Document Title: Description, AN, Isotherm Analysis New (and Old) Ways to Look at Soil		Part # and Rev. 13505-00	
		Release Date:	
Rev.	Description	Revision By	Date

Production Filename: 13505 (In Product Library)

Path to Working Files: DecaDoc\Application Notes\Master

Dimensions: 8.5 inch wide, 11 inch tall

Material: Paper, 92 Bright White or better, 75g/m² or heavier

Colors: Color Print on White

Printer: HP Color LaserJet 8550-PS

Finish: None

Adhesive: None

Special Notes: Illustrations are Ref Only ** Not to Scale ** (Shown page 1 of 5)

DECAGON DEVICES — *Application Note*

Isotherm Analysis: New (and Old) Ways to Look at Soil

By: Dr. Gaylon Campbell

One would not normally expect there to be a connection between food physics and geotechnical engineering, but there are several. Decagon builds instruments for measuring water activity in foods and for characterizing food moisture relations. We also build instrumentation for geotechnical engineering. In many cases the instruments are the same. Decagon recently introduced the AquaSorp IG isotherm generator to research markets in foods and pharmaceuticals. This report briefly discusses results of experiments using the AquaSorp IG to measure isotherms of soils.

The term *isotherm*, as used in food physics and physical chemistry, refers to the relationship between sample *water content* and *water activity* (think relative humidity) for a sample at some specified temperature. In geotechnical engineering we call such a relationship a soil moisture characteristic (see sidebar which relates water activity to other suction units).

The AquaSorp IG is shown in Figure 1. It has a sensitive balance inside which

Figure 1. Aquasorp Isotherm Generator

records the mass of a sample that is enclosed in a temperature controlled chamber. Moist or dry air is passed through the chamber, increasing or decreasing the water content of the sample. Periodically the flow of air stops and the sample water activity is determined by a cooled mirror dewpoint sensor in the sample chamber. In 24 to 48 hours a sample can be dried to around 3% relative humidity, wet to 90% humidity, and dried again to 3%. Since the data points are collected automatically, detailed moisture characteristics with hundreds of points are easily obtained.

Sidebar:

Measures of Soil Suction

In geotechnology soil suction is typically expressed in pressure units such as kPa, with a positive sign representing negative pore water pressure. In soil physics the negative sign is retained, and the quantity is called *water potential*. Water potential and water activity are related by the Kelvin equation from thermodynamics

$$\psi = RT \ln a_w$$

where R is the gas constant for water (462 kPa K^{-1}),and T is the Kelvin temperature. Suction can also be expressed in head units as cm of water. One kPa is equivalent to 10.2 cm of water. Schofield (1935) noted that a logarithmic scale was better suited to soil suction measurements than a linear scale, so introduced the pF scale, which has been used in geotechnology (McKeen, 1992). pF is the base 10 logarithm of the suction in cm of water. The pF scale has several advantages. Most importantly, it makes the moisture characteristic almost linear. Disadvantages are that it is based on antiquated (non SI) suction units and commits a serious mathematical *faux pas* by taking the logarithm of a number with units. Another disadvantage is that the numerical value increases with decreasing moisture. These problems are conveniently sidestepped by the *chi* measure advocated by Condon (2006). *Chi* is defined as

$$\chi = -\ln[-\ln(a_w)]$$

The following table compares *chi* with other measures of soil suction.