

CRD-C 649-95

Standard Test Method for Unit Weight, Marshall Stability, and Flow of Bituminous Mixtures*

1. Scope.

1.1 This test method is applicable for evaluation of all well-graded hot-mix bituminous pavement mixtures in which not more than 10 percent of the aggregate is retained on a 25.0 mm (1-in.) sieve. This test method is intended to be used for the determination of stability and flow of laboratory-prepared samples.

2. Apparatus.

2.1 A Marshall compaction mold and holder meeting the requirements shown in Figure 1. The mold holder shall be mounted on the compaction pedestal so that the center of the compaction mold is over the center of the post. The holder shall hold the compaction mold, collar, and baseplate securely in position during compaction of the specimen.

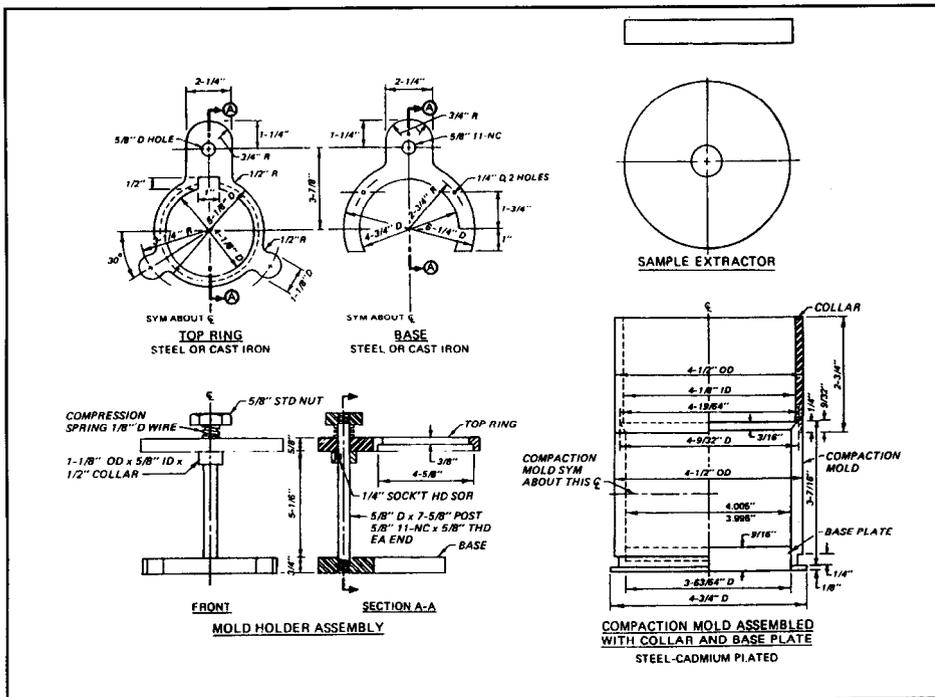


Figure 1. Marshall compaction mold and mold holder

*Formerly MIL-STD-620A, Method 100, 13 January 1996.

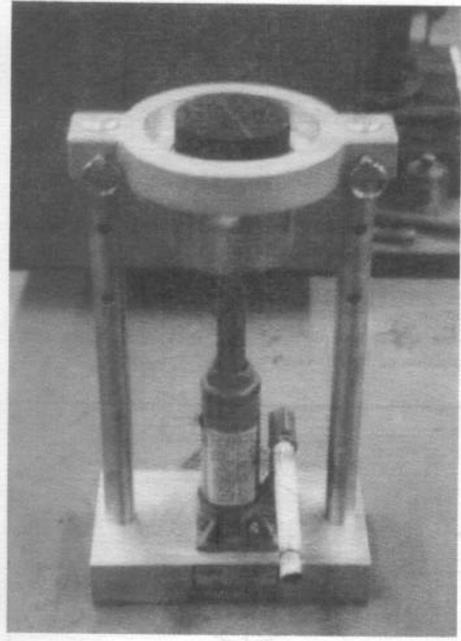


Figure 2. Specimen extractor

2.2 A specimen extractor (Figure 2) for removing the compacted specimen from the mold cylinder.

2.3 A compaction hammer (Figure 3) having a flat, circular tamping face and a 10 ± 0.01 -lb sliding mass with a free fall of 18 ± 0.025 in. For quality control or assurance work, it is recommended that two compaction hammers be available in case one is damaged.

Note: Mechanical hammers may be used when properly correlated with the standard hand hammer by determining the number of blow necessary with the mechanical hammer to produce the same density as that produced by the specified number of blows with the hand hammer. Some mechanical hammers marketed cannot reproduce the compactive effort of the hand hammer regardless of the number of blows applied.

2.4 A pedestal, on which to anchor the mold during compaction of the test specimen, consisting of a timber post having a minimum cross section of 8 by 8 in. and a height of 18 ± 1 in. capped with a 12- by 12- by 1-in. steel plate. Arrangements shall be made for placing the compaction mold directly over the 8- by 8-in. post. The compaction pedestal must be securely anchored to a concrete slab resting on the ground, or directly over an interior building column or similar location. Wooden floors or unsupported areas of concrete floors are unsuitable supports for the compaction pedestal. The use of a pedestal in accordance with these requirements is very important; otherwise, the

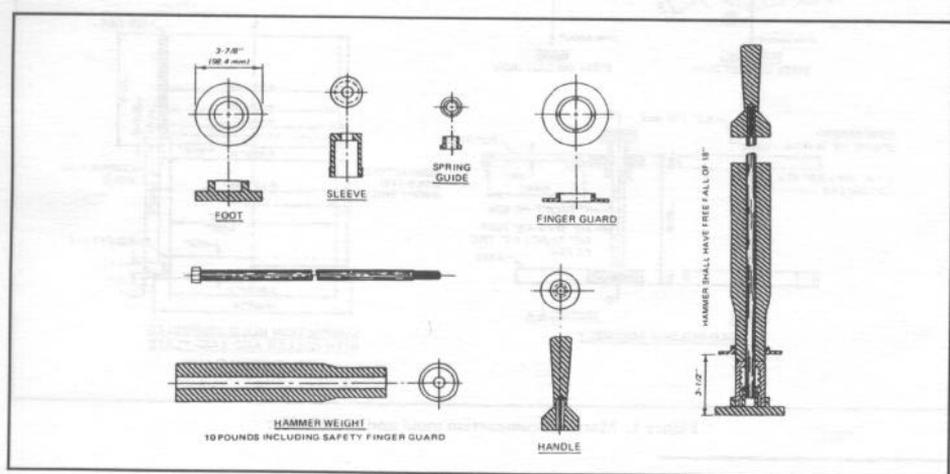


Figure 3. Compaction hammer

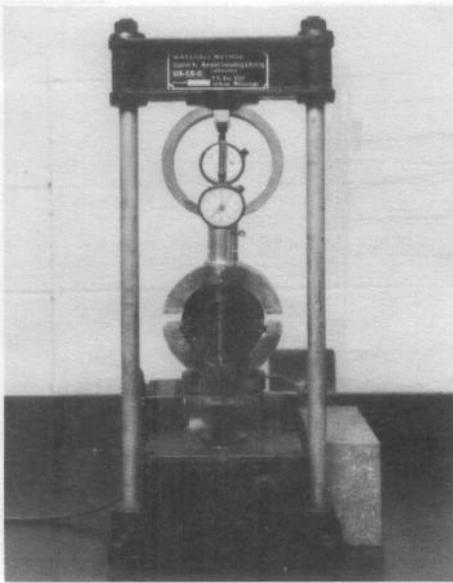


Figure 4. Marshall stability test apparatus

compaction obtained will not establish the proper density requirements for field compaction.

2.5 A breaking head (Figures 4 and 5) consisting of upper and lower cylindrical segments or test heads that have an accurately machined inside radius of curvature of 2.0000 ± 0.0025 in. The lower segment shall be mounted on a base having two perpendicular guide rods or posts extending upward. The upper segment shall be positioned so that the two segments are directed together without appreciable binding or loose motion on the guide rods.

2.6 A loading devise (Figures 4 and 6) consisting of a motor, mounted in a testing frame, that will produce a uniform vertical movement of 2.00 ± 0.05 in. per minute.

Note: A mechanical or hydraulic testing machine (Figure 7) may be used if the rate of movement can be maintained at 2.00 ± 0.05 in. per minute while the load is applied.

2.7 The proving ring (Figures 4 and 6) of 5,000 lbf capacity and sensitivity of 10 lbf for loads up to 1,000 lbf and 25 lbf for loads between 1,000 and 5,000 lbf. The micrometer dial on the proving ring shall be graduated in 0.00001-in. increments. Upper and lower proving ring attachments are required for fastening the

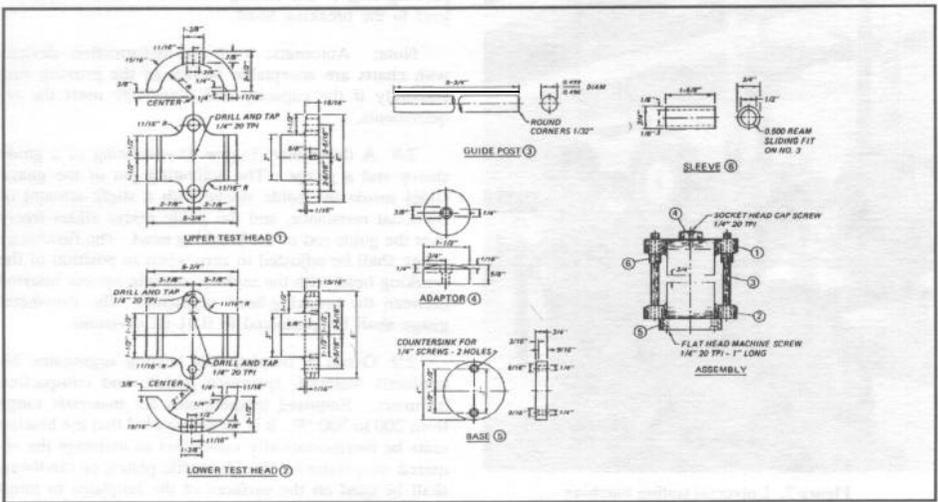


Figure 5. Marshall breaking head

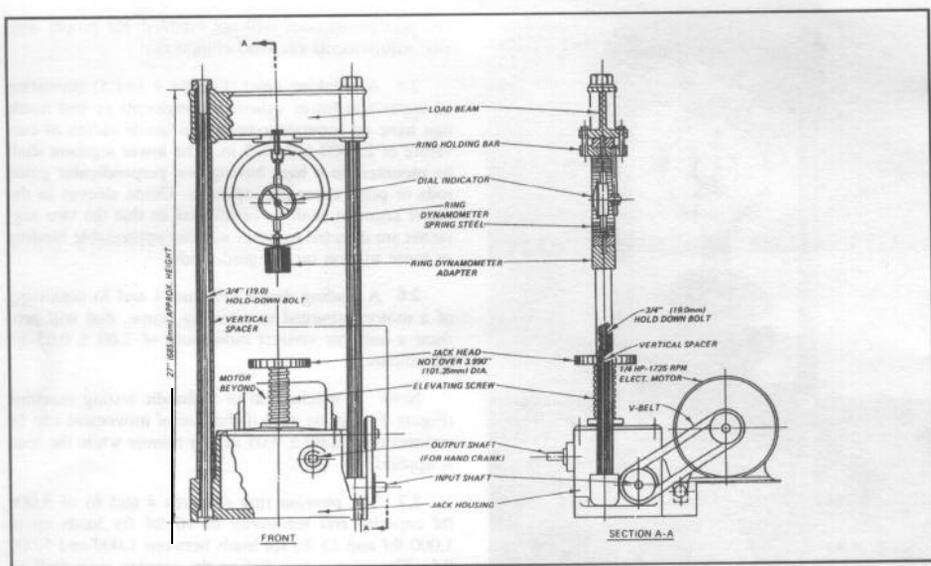


Figure 6. Marshall compression testing machine

proving ring to the testing frame and transmitting the load to the breaking head.

Note: Automatic load and deformation devices with charts are acceptable in lieu of the proving ring assembly if the capacity and sensitivity meet the requirements.

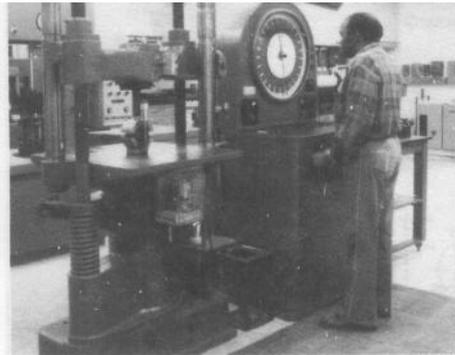


Figure 7. Universal testing machine

2.8 A flowmeter (Figure 4) consisting of a guide sleeve and a gauge. The activating pin of the gauge slides inside the guide sleeve with a slight amount of frictional resistance, and the guide sleeve slides freely over the guide rod of the breaking head. The flowmeter gauge shall be adjusted to zero when in position of the breaking head with the asphalt concrete sample inserted between the breaking-head segment. The flowmeter gauge shall be graduated in 0.01-in. divisions.

2.9 Ovens or hotplates for heating aggregates, bituminous material, specimen molds, and compaction hammers. Required temperatures for materials range from 200 to 300 °F. It is recommended that the heating units be thermostatically controlled to maintain the required temperatures. Shields, baffle plates, or sandbaths shall be used on the surfaces of the hotplates to minimize localized overheating.



Figure 8. Mechanical mixer

2.10 A metal pan or bowl. Hand mixing may be used; however, mechanical mixing is recommended (Figure 8). Any type of mechanical mixer may be used if the required mixing temperature can be maintained and a well-coated homogeneous mixture can be produced in the allowable time. Two 10-qt mixing bowls and two wire stirrers are recommended.

2.11 A water bath (Figure 9) at least 6 in. deep provided with mechanical water agitator, heating elements, and thermostatic controls capable of maintaining the bath water at temperatures ranging from 100 to 140 °F. The bath shall have a perforated false bottom or be equipped with a shelf for supporting specimens 2 in. above the bottom of the bath.

Note: Some water baths marketed are not equipped with agitators and will not maintain the 140 ± 1 °F temperature requirement.



Figure 9. Water bath

2.12 Any type of mechanical sieve shaker provided it has a capacity of six full-height, 8-in.-diameter sieves.

2.13 Sieves. Sieves of 8-in. diameter and of the following sizes are required: 25.0-mm, 19.0-mm, 12.5-mm, 9.5-mm, 4.75-mm, 2.36-mm, 1.18-mm, 600- μ m, 150- μ m, 300- μ m, and 75- μ m (1-in., 3/4-in., 1/2-in., No. 4, No. 8, No. 16, No. 30, No. 50, No. 100, and No. 200). The sieves shall conform to the requirements of ASTM E 11. Large, rectangular-shaped screens and shaking facilities are recommended for preparation of large samples.

2.14 One sink with cold running water is required to cool molded specimens prior to extrusion from the mold cylinder.

2.15 Appurtenant equipment.

(a) Containers for heating aggregates, such as flat-bottom metal pans, or other suitable containers.

(b) Containers for heating bituminous material, such as metal cups, beakers, or pouring pots.

(c) Mixing tools, either steel trowel (garden type) or spatula, for spading and handmixing.

(d) Thermometers for determining temperatures of aggregates, bitumen, and bituminous mixtures. Armored glass thermometers or dial-type with metal stem are recommended. They must have a range of 50 to 400 °F with a sensitivity of 5.0 °F.

(e) Thermometers for water bath with a minimum range of 99 to 141 °F and graduated to 0.5 °F.

(f) Balance, 2-kg capacity, sensitive to 0.1 g, for weighing molded specimens.

(g) Balance, 20-kg capacity, sensitive to 1.0 g, for preparing bitumen and aggregate mixtures.

(h) Wire basket and water bucket suitable for weighing molded specimens in water.

(i) Gloves for handling hot equipment.

(j) rubber gloves for removing specimens from water bath.

(k) Marking crayons for identifying specimens.

(l) Scoop, 2-qt size, for handling hot aggregates.

(m) Scoop, flat bottom, for placing mixture in specimen molds.

3. Preparation of Specimens.

3.1 Preparation of aggregates. Dry aggregates to constant weight at 230 ± 9 °F and separate the aggre-

gates by sieving into the desired sieve fractions. The following separations are recommended for paving mixtures having 19.0-mm (3/4-in.) nominal maximum size aggregate: 19.0-9.5-mm (3/6 3/8-in.), 9.5-mm 4.75-mm (3/8-in. to No. 4), 4.75-mm 2.36-mm (No. 4 to No. 8), and finer than 2.36-mm (No. 8). Aggregate separation may be accomplished in a large, processing-type sieve shaker, a standard mechanical sieve shaker, or a rocker-type hand shaker.

3.2 *Preparation of mixtures.* Weigh into individual pans the amount of each size fraction required to produce a batch that will result in the desired number of compacted specimens, each 2.5 ± 0.125 in. in height. This will require approximately 1,200 g of blended aggregate per specimen. Figure 10 illustrates the form recommended for recording these laboratory batch weights. Place the pans on the hotplate or in the oven, and heat to the temperatures indicated in this tabulation.

Bituminous Mixture Weights						
Job No.:		W/R No.:		Date: 3 June 1994		
Project: Typical Mix						
Description of Blend Used: Stockpile Samples						
Type of Bitumen: AC 20 Asphalt						
Aggr Temp: 300°F		Bitumen Temp: 270°F		Comp Temp: 250°F		
Blend No.						
Aggr Size	Per Cent	Weights		Per Cent	Weights	Accumulative Weights
Coarse	34.9	418.8	Aggregate	96.0	1200	1200
			Bitumen	4.0	50	
Fine	55.1	661.2	Aggregate	95.0	1200	1263
			Bitumen	5.0	63	
N. Sand	10.0	120.0	Aggregate	94.5	1200	1270
			Bitumen	5.5	70	
			Aggregate	94.0	1200	1277
			Bitumen	6.0	77	
			Aggregate	93.5	1200	1283
			Bitumen	6.5	83	
			Aggregate			
			Bitumen			
			Aggregate			
			Bitumen			
			Aggregate			
			Bitumen			
Total	100.0	1200				
Computed by: RTG		Checked by: RRU		Aggr blend prepared by: DK		Mix prepared by: JKS
						Compacted by: JKS

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Figure 10. Bituminous mixture weights

Type Bitumen	Mixing Temperature	
	Aggregate	Bitumen
Asphalt cement	300 ± 5 °F	270 ± 5 °F
Tar, RT-10, -11, -12, or -14	225 ± 5 °F	200 ± 5 °F

Charge the heated aggregate into the heated mixing bowl, and mix the dry aggregate thoroughly. Form a crater in the dry blended aggregate, and add the required weight of bitumen at the required temperature. Mix the aggregate and the bituminous material rapidly until the aggregate is thoroughly coated. Mixing should be completed as quickly as possible to minimize heat loss.

3.3 *Compaction of specimens.* Thoroughly clean the specimen mold assembly and the face of the compaction hammer, and heat them either in hot water on a hotplate or in an oven to a temperature between 180 and 250 °F. Place a piece of filter paper, paper towel, or kraft paper cut to size in the bottom of the mold before the mixture is introduced. Place the mixture in the mold, and spade with a heated spatula or trowel around the perimeter. Remove the collar, and smooth the surface of the mix with a trowel to a slightly rounded shape. Temperatures of the mixtures immediately prior to compaction shall be:

Type Bitumen	Compaction Temperature
Asphalt cement	250 ± 5 °F
Tar, RT-10, -11, -12, or -14	180 ± 5 °F

Replace the collar, place the mold assembly on the compaction pedestal in the mold holder, and apply the appropriate number of blows with the compaction hammer using a free fall of 18 in. The hammer should be held in a vertical position with one hand, and compaction should be performed with the other hand. A guide should not be used to hold the hammer vertical. After compaction, remove the baseplate and collar, invert the sample, and reassemble the mold. Apply the same number of compaction blows to the face of the inverted specimen. Fifty blows on each side of the specimen are used for mix design for roads, streets, and facilities for aircraft with tires inflated to 100 psi or less; 75 blows on each side of the specimen are used for mix designs for facilities that will be used by aircraft with tire pressures greater than 100 psi and for heavy duty

6. Safety Precautions.

Local exhaust ventilation (e.g., lab hoods) must be provided when bituminous materials are heated, since

heating may produce polynuclear aromatic compounds. Such compounds are known carcinogens.

COMPUTATION OF PROPERTIES OF BITUMINOUS MIXTURES																				
JOB NO.:		PROJECT:			DESCRIPTION OF BLEND:										DATE:					
SPECIMEN NO.	BITUMEN CONTENT-%	THICKNESS IN.	WEIGHT-GRAMS		VOLUME CC	SPECIFIC GRAVITY		BITUMEN BY VOLUME-%			VOIDS-PERCENT			UNIT WEIGHT LB/CU FT		STABILITY			FLOW 1/100'	
			IN AIR	IN WATER		ACTUAL	THEOR.	I	J	K	L	M	N	O	P	Q	R	S		
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S		
1	5.0		1231.0	717.4	513.6	2.397														
2			1242.4	722.4	520.0	2.389														
3			1223.5	710.5	513.0	2.385														
AVG						2.390	2.565	9.3	6.8	16.1	37.8	149.1								
1	6.5		1230.8	722.9	513.9	2.407														
2			1221.0	712.6	508.4	2.402														
3			1232.5	720.9	511.6	2.409														
AVG						2.406	2.543	10.5	5.5	16.0	65.6	150.1								
1	5.0		1185.1	695.3	488.8	2.420														
2			1233.7	721.4	512.3	2.408														
3			1239.9	727.6	512.3	2.420														
AVG						2.416	2.525	11.8	4.3	26.1	71.3	150.8								
1	5.5		1243.2	732.4	511.3	2.432														
2			1245.3	736.4	510.9	2.437														
3			1241.2	732.8	508.4	2.441														
AVG						2.437	2.506	13.0	2.8	15.8	82.3	152.1								

** FROM CONVERSION TABLE COMPUTED BY: RTG CHECKED BY: RJJ

WES FORM 883 *SP. GR. OF BITUMEN 1.028

Figure 12. Computation of properties of bituminous mixtures

COMPUTATION OF PROPERTIES OF BITUMINOUS MIXTURES																				
JOB NO.:		PROJECT:			DESCRIPTION OF BLEND:										DATE:					
SPECIMEN NO.	BITUMEN CONTENT-%	THICKNESS IN.	WEIGHT-GRAMS		VOLUME CC	SPECIFIC GRAVITY		BITUMEN BY VOLUME-%			VOIDS-PERCENT			UNIT WEIGHT LB/CU FT		STABILITY			FLOW 1/100'	
			IN AIR	IN WATER		ACTUAL	THEOR.	I	J	K	L	M	N	O	P	Q	R	S		
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S		
1	6.0		1244.7	730.8	513.9	2.422														
2			1244.1	731.8	512.3	2.428														
3			1248.7	735.1	512.6	2.431														
AVG						2.427	2.487	14.2	2.4	16.8	85.4	151.5								
1	6.5		1120.6	721.1	503.5	2.427														
2			1213.7	713.3	500.6	2.425														
3			1224.8	719.5	503.3	2.424														
AVG						2.425	2.468	13.3	1.7	12.0	89.5	151.3								

** FROM CONVERSION TABLE COMPUTED BY: RTG CHECKED BY: RJJ

WES FORM 883 *SP. GR. OF BITUMEN 1.028

Figure 12. (Concluded)

Volume¹ of specimen in cubic centimeters	Approximate thickness of specimen, in.	Correlation ratio
200-213	1.00	5.56
214-225	1.06	5.00
226-237	1.13	4.55
238-250	1.19	4.17
251-264	1.25	3.85
265-276	1.31	3.57
277-289	1.38	3.33
290-301	1.44	3.03
302-316	1.50	2.78
317-328	1.56	2.50
329-340	1.63	2.27
341-353	1.69	2.08
354-367	1.75	1.92
368-379	1.81	1.79
380-392	1.88	1.67
393-405	1.94	1.56
406-420	2.00	1.47
421-431	2.06	1.39
432-443	2.13	1.32
444-456	2.19	1.25

457-470	2.25	1.19
471-482	2.31	1.14
483-495	2.38	1.09
496-508	2.44	1.04
509-522	2.50	1.00
523-535	2.56	0.96
536-546	2.63	0.93
547-559	2.69	0.89
560-573	2.75	0.86
574-585	2.81	0.83
586-598	2.88	0.81
599-610	2.94	0.78
611-625	3.00	0.76
626-637	3.06	0.74
638-649	3.13	0.71
650-662	3.19	0.69
663-676	3.25	0.68

Note: The measured stability of a specimen multiplied by the correlation ratio determined for the thickness of the specimen equals the corrected stability for a 2.5-in. specimen.

¹Volume-thickness relation is based on a specimen diameter of 4 in. Thicknesses shown in Table I are for use when tests are conducted on specimens whose dimensions vary from the desired 2.5 ± 0.125 in. in height.