Designation: D6727/D6727M – 16

Standard Guide for Conducting Borehole Geophysical Logging—Neutron[1]

This standard is issued under the fixed designation D6727/D6727M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This guide is focused on the general procedures necessary to conduct neutron or neutron porosity (hereafter referred to as neutron) logging of boreholes, wells, access tubes, caissons, or shafts (hereafter referred to as boreholes) as commonly applied to geologic, engineering, groundwater and environmental (hereafter referred to as geotechnical) explorations. Neutron soil moisture measurements made using neutron moisture gauges, are excluded. Neutron logging for minerals or petroleum applications is excluded, along with neutron activation logs where gamma spectral detectors are used to characterize the induced gamma activity of minerals exposed to neutron radiation.

1.2 This guide defines a neutron log as a record of the rate at which thermal and epithermal neutrons are scattered back to one or more detectors located on a probe adjacent to a neutron source.

1.2.1 Induction logs are treated quantitatively and should be interpreted with other logs and data whenever possible.

1.2.2 Neutron logs are commonly used to: (*1*) delineate lithology, and (*2*) indicate the water-filled porosity of formations (see Fig. 1).

1.3 This guide is restricted to neutron logging with nuclear counters consisting of scintillation detectors (crystals coupled with photomultiplier tubes), or to He^3-tube detectors with or without Cd foil covers or coatings to exclude thermalized neutrons.

1.4 This guide provides an overview of neutron logging including: (*1*) general procedures; (*2*) specific documentation; (*3*) calibration and standardization, and (*4*) log quality and interpretation.

1.5 To obtain additional information on neutron logs see References section in this guide.

1.6 This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This guide should not be used as a sole criterion for neutron logging and does not replace education, experience, and professional judgment. Neutron logging procedures should be adapted to meet the needs of a range of applications and stated in general terms so that flexibility or innovation are not suppressed. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged without consideration of a project's many unique aspects. The word standard in the title of this document means that the document has been approved through the ASTM consensus process.

1.7 *Units*—The values stated in either inch-pound units or SI units given in brackets are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be use independently of the other. Combining values from the two systems may result in non-conformance with the standard. Add if appropriate: "Reporting of test results in units other than SI shall not be regarded as nonconformance with this standard."

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use. The use of radioactive sources in neutron logging introduces significant safety issues related to the transportation and handling of neutron sources, and in procedures to ensure that sources are not lost or damaged during logging. There are different restrictions on the use of radioactive sources in logging in different states, and the Nuclear Regulatory Agency (NRC) maintains strict rules and regulations for the licensing of personnel authorized to conduct nuclear source logging.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.01 on Surface and Subsurface Characterization.

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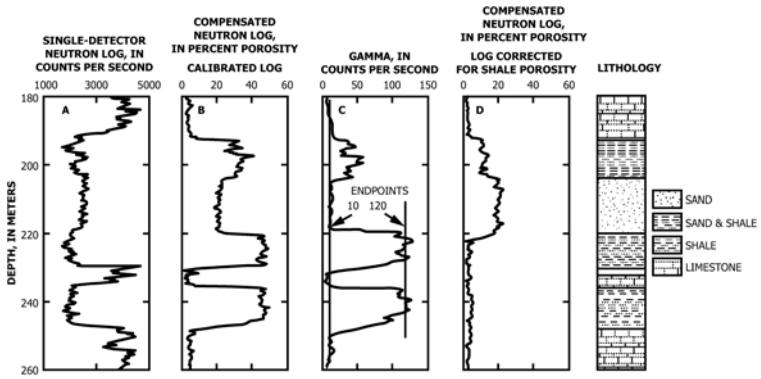
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**



A–Single detector epithermal neutron log plotted in counts per second.
B–Dual-detector neutron log calibrated in limestone porosity units.
C–Gamma log showing maximum and minimum values used as endpoints for the gamma activity scale.
D–Dual detector neutron log plotted in porosity units corrected for the non-effective porosity of clay minerals using the equation:

$$N_c = N_0 - C_{sh} \cdot \Phi_{sh}$$

where:

N_c = corrected neutron log,
N_0 = original neutron log,
C_{sh} = computed shale fraction based upon the gamma log position between the endpoints of 10 and 120 cps, and
Φ_{sh} = estimate of shale non-effective porosity of about 40 % picked from intervals on the log where $\Phi_{sh} = 1.0$.

FIG. 1 Typical Neutron Logs for a Sedimentary Rock Environment

D5088 Practice for Decontamination of Field Equipment Used at Waste Sites
D5608 Practices for Decontamination of Sampling and Non Sample Contacting Equipment Used at Low Level Radioactive Waste Sites
D5753 Guide for Planning and Conducting Borehole Geophysical Logging

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common technical terms in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *depth of exploration, n—in geophysics*, the radial distance from the measurement point to a point where the predominant measured response may be considered centered (not to be confused with depth below the surface).

3.2.2 *epithermal neutron, n*—neutron with kinetic energy somewhat greater than the kinetic energy associated with thermal lattice vibrations of the surrounding formation; such neutrons have been slowed enough by collisions with formation minerals to interact with the detector, but the population of epithermal neutrons is not strongly affected by absorption cross-sections of trace minerals in the geologic environment.

3.2.3 *neutron generator, n*—a device which includes a particle accelerator to generate a flux of high-energy neutrons, and which can be turned on and off through connection with an external power supply.

3.2.4 *neutron slowing distance, n*—the distance traveled by a neutron within a formation over the time required for the neutron to be slowed to half of its original velocity by repeated collisions with the atoms in the formation.

3.2.5 *thermalized neutron, n*—neutron that has been slowed to a kinetic energy approximately equal to that of the thermal kinetic energy of the surrounding formation.

3.2.6 *volume of exploration, n—in geophysics*, the volume, which is non-spherical and has gradation boundaries, that contributes 90 percent of the measured response and it determined by a combination of theoretical and empirical modeling.

4. Summary of Guide

4.1 This guide applies to borehole neutron logging.

4.2 This guide briefly describes the significance and use, apparatus, calibration and standardization, procedures, and reports for conducting borehole neutron logging.

5. Significance and Use

5.1 An appropriately developed, documented, and executed guide is essential for the proper collection and application of neutron logs.

5.2 The benefits of its use include improving selection of neutron logging methods and equipment; neutron log quality and reliability; usefulness of the neutron log data for subsequent display and interpretation.

5.3 This guide applies to commonly used neutron logging methods for geotechnical applications.

6. Interferences

6.1 Most extraneous effects on neutron logs are caused by logging too fast, instrument problems, borehole conditions, partially saturated formations, and geologic conditions.

6.2 Logging too fast can significantly degrade the quality of neutron logs, especially when neutron detectors are designed to