AASHTO re:source (formerly AMRL) In Focus

The Dynamic Shear Rheometer: Understanding the Temperature Requirements

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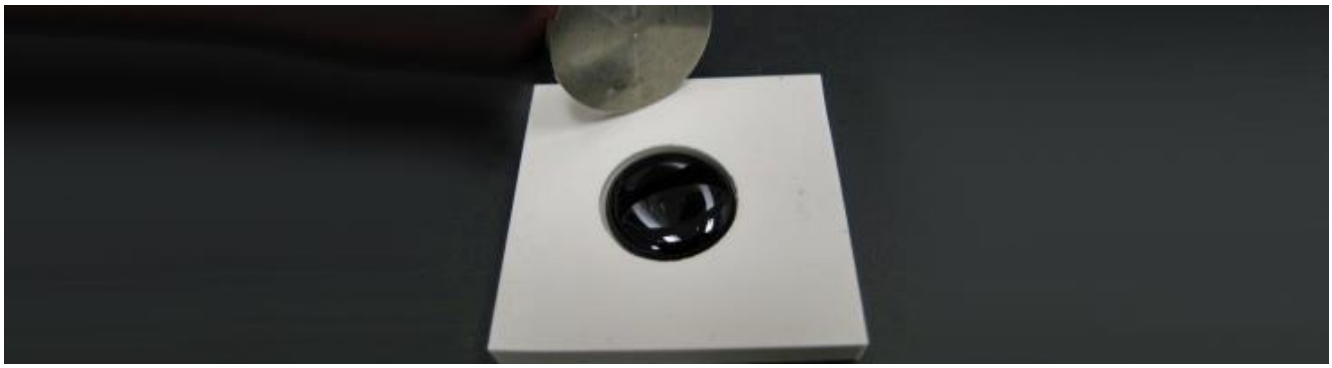

The Importance of Dynamic Shear Rheometer to the Performance-Graded Binder System
The dynamic shear rheometer (DSR), as described by *AASHTO T 315*, is arguably the most important apparatus used in the performance-graded (PG) binder system. The DSR is utilized in several instances as part of the binder grading specification, *AASHTO M 320*, and the provisional specification, *AASHTO MP 19*, which includes *AASHTO TP 70*, *The Multiple Stress Creep Recovery (MSCR) Test*. The MSCR test is performed on the DSR, and refers to *AASHTO T 315* for calibration and standardization requirements of the apparatus.

The Importance of Temperature Measurements in Asphalt Testing
It is well known that the properties of asphalt binder are highly sensitive to changes in temperature. Even small variations in temperature can produce vast differences in asphalt behavior. In fact, experts conclude that a change in temperature as small as one degree Celsius can produce changes in DSR measurements as great as 10 to 12%. As a result, the requirements of *AASHTO T 315* place a great deal of emphasis on ensuring the accuracy of temperature measurements. Because of the complex nature of the requirements, this portion of the standard can be difficult to interpret. This article provides guidance on the temperature requirements for *AASHTO T 315* and describes policies specific to the AASHTO Accreditation Program (AAP). These policies pertain particularly to the 2010 revision of *AASHTO T 315*, which is the current version of the standard at the time of publication of this article.

General Requirements
AASHTO T 315 requires specific temperature measurement equipment to ensure that the temperature between the plates is the temperature being measured by the DSR temperature detector. This is accomplished through a chain of calibrations and standardizations that begin with the reference thermometer (Section 6.6), extend to the portable thermometer (Section 6.7), and finally end with the temperature detector in the DSR itself.

Equipment Identified
There are two thermometers referenced in *AASHTO T 315*:

1. **The Portable Thermometer (Section 3.2.12 and Section 6.7):**
   The portable thermometer is used to standardize the temperature readings of the DSR. This device is defined as one unit comprised of the temperature detector, electronic circuitry, and a readout system. The entire unit (temperature detector and readout system) must be standardized as one device. Partial calibration of either the temperature detector or the readout system and its electronic circuitry as separate units is not an acceptable practice.

   The portable thermometer must be a resistance thermometer, usually either a thermistor or an industrial platinum resistance thermometer (IPRT). The device may produce a readout in either ohms or degrees Celsius. If readable in degrees Celsius, the device must have resolution of 0.1°C. If readable in ohms, the resistive readout must be converted to degrees Celsius by use of a polynomial best-fit equation.

   Please note that laboratories that are AASHTO accredited must maintain their own portable thermometer, even if an outside agency performs the standardization of their DSR's temperature detector. A thermocouple cannot be used as a portable thermometer for *AASHTO T 315*, as this type of device is not a resistive detector, and generally has a higher measurement uncertainty than a thermistor or IPRT.
2. **The Reference Thermometer (Section 3.2.13 and Section 6.6):**
   The reference thermometer is used to standardize the temperature readings of the portable thermometer. The terminology section of *AASTHO T 315* states that the thermometer must be NIST-traceable, and the apparatus section

provides the user with two options for this equipment, each with their own accuracy and readability requirements: a partial immersion liquid-in-glass thermometer (Section 6.6.1) or an electronic thermometer (Section 6.6.2).

If the laboratory maintains a liquid-in-glass thermometer as their reference device, it must be a partial immersion thermometer and have subdivisions of 0.1°C and an ice point. It is possible that, in order to cover the entire range of testing temperatures covered, more than one liquid-in-glass thermometer will be needed. If an electronic thermometer is used as the reference device, it must have a resolution of 0.01°C.

If an electronic thermometer is used as the reference thermometer, it must produce a direct readout in degrees Celsius. Resistance readings in ohms that are converted to degrees Celsius by use of a polynomial best-fit equation are not acceptable for the reference thermometer. The reliability of an ohm-to-degree conversion is dependent upon a host of things including the order and type of polynomial used, the substrate used in the resistive detector, and its sensitivity to temperature change. While a readout in ohms is acceptable for the portable thermometer, this is only the case because the measurements and subsequent conversions to temperature are standardized against a reference thermometer that reads in degrees Celsius.

If a laboratory hires an outside agency to standardize the temperature readings of their portable thermometer, the laboratory does not need to maintain their own reference thermometer to be AASHTO accredited. The outside agency that the laboratory uses must provide the laboratory with the calibration information and model and serial number of the reference thermometer used.

It is Possible to Have one Device that Conforms to Both Requirements

According to Section 6.7, the laboratory can use just one thermometer if it conforms to the requirements of both Section 6.6 and Section 6.7. An AASHTO accredited laboratory that utilizes this option must have the temperature readings of the device standardized according to Section 9.3.1. Please keep in mind that a device that only produces a resistance readout (ohms) cannot be used in this case. In addition, an AASHTO accredited laboratory that only uses one device that meets the requirements of both the reference thermometer and the portable thermometer must maintain their own device, even if standardization of the DSR's temperature detector is performed by an outside agency.

Calibration of the Reference Thermometer

The test method specifies that if the reference thermometer is a partial immersion liquid-in-glass thermometer, it must be standardized in accordance with *ASTM E563*. *ASTM E563* is the method for preparing an ice-point bath to be used as a reference temperature. There are many provisions in this standard that would make it very difficult for a laboratory to perform this practice on their own. If a laboratory attempts to perform an ice-point standardization, the AASHTO re:source scrutinize the laboratory's records to ensure that this standard is actually being implemented properly.

AASHTO T 315 states that if the thermometer is electronic, it must have an "accuracy of ±0.05°C." In addition, *AASHTO T 315* specifies that the electronic thermometer must be standardized in accordance with *ASTM E77*. Please note, however, that *ASTM E77* is actually the standard test method for the inspection and verification of liquid-in-glass thermometers, and is improperly referenced in *AASHTO T 315*. AASHTO accredited laboratories must have their electronic reference thermometer calibrated, and the calibration certificate must include a statement of measurement uncertainty that is no greater than ±0.05°C. Just as in the case of the portable thermometer, the reference thermometer must be calibrated as a unit that includes the temperature detector and readout device including all electronic circuitry.

Calibration of the reference thermometer must be performed annually. However, if the reference thermometer is also used as the portable thermometer in accordance with Section 6.7 of *AASHTO T 315*, the device must be calibrated at 6-month intervals to comply with the requirements of Section 9.3.1.

The Standardization of the Portable Thermometer

Section 9.3.1 recommends that the device be standardized as a unit at 6°C increments over the range of testing with a reference thermometer that meets the requirements of Section 6.6. The AASHTO Accreditation Program requires that laboratories accredited for *AASHTO T 315* adhere to this recommended procedure. The portable thermometer must be standardized every six months. Often times the manufacturer or supplier of resistance thermometers provide a certificate for the probe and/or multimeter indicating that the device was standardized by use of a resistor. Alternatively, these devices sometimes come supplied with a reference resistor, with the indication that the resistor can be used to standardize the device. Unfortunately, the use of resistance in standardizing the portable thermometer is not acceptable for *AASHTO T 315*, and the device will have to be standardized with a reference thermometer in order to meet the requirements of the standard.

The Standardization of the DSR's Temperature Detector

Section 9.4 provides instruction for standardization of the internal temperature detector of the DSR. The user may perform this standardization using either a silicone rubber wafer (Section 9.4.1) or a temperature probe inside a dummy test specimen

(Section 9.4.2). In either case, the DSR's temperature detector must be standardized at 6°C increments over the range of testing with a portable thermometer that meets the requirements of Section 6.7. Section 9.4.4 requires the temperature corrections to be plotted, but this typically occurs within the equipment without the technician performing any physical data plotting. Standardization of the DSR's temperature detector must be completed every six months. However if you are ever unsure about the accuracy of the device, you should increase the frequency of standardization or both the temperature detector and torque transducer.

Preparing for an AASHTO re:source On-Site Assessment

If you have any questions or concerns regarding the temperature requirements for *AASHTO T 315*, it is recommended that you discuss these issues with your assessor prior to the on-site assessment. The assessor will be able to assist you by letting you know what type of documentation you will be expected to produce, and can answer any questions that you might have regarding your apparatus. In general, you can best prepare for an AASHTO re:source on-site assessment for *AASHTO T 315* by doing the following:

- Have a portable thermometer that meets the requirements of Sections 3.2.12 and 6.7 available.
- If the portable thermometer is standardized in-house, have a reference thermometer that meets the requirements of Sections 3.2.13 and 6.6 available.
- Provide records that indicate that the portable thermometer has been standardized at 6°C increments over the range of testing with the reference thermometer.
- If the portable thermometer is standardized in-house, have records available that indicate that the reference thermometer has been calibrated.
- If the reference thermometer used consists of a partial immersion liquid-in-glass thermometer that is standardized in-house at the ice point, be prepared to discuss the procedure used to perform the ice point verification and have equipment available for review so that the assessor can ensure conformance to *ASTM E563*.
- If the reference thermometer consists of an electronic thermometer, ensure that the records indicate that the device has an estimated measurement uncertainty no greater than 0.05°C.
- If the portable thermometer is standardized by an outside agency, ensure that the assessor is able to verify that the reference thermometer meets the requirements of Sections 3.2.13 and 6.6.
- Ensure that the records for both the portable thermometer and, if used, the electronic reference thermometer, clearly indicate that the readout device, detector, and all associated circuitry were calibrated or standardized as an integral unit.
- Have records available that indicate that the DSR's temperature detector has been standardized at 6°C increments over the range of testing with the portable thermometer.

Other Resources

Laboratories that wish to seek additional guidance on the requirements of *AASHTO T 315* have a number of resources available to them. Publications such as the Asphalt Institute's *Asphalt Binder Testing: Technician's Manual for Specification Testing of Asphalt Binders (Manual Series 25)* are an excellent resource for laboratory technicians and engineers that wish to gain a better understanding of the requirements of the DSR and other PG tests. Finally, several articles on the topics of thermometers, calibration, standardization, and uncertainty are available on our re:source University..