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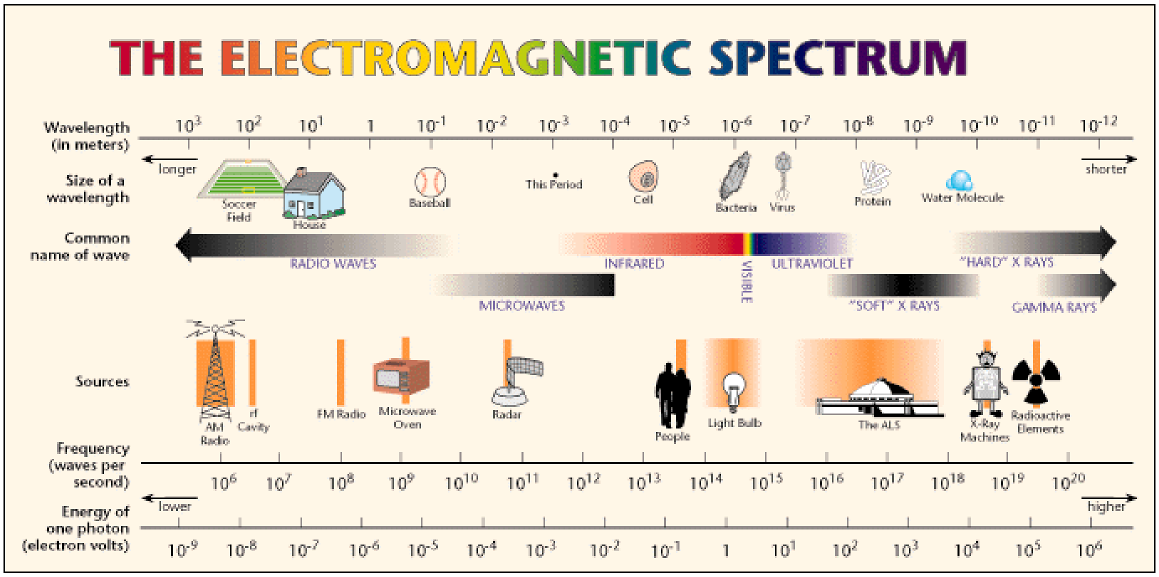
# Grain Moisture Meter (GMM) Series Part 3 -
# Grain Moisture Meter Measurement Technology - Near Infrared

*By G. Diane Lee*
*(in collaboration with John W. Barber)*

Currently there are two technologies used in commercial grain moisture measuring devices in the United States—dielectric and near infrared. GMMs measure an optical or electrical property of the grain. When these optical or electrical properties are compared to known grain moisture values, a calibration for the grain can be developed, and based on this calibration the device can provide a moisture reading related to the measurement of the optical or electrical property of that grain. The September 2006 Weights & Measures Quarterly article, "What do Grain Moisture Meters Measure and How are They Calibrated," addressed the dielectric technology (measuring the electrical property in grain). Part 3 of this series will review near infrared technology. Much of this article is based on information from a presentation by John W. Barber, "Grain Moisture Meters from Theory to Practice."

**Electromagnetic Spectrum**

Near infrared grain moisture meters measure the effect of moisture on optical properties of grain in the near infrared portion of the electromagnetic spectrum. To begin this discussion let's first discuss the electromagnetic spectrum. The electromagnetic spectrum is the name for types of radiation energy. Near infrared is a type of energy that is part of the electromagnetic spectrum. The electromagnetic spectrum consists of radio waves, microwaves, infrared light, visible light (light visible to our eyes), ultraviolet light, x-rays, and gamma rays. These energies are also described in terms of their wavelengths or their frequencies. The spectrum ranges from lower radiation energy, "radio waves" (long wavelengths, low frequency, and low energy), to higher radiation energy, "gamma rays" (short wavelengths, high frequency, and high energy). Radioactive materials can emit gamma rays. Most people may think of these two energies, radio waves and gamma rays, as different and in some respects they are different. Exposure to gamma rays is harmful, but we are exposed to radio waves on a daily basis through the television and radio. But, while they are different in that respect, they are similar in that radio waves and gamma rays are both electromagnetic radiation. Electromagnetic radiation can be described as a stream of photons. A photon is a measurement of the smallest unit of light/electromagnetic energy. Each photon contains an amount of energy. The difference between the various types of electromagnetic radiation in the electromagnetic spectrum is the amount of energy in the photon. As noted above, gamma rays have high energy and radio waves have low energy (see diagram of the electromagnetic spectrum below).

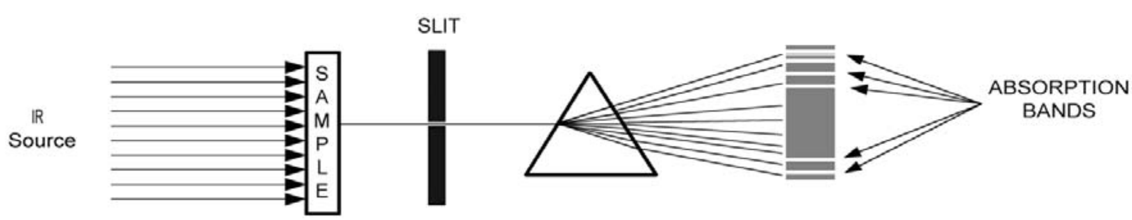



Courtesy of the Advanced Light Source, Berkeley Laboratory

**Near Infrared Grain Moisture Meter Technology**

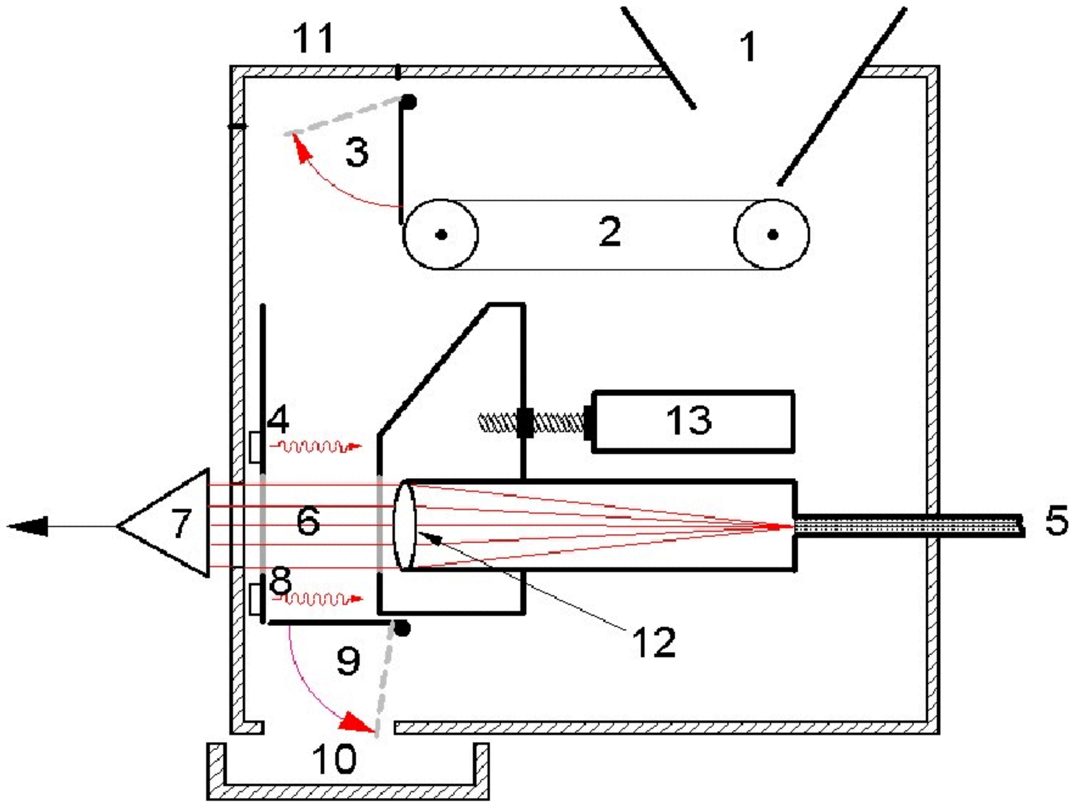
Infrared energy was discovered by Sir William Herschel in the 1800s. He discovered that there is energy from the sun that lies below the red region of visible light. He called this energy, "calorific rays." This energy is now called infrared.

In the early 1900's W. W. Coblentz discovered that compounds with similar chemical groupings have characteristic absorption bands in the infrared region. The main constituents of grain (protein, oil, starch, and water) all have characteristic absorption bands in the near infrared region (see Diagram 1 of the electromagnetic spectrum.)



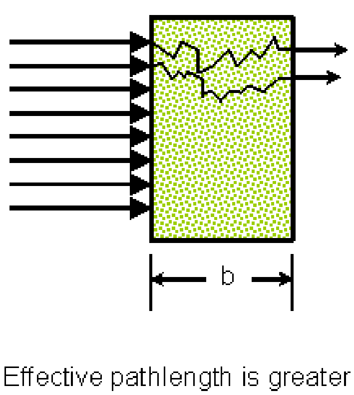

(Diagram 2)
Diagram courtesy of John W. Barber, Grain Moisture Meters from Theory to Practice

As depicted in Diagram 2, absorption bands can be detected when full-spectrum, collated light is passed through a sample, such as grain, and the transmitted light is directed through a slit to a prism that separates the transmitted light into spectral components with different wavelengths. A typical near infrared grain analyzer scans the sample of grain with monochromatic light over wavelengths ranging from 850 to 1050 nanometers and measures the transmitted energy for each wavelength scanned. In a grain analyzer a sample of grain is dropped through a hopper (1) to a sample chamber (6), which has windows on both sides of the chamber. Light from a scanning monochromator (5) is applied to the chamber filled with grain and a detector (7) senses the amount of near infrared light passing through the chamber. See Diagram 3 on the following page.




(Diagram 3)
Diagram courtesy of John W. Barber, Grain Moisture Meters from Theory to Practice

Using the Beer-Lambert Law, where A is absorbance, *a* is a constant associated with a constituent at a particular wavelength, *b* is the path length through the sample, and C is the constituent concentration, a relationship of the absorbance of light to the properties of material through which the light is traveling is established.




(Diagram 4)
Diagram courtesy of John W. Barber, Grain Moisture Meters from Theory to Practice

When an infrared radiation source (light) is applied to a grain sample, characteristic absorption bands can be observed. This optical characteristic can be compared to known moisture values to develop a calibration for the near infrared grain moisture meter. This absorption is affected by the amount of moisture, protein, starch and oil in the sample, the kernel shape and condition, kernel packing, foreign material, and temperature of the sample. Therefore, there are differences in the absorption for different grain types and classes and thus different calibrations for different grain types.

NIST WMD greatly appreciates the contributions from John W. Barber of J B Associates in the development of this article.

Look for Part 4 in this series of articles on grain moisture meters in the November edition of the *W&M Quarterly* which will address field test methods, testing apparatus and equipment for the evaluation of GMMs. If you have any questions or comments, you may contact Diane Lee by e-mail at diane.lee@nist.gov.

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