



Designation: B567 – 98 (Reapproved 2009a)

Standard Test Method for

Measurement of Coating Thickness by the Beta Backscatter Method¹

This standard is issued under the fixed designation B567; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the beta backscatter gages for the nondestructive measurement of metallic and nonmetallic coatings on both metallic and nonmetallic substrate materials.

1.2 The test method measures the mass of coating per unit area, which can also be expressed in linear thickness units provided that the density of the coating is known.

1.3 The test method is applicable only if the atomic numbers or equivalent atomic numbers of the coating and substrate differ by an appropriate amount (see 6.2).

1.4 Beta backscatter instruments employ a number of different radioactive isotopes. Although the activities of these isotopes are normally very low, they can present a hazard if handled incorrectly. This standard does not purport to address the safety issues and the proper handling of radioactive materials. It is the responsibility of the user to comply with applicable State and Federal regulations concerning the handling and use of radioactive material. Some States require licensing and registration of the radioactive isotopes.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *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 limitations prior to use.*

2. Terminology

2.1 Definitions of Terms Specific to This Standard:

2.1.1 *activity*—the nuclei of all radioisotopes are unstable and tend to change into a stable condition by spontaneously

emitting energy or particles, or both. This process is known as radioactive decay. The total number of disintegrations during a suitably small interval of time divided by that interval of time is called “activity.” Therefore, in beta backscatter measurements, a higher activity corresponds to a greater emission of beta particles. The activity of a radioactive element used in beta backscatter gages is generally expressed in microcuries ($1 \mu\text{Ci} = 3.7 \times 10^4$ disintegrations per second).

2.1.2 *aperture*—the opening of the mask abutting the test specimen. It determines the size of the area on which the coating thickness is measured. This mask is also referred to as a platen, an aperture plate, a specimen support, or a specimen mask.

2.1.3 *backscatter*—when beta particles pass through matter, they collide with atoms. Among other things, this interaction will change their direction and reduce their speed. If the deflections are such that the beta particle leaves the body of matter from the same surface at which it entered, the beta particle is said to be backscattered.

2.1.4 *backscatter coefficient*—the backscatter coefficient of a body, R , is the ratio of the number of beta particles backscattered to that entering the body. R is independent of the activity of the isotope and of the measuring time.

2.1.5 *backscatter count*—

2.1.5.1 *absolute backscatter count*—the absolute backscatter count, X , is the number of beta particles that are backscattered during a finite interval of time and displayed by the instrument. X will, therefore, depend on the activity of the source, the measuring time, the geometric configuration of the measuring system, and the properties of the detector, as well as the coating thickness and the atomic numbers of the coating and substrate materials. X_0 is the count produced by the uncoated substrate, and X_s that of the coating material. To obtain these values, it is necessary that both these materials are available with a thickness greater than the saturation thickness (see 2.1.12).

2.1.5.2 *normalized backscatter*—the normalized backscatter, x_n , is a quantity that is independent of the activity of the source, the measuring time, and the properties of the

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detector. The normalized backscatter is defined by the equation:

$$x_n = \frac{X - X_0}{X_s - X_0}$$

where:

- X_0 = count from the substrate,
- X_s = count from the coating material, and
- X = count from the coated specimen, and each count is for the same interval of time.

Because X is always $\geq X_0$ and $\leq X_s$, x_n can only take values between 0 and 1. (For reasons of simplicity, it is often advantageous to express the normalized count as a percentage by multiplying x_n by 100.)

2.1.5.3 normalized backscatter curve—the curve obtained by plotting the coating thickness as a function of x_n .

2.1.6 beta particles—beta particles or beta rays are high-speed electrons that are emitted from the nuclei of materials undergoing a nuclear transformation. These materials are called beta-emitting isotopes, beta-emitting sources, or beta emitters.

2.1.7 coating thickness—in this test method, coating thickness refers to mass per unit area as well as geometrical thickness.

2.1.8 dead time or resolving time—Geiger-Müller tubes used for counting beta particles have characteristic recovery times that depend on their construction and the count rate. After reading a pulse, the counter is unresponsive to successive pulses until a time interval equal to or greater than its dead time has elapsed.

2.1.9 energy—it is possible to classify beta emitters by the maximum energy of the particles that they release during their disintegration. This energy is generally given in mega-electronvolts, MeV.

2.1.10 equivalent (or apparent) atomic number—the equivalent atomic number of an alloy or compound is the atomic number of an element that has the same backscatter coefficient as the material.

2.1.11 half-life, radioactive—for a single radioactive decay process, the time required for the activity to decrease by half.

2.1.12 saturation thickness—the minimum thickness of a material that produces a backscatter that is not changed when the thickness is increased. (See also [Appendix X1](#).)

2.1.13 sealed source or isotope—a radioactive source sealed in a container or having a bonded cover, the container or cover being strong enough to prevent contact with and dispersion of the radioactive material under the conditions of use and wear for which it was designed.

2.1.14 source geometry—the spatial arrangement of the source, the aperture, and the detector with respect to each other.

3. Summary of Test Method

3.1 When beta particles impinge upon a material, a certain portion of them is backscattered. This backscatter is essentially a function of the atomic number of the material.

3.2 If the body has a surface coating and if the atomic numbers of the substrate and of the coating material are sufficiently different, the intensity of the backscatter will be

between two limits: the backscatter intensity of the substrate and that of the coating. Thus, with proper instrumentation and if suitably displayed, the intensity of the backscatter can be used for the measurement of mass per unit area of the coating, which, if the density remains the same, is directly proportional to the thickness.

3.3 The curve expressing coating thickness (mass per unit area) versus beta backscatter intensity is continuous and can be subdivided into three distinct regions, as shown in [Fig. 1](#). The normalized count rate, x_n , is plotted on the X-axis, and the logarithm of the coating thickness, on the Y-axis. In the range $0 \leq x_n \leq 0.35$, the relationship is essentially linear. In the range $0.35 \leq x_n \leq 0.85$, the curve is nearly logarithmic; this means that, when drawn on semilogarithmic graph paper, as in

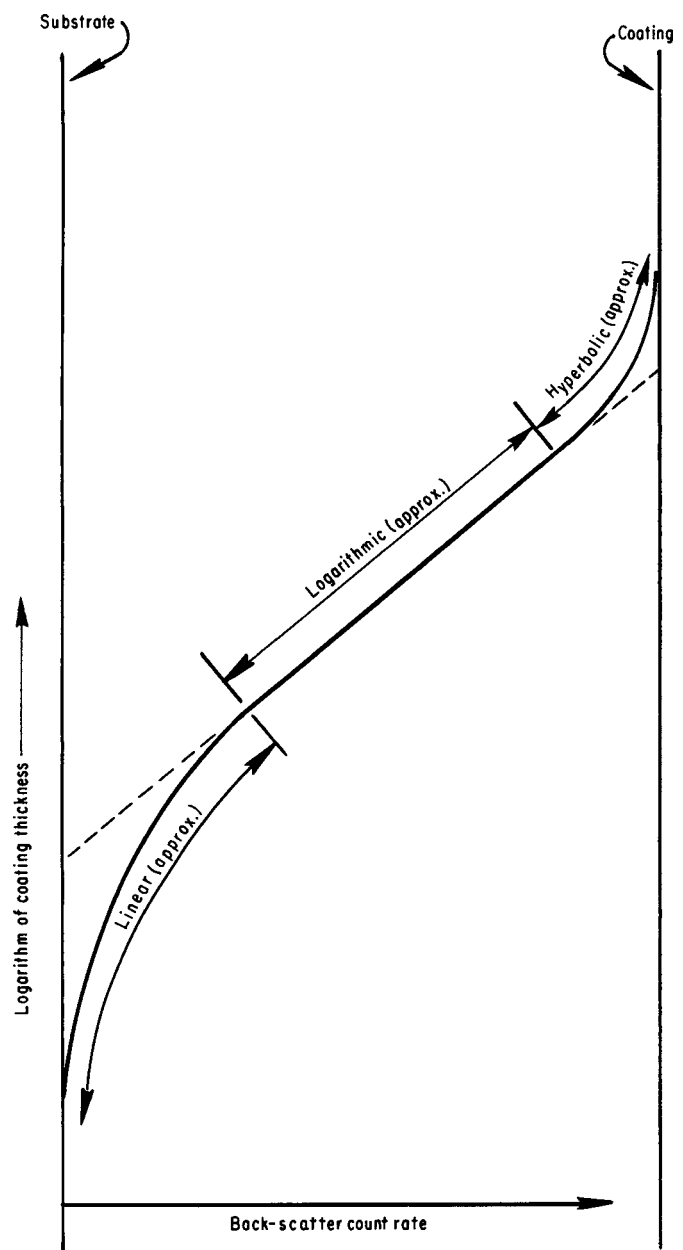


FIG. 1 Normalized Backscatter