Advanced Yerzley Oscillograph – IV
Calibration Procedure

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Introduction:

Yerzley Oscillograph is an efficient means of obtaining the mechanical properties of rubber and similar materials. The calculations for dynamic properties rely on the "moment of inertia – I" of "the beam". The component of the oscillograph, called "the beam" does not have a simple geometry; so it is not easy to determine it's "I" value purely from geometry. Furthermore, there are many components attached to this beam that affect the actual moment of inertia. The ASTM Standard D945-06 on page 9, in paragraph 13.10 mentions that **0.100 slug-ft.sq** is an approximate value that has historical acceptance.

It is possible to determine the moment of inertia of the beam together with all it's attached components experimentally. The method below is based on the paper by Dr. F.L.Yerzley, published in the proceedings of the ASTM in volume 39, 1939.

Calibration Method:

In this method, we replace the rubber specimen with a suitable spring. The rubber specimens have large energy losses compared to a spring. During the motion of the oscillograph, part of the energy of oscillation is converted into heat in the rubber and as a result, the motion dies out relatively quickly. In contrast, a steel spring has fewer losses. A typical rubber specimen might oscillate for two to three seconds; whereas, a steel spring may still be oscillating after twenty seconds.

1. Measure the unloaded height of the spring.
2. Install the spring in the oscillograph.
3. Set zero on the displacement sensor window.
4. Add weights till you observe approximately 20% deflection. Note the deflection amount.
5. Determine the weight/force acting on the spring. The standard weights are 1.41372 lb and the moment arm to the forward position F is 6.25 inches. Therefore if two weights are used the force on the spring would be (2)(1.41372)(6.25) => 17.6715 lb.
6. The spring constant K' is defined by the following equation:

   Force = K' (deflection)/(Initial height)

   Where: F is the force on the spring in pounds
   K' is the spring constant

Deflection is the amount measured in inches
Initial height is also in inches.

7. Equation 9 on page 4 of the 1939 paper defines K' as follows:

$$K' = 4\pi^2 h I \; f^2 \; / \; l^2$$

Where
h is the initial height
I is the moment of inertia of the beam + weights
f is the frequency in cycles/second
l is the moment arm spring to fulcrum.

8. Run a Dynamic Parameters test with the spring. The frequency will be calculated for you
9. Initial height "*h*" and the moment arm "*l*" are known quantities. We can solve for I, the moment of inertia.

Example:

Unloaded height of spring: 1.756 in => 0.146 ft
Moment arm: 1.600 in => 0.133 ft
Frequency = 2.479 cycles/second.
Used 4 weights at position F; therefore force on spring is 35.34 lb.
Two weights were used during the dynamic parameters test for frequency.
Measured a deflection of 0.191 inches.

K' = (35.34)(1.756)/(0.191) = 324.9 lb.

$$I = (K' \; l^2) / (4\pi^2 h \; f^2)$$

I = (324.9)(0.133)(0.133) / (4π)(π)(0.146)(2.479)(2.479)
I = 0.162248 slug-ft.sq

This value is the combined moment of inertia of the beam and the two weights used during the dynamic parameters test for frequency.

Moment of Inertia of Beam = 0.162248 – 2(0.03220) = **0.0978 slug-ft.sq**

This is the measured value for the moment of inertia of the beam. Notice that is very close to the historically accepted value of 0.100 slug-ft.sq.

The conversion factor from slug-ft.sq to kg-m.sq is 1.356. Simply multiply moment of inertia in slug-ft.sq with 1.356 to obtain moment of inertia in kg-m.sq