

# DYNAMIC SHEAR RHEOMETER (DSR) **COMPLEX SHEAR MODULUS, $G^*$ , AND PHASE ANGLE, $\delta$**

## EN 14770: Bitumen and bituminous binders – Determination of complex shear modulus and phase angle – Dynamic Shear Rheometer (DSR)

### Overview

The test is used to determine the complex shear modulus,  $G^*$ , and the phase angle,  $\delta$ , of bitumen and bituminous binders under oscillating stress at different temperatures.

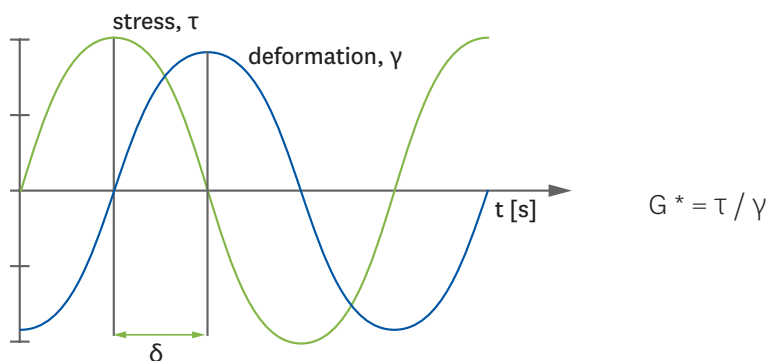
The test determines the rheological characteristics of bitumen and bituminous binders using a Dynamic Shear Rheometer (DSR) at defined test temperatures and test frequencies. The complex shear modulus,  $G^*$ , and the phase angle,  $\delta$ , are the most common parameters which are determined.

The complex shear modulus,  $G^*$ , is usually used to assess the behaviour of bituminous binders at a typical temperature range between 10 °C and 90 °C; test frequencies are typically within a range of 0,1 to 10 Hz.

### Definition and Terminology

Complex shear modulus  $G^*$ : The complex shear modulus,  $G^*$ , is the quotient of the maximum stress,  $\tau$ , and the maximum deformation,  $\gamma$ , at sinusoidal oscillation loading.

Phase angle  $\delta$ : The phase angle,  $\delta$ , is the phase difference between stress and strain while testing.



At the time of publication of this document, EN 14770:2012 'Bitumen and bituminous binders - Determination of complex shear modulus and phase angle - Dynamic Shear Rheometer (DSR)' was the reference for testing. This document does not overrule the test standard EN 14770, but is intended to help users of the standard to be aware of important factors. However, the reference for testing remains EN 14770. Temperatures, times, and dimensions and their tolerances must be strictly observed, that is checked for accuracy and for maintaining the tolerance during application. From experience, rheological tests should preferably be carried out by laboratory technicians trained in the individual procedures to be applied.

## Practical Information:

**The bitumen sample must adhere securely and completely to the test plates, otherwise the result of the test will not be valid.**

- Silicone moulds are recommended for test specimen preparation.
- Grease or release agents must not be used.
- Test plates must be clean, see section 6.2 of EN 14770.
- Pre-heat test plates to ensure good adhesion, see section 8.1 of EN 14770.
- When the testing is complete, it is recommended to check the test plates to ensure that the sample was fully adhered; if there is any evidence that the sample did not fully adhere, discard the results.

**The behaviour of bitumen is highly temperature-dependent, therefore precise temperature control of the bitumen sample and the stability of the test temperature are critical.**

- The temperature measuring device of the Dynamic Shear Rheometer should be regularly verified and/or calibrated, see Note 2 in section 6.1 of EN 14770.
- Test specimens need to reach thermal equilibrium before testing, a description is given in Annex B of EN 14770. Note 1 in section 8.3 suggests that 10 to 20 minutes have been found practical for most purposes.
- Test temperatures should be recorded over the duration of the test.
- When the testing is complete, it is recommended to check that test temperatures were within a range of  $\pm 0,1$  °C, see section 5.1 of EN 16659; otherwise discard the results.

**Testing must be carried out in the linear viscoelastic range of the bituminous binder.**

- The linear viscoelastic range is defined in section 3.6 of EN 14770.
- The linear viscoelastic range must be determined before the actual test as described in Annex C of EN 14770.
- According to Annex C, data from previous experiences can be used to define the linear viscoelastic range.
- In exceptional circumstances testing can be done outside the linear viscoelastic range, but the results must be treated with caution.

**The test geometry and gap need to be selected depending on the test conditions.**

- Usually, 25 mm test plates are used with 1 mm gaps, while 8 mm plates are used with 2 mm gaps.
- The test geometry is selected in order to test within the compliance limits of the instrument, see instrument manual. When reaching these limits, testing is stopped and a new test geometry is chosen to continue testing over further temperatures, see section 8.4 of EN 14770.
- From experience, 8 mm plates are usually used at temperatures below 40 °C, while 25 mm plates are usually used at temperatures above 30 °C. The overlap is used for checking that instrument compliance limits have not been reached, see section 8.4 of EN 14770.
- Zero gap setting needs to be done for each test geometry before placing the sample, as it is essential that the thickness of the specimen is within the acceptable tolerances, see section 8.2 of EN 14770.

**The sample needs to be prepared for testing.**

- The rheological behaviour of the sample can be affected by the storage conditions. Section 7.3 of EN 14770 provides information on minimum and maximum storage periods.
- The test specimen dimensions are important, it is therefore recommended that silicone moulds are used to prepare the test specimens.
- After placing the specimen in the test geometry, and before setting the definitive test gap, it needs to be trimmed to a cylindrical shape, see section 8.2 of EN 14770. We recommend to trim the bitumen specimen at the gap position  $+0,05$  mm.
- The sample must not be trimmed after setting the geometry to the definitive test gap.

