

1303**LIQUID LIMIT DETERMINATION**

AASHTO Designation T 89

1303.1 DEFINITION

The Liquid Limit of a soil is that water content, as determined in accordance with the following procedure, at which the soil passes from a plastic to a liquid state.

1303.2 APPARATUS

- A. Evaporating Dish - A porcelain dish (preferably unglazed) about 115mm (4 1/2 inches) in diameter.
- B. Spatula - A spatula having a blade about 75mm (3 inches) in length and about 20mm (3/4 inches) in width.
- C. Liquid Limit Device - A mechanical device consisting of a brass dish and carriage as described and shown in AASHTO T 89.
- D. Grooving Tool - A combined grooving tool and gauge conforming to the dimensions as shown in AASHTO T 89.
- E. Containers - Suitable containers with lids which will prevent loss of moisture prior to and during weighing. Containers should be fabricated from corrosion-resistant material. One container is needed for each moisture content determination.
- F. Balance - A balance conforming to the requirements of AASHTO M 231, Class C, with a readability, sensitivity of 0.01 grams and an accuracy of 0.02 grams.
- G. Oven - A thermostatically-controlled, drying oven capable of maintaining a temperature of 110 ± 5 °C (230 ± 9 °F) for drying moisture samples.

1303.3 Adjustment of the Mechanical Device

- A. Inspection
 - 1. Check the liquid limit device to determine that it is in good working order.
 - 2. The pin connecting the cup shall not be worn sufficiently to permit side play.

3. The screws connecting the cup to the hanger arm shall be tight.
4. A cup that has been grooved from use shall be replaced.
5. The grooving tool shall be inspected to determine that critical dimensions conform to AASHTO T 89.

B. Adjustments

1. By means of the gauge on the handle of the grooving tool, and the adjustment plate on the liquid limit device, the height to which the cup is lifted shall be adjusted so that the point on the cup which comes in contact with the base is exactly $10\text{mm} \pm 2\mu\text{m}$ above the base.
2. Determine the point on the cup which comes in contact with the base.
 - a. For new cups, place a piece of carbon paper on the base. Allowing the cup to drop several times will mark the contact spot.
 - b. For used cups, a slightly worn spot will be present.
3. After the contact point is determined place a piece of masking tape across the bottom of the cup. The edge of the tape, away from the hanger, should bisect the contact spot on the cup and remain parallel with the axis of the cup hanger. **See Section 1303.10 for a diagram of the cup and a figure showing the location of the tape.**
4. Turn the crank until the cup is raised to its maximum height. Slide the gauge under the cup from the front. Observe whether the gauge contacts the cup or the tape. If the tape edge and the cup are both contacted the height is approximately correct. If not, adjust the cup until simultaneous contact is made.
5. The adjustment plate shall then be secured by tightening the screws. With the gauge still in place the adjustment shall be checked by revolving the crank several times. If the adjustment is correct a slight ringing or clicking sound will be heard when the cam strikes the cam follower. If the cup is raised off the gauge or no sound is heard further adjustments shall be made.

6. Always remove the tape after completion of the adjustments.

1303.4 PROCEDURE - STANDARD METHOD (AASHTO T 89, Method A)
(Refer to Section 1301)

- A. A soil sample of about 100 grams of material passing the 425 μ m (#40) sieve shall be placed in the evaporating dish and thoroughly mixed with distilled or demineralized water by alternately and repeatedly, stirring, kneading and chopping with a spatula. Further additions of water shall be made in small (1-3ml) increments. With each increment, the water shall be thoroughly mixed with the soil before another increment of water is added. Take approximately a 10 gram sample from the mixed soil and lay aside to season for use in the plastic limit test. (See Section 1304.)

NOTE 1: Once testing has begun **NO** additional dry soil shall be added to the moistened soil. If too much water has been added, the sample shall be discarded, or the sample shall be mixed and kneaded until natural evaporation lowers the closure point into an acceptable range.

NOTE 2: Some soils absorb water more slowly than others so that it is possible to add the water so fast that a false liquid limit value is obtained. This can be avoided if the sample is mixed thoroughly or more time is allowed.

- B. When sufficient water has been mixed with the soil to form a uniform mass of stiff consistency, a sufficient quantity of this mixture is placed in the liquid cup and spread out by use of the spatula. The soil shall be leveled with the spatula and trimmed to a depth of 100 μ m at the point of its maximum thickness.
- C. The soil in the cup shall be divided by a firm stroke of the grooving tool along the diameter through the centerline of the cam follower so that a clean sharp groove of the proper dimensions will be formed. To avoid tearing of the sides of the groove or slipping of the soil cake on the cup, 6 strokes maximum from front to back or back to front shall be permitted. The depth of the groove should be increased with each stroke and only the last stroke should scrape the bottom of the cup.
- D. The cup containing the sample shall be lifted and dropped by turning the crank at the rate of two revolutions per second until the two sides of the sample come in contact at the bottom of the groove along a distance of about 12mm (1/2 inch). Do not hold the base of the machine while turning the crank. Record the number of blows required to close the groove. (A motorized device is acceptable provided it produces the same liquid limit values.)

NOTE 3: Frequently check the liquid limit device's adjustment and tighten the screws connecting the brass cup to the hanger arm.

- E. A slice of soil approximately the width of the spatula extending from edge to edge of the soil cake at right angles to the groove, including that portion of the groove in which the soil flowed together, shall be removed and placed in a suitable container.
- F. The container and soil shall be weighed and the weight recorded. The soil in the container shall be oven-dried to a constant weight at 110 ± 5 °C (230 ± 9 °F) and weighed. This weight shall be recorded and the loss in weight due to drying shall be recorded as the weight of water. (1303 Figure 1)
- G. Transfer the remaining soil in the cup to the evaporating dish. Wash and dry the cup and grooving tool in preparation for the next trial.
- H. The foregoing operations shall be repeated for at least two additional portions of the sample to which sufficient water has been added to bring the soil to a more fluid condition. The object of this procedure is to obtain samples of such consistency that at least one determination will be made in each of the following ranges: 25-35 blows, 20-30 blows and 15-25 blows so the range in the three determinations is at least 10 blows. (EXAMPLE: 28-23-18 blows.) Ideally, a spread greater than 10 blows is desired in the determinations.

1303.5 ALTERNATE METHOD (One Point) (See AASHTO T 89, Method B)

- A. The procedure is the same as prescribed in Section 1303.4 except that only one moisture sample shall be taken for the accepted trial.
- B. At least two groove closures shall be observed before one is accepted for the record to assure that the accepted number of blows is characteristic of the soil being tested.

NOTE 4: Some soils absorb water more slowly than others so that it is possible to add the water so fast that a false liquid limit value is obtained. This can be avoided if the sample is mixed thoroughly or more time is allowed.

- C. Groove closures may be taken between 15-40 blows. This will give accuracy of $\pm 5\%$ of the true liquid limit.
- D. For accuracy equal to that obtained by the three-point method, the accepted number of blows shall be restricted to 22-28 blows.

1303.6 CALCULATIONS for STANDARD METHOD (Three points)

- A. The water content of the soil shall be expressed as the moisture content in percentage of the weight of the oven-dried soil and calculated as follows:

$$\% \text{ Moisture} = \frac{\text{Weight of Water}}{\text{Weight of Oven-dried Soil}} \times 100$$

As in the example (Can #1):

$$\% \text{ Moisture} = \frac{3.02}{0.44} \times 100 = 28.9$$

NOTE 5: See Form #2485 (Section 1303.8)

- B. A "flow curve" representing the relation between moisture content and corresponding number of blows shall be plotted on a semi logarithmic graph. The flow curve shall be a straight line drawn as nearly as possible through the three or more plotted points. See Form #2485 (Section 1303.8)
- C. Liquid Limit - The moisture content corresponding to the intersection of the flow curve at 25 blows shall be taken as the liquid limit of the soil. Report this value to the nearest whole number.

1303.7 CALCULATIONS - ALTERNATE METHOD

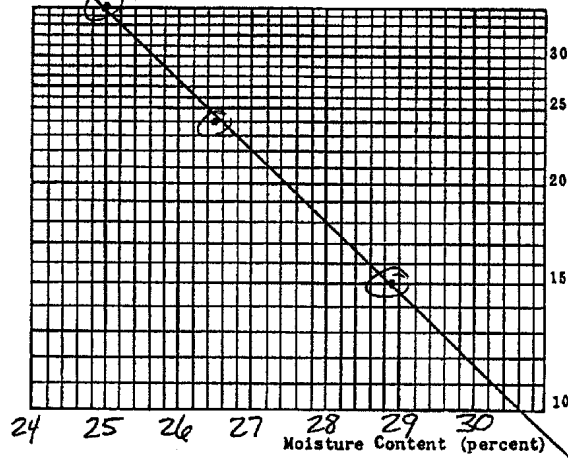
- A. See Section 1303.6A (above).
- B. The liquid limit shall be determined by using the Chart Tables (Section 1303.9)

1303.8 EXAMPLE - FORM # 2485

Mn/DOT 2485 (3-77)

Lab. No. SS93XXX Date 1-1-93

Operator DL Computer DL



LIQUID LIMIT DETERMINATION (A.A.S.H.O. T. 89)

No. of Blows	15	24	35
Can No.	#1	#2	#3
Wet Weight gms.	27.84	28.89	27.84
Dry Weight gms.	24.82	25.86	25.19
Loss gms. (WATER WT.)	3.02	3.03	2.65
Can Weight gms.	14.38	14.42	14.58
Dry Soil Weight gms.	10.44	11.44	10.61
Moisture Content %	28.9	26.5	25.0
Correction Factor ^(see point) _(method)			
Liquid Limit			

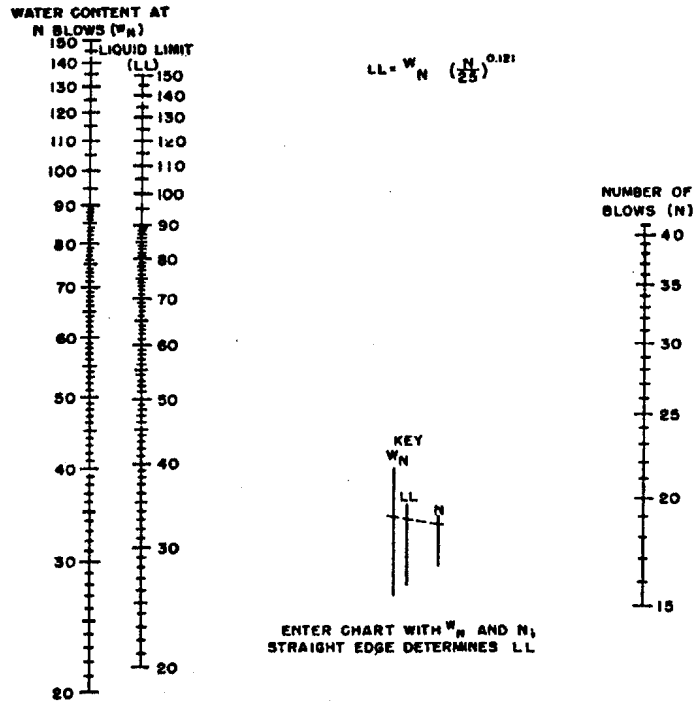
PLASTIC LIMIT DETERMINATION (A.A.S.H.O. T. 90)

	1	2
Can No.	#4	#5
Wet Weight gms.	19.21	18.80
Dry Weight gms.	18.40	18.06
Loss gms. (WATER WT.)	0.81	0.74
Can Weight gms.	14.47	14.58
Dry Soil Weight gms.	3.93	3.48
Plastic Limit %	20.61	21.26
Average Plastic Limit %		

Liquid Limit % 26
 Plastic Limit % 21
 Plasticity Index 5

1303.9

EXAMPLE - CHART TABLES for ALTERNATE METHOD



Nomographic Chart Developed by the Waterways Experiment Station, Corps of Engineers, U.S. Army, to Determine Liquid Limit Using Mean Slope Method

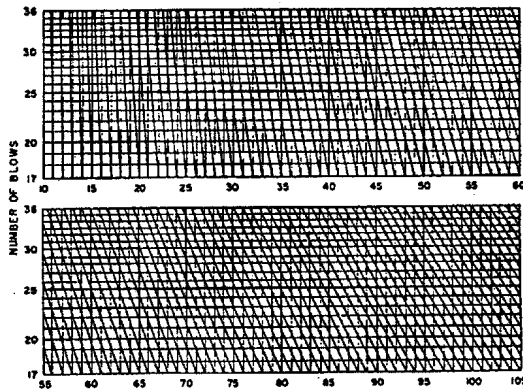
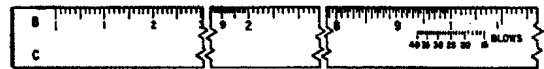
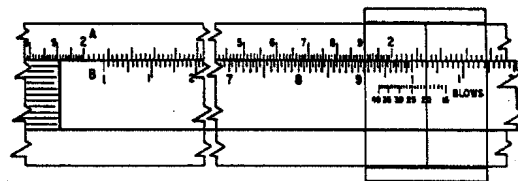


Chart Developed by Washington State Highway Department for the Calculation of the Liquid Limit



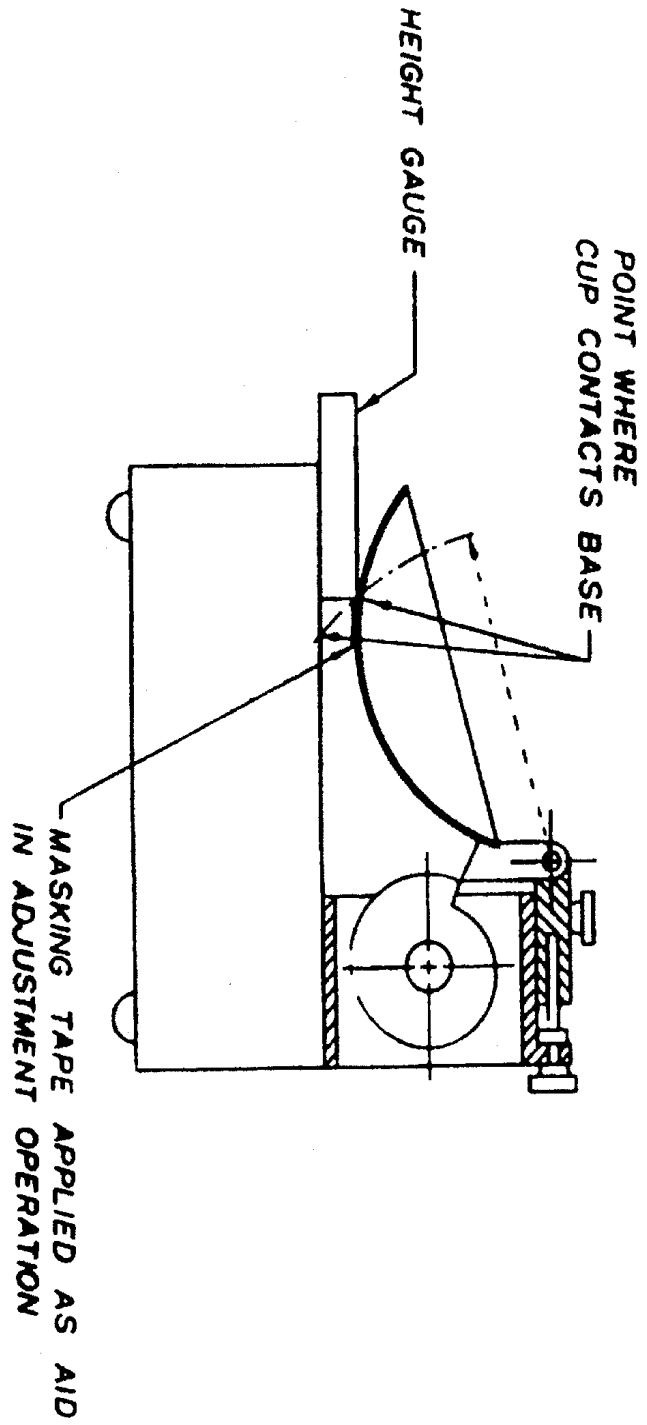
A - LOCATION OF SPECIAL SCALE (BLOWS) WITH RESPECT TO B SCALE OF SLIDE RULE



B - SLIDE RULE SET FOR 21.4 PERCENT MOISTURE AT 20 BLOWS, INDICATING CALCULATED LIQUID LIMIT OF 20.8

Slide Rule with Special Scale for the Calculation of the Liquid Limit

1303.10 LIQUID LIMIT DEVICE



Liquid Limit Device