# DENSITY – NUCLEAR DENSITY GAUGE

## General Description

***The following description of a Mn/DOT's Nuclear Density Gauge is based on a Mn/DOT report[1] and product literature[2].***

Mn/DOT uses the Seaman C-200 Nuclear Density Testing device to non-destructively measure the in place field density of bituminous pavement and granular base materials at the time of construction. The Seaman testing device is capable of making rapid nondestructive determinations of aggregate shouldering and base material densities in the range of 70 to 170 pounds per cubic foot (PCF).

Compaction and density is a strong indicator of the percentage of voids in a bituminous pavement, which have been correlated to the quality and life of a bituminous pavement product.

In nuclear density testing pavement material is exposed to a known amount of gamma radiation from an encapsulated radioactive source. A Geiger-Mueller detector tube measures the amount of radiation reflected from the material to the meter. This radiation ionizes the gasses in the detector tube to create electrical pulses that the meter counts. Since dense materials absorb more radiation than the same material with a lower density, a high meter count implies the test material is of relatively low density, while a low meter count implies the test material has a relatively high density.

http://www.seamannuclear.com/Manuals.htm

Moisture measurement is possible as part of a density test, and is based on the neutron moderation principle. A moisture detector is located on the right side of the base, opposite the Geiger-Mueller detector. The radioactive source in the meter emits high-speed neutrons that travel at the speed of light. The neutrons have the same atomic weight as a hydrogen atom. When the high-speed neutrons encounter hydrogen atoms in the test material, the resulting collision reduces the speed of the neutron. The neutrons are now called slow-speed, or thermal neutrons, and travel at 1/1,000,000 the speed of a high-speed neutron. The moisture detector in the meter is sensitive only to slow speed neutrons. The greater the moisture count, the greater the amount of moisture in the sample being tested.

The device generally samples material to an approximate depth of 2 inches, but may be adjusted to take measurements of thinner layers. It is assumed that density measurements of bituminous and aggregates,

[1] Beaudry, Terrence M., "Mn/DOT's Non-Destructive Testing Program" (1995). Minnesota Department of Transportation. Available online at http://www.mrr.dot.state.mn.us/research/pdf/199507.pdf.

[2] "The C-200 Analyzer – Nuclear Density Meter, rev. 3" (1988). Seaman Nuclear Corporation.

and measurements of granular base moisture are representative of the material conditions throughout the entire lift thickness.

Subgrade and grading soils are not tested with the nuclear device. Nuclear testing can produce adequate results on mechanically placed homogeneous isotropic graded soils. Isotropic soils must display the same properties in all directions, horizontal and vertical. Variability of soils and the presence of trace elements that may exist in variable quantities within the matrix of grading materials, causing the testing device to produce questionable results.

The gage is maintained and stored in Mn/DOT's Materials Lab. Use and licensing is presently administered by the Bituminous Unit. The amount of use is highly variable.

Trained users of the Nuclear Density Gauge include members of the Bituminous Engineering and the Grading & Base units in the Central lab.

## Procedure

The Nuclear Density Gauge uses an internal particle count that ensures the gauge is functioning within normal parameters. The Air Gap method is used to remove the material chemical effect from density readings Typical test adjustments include the length of test 60 seconds or less), and the mode of operation. The bituminous pavement testing uses the touchable mode, where the base of the gauge directly contacts the surface. Touchable mode is preferred where surface conditions are flat, and allow uniform seating of the device. When uneven seating conditions occur the device can also operate in untouchable mode, where the base is elevated 0.25 in.

## For more information:

For more information about MnROAD and the Road Research program at Mn/DOT:

Tim Clyne
Minnesota Road Research
Office of Materials
Phone: 651-366-5473
E-mail: Tim.Clyne@dot.state.mn.us

Ben Worel
Minnesota Road Research
Office of Materials
Phone: 651-366-5522
Email: Ben.Worel@dot.state.mn.us

www.dot.state.mn.us/mnroad