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# Standard Practice for Thermoelectric Sorting of Electrically Conductive Materials[1]

This standard is issued under the fixed designation E977; 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 practice covers the procedure for sorting materials using the thermoelectric method, which is based on the Seebeck effect. The procedure relates to the use of direct- and comparator-type thermoelectric instruments for distinguishing variations in materials which affect the thermoelectric properties of those materials.

1.2 While the practice is most commonly applied to the sorting of metals, it may be applied to other electrically conductive materials.

1.3 Thermoelectric sorting may also be applied to the sorting of materials on the basis of plating thickness, case depth, and hardness.

1.4 *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 *Descriptions of Terms:*

2.1.1 *acceptance limits*—the thermoelectric response that establishes the group into which the material being examined belongs.

2.1.2 *comparative instrumentation*—a system that uses electrode assemblies (probes), associated electronics, and known standards to measure a thermoelectric response from an electrically-conductive material. This response is compared with that of the reference standard.

2.1.3 *direct instrumentation*—a system that specifically measures and displays the voltage (or an arbitrary unit) generated between the electrodes when they are at different temperatures and in contact with the material.

2.1.4 *electrode*—the conductors used in thermoelectric sorting instruments used to generate the Seebeck effect with the material under test.

2.1.5 *Seebeck effect*—the thermoelectric electromotive force (emf) produced in a circuit connecting two dissimilar conductors at two points of different temperatures. The magnitude of this emf is a function of the chemistry of the materials, surface metallurgical structure, and the temperature at the junctions. See Fig. 1.



## 3. Summary of Practice

3.1 The two techniques that are primarily used in thermoelectric sorting are direct and comparative instrumentation. In the direct instruments, equipment is standardized by placing materials with known chemistry and metallurgical structure in the test system. The value of the thermoelectric voltage (or arbitrary unit) is read on the scale of an indicator. In the comparative instruments, the thermoelectric response of the test piece is compared with that of a known standard(s) and the response indicates whether the piece is within the acceptance limits.

3.1.1 Both kinds of instrumentation require comparing the pieces to be examined with the known standard(s). Two or more samples representing the acceptance limits may be required.

3.1.2 *Direct Thermoelectric Instrumentation*—a known standard(s) is inserted in the system and the controls of the instrument are adjusted to obtain a voltage (or arbitrary unit) reading(s). The process is then continued by inserting the pieces to be sorted into the system, and observing the instrument reading(s).

[1] This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.10 on Specialized NDT Methods.

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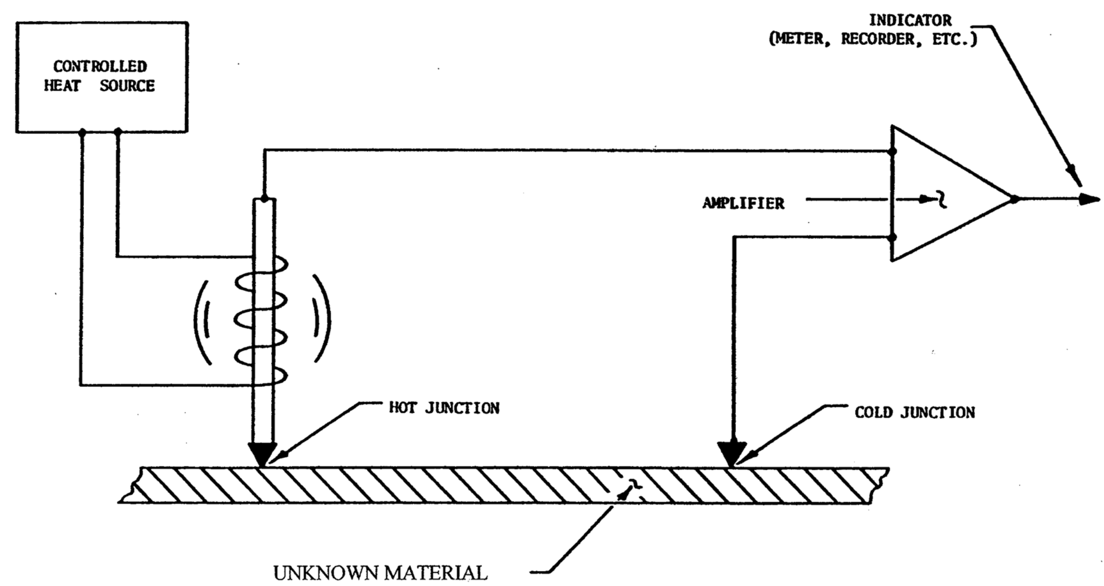


**FIG. 1 Typical Circuit Used in Thermoelectric Material Sorting Instruments**

3.1.3 *Comparative Instrumentation*—Known standards representing the acceptance limits are inserted into the system. The instrument controls are adjusted for appropriate response. The process is then continued by inserting the pieces to be sorted in the system, and observing the instrument response.

3.2 In both instruments, the range of the instrument response must be adjusted during standardization so that any anticipated deviation from the known standard(s) will be recognized as within the required acceptance limits.

3.3 The examination process may consist of manual insertion of one piece after another into the system, or an automated feeding and classifying mechanism may be employed.



## 4. Application

4.1 Thermoelectric techniques provide a method for sorting large quantities of conductive materials. The ability to accomplish satisfactorily these types of separations is dependent upon the relation of the thermoelectric voltages with regard to composition, condition, structure, and processing.

4.2 Comparative instrumentation is used when high-sensitivity testing is required. The advantage of this method is that it reduces internal or external disturbances such as temperature variations of the material or probes, or both.

4.3 The success of an attempted sort will be affected by instrument factors such as electrode composition, electrode temperature differential, and electrode contact.

4.4 The degree of reliability of instrument readings will be affected greatly by the coupling between the electrodes and the part and the accuracy with which the temperature is held constant during the measuring period. The surface of the materials and of both electrodes must be kept free of any insulating materials such as surface oxide, dirt, paint, or other foreign material.

## 5. Interference

5.1 The specific influence of the following variables must be considered for proper interpretation of the results obtained:

5.1.1 A correlation shall be established so that if the thermoelectric properties of the various groups overlap, auxiliary methods are used for supplementary examination.

5.1.2 In sorting materials, a temperature differential must be used that will result in a well-defined separation of the thermoelectric properties.

5.1.3 Contaminates that will electrically insulate material being examined, such as rust, grease, oil, mill scale; or surface coatings such as paint, plastic, and so forth, must be removed to ensure clean contact between the material and the electrodes of the device.

5.1.4 Extreme temperature differences between the standard(s) and the pieces will alter the emf generated. Known standard(s) should be at the same temperature as the pieces being examined.

5.1.5 The geometry and mass of the standard and part need not be a consideration to permit sorting. Fixturing may be required where the part mass is insufficient to provide an adequate heat sink (for example, thin foil, small-diameter wire, small bearings, etc.).