Bellingham + Stanley Technical Bulletin

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Title: ***Principles of Refractometry***

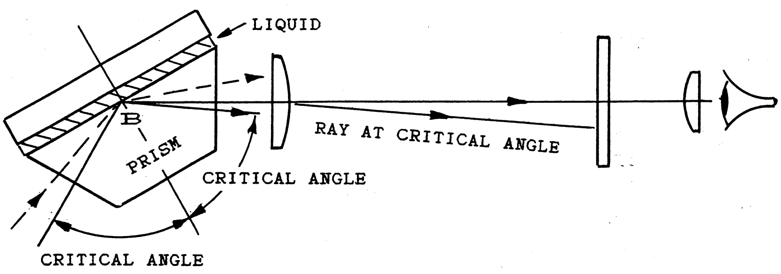
Light travels at different speeds through different media and when a ray of light crosses the interface between two substances it changes direction. The emerging ray is called the refracted ray and the phenomenon is called ***refraction***.

The ***refractive index*** (RI) of a substance, usually given the symbol ***n***, is a measure of the speed of light through the substance and is defined as the ratio of the speed of light in the substance to the speed of light in a vacuum. For practical purposes the speed of light in air rather than vacuum is used, the difference being very small.

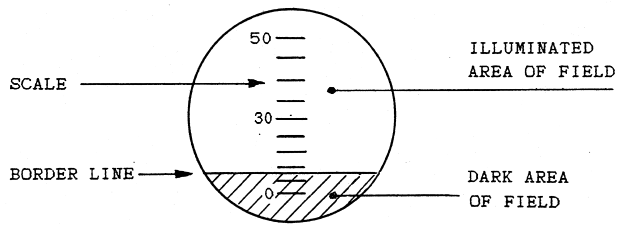
$$\text{Refractive Index of given substance (n)} = \frac{\text{Speed of light in substance}}{\text{Speed of light in vacuum}}$$

The speed of light through a medium depends on the ***wavelength*** (or colour) of the light. RI must therefore be defined at a specific wavelength, usually sodium light. For example, n_D denotes a refractive index based on the sodium D-line wavelength of 589 nm.

RI is also a function of ***temperature.*** An increase in temperature usually gives rise to a decrease in density and light travels more rapidly through a lower density medium. RI therefore tends to decrease with increasing temperature.

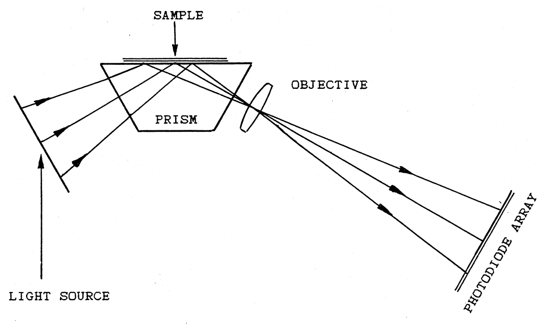


A ***refractometer*** is used to measure the refractive index of substances, usually liquids. Most refractometers are based on the ***critical angle effect***, which defines the point of balance, the shadow point or ***borderline***, between refraction and total internal reflection of light at a prism/sample interface.



The RI of the sample is derived from the geometry of the optical path and the refractive index of the prism material.

Modern ***digital automatic refractometers*** use a light sensitive integrated circuit (self-scanned array) to detect the exact position of the borderline. Bellingham+Stanley instruments also incorporate special software for interpreting ‘fuzzy’ borderlines that many products tend to produce. In this way, there is no subjective human judgement needed in taking a reading - a major advantage of an automatic instrument.



When the composition of a substance changes, so does its RI. Thus a measure of RI can yield information about the composition of a substance. For example, when a substance is dissolved in a liquid the RI increases. Thus a measure of the RI of a sugar solution in water can be used to determine the ***solution concentration***.

There are numerous uses and therefore refractometers are calibrated with one or more ***scales*** to suit the particular application(s). For optical instruments a scale is visible via the instrument eyepiece and readings are taken where the borderline intersects the scale. With electronic instruments, different scales can be programmed and the result is displayed in digital form.

Apart from the fundamental Refractive Index scale, the ***Brix scale*** is the most widely used scale on a refractometer. Brix, or sugar %, is an internationally recognised scale, which relates the concentration of sucrose in water at 20 °C to the RI of the solution (wt/wt). Most food products are more complex than a sucrose solution; many other soluble ingredients may contribute to the overall RI. However, the Brix scale is still used as the standard. For non-sucrose based products the term ‘apparent Brix’ is strictly more correct.

More generally, refractometers are used to measure a RI of pure substances (liquid) as a unique characteristic, or used to measure the concentration of one substance dissolved in another. Refractometry is therefore an ideal technique for ***Quality Control*** in many industries. The most common uses of refractometers are in the food and drink industries where the dissolved solids content of liquid food products is measured as a ‘Brix value’.

Types of refractometers

There are three main types of refractometer: portable hand-held instruments used for ‘on-the-spot’ measurements, high accuracy bench instruments for use in laboratories and process or ‘in-line’ refractometers for monitoring and control in manufacturing processes.

Bench type instruments can be further classified into two types:

Abbe Refractometers	These are optical-mechanical instruments and they derive their name from the 19th Century physicist, Ernst Abbe.
Automatic Digital Refractometers	These are solid state electronic instruments incorporating flexible software and designed primarily for use in quality control applications.

High accuracy may be achieved with both Abbe and Digital Automatic refractometers. The latter are generally more expensive instruments and tend to be favoured by quality control laboratories. ***Bellingham+Stanley*** offers a wide range of refractometers covering all the types described above. The RFM Automatic Digital Refractometers are used by many companies in a variety of industries in over seventy countries and are regarded as leaders in modern refractometry.