

## **WSDOT Errata to FOP for AASHTO T 89**

### ***Determining the Liquid Limit of Soils***

WAQTC FOP for AASHTO T 89 has been adopted by WSDOT with the following changes:

**Procedure – Method A (Multi-Point) – *Not recognized by WSDOT, use Method B (Single-Point):***



## DETERMINING THE LIQUID LIMIT OF SOILS FOP FOR AASHTO T 89

### Scope

This procedure covers the determination of the liquid limit of a soil in accordance with AASHTO T 89-22. It is used in conjunction with the FOP for AASHTO T 90, Determining the Plastic Limit and Plasticity Index of Soils. The three values are used for soil classification and other purposes.

### Apparatus

- Dish: preferably unglazed porcelain or similar mixing dish, about 115 mm (4.5 in.) in diameter.
- Spatula: having a blade 75 to 100 mm (3 to 4 in.) long and about 20 mm (3/4 in.) wide.
- Liquid Limit Device: manually or mechanically operated, consisting of a brass cup, carriage, and base plate and conforming to the critical dimensions shown in AASHTO T 89 Figure 1.
- Grooving Tool: used to cut the soil in the liquid limit device cup and conforming to the critical dimensions shown in AASHTO T 89 Figure 1.



- Gauge: either part of the grooving tool or a separate metal bar,  $10.0 \pm 0.2$  mm ( $0.394 \pm 0.008$  in.) thick and approximately 50 mm (2 in.) long.
- Containers: corrosion resistant, suitable for repeated heating and cooling, having close fitting lids to prevent the loss of moisture. One container is needed for each moisture content determination.
- Balance: conforming to AASHTO M 231, class G1, sensitive to 0.01 g with a minimum capacity of 100 g.
- Oven: thermostatically controlled, capable of maintaining temperatures of  $110 \pm 5^\circ\text{C}$  ( $230 \pm 9^\circ\text{F}$ ).
- Graduated cylinders for measuring distilled or demineralized water.

- Sieve: 0.425 mm (No. 40) sieve meeting the requirements of the FOP for AASHTO T 27/T 11.

### Adjustment of Liquid Limit Device

The liquid limit device shall be inspected to determine that the device is in good working order; that the pin connecting the cup is not worn to permit side play; that the screws connecting the cup to the hanger are tight; that the points of contact on the cup and base are not excessively worn; that the lip of the cup is not excessively worn; and that a groove has not been worn in the cup. The grooving tool shall be inspected to determine that the critical dimensions are correct.

*Note 1:* Wear is considered excessive when the point of contact on the cup or base exceeds approximately 13 mm (0.5 in.) in diameter, or when any point on the rim of the cup is worn to approximately 1/2 the original thickness. A slight groove in the center of the cup is not objectionable. If the groove becomes pronounced, the cup shall be replaced. A base that is excessively worn may be refinished as long as it is maintained within the tolerances specified.

Adjust the height of drop of the cup so that the point on the cup that comes in contact with the base rises to a height of  $10.0 \pm 0.2$  mm ( $0.394 \pm 0.008$  in.).

*Note 2:* Check the height of the drop, before each new sample, by turning the crank at two revolutions per second while holding the gauge in position against the cup. If a ringing or clicking sound is heard without the cup rising from the gauge, the adjustment is correct. If no ringing is heard or if the cup rises from gauge, readjust the height of the drop. If the cup rocks on the gauge during this checking operation, the cam follower pivot is excessively worn and should be replaced.

### Sample

Samples must be prepared per the AASHTO R 58 or R 74. Obtain a sample with a mass of about 100 g taken from the portion of the material passing the 0.425 mm (No. 40) sieve.

The mass required depends upon the method chosen. Method A (multi-point method) requires approximately 100 g. Method B (single point method) requires approximately 50 g.

### Procedure – Method A (Multi-Point)

1. Determine mass of empty dry container(s) and lid(s) to the nearest 0.01 g.
2. Place the sample in the dish and thoroughly mix with 15 to 20 mL of distilled or demineralized water by alternately and repeatedly stirring, kneading, and chopping with a spatula. Further additions of water shall be in increments of 1 to 3 mL. Each increment shall be thoroughly mixed with the soil before another increment is added. Once testing has begun, no additional dry soil should be added to the moistened soil. The cup of the Liquid Limit device shall not be used for mixing soil and water. If too much water is added, the sample shall either be discarded or mixed and kneaded until natural evaporation lowers the moisture content.

*Note 3:* Some soils are slow to absorb water. It is possible to add water so fast that a false LL value is obtained. This can be avoided by allowing more mixing and/or time. Also, tap water may be used for routine testing if comparative tests indicate no differences in results between using tap water and distilled or demineralized water.

3. Add sufficient water to form a uniform mass of a stiff consistency.

4. Place enough material in the cup so that, when squeezed and spread with the spatula, the soil will rest in the cup above the spot where the cup rests on the base and will be 10 mm thick at the point of maximum thickness. Use as few strokes of the spatula as possible, taking care to prevent the entrapment of air bubbles in the sample.
5. Divide the soil in the cup with a firm stroke of the grooving tool. Avoid tearing of the sides of the groove or slipping of the soil cake on the cup. Up to six strokes are permitted with a stroke from front to back or from back to front counting as 1 stroke. The depth of the groove should be increased with each stroke, and only the last stroke should scrape the bottom of the cup.
6. Lift and drop the cup by turning the crank at a rate of approximately two revolutions per second until the two halves of the soil pat come together along a distance of about 13 mm (0.5 in.). Do not hold the base while the crank is turned. Record the number of shocks required to close the groove this distance.

*Note 4:* Some soils tend to slide on the cup instead of flowing. If this occurs, water should be added, the sample remixed, and the procedure repeated. If the soil continues to slide on the cup, the test is not applicable, and a note should be made that the liquid limit could not be determined.

7. Use the spatula to obtain a moisture content sample by slicing through the soil pat perpendicularly to the groove. Remove the sample extending edge to edge and including the portion of the groove that flowed together. Place it into a suitable container and cover for subsequent moisture determination.
8. Determine the moisture percentage of the moisture content sample in accordance with the FOP for AASHTO T 255/T 265 (Soil).
9. Place the soil remaining in the cup back in the mixing dish and add 1 to 3 mL of water or use previously prepared portions to which sufficient water has been added to result in a more fluid condition.
10. Repeat Steps 4 through 9, a minimum of two times. The object is to have a determination in all three shock ranges 25-35, 20-30, and 15-25 and span a range of at least 10 shocks.
11. Determine the moisture content of the moisture content sample in accordance with the FOP for AASHTO T 255/T 265 (Soil). (Remove lids and keep with containers while drying.)

### **Flow Curve – Method A**

Prepare a flow curve on a semi-logarithmic graph with moisture content on the arithmetic vertical axis and the number of shocks on the logarithmic horizontal axis. The flow curve is a straight line drawn as closely as possible through three or more plotted points.

### **Liquid Limit – Method A**

Determine the liquid limit. The moisture content at the intersection of the flow curve and the 25 shock line is the liquid limit.

### Procedure – Method B (Single-Point)

1. Determine mass of empty dry container(s) and lid(s) to the nearest 0.01 g.
2. Place the sample in the dish and thoroughly mix with 8 to 10 mL of distilled or demineralized water, and follow the mixing procedure in Method A, Step 1.
3. Follow the procedure in Method A except that the soil pat should be prepared with water to produce a consistency that will close the two halves of the soil pat at least 13 mm (0.5 in.) within 22 to 28 shocks of the cup.

**Note 5:** Groove closures occurring between 15 and 40 blows may be accepted if variations of  $\pm 5$  percent of the true liquid limit are tolerable.

4. Return the soil remaining in the cup to the mixing dish and, without adding any additional water, repeat Step 2. If the closure again occurs within the acceptable range and is within 2 shocks of the first, obtain a moisture content specimen as described in Method A.
5. Determine the moisture content of the moisture content sample in accordance with the FOP for AASHTO T 255/T 265 (Soil).
6. Determine the moisture content of the moisture content sample in accordance with the FOP for AASHTO T 255/T 265 (Soil). (Remove lids and keep with containers while drying.)

### Liquid Limit – Method B

Calculate the liquid limit as follows:

$$LL = (W_N)(N/25)^{0.121}$$

Where:

- LL = liquid limit  
 $w_N$  = moisture content of sample at N blows  
 N = number of blows

Example:

$$w_N = 16.0\% \quad \text{and} \quad N = 23$$

$$LL = 16.0\% \times \left(\frac{23}{25}\right)^{0.121} = 15.8\%, \text{ report } 16\%$$

Or using Table 1 (when number of shocks to closure of gap is 22-28):

$$LL = 16.0\% \times 0.990 = 15.8\%, \text{ report } 16\%$$

**Table 1**

<u>N</u>	<u>(N/25)<sup>0.121</sup></u>
22	0.985
23	0.990
24	0.995
25	1.000
26	1.005
27	1.009
28	1.014

Use Method A for referee testing to settle a dispute.

### **Report**

- Results on forms approved by the agency.
- LL rounded to the nearest 1 percent.





## PERFORMANCE EXAM CHECKLIST

### DETERMINING THE LIQUID LIMIT OF SOILS FOP FOR AASHTO T 89

Participant Name \_\_\_\_\_ Exam Date \_\_\_\_\_

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	Trial 1	Trial 2
1. Describe the inspection for wear of the liquid limit device:		
a. Cup to base connection pin does not allow side to side play of cup?	_____	_____
b. Wear at contact between cup and base ½ inch or less?	_____	_____
c. Edge of cup no less than ½ original thickness?	_____	_____
2. Describe how the height of the cup drop is adjusted:		
a. Checked before each use?	_____	_____
b. Turn crank while holding gauge in position under cup?	_____	_____
c. Check for ringing or clicking without rising of cup?	_____	_____
d. Cup does not rock?	_____	_____
3. Describe initial sample preparation:		
a. Material separated on appropriate sieves?	_____	_____
b. Soil sufficiently pulverized for separation of grains?	_____	_____
c. Material passing the No. 40 recombined and mixed?	_____	_____
4. Mass of empty dry container(s) and lid(s) determined to 0.01 g?	_____	_____
<b>Method A</b>		
5. Preparation of the sample for <b>Method A</b> :		
a. Sample mass approximately 100 g. of minus No. 40?	_____	_____
b. Sample mixed in dish with 15 to 20 ml of distilled or demineralized water?	_____	_____
c. Mixed with spatula until stiff consistency?	_____	_____
d. No dry soil added to lower moisture content?	_____	_____
6. Material placed in cup, centered, 10 mm thick?	_____	_____
7. Soil divided by using up to 6 strokes, preventing tearing or slipping of soil pat?	_____	_____

**OVER**

- 8. Cup lifted and dropped at a rate of 2 revolutions per second? \_\_\_\_\_
- 9. Soil pat halves come together over length of 13 mm (0.5 inch)? \_\_\_\_\_
- 10. Moisture sample properly taken and wet mass determined? \_\_\_\_\_
- 11. Moisture content determined by the FOP for AASHTO T 255/T 265 (soils)? \_\_\_\_\_
- 12. Steps repeated to achieve determinations in three shock ranges of 25-35, 20-30, and 15-25? \_\_\_\_\_
- 13. Flow curve plotted with shocks on logarithmic scale and the moisture on arithmetic scale? \_\_\_\_\_
- 14. Liquid Limit correctly calculated and rounded to nearest whole number? \_\_\_\_\_

**Method B**

- 5. Preparation of the sample for **Method B**:
  - a. Sample mass approximately 50 g. of minus No. 40? \_\_\_\_\_
  - b. Sample mixed in dish with 8 to 10 ml of distilled or demineralized water? \_\_\_\_\_
  - c. Mixed with spatula until stiff consistency? \_\_\_\_\_
  - d. No dry soil added to lower moisture content? \_\_\_\_\_
- 6. Material placed in cup, centered, 10 mm thick? \_\_\_\_\_
- 7. Soil divided by using up to 6 strokes with the grooving tool, preventing tearing or slipping of soil pat? \_\_\_\_\_
- 8. Cup lifted and dropped at a rate of 2 revolutions per second? \_\_\_\_\_
- 9. Soil pat halves come together over length of 13 mm (0.5 inch) between in the 23-28 shock range? \_\_\_\_\_
- 10. Second trial performed with soil pat closure within ± 2 shocks of previous trial? \_\_\_\_\_
- 11. Moisture sample properly taken and wet mass determined? \_\_\_\_\_
- 12. Moisture content determined by the FOP for AASHTO T 255/T 265 (soils)? \_\_\_\_\_
- 13. Liquid limit correctly calculated using equation or Table 1 and rounded to nearest whole number? \_\_\_\_\_
- 14. Results reported on standard agency form? \_\_\_\_\_

Comments: First attempt: Pass \_\_\_\_\_ Fail \_\_\_\_\_ Second attempt: Pass \_\_\_\_\_ Fail \_\_\_\_\_

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Examiner Signature \_\_\_\_\_ WAQTC #: \_\_\_\_\_