



Standard Practice for Definition and Determination of Thermionic Constants of Electron Emitters¹

This standard is issued under the fixed designation F83; 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.

INTRODUCTION

Cathode materials are often evaluated by an emission test which in some ways measures the temperature-limited emission. A more basic approach to this problem is to relate the emission to fundamental properties of the emitter, in particular, the work function. Comparisons are conveniently made between emitters using the thermionic constants, that is, the work function, the emission constant, and the temperature dependence of the work function. These quantities are independent of geometry and field effects when properly measured. Although referred to as “constants” these quantities show variations under different conditions. Considerable confusion exists over the definition, interpretation, and usage of these terms and, hence, there is a need for at least a general agreement on nomenclature.

1. Scope

1.1 This practice covers the definition and interpretation of the commonly used thermionic constants of electron emitters **(1, 2, 3)**,² with appended standard methods of measurement.

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

1.3 *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. Referenced Documents

2.1 ASTM Standards:³

F8 Recommended Practice for Testing Electron Tube Materials Using Reference Triodes⁴

¹ This practice is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.03 on Metallic Materials.

Current edition approved May 1, 2013. Published May 2013. Originally approved in 1967. Last previous edition approved in 2009 as F83 – 71 (2009). DOI: 10.1520/F0083-71R13.

² The boldface numbers in parentheses refer to references at the end of this practice.

³ 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.

⁴ Withdrawn.

3. Terminology

3.1 Definitions:

3.1.1 *effective work function*, ϕ —the work function obtained by the direct substitution of experimentally determined values of emission current density and temperature into the Richardson-Dushman equation of electron emission of the form:

$$J = AT^2 e^{-\phi/kT} \quad (1)$$

For direct calculation of the work function, this is conveniently put in the form:

$$\phi = (kT/e) \ln(AT^2/J) \quad (2)$$

where:

J = emission current density in A/cm² measured under specified field conditions except zero field. (J_0 = emission current density in A/cm² measured under zero field conditions.)

A = the theoretical emission constant, which is calculated from fundamental physical constants, with its value generally taken as 120 A/cm²·K². A more exact calculation **(3)** gives 120.17 which is used in determining the effective work function.

T = cathode temperature, K.

e = electronic charge, C.

e = natural logarithmic base.

k = Boltzmann's constant.

ϕ = work function, V.

The form of Eq 1 is a simplified form of the emission