Errors in Soil Bulk Density and Water Content Measurements With Gamma Ray Attenuation

To the interesting report by Gardner, Campbell, and Calissendorff (1) we wish to point out that the explanation for the nonlinearity of their Fig. 4 does not hold.

Let us first assume that influence of the 0.103 MeV peak of $^{241}$Am is detectable. Due to the lower attenuation coefficient for 0.103 MeV gamma's than for 0.060 MeV ones, the relative influence of the 0.103 MeV gamma's will increase with increasing absorber thickness. Obviously this means that for a thin absorber, the attenuation coefficient could be found close to the theoretical value while thicker absorbers lead to a decrease in attenuation coefficient. However Gardner et al. found for the thicker absorber already a value close to the theoretical value ($\mu_w = 0.2036$ cm g$^{-1}$ and theoretical value = 0.204 cm g$^{-1}$) (1, 2), while their nonlinear part in Fig. 4 (which is given for a glass absorber but which effect on water absorber was found to be the same) shows an attenuation coefficient for water of about 0.215 cm g$^{-1}$ which is much higher than the theoretical value. For this reason Gardner et al.'s explanation can not hold.

Beside this, it is not expected that low energetic gamma's of 0.103 MeV can influence the Am counting when electronic discrimination is used. Groenevelt, de Swart, and Cisler pointed out that a number of collisions are needed before a 0.103 MeV gamma has the energy to let it be counted in the Am channel, and for this reason the probability for this gamma to pass the collimation in front of the detector is extremely low. Illustratively measurements were done with a $^{57}$Co source, with a 0.121 MeV and a 0.136 MeV peak, placed in the Am source holder of the gamma energy soil column scanner described (Monoenergetic gamma sources closer to or not available.) By comparison of integral and differential countings in the original Am channel that the differential count rate is only 6% of the integral count rate for all sort of absorbers. This means that constant escape peak influence is detected independently of the type of absorber.

Since the 0.103 MeV peak of $^{241}$Am is only 4% of the total Am desintegrations and a 0.060 MeV peak about 40% of it, the addition due to a 0.103 MeV peak is about 0.6% for zero absorber and 0.7% after attenuation through 6 cm of water. This small variation can not account for such a nonlinearity as in Gardner et al.'s Fig. 4 (1).

A reason for the observed nonlinearity may be an incorrectly determined dead time value. A too high apparent dead time for Am overcorrects the countings which results in an attenuation coefficient higher than the theoretical one as was found by Gardner et al. for a thin absorber as was found by Gardner et al. Apparent dead time is the sum of a real electronic dead time and an accidental coincidency dead time ("pile up"). This pile up is larger in the Cs channel than in the Am channel since its value is strongly affected by the relative channel width. For example, we found for the Cs channel an apparent dead time of 6.5 $\mu$sec but for the Am channel of 4.75 $\mu$sec. Gardner et al. determine

1 L. Stroosnijder and J. G. de Swart. Column scanning with simultaneous use of $^{241}$Am and $^{137}$Cs gamma radiation. Draft of publication available on request.