MEASUREMENT OF BITUMINOUS MATERIALS
5-693.200

5-693.201 GENERAL

A. This section describes procedures for measuring or weighing bituminous materials. Report forms and useful tables are shown to assist the Inspector.

B. It is imperative that the Inspector determine accurately the quantities of bituminous material used on the job. The unit of payment for asphalt cement is the ton. For other bituminous materials the unit is the gallon at 60° F. Consequently, it is necessary to accurately determine the temperature of the material at the time when measurements are made and to correct the measured volume to compensate for the expansion or contraction resulting from the material being at a higher or lower temperature than 60° F.

If the pay item is on a gallon basis, the weight per gallon of the bitumen at 60° F. will be furnished by the Laboratory and the volume of the material can be calculated as follows:

The gallons of bituminous material

$$= \frac{\text{Net Weight (Lbs.)}}{\text{Laboratory Lbs./Gal. (60° F.)}}$$

5-693.210 VOLUME MEASUREMENTS

The volume of bituminous material at a given temperature in a storage tank is determined by use of graduated stick or a calibration chart. A calibration chart should accompany all storage tanks used for bituminous materials.

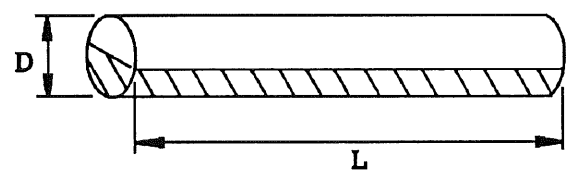
A. Graduated measuring sticks or calibrated charts may be constructed to permit a direct reading of material left in the tank or the amount removed from the tank. Measuring sticks are constructed by either adding known volumes of material to the tank and marking corresponding graduations or by marking the stick to correspond to a calibration chart. Care must be taken in sticking a tank to insure that the stick is always placed in the same position for all measurements and that the tank is level.

B. Calibration Charts are complied to obtain the volume of material in a tank if a measurement from the top of the tank to the surface of the material is known. Care must be taken to always measure from a reference mark, to be sure the tank is level and to interpolate properly between values given in the calibration chart. For cylindrical tanks in a horizontal position, interpolation between points is not linear.

C. Storage Tank Volumes

The following information is given to compute the theoretical volume of storage tanks and construct graduated sticks or calibration charts. If heating coils are present in the tank, measurements must either be made with material above the coils or the volume of material displaced by the coils must be compensated for.

1. Volumes of horizontal cylindrical tanks with flat ends may be computed by using the method shown in Table A. Volumes of horizontal cylindrical tanks with rounded or bumped ends may be computed by this method but with a lesser degree of accuracy and should be used for check purposes only.



2. Volumes of Irregular Shaped Tanks

Volumes of elliptical shaped tanks, irregular shaped tanks and tanks with large heating coils or flues may be calibrated by filling the tank with fuel oil through a metering pump, and calibrating a measuring stick to match the metering pump.

The tank should be calibrated in small enough increments to insure an accurate calibration and minimize the error in measuring quantities.

Commercial metering pumps are calibrated by the Department of Public Service Division of Weights and Measures. Non–commercial metering pumps should be checked for accuracy.

5-693.220 DENSITY OF BITUMINOUS MATERIAL

The specific gravity/weight per gallon of bituminous materials will vary with the source of material, type and grade and temperature. Use the specific gravity/weight per gallon provided on the Material Invoice.

5-693.230 TEMPERATURE CORRECTION FACTORS

The temperature correction factor is used to convert gallons of bitumen at any temperature to gallons at 60° F. The volume is simply multiplied by the proper correction factor.

A series of tables with the necessary correction factors will be found in section 5-693.240. The importance of using the correct Temperature–Volume Table is emphasized. The Tables shown are as follows:

5-693.240 Table B: Temperature–Volume correction factors for Group 0, weight per gallon over 8.046.

5-693.240 Table C: Temperature–Volume correction factors for Group 1, weight per gallon 7.081 to 8.046.

5-693.240 Table D: Temperature–Volume correction factors for Asphalt Emulsion.

5-693.250 REPORTS

Mn/DOT TP 21838 (4/80) BITUMINOUS PROJECT SUMMARY is used to report the delivery of all transports or tank cars. For instructions on completing this form see Sec. .700.

TABLE A
Quantities for Various Depths of Cylindrical Tanks in the Horizontal Position

% Depth Filled	% of Capacity	% Depth Filled	% of Capacity	% Depth Filled	% of Capacity	% Depth Filled	% of Capacity
1	0.20	26	20.73	51	51.27	76	81.50
2	0.50	27	21.86	52	52.55	77	82.60
3	0.90	28	23.00	53	53.81	78	83.68
4	1.34	29	24.07	54	55.08	79	84.74
5	1.87	30	25.31	55	56.34	80	85.77
6	2.45	31	26.48	56	57.60	81	86.77
7	3.07	32	27.66	57	58.86	82	87.76
8	3.74	33	28.84	58	60.11	83	88.73
9	4.45	34	30.03	59	61.36	84	89.68
10	5.20	35	31.19	60	62.61	85	90.60
11	5.98	36	32.44	61	63.86	86	91.50
12	6.80	37	33.66	62	65.10	87	92.36
13	7.64	38	34.90	63	66.34	88	93.20
14	8.50	39	36.14	64	67.56	88	94.02
15	9.40	40	37.39	65	68.81	90	94.80
16	10.32	41	38.64	66	69.97	91	95.55
17	11.27	42	39.89	67	71.16	92	92.26
18	12.24	43	41.14	68	72.34	93	96.93
19	13.23	44	42.40	69	73.52	94	97.55
20	14.23	45	43.66	70	74.69	95	98.13
21	15.26	46	44.92	71	75.93	96	98.66
22	16.32	47	46.19	72	77.00	97	99.10
23	17.40	48	47.45	73	78.14	98	99.50
24	18.50	49	48.73	74	79.27	99	99.80
25	19.61	50	50.00	75	80.39		

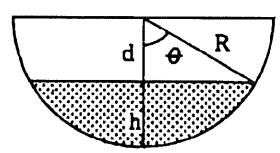
$$\text{Full capacity of tank in U.S. gallons} = \frac{0.7854 \times D^2 \times L}{231}$$

Note: The formula for direct computation of quantity when tank is less than half full is shown below. When more than half full, compute the full capacity of the tank as noted above; consider the shaded portion to represent the unfilled portion at the top of the tank and compute its volume as indicated below; then deduct the volume determined for the unfilled portion from the total volume of the tank to arrive at the volume of the filled portion.

First, compute θ where $\cos\theta = \frac{d}{R} = \frac{R-h}{R}$

Then $A = \pi R^2 \frac{\theta}{180} - R \sin\theta\,(R-h)$

And $V = L \dfrac{\left[\pi R^2 \frac{\theta}{180} - R \sin\theta\,(R-h)\right]}{231}$



Where
- A = Cross section area of filled portion of tank in sq. in.
- V = Volume of filled portion of tank in U.S. gallons
- D = Diameter of interior of tank in inches
- R = Radius of interior of tank in inches
- h = Depth of liquid in inches
- d = R–h, inches

Note: The volume occupied by any piping, fittings or other material inside the tank must be deducted from the volume computed by use of the table or formula.

TABLE B
TEMPERATURE–VOLUME CORRECTION TABLE
GROUP O

Asphalt Cement, Cut–back Asphalts, and Road Oil over 8.046 lbs. per gallon

(°F.)	Factor	(°F.)	Factor	(°F.)	Factor	(°F.)	Factor
50	1.0035	90	0.9896	130	0.9758	170	0.9621
51	1.0031	91	0.9892	131	0.9754	171	0.9618
52	1.0028	92	0.9889	132	0.9751	172	0.9614
53	1.0024	93	0.9885	133	0.9747	173	0.9611
54	1.0021	94	0.9882	134	0.9744	174	0.9607
55	1.0017	95	0.9878	135	0.9740	175	0.9604
56	1.0014	96	0.9875	136	0.9737	176	0.9601
57	1.0010	97	0.9871	137	0.9734	177	0.9597
58	1.0007	98	0.9868	138	0.9730	178	0.9594
59	1.0003	99	0.9864	139	0.9727	179	0.9590
60	1.0000	100	0.9861	140	0.9723	180	0.9587
61	0.9997	101	0.9857	141	0.9720	181	0.9584
62	0.9993	102	0.9854	142	0.9716	182	0.9580
63	0.9990	103	0.9851	143	0.9713	183	0.9577
64	0.9986	104	0.9847	144	0.9710	184	0.9574
65	0.9983	105	0.9844	145	0.9706	185	0.9570
66	0.9979	106	0.9840	146	0.9703	186	0.9567
67	0.9976	107	0.9837	147	0.9699	187	0.9563
68	0.9972	108	0.9833	148	0.9696	188	0.9560
69	0.9969	109	0.9830	149	0.9693	189	0.9557
70	0.9965	110	0.9826	150	0.9689	190	0.9553
71	0.9962	111	0.9823	151	0.9686	191	0.9550
72	0.9958	112	0.9819	152	0.9682	192	0.9547
73	0.9955	113	0.9816	153	0.9679	193	0.9543
74	0.9951	114	0.9813	154	0.9675	194	0.9540
75	0.9948	115	0.9809	155	0.9672	195	0.9536
76	0.9944	116	0.9806	156	0.9669	196	0.9533
77	0.9941	117	0.9802	157	0.9665	197	0.9530
78	0.9937	118	0.9799	158	0.9662	198	0.9526
79	0.9934	119	0.9795	159	0.9658	199	0.9523
80	0.9930	120	0.9792	160	0.9655	200	0.9520
81	0.9927	121	0.9788	161	0.9652	201	0.9516
82	0.9923	122	0.9785	162	0.9648	202	0.9513
83	0.9920	123	0.9782	163	0.9645	203	0.9509
84	0.9916	124	0.9778	164	0.9641	204	0.9506
85	0.9913	125	0.9775	165	0.9638	205	0.9503
86	0.9909	126	0.9771	166	0.9635	206	0.9499
87	0.9906	127	0.9768	167	0.9631	207	0.9496
88	0.9902	128	0.9764	168	0.9628	208	0.9493
89	0.9899	129	0.9761	169	0.9624	209	0.9489

GROUP O (cont'd)

(°F.)	Factor	(°F.)	Factor	(°F.)	Factor	(°F.)	Factor
210	0.9486	250	0.9352	290	0.9220	330	0.9089
211	0.9483	251	0.9349	291	0.9217	331	0.9086
212	0.9479	252	0.9346	292	0.9213	332	0.9083
213	0.9476	253	0.9342	293	0.9210	333	0.9079
214	0.9472	254	0.9339	294	0.9207	334	0.9076
215	0.9469	255	0.9336	295	0.9204	335	0.9073
216	0.9466	256	0.9332	296	0.9200	336	0.9070
217	0.9462	257	0.9329	297	0.9197	337	0.9066
218	0.9459	258	0.9326	298	0.9194	338	0.9063
219	0.9456	259	0.9322	299	0.9190	339	0.9060
220	0.9452	260	0.9319	300	0.9187	340	0.9057
221	0.9449	261	0.9316	301	0.9184	341	0.9053
222	0.9446	262	0.9312	302	0.9181	342	0.9050
223	0.9442	263	0.9309	303	0.9177	343	0.9047
224	0.9439	264	0.9306	304	0.9174	344	0.9044
225	0.9436	265	0.9302	305	0.9171	345	0.9040
226	0.9432	266	0.9299	306	0.9167	346	0.9037
227	0.9429	267	0.9296	307	0.9164	347	0.9034
228	0.9426	268	0.9293	308	0.9161	348	0.9031
229	0.9422	269	0.9289	309	0.9158	349	0.9028
230	0.9419	270	0.9286	310	0.9154	350	0.9024
231	0.9416	271	0.9283	311	0.9151	351	0.9021
232	0.9412	272	0.9279	312	0.9148	352	0.9018
233	0.9409	273	0.9276	313	0.9145	353	0.9015
234	0.9405	274	0.9273	314	0.9141	354	0.9011
235	0.9402	275	0.9269	315	0.9138	355	0.9008
236	0.9399	276	0.9266	316	0.9135	356	0.9005
237	0.9395	277	0.9263	317	0.9132	357	0.9002
238	0.9392	278	0.9259	318	0.9128	358	0.8998
239	0.9389	279	0.9256	319	0.9125	359	0.8995
240	0.9385	280	0.9253	320	0.9122	360	0.8992
241	0.9382	281	0.9250	321	0.9118	361	0.8989
242	0.9379	282	0.9246	322	0.9115	362	0.8986
243	0.9375	283	0.9243	323	0.9112	363	0.8982
244	0.9372	284	0.9240	324	0.9109	364	0.8979
245	0.9369	285	0.9236	325	0.9105	365	0.8976
246	0.9365	286	0.9233	326	0.9102	366	0.8973
247	0.9362	287	0.9230	327	0.9099	367	0.8969
248	0.9359	288	0.9227	328	0.9096	368	0.8966
249	0.9356	289	0.9223	329	0.9092	369	0.8963

TABLE C
TEMPERATURE – VOLUME CORRECTION TABLE
GROUP 1
Cut–back Asphalts and Road Oils from 7.081 to 8.046 lbs per gallon

(°F.)	Factor	(°F.)	Factor	(°F.)	Factor	(°F.)	Factor
50	1.0040	90	0.9881	130	0.9725	170	0.9570
51	1.0036	91	0.9877	131	0.9721	171	0.9566
52	1.0032	92	0.9873	132	0.9717	172	0.9562
53	1.0028	93	0.9869	133	0.9713	173	0.9559
54	1.0024	94	0.9865	134	0.9709	174	0.9555
55	1.0020	95	0.9861	135	0.9705	175	0.9551
56	1.0016	96	0.9857	136	0.9701	176	0.9547
57	1.0012	97	0.9854	137	0.9697	177	0.9543
58	1.0008	98	0.9850	138	0.9693	178	0.9539
59	1.0004	99	0.9846	139	0.9690	179	0.9536
60	1.0000	100	0.9842	140	0.9686	180	0.9532
61	0.9996	101	0.9838	141	0.9682	181	0.9528
62	0.9992	102	0.9834	142	0.9678	182	0.9524
63	0.9988	103	0.9830	143	0.9674	183	0.9520
64	0.9984	104	0.9826	144	0.9670	184	0.9517
65	0.9980	105	0.9822	145	0.9666	185	0.9513
66	0.9976	106	0.9818	146	0.9662	186	0.9509
67	0.9972	107	0.9814	147	0.9659	187	0.9505
68	0.9968	108	0.9810	148	0.9655	188	0.9501
69	0.9964	109	0.9806	149	0.9651	189	0.9498
70	0.9960	110	0.9803	150	0.9647	190	0.9494
71	0.9956	111	0.9799	151	0.9643	191	0.9490
72	0.9952	112	0.9795	152	0.9639	192	0.9486
73	0.9948	113	0.9791	153	0.9635	193	0.9482
74	0.9944	114	0.9787	154	0.9632	194	0.9478
75	0.9940	115	0.9783	155	0.9628	195	0.9475
76	0.9936	116	0.9779	156	0.9624	196	0.9471
77	0.9932	117	0.9775	157	0.9620	197	0.9467
78	0.9929	118	0.9771	158	0.9616	198	0.9463
79	0.9925	119	0.9767	159	0.9612	199	0.9460
80	0.9921	120	0.9763	160	0.9609	200	0.9456
81	0.9917	121	0.9760	161	0.9605	201	0.9452
82	0.9913	122	0.9756	162	0.9601	202	0.9448
83	0.9909	123	0.9752	163	0.9597	203	0.9444
84	0.9905	124	0.9748	164	0.9593	204	0.9441
85	0.9901	125	0.9744	165	0.9589	205	0.9437
86	0.9897	126	0.9740	166	0.9585	206	0.9433
87	0.9893	127	0.9736	167	0.9582	207	0.9429
88	0.9889	128	0.9732	168	0.9578	208	0.9425
89	0.9885	129	0.9728	169	0.9574	209	0.9422

GROUP 1 (cont'd)

(°F.)	Factor	(°F.)	Factor	(°F.)	Factor	(°F.)	Factor
210	0.9418	245	0.9286	280	0.9157	315	0.9029
211	0.9414	246	0.9283	281	0.9153	316	0.9025
212	0.9410	247	0.9279	282	0.9149	317	0.9021
213	0.9407	248	0.9275	283	0.9146	318	0.9018
214	0.9403	249	0.9272	284	0.9142	319	0.9014
215	0.9399	250	0.9268	285	0.9138	320	0.9010
216	0.9395	251	0.9264	286	0.9135	321	0.9007
217	0.9391	252	0.9260	287	0.9131	322	0.9003
218	0.9388	253	0.9257	288	0.9127	323	0.9000
219	0.9384	254	0.9253	289	0.9124	324	0.8996
220	0.9380	255	0.9249	290	0.9120	325	0.8992
221	0.9376	256	0.9245	291	0.9116	326	0.8989
222	0.9373	257	0.9242	292	0.9113	327	0.8985
223	0.9369	258	0.9238	293	0.9109	328	0.8981
224	0.9365	259	0.9234	294	0.9105	329	0.8978
225	0.9361	260	0.9231	295	0.9102	330	0.8974
226	0.9358	261	0.9227	296	0.9098	331	0.8971
227	0.9354	262	0.9223	297	0.9094	332	0.8967
228	0.9350	263	0.9219	298	0.9091	333	0.8963
229	0.9346	264	0.9216	299	0.9087	334	0.8960
230	0.9343	265	0.9212	300	0.9083	335	0.8956
231	0.9339	266	0.9208	301	0.9080	336	0.8952
232	0.9335	267	0.9205	302	0.9076	337	0.8949
233	0.9331	268	0.9201	303	0.9072	338	0.8945
234	0.9328	269	0.9197	304	0.9069	339	0.8942
235	0.9324	270	0.9194	305	0.9065	340	0.8938
236	0.9320	271	0.9190	306	0.9061	341	0.8934
237	0.9316	272	0.9186	307	0.9058	342	0.8931
238	0.9313	273	0.9182	308	0.9054	343	0.8927
239	0.9309	274	0.9179	309	0.9050	344	0.8924
240	0.9305	275	0.9175	310	0.9047	345	0.8920
241	0.9301	276	0.9171	311	0.9043	346	0.8916
242	0.9298	277	0.9168	312	0.9039	347	0.8913
243	0.9294	278	0.9164	313	0.9036	348	0.8909
244	0.9290	279	0.9160	314	0.9032	349	0.8906

TABLE D
TEMPERATURE – VOLUME CORRECTION TABLE
ASPHALT EMULSION (ANIONIC & CATIONIC)

°C[t]	°F	M*	°C[t]	°F	M*	°C[t]	°F	M*	°C[t]	°F	M*
4.4	40	1.0050	26.7	80	0.99500	48.9	120	0.98500	71.1	160	0.97500
5.0	41	1.0048	27.2	81	0.99475	49.4	121	0.98475	71.7	161	0.97475
5.6	42	1.0045	27.8	82	0.99450	50.0	122	0.98450	72.2	162	0.97450
6.1	43	1.0043	28.3	83	0.99425	50.6	123	0.98425	72.8	163	0.97425
6.7	44	1.0040	28.9	84	0.99400	51.1	124	0.98400	73.3	164	0.97400
7.2	45	1.0038	29.4	85	0.99375	51.7	125	0.98375	73.9	165	0.97375
7.8	46	1.0035	30.0	86	0.99350	52.2	126	0.98350	74.4	166	0.97350
8.3	47	1.0033	30.6	87	0.99325	52.8	127	0.98325	75.0	167	0.97325
8.9	48	1.0030	31.1	88	0.99300	53.3	128	0.98300	75.6	168	0.97300
9.4	49	1.0028	31.7	89	0.99275	53.9	129	0.98275	76.1	169	0.97275
10.0	50	1.00250	32.2	90	0.99250	54.4	130	0.98250	76.7	170	0.97250
10.6	51	1.00225	32.8	91	0.99225	55.0	131	0.98225	77.2	171	0.97225
11.1	52	1.00200	33.3	92	0.99200	55.6	132	0.98200	77.8	172	0.97200
11.7	53	1.00175	33.9	93	0.99175	56.1	133	0.98175	78.3	173	0.97175
12.2	54	1.00150	34.4	94	0.99150	56.7	134	0.98150	78.9	174	0.97150
12.8	55	1.00125	35.0	95	0.99125	57.2	135	0.98125	79.4	175	0.97125
13.3	56	1.00100	35.6	96	0.99100	57.8	136	0.98100	80.0	176	0.97100
13.9	57	1.00075	36.1	97	0.99075	58.3	137	0.98075	80.6	177	0.97075
14.4	58	1.00050	36.7	98	0.99050	58.9	138	0.98050	81.1	178	0.97050
15.0	59	1.00025	37.2	99	0.99025	59.4	139	0.98025	81.7	179	0.97025
15.6	60	1.00000	37.8	100	0.99000	60.0	140	0.98000	82.2	180	0.97000
16.1	61	0.99975	38.3	101	0.98975	60.6	141	0.97975	82.8	181	0.96975
16.7	62	0.99950	38.9	102	0.98950	61.1	142	0.97950	83.3	182	0.96950
17.2	63	0.99925	39.4	103	0.98925	61.7	143	0.97925	83.9	183	0.96925
17.8	64	0.99900	40.0	104	0.98900	62.2	144	0.97900	84.4	184	0.96900
18.3	65	0.99875	40.6	105	0.98875	62.8	145	0.97875	85.0	185	0.96875
18.9	66	0.99850	41.1	106	0.98850	63.3	146	0.97850			
19.4	67	0.99825	41.7	107	0.98825	63.9	147	0.97825			
20.0	68	0.99800	42.2	108	0.98800	64.4	148	0.97800			
20.6	69	0.99775	42.8	109	0.98775	65.0	149	0.97775			
21.1	70	0.99750	43.3	110	0.98750	65.6	150	0.97750			
21.7	71	0.99725	43.9	111	0.98725	66.1	151	0.97725			
22.2	72	0.99700	44.4	112	0.98700	66.7	152	0.97700			
22.8	73	0.99675	45.0	113	0.98675	67.2	153	0.97675			
23.3	74	0.99650	45.6	114	0.98650	67.8	154	0.97650			
23.9	75	0.99625	46.1	115	0.98625	68.3	155	0.97625			
24.4	76	0.99600	46.7	116	0.98600	68.9	156	0.97600			
25.0	77	0.99575	47.2	117	0.98575	69.4	157	0.97575			
25.6	78	0.99550	47.8	118	0.98550	70.0	158	0.97550			
26.1	79	0.99525	48.3	119	0.98525	70.6	159	0.97525			

LEGEND:
t = observed temperature in degrees Celsius (Fahrenheit)
M = multiplier for correcting volumes to the basis of 15.6°C (60°F)
*Multiplier (M) for °C is a close approximation.