



Standard Test Method for Trace Element Analysis of Hazardous Waste Fuel by Energy-Dispersive X-Ray Fluorescence Spectrometry¹

This standard is issued under the fixed designation D 5839; 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 test method applies to the determination of trace element concentrations by energy-dispersive X-ray fluorescence (EDXRF) spectrometry in typical liquid hazardous waste fuels (LHWF) used by industrial furnaces.

1.2 This test method has been used successfully on numerous samples of LHWF that are mixtures of solvents, oils, paints, and pigments for the determination of the following elements: Ag, As, Ba, Cd, Cr, Hg, Ni, Pb, Sb, Se, and Tl.

1.3 This test method also may be applicable to elements not listed above and to the analysis of trace metals in organic liquids other than those used as LHWF.

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. Referenced Documents

2.1 ASTM Standards:

C 982 Guide for Selecting Components for Energy-Dispersive X-Ray Fluorescence (XRF) Systems²

3. Summary of Test Method

3.1 A weighed portion of the sample is transferred to a porcelain evaporating dish and placed on a hot plate. The sample is heated for 15 to 30 min at a temperature not exceeding 105°C to evaporate highly volatile components. The dish is removed from the hot plate and allowed to cool. Graphite powder is blended with the evaporated sample until a homogeneous paste is produced and the sample weight is recorded. The blended sample is inserted in a disposable sample cup and placed in the X-ray spectrometer for analysis.

3.2 The K Spectral X-ray emission lines are used for Ag, As, Ba, Cd, Cr, Ni, Sb, and Se.

3.3 The L spectral X-ray emission lines are used for Hg, Pb, and Tl.

4. Significance and Use

4.1 The analysis of trace elements is often a regulatory and process specific requirement for facilities utilizing LHWF. With proper instrument standardization, set-up, and quality control, this test method provides the user an accurate, rapid, nondestructive method for trace element determinations.

5. Interferences

5.1 Spectral Overlaps:

5.1.1 Samples containing a mixture of elements often exhibit X-ray emission line overlap. Modern Si (Li) detectors generally provide adequate resolution to minimize the effects of spectrum overlaps on the analytical results of the LHWF. In those cases where direct emission line overlap exists, spectral deconvolution methods extract corrected analyte emission line intensities. Table 1 lists the significant line overlaps observed for the elements analyzed in LHWF. Follow the EDXRF manufacturer's recommendations concerning spectral deconvolution of the emission lines.

NOTE 1—Not all possible interferences are listed in Table 1. The LHWF samples to be analyzed may have other emission line interferences not mentioned. Consult the manufacturer's recommendations for optimum deconvolution methods.

5.2 Matrix Interferences:

5.2.1 Large concentration variations of metal or matrix components, or both, in LHWF samples can result in non-linear metal X-ray intensity response at increasing metal concentrations. Untreated matrix interactions may have a deleterious effect on metal determination accuracy. Matrix interactions, if exhibited by the LHWF samples, must be accounted for by method calibration.

6. Apparatus

6.1 *Energy Dispersive X-Ray Spectrometer*, capable of measuring the wavelengths listed in Table 1. Refer to C 982 for system specifications.

6.2 *Hot Plate*, with temperature control to 105°C.

6.3 *Analytical Balance*, capable of weighing to 0.001 g.

6.4 *Porcelain Evaporating Dishes*, 70 to 150 mL capacity.

7. Reagents and Materials

7.1 *Purity of Reagents*—Use reagent grade chemicals in all tests. Unless otherwise indicated, all reagents will conform to

¹ This guide is under the jurisdiction of ASTM Committee D-34 on Waste Management and is the direct responsibility of Subcommittee D34.02 on Physical and Chemical Characterization.

Current edition approved Jan. 10, 1996. Published March 1996.

² *Annual Book of ASTM Standards*, Vol 12.01.

TABLE 1 Common Emission Line Spectral Interferences for LWHF Analysis

Element	Lines Determined	Spectral Interferences
As	K α , K β	Pb L α , Hg L β , Tl L α L β
Cr	K α , K β	V K β , Mn K α
Hg	L α , L β	As K β , Se K α , Pb L β , Tl L α , Br K α
Ni	K α , K β	Cu K β , Cu K α
Pb	L α , L β	As K α , Se K β Hg L β Tl L α , Tl L β , Br K α , Br K β
Se	K α , K β	Pb L β , Hg L β , Tl L β
Tl	L α , L β	As K α , As K β , Se K β , Pb L α , Br K α , Hg L α , Hg L β

the specifications of the Committee on Analytical Reagents of the American Chemical Society where such specifications are available.³ Other grades may be used, provided it is first ascertained that the reagent is of sufficient high purity to permit its use without lessening the accuracy of the determination.

7.2 Use graphite powder, mixing grade, 44 μm , 325 mesh.⁴

7.3 Use oil-based Ag, As, Ba, Cd, Cr, Hg, Ni, Pb, Sb and Se standards, 10 to 10 000 mg/kg depending on the user's analytical requirements. If the results of this test method are to be used for compliance purposes, standards or a commercial source must be traceable to NIST or other certifying body. Quality control samples for analyses done for compliance purposes may need to be prepared with standards from a different vendor or lot number.

7.4 Use oil or solvent-based Tl standard, 10 to 1000 mg/kg depending on the user's analytical requirements. If the results of this test method are to be used for compliance purposes, standards or a commercial source must be traceable to NIST or other certifying body.⁵

7.5 Use paraffinic base oil.

7.6 Use sample cups, vented or unvented.

7.7 Use thin-film sample support.

NOTE 2—The user should select a thin-film support that provides for maximum transmittance and is resistant to typical components in LWHF. The thin-film supports used in the development of this test method were 4 μm Prolene.

8. Sampling

8.1 Because stratification or layering of liquid samples is possible, the laboratory sample should be thoroughly mixed by shaking prior to withdrawing a portion for testing, or use a sampling method that assures all portions of the sample are represented.

9. Preparation of Apparatus

9.1 Follow the manufacturer's instructions for set-up, conditioning, preparation, and maintenance of the XRF spectrometer.

³ *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmaceutical Convention, Inc. (USPC), Rockville, MD.

⁴ This reagent, or its equivalent, is available from Chemplex Industries, Inc., 160 Marbledale Road, Tuckahoe, NY 10707.

⁵ This reagent, or its equivalent, is available from Alfa Aesar, Johnson Matthey Inc., 30 Bond Street, Ward Hill, MA 01835.

9.2 Obtain reference spectra from pure element standards for all analytes and interelement correction metals.

9.3 Address spectral interferences, as listed in 5.1.1, in accordance with manufacturer's recommendations.

10. Calibration and Standardization

10.1 Calibrate the spectrometer to an appropriate reference element at the minimum frequency specified by the manufacturer.

10.2 Analytical standards should be gravimetrically prepared by blending the elemental standards and graphite listed in Section 7. These preparations can contain single or multiple elements and should be prepared at combinations and ratios to meet the user's individual needs. For example, a Pb and Cd standard at 125 ppm each could be prepared by gravimetrically combining 2 g oil-based Pb standard (500 ppm), 2 g oil-based Cd standard (500 ppm) and 4 g graphite and blending to a homogeneous mixture. For this example, the Pb concentration is calculated as follows:

$$\begin{aligned} \text{Pb Standard Concentration} &= 500 \text{ ppm} \\ &\times \frac{\text{Pb Std. (g)}}{\text{graphite (g)} + \text{Cd Std. (g)} + \text{Pb Std. (g)}} \end{aligned} \quad (1)$$

10.3 The metals standard/graphite paste is placed in an XRF sample cup and affixed with a thin-film support. The sample cup is inverted and lightly tapped on a level surface until the blended paste makes full contact (no air spaces) with the thin-film support.

10.3.1 The standard blends in the sample cups are placed into the spectrometer's designated sample holder. Avoid touching the thin-film, as this can further reduce transmittance. Initiate data acquisition for the desired elements according to the manufacturer's instructions.

10.4 Two alternative standards calibration methods may be used:

10.4.1 *Test Method A (Empirical Calibration Method)*—Organic-based metals standards containing the metals of interest are prepared as described in 10.2. The standard metal concentrations must bracket the unknown LWHF concentration levels. If the standard concentrations are less than 0.1 % by weight, a linear calibration method may be used to plot metal emission intensity response against metal concentration.

10.4.1.1 If metal concentration exceeds 0.1 % by weight, then a matrix correction technique is employed. Standard mixtures of varying metal composition must be prepared that bracket the LWHF unknown concentrations. Eq A is solved for the slope, intercept and all alpha terms:

$$C_i = B_i + K_i I_i (1 + \sum \alpha_{ij} C_j) \quad (2)$$

where:

C_i = concentration of analyte element i ,

B_i = intercept term,

K_i = slope term,

I_i = X-ray intensity of element, i ,

α_{ij} = alpha coefficient describing the matrix interaction of element j on analyte i , and

C_j = concentration of matrix element j .

10.4.2 *Test Method B (Fundamental Parameters Method)*—