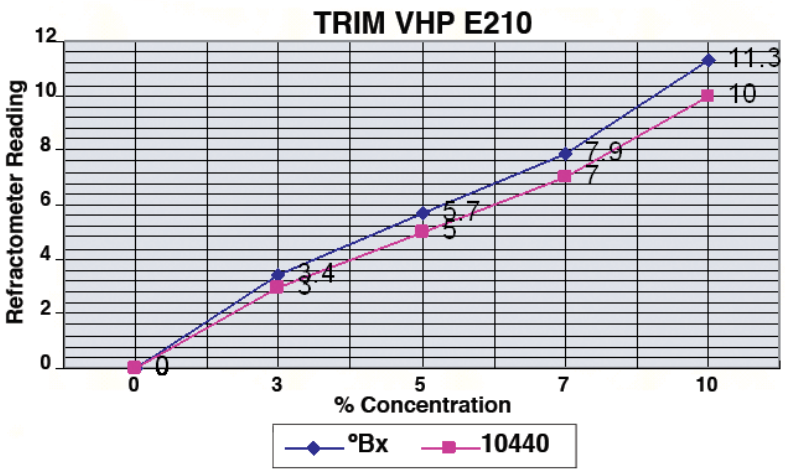
Concentration Control of Coolants by Refractometer

The ability to accurately measure and control the concentration of coolants is the single most important marker of success in a coolant management program. The refractometer is of key importance. It is an easy, user-friendly way to get a relatively accurate measurement of coolant concentration.

Refractometers measure the amount that light is bent (refracted) as it passes through a thin film of fluid on the instrument prism. This bending is reflected on a scale in the instrument that is calibrated in either refractive index (nD), Brix degrees (°Bx), or another specialized unit of measure (such as °F or °C for anti-freeze, or % alcohol for beer and wine).

Measuring concentration with the refraction of light relies not only on the fact that fluids bend light, but also that the concentration of materials dissolved or emulsified in the fluid affects the amount of bending that occurs. The degree of refraction is a function of the dissolved material and the solvent it is dissolved in, and is proportional to the amount of dissolved material present in the fluid. So, it is possible to use a refractometer to measure the concentration of the material dissolved in the fluid. To do this effectively one must establish standards to convert the refractometer reading into % concentration (or whatever other value is related to fluid concentration and/or refraction). A set of standards is developed for a specific product by taking refractometer readings from each concentration range of interest and plotting the results. The slope of



the curve, normally a straight line, is then determined. This is usually, though not necessarily, the case for metalworking fluids within the ranges of interest.

Master Chemical publishes both the graph and the slope of the line. This is referred to as the refractometer factor %Brix, or %Bx, in our Data and Information (D&I) sheets. So, if you take a refractometer reading using a refractometer calibrated in Brix you may arrive at the concentration by refractometer by either finding the value read on the refractometer and multiplying it by the %Brix (refractometer reading X %Bx = the volume, volume % of TRIM® fluid present) or by referring to a chart like the one above.

As with any test method, it is important to understand its strengths and limitations:

1. Temperature has a major affect on refractometer readings. The traditional measuring temperature is 20°C (68°F), this being the temperature on which the standards are established. However, the instrument, fluid, and surrounding environment should have the same temperature and where needed, a temperature correction applied.
2. Refractometers are very susceptible to shifts in reading because of evaporation. Once fluid is applied to the prism, a reading needs to be taken ASAP and the sample reapplied between readings.
3. The wave length of the light source can be another source of error as the wave length of day light and industrial fluorescent light is significantly different, but also because these and other light sources often generate mixed wave length light. This is one of the reasons we sometimes see "fuzzy" readings.
4. The amount light is refracted is affected by anything that gets into the fluid, including tramp oil and hard water minerals. So, as the fluid ages, it is likely to read higher than it actually is.

5. It is critical that the calibration of the refractometer be checked and corrected regularly. Using the traditional standard (distilled water) the instrument should read "0".

While there are many different refractometers available in the market place, Master Chemical offers a variety of three units which perform very well for plant use. They are calibrated in Bx° or 10440. The first, (**A)** somewhat more expensive unit, is fully digital, temperature corrected, has an internal 589nm light source and a cover to reduce evaporation, optional stand, and measures Bx°. The other two are analog optical refractometers: one (**B**) is temperature corrected and more operator friendly measuring 10440, while the third (**C**) is much less expensive but must be calibrated and a temperature correction factor applied with each use, and measures Bx°.

Using an digital refractometer:

1. Calibrate the unit using distilled water once a day or whenever it is subjected to severe shock, or temperature change. To do this, place a drop of the reference water in the clean prism well, turn on the unit and follow the instructions for confirming the instrument reads "0".
2. Place a representative sample of the fluid to be tested into the clean sample well.
3. Press the "Go" button to initiate the reading.
4. Multiply the refractometer reading by the refractometer factor (%Brix) to get the % by volume of the tested fluid.

Using an analog refractometer:

1. Test the accuracy of the unit (recalibrate if necessary) using a distilled water standard and the light source you expect to encounter.
2. Place a representative sample of the fluid to be tested on a clean, scratch-free prism and close the cover.
3. Read the results on the scale, noting the quality of the line. The "fuzzier" and broader the line, the more likely that contamination or other problems are affecting the fluid. Sometimes using a small flashlight to provide lighting is useful.
4. Multiply the refractometer reading by the refractometer factor (%Brix) to get the % by volume of the tested fluid.

While digital refractometers provide quick, easy and very accurate readings, they do not provide some of the subjective information about the state of the product being tested. If, over time, the line in the analog refractometer gets broad and fuzzy it may be the affects of bacteria or hard water eating up the emulsifiers in a soluble oil; this can cause the emulsion to "coarsen up," making the line difficult to read. If after the initial charge the line is anything other than crisp and clean it may suggest that either the product was mixed incorrectly or mixed in very bad water. The new digital refractometers are unsurpassed in their ability to get an accurate, repeatable reading in used working solutions – one of the most difficult analytical environments in which to work. In short, the refractometer is an effective, useful and eminently practical tool for managing coolants at the "front line," but as always it is critical to understand the strengths and weaknesses of the technology.

NOTES:

1. Refractive Index or nD is the actual amount light is bent passing through the fluid. The international standard for triple distilled water at 20^0C is 1.3330 with a 589 nm light source. This value is regarded as a natural or physical constant by NIST and serves as the standard reference value.
2. One Brix or ^{0}Bx is the amount that light is bent when it passes through a solution of sucrose made by adding 1 gram of sucrose to 100 grams of distilled water at 20^0C.
3. Master Chemical publishes refractometer factors based on the Brix scale, as it is the most commonly available scale in North America. You can find these factors on our container labels and Data and Information sheets. If you have an instrument calibrated in something other than Brix, contact our Tech Line for assistance.
4. Factors for any product can be developed by making a series of dilutions within the concentration range of interest, then reading and plotting the refractometer results against the known concentrations. The slope of that curve should be the refractometer factor for the tested product and the refractometer used for the testing.
5. The water used to mix the fluid can significantly impact the refractometer reading of the diluted product. It is important to check the RI of both pure water and the water used to mix the fluid to understand its impact on the final mixture.

For additional information regarding controlling coolant concentration with refractometers, contact: your Master Chemical District Manager or Authorized Distributor, our **Tech Line 800 537-3365** (North America only), or our web site **www.masterchemical.com**

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