# Some explanations about the equivalence of specific gravity to relative density

**L. Palaniappan**[1], **V.Velusamy**[2]
[1]*Department of Physics (DDE), Annamalai University, Annamalainagar-608002, TN, India.*
[2]*Department of Physics, Kongu Engineering College, Perundurai -638052, TN, India.*

**E-mail:** veluphysics@yahoo.com

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**Abstract**

The concept of specific gravity and relative density are well familiar and are closely interlinked. This letter offers some more explanations that support their equivalence. These concepts are very interesting to academics, industrialists, even medical professionals dealing with hemodynamics, fluid dynamics, hydrostatics, hydrometer and other related subjects.

**Keywords:** Density, Relative density and Specific gravity.

**Resumen**

El concepto de la gravedad específica y la densidad relativa son muy familiares y están estrechamente vinculados entre sí. Este artículo ofrece algunas explicaciones adicionales que apoyan su equivalencia. Estos conceptos son muy interesantes para los académicos, industriales e incluso para los profesionales médicos que manejan la hemodinámica, la dinámica de fluidos, la hidrostática, el hidrómetro y otros temas relacionados.

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## I. INTRODUCTION

It is well known that in many articles, the authors and the researchers have commonly used the term specific gravity as equal to that of relative density [1, 2]. The term specific gravity, as it is a ratio of densities is a dimensionless quantity and is often represented as the density of the substance divided by the density of water at the same external conditions. Also the relative density of a substance is measured by a similar procedure, provided relative to that of water, using specific gravity bottle [3]. Thus it is quite interesting to know how this relationship between the specific gravity and relative density is valid. Literature presents voluminous explanations about these two components separately but the reason or logic behind their equivalence is not at all available to the best of our knowledge. Thus the present letter is devoted for unraveling the reasons for their equivalence and hence adds few more new ideas to the existing knowledge.

## II. THE TERM "RELATIVE DENSITY"

Basically, density is the ratio of mass to its volume. Density is often classified as absolute density and relative density.

The above definition for density is not in a clear form or full statement. It simply refers to absolute density. Absolute density of a substance is defined as the ratio between the mass of the substance to its volume.

Usually to find out the absolute density of a substance (preferably solid), a balance is used and its mass is found our first. Next, using geometry (measure length, breadth, height etc) its volume is calculated. Then dividing the mass by the volume, the absolute density can be determined.

Thus, absolute density needs no other reference materials. It fully depends on its own material. This is the actual density of the substance.

For fluids (liquids and gases), the procedure is not so simpler. The mass and volume determinations strictly depend on external conditions (of course, for solids also). A slight change in external condition such as temperature, pressure, etc., is expected to have large influence on these factors. Consideration of geometry for the determination of volume of fluids may not be thoroughly reliable and many times yields only approximate values and some time not at all feasible. Further it needs cumbersome practices.

There are quite a number of instrument that are used to measure volume of liquids. This includes: graduated cylinders, pipettes, burettes, syringes, volumetric flasks and beakers. Similarly for measurement of volume of gases, gas syringes, bellows, turbine flow meters, ultrasonic flow meters, etc., are in practice. But all these instruments are definitely not 'plug & play' type. They need and vary in calibrations, settings, procedures, precautions etc and offer tiresome procedures.

Thus absolute density is not possible accurately for liquids and gases. Only relative density is possible. This relative density is commonly multiplied by water density and is referred as density of the respective liquid (or gas).

But the water density is again not absolute. So, for liquids and gases, it is customary to eliminate the volume term from the formula by including a reference material.

The term ‘relative’ is used whenever it is compared with a reference material (as relative permittivity, relative permeability etc). So, the term now should be relative density and not absolute density. This relative density simple tells us how much times it is more (or less) denser than the reference material and this will never give us the the absolute density at any time. Thus:

*relative density=density of substance/density of reference*.

For liquids:

*relative density=density of liquid/density of water*.

For gases:

*relative density=density of gas/density of air*.

$$\textit{relative density (of liquid)}=(M_l/V_l)/\,(M_w/V_w) \qquad (1)$$

Where $M_l$ and $V_l$ denote the mass and volume of the liquid.

$M_w$ and $V_w$ denote the mass and volume of the water.

For liquids (also for gases), a container will be used to find the mass of the liquid and water. As the same specific gravity bottle (5 ml or 10ml) is used for this purpose:

$$V_1 = V_{w.} \qquad (2)$$

Thus:

$$\textit{relative density of liquid}=M_1/M_2 \qquad (3)$$

So, from relations (1) and (3):

$$\textit{density of liquid} = (M_1 / M_2) \text{ x } \textit{density of water} \qquad (4)$$

Again this, is not absolute density because water, being a liquid, its density is not absolute but empirical. So, the density of liquids and gases are never absolute but relative to a reference, (usually water or air). Since absolute density is never possible accurately for liquids and gases, the relative density is always used to find the density. Also, water (air for gases) is the common reference material.

## III IN THE CASE OF SOLIDS

But for solids, absolute density as well as relative density, is possible without any loss in accuracy. Application of geometry or instruments is quite feasible and they can offer accurate measurements, and hence the accurate absolute density can be obtained. Either by direct means or by indirect means such as Archimedes Principle, the volume term can be eliminated for using a reference material and can go for relative density. Thus as regards solids absolute density and relative density exists and one should specify it tersely. However the formula remains the same.

## IV. THE TERM “SPECIFIC GRAVITY”

Gravity in general refers to the extent of attraction offered by the earth on the substance under consideration. It is also a fact that the gravity in a given place is always constant irrespective of time and other experimental conditions. As per Newton’s law of gravity and as per the general logic, the gravity depends on the mass of the interacting components (or bodies) as well as their separating distance and not on their volume or size or shape, etc.

Assuming the method of evaluation of ratio of gravities for two different components, say *A* and *B*. Gravity of *A* means the extent of attraction available between *A* and the earth, and so for *B*. Hence, for both components, the inter distance between the components and the earth is same as well as the mass of the earth is common for both. Thus these two terms can be eliminated and hence we can write:

*gravity of A*=*constant* x *mass of A,*

*gravity of B*=*constant* x *mass of B.*

Thus:

$$\textit{the ratio of gravity=mass of A/mass of B.} \qquad (5)$$

If the component *B* is specified to be water, then the ratio of gravity is aptly called as specific gravity and further Equation 5 seems to be same as that of Equation 3. Thus relative density (of liquids) can be conveniently being termed as specific gravity.

While taking readings for the measurement of relative density, the individual components are considered in a given place, and with the given setup such that, it doesn’t violate the general rules of gravity, and hence the calculated specific gravity identically resembles the relative density.

For the concept of (absolute) density, which is unique and absolute for a given substance, there is no reference material. Hence, density of a substance cannot be compared with its gravity. Thus, density (of any substance) cannot be related to the specific gravity, but relative density can.

Specific gravity may be defined as the ratio of gravity experienced by a substance in comparison to the gravity of a reference material, say water (or air). By remembering the terms and definitions for specific heat, specific resistance etc., it can be inferred that all these definitions are defined likewise. Where ever term ‘specific’ is used, it is always associated with some restrictions and for specific gravity it is associated with water (or air) density. Thus:

*specific gravity=density of substanace/density of reference* (*usually water*).

So, it is understood from the above analysis that, for liquids:

*specific gravity = relative density*.

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