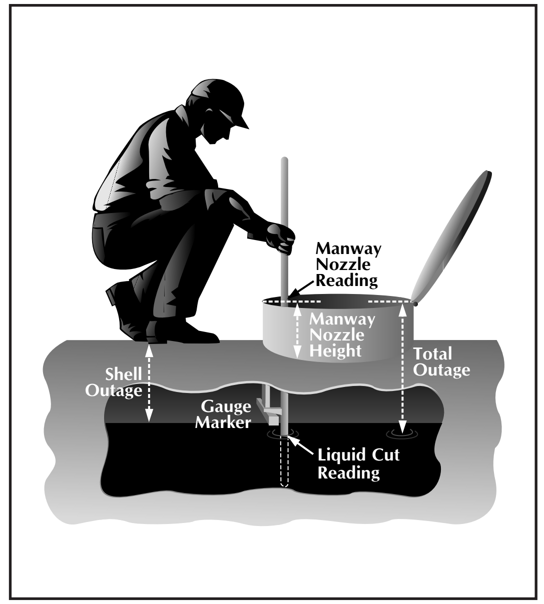


Figure 1

Positioning And Reading The Long Pole

The method of using and reading a long pole is the same for all types of non-pressure tank cars. The pole is inserted through the manway at the top centerline of the tank. Caution must be taken that the pole is held vertically, and that the end of the pole rests on the bottom of the tank and not on a heater coil or other internal appurtenance. Withdraw the pole and note the point where the liquid cuts the pole. This reading is the shell innage measurement (Figure 2).

Gauge Tables

ARL cars are water gauged, using the most accurate methods available and approved by the American Petroleum Institute. Water is incrementally transferred from several overhead storage tanks with certified capacities into the tank car. The shell full water capacity is determined for each car and is stencilled on each end of the tank. Data accumulated in water gauging is used to prepare gauge tables for each lot of tank cars. Two types of gauge tables are prepared:

1. **Innage Table —** Calibrated from the <u>bottom</u> of the tank upward, this table indicates the number of gallons <u>in</u> a tank at quarter-inch increments.

2. **Outage Table —** Calibrated from the <u>top</u> of the tank downward, this table indicates the number of gallons <u>out</u> of a tank at quarter-inch increments.

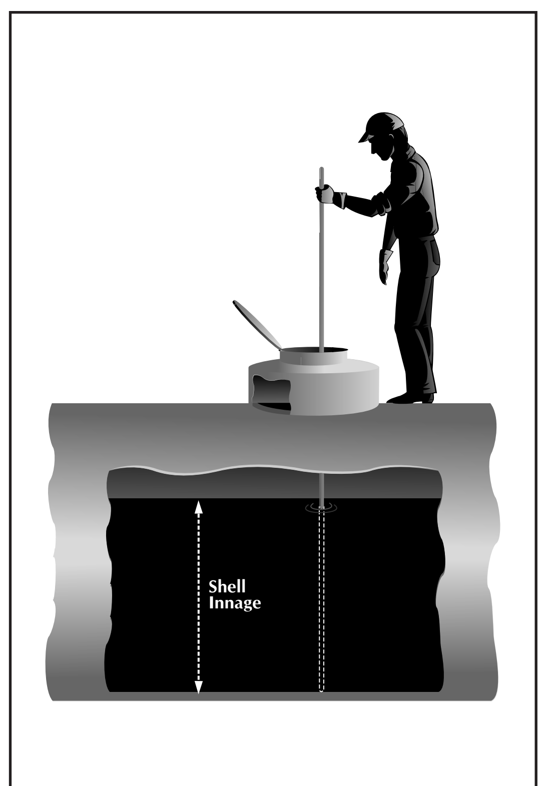
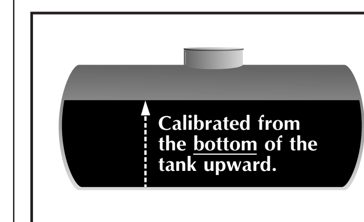


Figure 2

INNAGE TABLE NO. 557

In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.
0		10	614	20	1702	30	3034	40	4514	50	6030	60	7478	70	8765	76	9411	82	9897
1/4			637		1733		3070		4551		6067		7512		8794		9436		9913
1/2			660		1764		3106		4589		6105		7546		8823		9459		9923
3/4			683		1794		3142		4627		6142		7580		8852		9482		9943
1	21	11	707	21	1824	31	3178	41	4665	51	6179	61	7614	71	8881	77	9504	83	9957
1/4	31		730		1854		3214		4702		6216		7648		8909		9526		9971
1/2	41		753		1884		3250		4740		6253		7682		8937		9548		9983
3/4	51		776		1916		3286		4778		6290		7716		8965		9570		9995
2	61	12	800	22	1948	32	3323	42	4816	52	6327	62	7750	72	8993	78	9592	84	10007
1/4	72		823		1980		3359		4853		6364		7784		9021		9613		10018
1/2	84		847		2012		3396		4891		6401		7814		9048		9634		10030
3/4	96		871		2044		3433		4929		6438		7852		9075		9655		10042
3	108	13	897	23	2076	33	3470	43	4967	53	6475	63	7885	73	9102	79	9676	85	10054
1/4	122		923		2108		3506		5014		6511		7918		9129		9697		10066
1/2	136		949		2140		3543		5052		6548		7951		9156		9717		10074
3/4	151		975		2172		3580		5090		6585		7984		9182		9737		10081
4	166	14	1001	24	2205	34	3617	44	5182	54	6622	64	8017	74	9208	80	9756	86	10088
1/4	181		1028		2238		3654		5165		6658		8050		9234		9775		10095
1/2	197		1056		2271		3691		5203		6695		8083		9260		9793		
3/4	213		1083		2304		3728		5241		6731		8116		9285		9811	SHELL FULL	
5	230	15	1111	25	2337	35	3765	45	5279	55	6767	65	8148	75	9310	81	9829		
1/4	247		1138		2370		3802		5316		6803		8180		9335		9847		
1/2	265		1167		2403		3839		5354		6839		8212		9361		9864		
3/4	282		1195		2436		3876		5392		6875		8244		9386		9881		
6	299	16	1224	26	2469	36	3914	46	5430	56	6911	66	8276						
1/4	317		1252		2503		3951		5467		6947		8308						
1/2	335		1281		2538		3988		5505		6983		8340						
3/4	354		1310		2573		4025		5543		7019		8371						
7	373	17	1350	27	2608	37	4063	47	5581	57	7055	67	8402						
1/4	393		1369		2643		4100		5618		7091		8433						
1/2	413		1399		2678		4137		5656		7127		8464						
3/4	433		1428		2713		4175		5694		7162		8495						
8	453	18	1458	28	2749	38	4213	48	5731	58	7197	68	8526						
1/4	472		1487		2784		4250		5768		7232		8556						
1/2	492		1518		2819		4287		5806		7268		8586						
3/4	512		1548		2854		4325		5844		7303		8616						
9	532	19	1579	29	2890	39	4363	49	5881	59	7338	69	8646						
1/4	552		1609		2926		4400		5918		7373		8676						
1/2	572		1640		2962		4438		5956		7408		8706						
3/4	593		1670		2998		4476		5993		7443		8736						



OUTAGE TABLE NO. 558

In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.	In.	Gal.
0		10	718	20	1977	30	3500	40	5161	50	6842	60	8449	70	9863	76	10552	81	10982
1/4	3		745		2012		3540		5204		6885		8487		9895		10579		10999
1/2	8		772		2047		3581		5246		6926		8525		9926		10598		11015
3/4	14		799		2083		3622		5287		6967		8563		9957		10625		11031
1	23	11	826	21	2119	31	3663	41	5330	51	7009	61	8602	71	9988	77	10650	82	11046
1/4	32		854		2155		3702		5372		7051		8639		10017		10674		11061
1/2	42		882		2191		3743		5414		7091		8678		10049		10697		11075
3/4	53		911		2227		3785		5456		7133		8715		10079		10720		11088
2	64	12	938	22	2265	32	3827	42	5498	52	7175	62	8753	72	10109	78	10742	83	11101
1/4	77		966		2302		3868		5540		7216		8789		10139		10764		11114
1/2	90		995		2339		3908		5583		7257		8826		10169		10786		11124
3/4	104		1026		2376		3949		5625		7298		8863		10198		10808		11133
3	119	13	1056	23	2413	33	3990	43	5667	53	7339	63	8900	73	10228	79	10829	84	11142
1/4	134		1086		2450		4032		5709		7380		8936		10255		10850		11151
1/2	150		1116		2487		4073		5751		7421		8973		10284		10871		11157
3/4	166		1147		2525		4114		5793		7461		9009		10311		10890		11162
4	183	14	1178	24	2563	34	4156	44	5835	54	7502	64	9045	74	10339	80	10910	85	11165
1/4	200		1208		2601		4197		5877		7543		9081		10366		10930		
1/2	218		1239		2640		4240		5919		7584		9118		10393		10947	EMPTY	
3/4	236		1270		2678		4281		5961		7624		9152		10420		10965		
5	255	15	1301	25	2716	35	4323	45	6005	55	7664	65	9188	75	10447				
1/4	275		1333		2754		4364		6048		7704		9224		10474				
1/2	294		1365		2792		4405		6090		7744		9259		10500				
3/4	314		1397		2830		4447		6132		7785		9294		10526				
6	335	16	1430	26	2868	36	4489	46	6174	56	7825	66	9329						
1/4	356		1463		2907		4530		6218		7865		9364						
1/2	378		1496		2946		4572		6259		7904		9398						
3/4	401		1529		2985		4614		6300		7944		9433						
7	423	17	1563	27	3024	37	4655	47	6341	57	7984	67	9467						
1/4	444		1597		3063		4698		6383		8023		9500						
1/2	468		1630		3102		4740		6425		8062		9534						
3/4	491		1664		3141		4782		6467		8101		9569						
8	516	18	1697	28	3181	38	4824	48	6510	58	8140	68	9603						
1/4	540		1731		3221		4865		6551		8179		9636						
1/2	564		1766		3261		4907		6592		8219		9669						
3/4	588		1797		3300		4949		6635		8257		9702						
9	613	19	1835	29	3339	39	4992	49	6675	59	8297	69	9736						
1/4	639		1870		3380		5033		6718		8335		9768						
1/2	665		1905		3420		5075		6760		8373		9800						
3/4	692		1940		3461		5119		6771		8411		9832