Standard Procedure SP 0011-3:2005

Methods of determining the density of materials - Part 3: Determining the density of irregular-shaped objects (Buoyancy method)

1 Scope

This procedure is adapted from BS 903-A1:1996 – Physical testing of rubber – Determination of density.
It can be used to determine the real density of any non-porous, irregular-shaped object, or the apparent density of any hollow or porous, irregular-shaped object. The method also works for regular-shaped objects, although **SP 0011-1:2005** details an easier method.

2 Definitions

density
the mass per unit volume of a uniform material

apparent density
the overall density of a hollow or porous object. It is calculated from the total mass of the object, including trapped air or gases, divided by the total volume.

3 Principle

The object is weighed to determine its mass. It is then suspended in water and reweighed. The difference in mass equals the mass of water displaced by the object. This is numerically equal to the volume of water (since the density of water is 1 g cm^{-3}), which equals the volume of the object. Dividing the object's mass by its volume gives its density.

4 Apparatus

- balance that can weigh an object suspended underneath it to the nearest 0.01 g
- beaker of water, large enough to submerge the test specimen
- waterproof thread (e.g. nylon), as thin as possible, but strong enough to hold the test specimen

5 Test Specimens

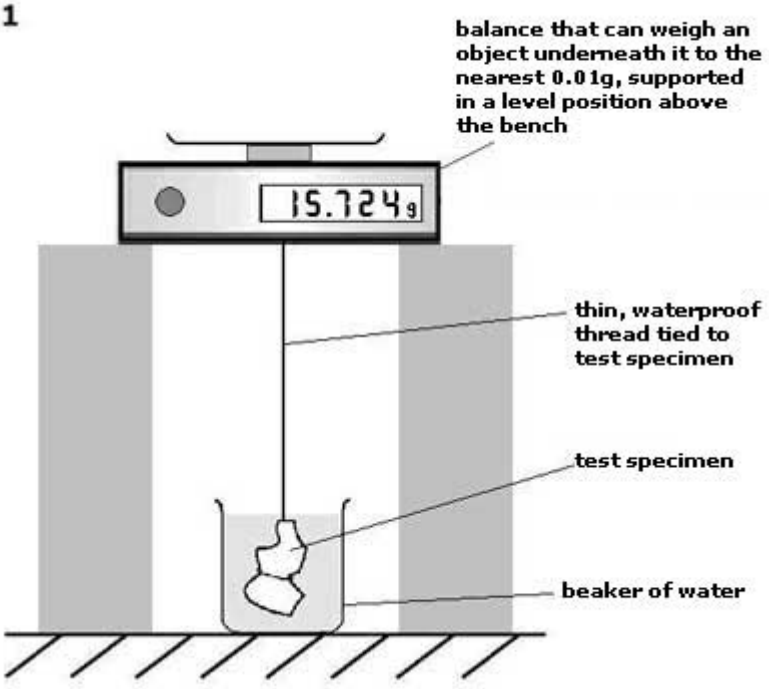
Test specimens can be of any size and shape that fits inside the beaker, but they should not trap bubbles on their surface when submerged in the water.

At least three specimens of each material should be tested.

6 Procedure

- Support the balance in a level position above the bench, so that the specimen can be hung from the weighing hook on its underside.
- Hang a length of thin, waterproof thread from the hook. The thread must be long enough to tie around the test specimen, but must not rest on the bench.
- Tare (zero) the balance.
- Unhook the thread and tie it around the specimen. Hook it back on and weigh the specimen while it hangs below the balance.
- Unhook the thread from the balance, and lower the specimen into a beaker of water. Move the specimen through the water to remove any bubbles on its surface.
- Hook the thread back onto the balance and weigh the specimen while suspended in the water. It must be fully submerged and must not touch the sides or bottom of the beaker. (See figure 1.)

figure 1



7 Expression of Results

Calculate the density ρ of the specimen in grams per cubic centimetre (g cm^{-3}) using the formula: $\rho = m_1 /(m_1 – m_2)$

where

m_1 is the mass, in grams, of the specimen hanging in air

m_2 is the mass, in grams, of the specimen hanging in the water

$(m_1 - m_2)$ = mass of water displaced = the volume of the specimen in cubic centimetres.

Note:

- Density in kilograms per cubic metre (kg m^{-3}) = 1000 x density in grams per cubic centimetre (g cm^{-3})
- ρ is the Greek letter rho pronounced ‘roh’.

8 Test Report

Your test report should include:

(a) reference to this standard procedure;

(b) the density of each test specimen in both g cm^{-3} and kg m^{-3};

(c) the average density of each material (calculated by adding the densities of all test specimens of that material and dividing the total by the number of specimens of that material tested);

(d) whether the real or apparent density was determined.