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Standard Guide for Specifying the Chemical Compositions and Selecting Sampling Practices and Quantitative Analysis Methods for Metals, Ores, and Related Materials[1]

This standard is issued under the fixed designation E1282; 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 covers procedures for specifying compositional requirements and identifying appropriate sampling and quantitative analysis test methods to be referenced in product specification standards for metals, ores, and related materials. It is not intended to replace or conflict with either individual product specifications or standards covering broad classifications of products such as Test Methods and Practices A751.

1.2 *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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A276 Specification for Stainless Steel Bars and Shapes
A751 Test Methods and Practices for Chemical Analysis of Steel Products
E34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys (Withdrawn 2017)[3]
E135 Terminology Relating to Analytical Chemistry for Metals, Ores, and Related Materials
E255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition
E342 Test Method for Determination of Chromium Oxide in Chrome Ores by Permanganate Titrimetry
E350 Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
E1601 Practice for Conducting an Interlaboratory Study to Evaluate the Performance of an Analytical Method

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this guide, see Terminology E135.

[1] This guide is under the jurisdiction of ASTM Committee E01 on Analytical Chemistry for Metals, Ores, and Related Materials and is the direct responsibility of Subcommittee E01.20 on Fundamental Practices.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

4. Significance and Use

4.1 This guide is intended to assist those writing or revising compositional specifications, sampling practices, and test methods for ferrous and non-ferrous metals, ores, and related materials. It is directed toward those areas that must be addressed to properly coordinate compositional specification, sampling practice, and test methods. Its use will help ensure that compositional requirements are clearly defined and that sampling practices and test methods are available to meet product specifications.

4.2 This guide does not attempt to define which elements should be controlled, where samples should be taken, or how they should be analyzed. These items are addressed in standards such as Specification A276, ~~Methods, Practices~~Test Methods and ~~Terminology~~Practices A751, Test Method E34, Practice E255, Test Method E342, and Test Methods E350.

4.3 A primary purpose for ASTM sampling practices and test methods is to provide widely-accepted and tested methodology for use in meeting ASTM product specifications. Although it is recognized that individual laboratories are free to use other methods, the availability of ASTM approved methodology is essential for referee purposes and to demonstrate that properly equipped laboratories can make the required measurements.

4.4 Sampling practices and test methods to be recommended for use in testing a given product are most easily selected cooperatively by the specification-writing and the methods-writing committees that have jurisdiction over the product. When existing sampling or test methods do not meet the needs of the new product specification standard, the specification-writing committee should request that the methods-writing committee develop the required standards. ASTM Committee E01 is responsible for test methods and practices covering the sampling and analysis of most metals, ores, and related materials.

5. ~~Procedure~~Specifying Chemical Composition

5.1 List those elements which either positively or negatively influence the product's processing, properties, or performance. Do not list elements for which no justification exists for exercising compositional control or for which no test methods exist. Nonessential compositional specifications increase testing costs with no benefit to producer or consumer.

5.2 Establish the compositional requirements for each element identified in 5.1 as a composition range, a maximum, or a minimum. Where possible, it is desirable to express composition in mass fraction percent. Always list the element in the stoichiometric form in which the composition is to be reported. For example, depending on the material, calcium might be specified and reported as Ca, $CaCO_3$, or CaO. Occasionally, it may be necessary to specify that the sum of a limited number of specific element compositions must not exceed some maximum value or must remain above some minimum value. Ensure that measurement uncertainties, particularly at the lower quantitation limits, do not contribute significantly to calculated sums.

5.2.1 Nonspecific phrases such as *balance* or *remainder* may be listed for informational purposes only, but must have an accompanying footnote stating that quantitative measurement is not required. An example of an acceptable footnote is: "For information only. Quantitative determination of this element is not required." Avoid assigning quantitative compositional specifications to nonspecific items such as "all other elements" or "all residuals." It is not possible to use element-specific test methods to meet a non-element-specific compositional specification (Note 1).

NOTE 1—The purity of high purity metals is often best ascertained by the determination of residual elements. In these cases, each element to be determined must be listed with either a maximum composition for each element or a minimum composition for the sum of the listed determinations. See Table 1.

5.2.2 When specifying the composition of components in a composite, define the components consistent with both commercial requirements and testing capabilities. For example, if a specification requires that both the coating and base metal be analyzed separately, ensure that it is possible to quantitatively separate the coating from the base metal prior to analysis.

5.2.3 If compositional requirements differ among various applications for a given alloy, it may be necessary to specify composition by application within a grade, or to create a separate grade for those applications.

5.2.4 Refer to Table 1 as an example of a possible format for presenting compositional specifications.

~~5.3 Identify standard sampling practices that can be used at each processing step or for each product form for which compositional requirements are identified as described below.~~

TABLE 1 Example of Typical Alloy Compositional Requirements

Element	Composition[A]	
	Grade A	Grade B
Carbon:	0.20–0.30	0.45–0.75
Carbon	0.20–0.30	0.45–0.75
Manganese:	1.0, max	1.3, max
Manganese	1.0, max	1.3, max
Chromium	20.0–28.5	32.5–38.0
Iron	25, min	balance[B]
Copper + Vanadium	0.02, max	0.50, min
Oxygen	25 μg/g, max	50 μg/g, max
Aluminum[C]	0.02–0.10	0.20–0.30

[A] All compositions are given in mass fraction percent, unless otherwise stated.
[B] For information only. Quantitative determination of this element is not required.
[C] The aluminum composition requirement applies only to material made for high-temperature applications and its quantitative determination is not required on material designated for other uses.

5.3.1 Ensure that each selected sampling practice can be conducted without unacceptably interrupting production, interfering with product quality, or risking the health or safety of employees.

5.3.2 Ensure that the selected sampling hardware and practices are reliable. For example, in heat analysis sampling, ensure that the ratio of successful (solid, non-porous, completely filled mold) to unsuccessful samplings is acceptable. Also, provision should be made for resampling when needed.

5.3.3 Ensure that the composition of each element to be determined in the sample is representative of the bulk material. For example, many commercially available molten-metal sampling devices used in the steel industry contain deoxidizing elements, such as aluminum, which alloy with the test sample. Samples taken using such devices cannot be used to determine these elements in the bath. In addition, the unusually high composition of the deoxidizing element may interfere with the determination of other elements in the sample. If any of these elements are to be included in the product specification, more than one sampling device will be required.

5.3.4 Ensure that adequate samples are taken to permit the determination of all elements to be included in the specification. Some determinations, such as hydrogen, may require special sampling and storage practices.

5.3.5 Ensure that each selected sampling practice provides samples of sufficient size and shape for both production and referee analyses. Samples should be in a form amenable to rapid transport to the laboratory, and should require a minimum of time and effort to prepare for chemical analysis. Following production analysis, sufficient representative material must remain for any recheck analyses by the same or other test methods, as required.

5.4 Identify all test methods that can be used to determine all elements for which compositions are to be specified as described in 5.4.1 – 5.4.4.

5.4.1 Using the lists of elements and associated compositions generated in 5.2, identify the test methods that cover the listed composition ranges for the analyses. Most in-process (control) analyses are performed by spectrometric test methods using solid samples. Sometimes final product, recheck, or referee analyses are performed by a combination of classical chemical and instrumental test methods that may require a dissolved sample be obtained from drilled or machined chips.

5.4.2 Eliminate from further consideration any methodologies that are subject to uncorrectable chemical or spectral interferences due to elements expected to exist in the sample, including those for which compositions are not specified. Such interferences are identified in each ASTM test method. The Scope and Interferences sections of each method must be carefully interpreted by a skilled analyst before that method is applied to the analysis of a material that was not considered by the authors of the method.

5.4.3 Ensure that the identified test methods are capable of attaining sufficient precision to comply with the intended compositional requirements. Refer to the performance data in the ASTM test methods to ensure that the repeatability (*r*) and reproducibility (*R*) obtained during interlaboratory testing for each method are sufficient to meet the intended requirements. Definitions of *r* and *R* can be found in Terminology E135, and Practice E1601. State compositional requirements using the number of significant digits that are consistent with the *R* performance data associated with the selected test method and the needs of the product specification. Compositional specifications will indicate various numbers of significant digits.