



Standard Practices for Apparatus, Reagents, and Safety Considerations for Chemical Analysis of Metals, Ores, and Related Materials¹

This standard is issued under the fixed designation E50; 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 U.S. Department of Defense.

1. Scope

1.1 These practices cover laboratory apparatus and reagents that are required for the chemical analysis of metals, ores and related materials by standard methods of ASTM. Detailed descriptions of recommended apparatus and detailed instructions for the preparation of standard solutions and certain nonstandardized reagents will be found listed or specified in the individual methods of analysis. Included here are general recommendations on the purity of reagents and protective measures for the use of hazardous reagents.

1.2 These recommendations are intended to apply to the ASTM methods of chemical analysis of metals when definite reference is made to these practices, as covered in Section 4.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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 whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific hazards are given in Section 8.

NOTE 1—The use of the verb “shall” (with its obligatory third person meaning) in this standard has been confined to those aspects of laboratory safety where regulatory requirements are known to exist. Such regulations, however, are beyond the scope of these practices.

2. Referenced Documents

2.1 ASTM Standards:²

D1193 Specification for Reagent Water

¹ These practices are under the jurisdiction of ASTM Committee E01 on Analytical Chemistry for Metals, Ores, and Related Materials and are 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.

E1 Specification for ASTM Liquid-in-Glass Thermometers
E77 Test Method for Inspection and Verification of Thermometers
E100 Specification for ASTM Hydrometers
E126 Test Method for Inspection, Calibration, and Verification of ASTM Hydrometers
E287 Specification for Laboratory Glass Graduated Burets
E288 Specification for Laboratory Glass Volumetric Flasks
E438 Specification for Glasses in Laboratory Apparatus
E542 Practice for Calibration of Laboratory Volumetric Apparatus
E694 Specification for Laboratory Glass Volumetric Apparatus
E969 Specification for Glass Volumetric (Transfer) Pipets
E1044 Specification for Glass Serological Pipets (General Purpose and Kahn)
E1621 Guide for Elemental Analysis by Wavelength Dispersive X-Ray Fluorescence Spectrometry

3. Terminology

3.1 For definitions of terms used in these practices, refer to Terminology E135.

4. Significance and Use

4.1 The inclusion of the following paragraph, or a suitable equivalent, in any standard (preferably after the section on Scope) is due notification that the apparatus and reagents required in that standard are subject to the recommendations set forth in these practices.

“Apparatus and Reagents”—Apparatus and reagents required for each determination are listed in separate sections preceding the procedure. Apparatus, standard solutions, and certain other reagents shall conform to the requirements prescribed in ASTM Practices E50, for Apparatus, Reagents, and Safety Considerations for Chemical Analysis of Metals, Ores, and Related Materials.”

4.2 It is assumed that the users of these practices will be trained analysts capable of performing common laboratory procedures skillfully and safely. It is expected that work will be performed in a properly-equipped laboratory.

5. Purity of Water and Reagents

5.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water conforming

TABLE 1 Chemical Reagents Specified in ASTM Methods for Chemical Analysis of Metals

Name	Formula
* Acetic acid	CH ₃ COOH
Acetone	CH ₃ COCH ₃
Acetylacetone (2,4-pentanedione)	CH ₃ COCH ₂ COCH ₃
Alizarin-Red-S	C ₆ H ₄ COC ₆ H-1,2-(OH) ₂ -3-SO ₃ NaCO
Aluminon (aurintricarboxylic acid-ammonium salt)	(4-HOC ₆ H ₃ -3-COONH ₄) ₂ C:C ₆ H-3-(COONH ₄):O
Aluminum metal (99.9 % min)	Al
* Aluminum metal (sheet or rolled foil)	Al
Aluminum ammonium sulfate	Al ₂ (NH ₄) ₂ (SO ₄) ₄ ·24H ₂ O
Aluminum nitrate	Al(NO ₃) ₃ ·9H ₂ O
Aluminum sulfate	Al ₂ (SO ₄) ₃ ·18H ₂ O
Aluminum oxide, fused (Alundum)	
1-Amino-2-naphthol-4-sulfonic acid	NH ₂ C ₁₀ H ₅ (OH)SO ₃ H
Ammonium acetate	CH ₃ COONH ₄
Ammonium benzoate	C ₆ H ₅ COONH ₄
Ammonium bifluoride	NH ₄ FHF
Ammonium bisulfate	NH ₄ HSO ₄
Ammonium bisulfite	NH ₄ HSO ₃
Ammonium carbonate	(NH ₄) ₂ CO ₃
* Ammonium chloride	NH ₄ Cl
* Ammonium citrate	CH ₂ (COONH ₄)C(OH)(COOH)CH ₂ COONH ₄
Ammonium fluoride	NH ₄ F
* Ammonium hydroxide ^A	NH ₄ OH
Ammonium iodide	NH ₄ I
Ammonium molybdate	(NH ₄) ₂ MoO ₄
* Ammonium heptamolybdate tetrahydrate	(NH ₄) ₆ Mo ₇ O ₂₄ ·4H ₂ O
Ammonium nitrate	NH ₄ NO ₃
* Ammonium oxalate	NH ₄ OCOCOONH ₄ ·H ₂ O
* Ammonium phosphate, dibasic (diammonium acid phosphate)	(NH ₄) ₂ HPO ₄
* Ammonium persulfate (ammonium peroxydisulfate)	(NH ₄) ₂ S ₂ O ₈
* Ammonium sulfate	(NH ₄) ₂ SO ₄
* Ammonium tartrate	NH ₄ OCO(CHOH) ₂ COONH ₄
Ammonium thiocyanate	NH ₄ SCN
Ammonium vanadate	NH ₄ VO ₃
Antimony metal (powder)	Sb
Antimony trichloride	SbCl ₃
* Arsenic trioxide	As ₂ O ₃
Asbestos (for use with Gooch crucible)	
Barium Chloride	BaCl ₂ ·2H ₂ O
Barium diphenylamine sulfonate	(C ₆ H ₅ NHC ₆ H ₄ -4-SO ₃) ₂ Ba
* Benzoic acid	C ₆ H ₅ COOH
α-Benzoin oxime (benzoin anti-oxime)	C ₆ H ₅ CHOHC:NOHC ₆ H ₅
Beryllium sulfate	BeSO ₄ ·4H ₂ O
Bismuth metal (99.9 % min)	Bi
Boric acid	H ₃ BO ₃
Bromocresol green (3',3'',5',5''-tetrabromo- <i>m</i> -cresolsulfonephthalein)	C ₆ H ₄ SO ₂ OC(C ₆ H-3,5-Br ₂ -2-CH ₃ -4-OH) ₂
Bromocresol purple (5',5''-Dibromo- <i>o</i> -cresolsulfonephthalein)	C ₆ H ₄ SO ₂ OC(C ₆ H ₂ -3-CH ₃ -5-Br-4-OH) ₂
Bromine (liquid)	Br ₂
Bromophenol blue (3',3'',5',5''-tetrabromophenolsulfonephthalein)	C ₆ H ₄ SO ₂ OC(C ₆ H ₂ -3,5-Br ₂ -4-OH) ₂
1-Butanol	CH ₃ CH ₂ CH ₂ CH ₂ OH
Butyl acetate (normal)	CH ₃ COOCH ₂ CH ₂ CH ₂ CH ₃
* Cadmium chloride	CdCl ₂ ·2½ H ₂ O
Cadmium chloride, anhydrous	CdCl ₂
* † Calcium carbonate (low-boron)	CaCO ₃
Carbon dioxide (gas)	CO ₂
Carbon dioxide (solid)	CO ₂
Carbon tetrachloride	CCl ₄
Carminic acid	1,3,4-(HO) ₃ -2-C ₆ H ₁₁ O ₆ C ₆ COC ₆ H-5-COOH-6-OH-8-CH ₃ CO
* Chloroform	CHCl ₃
Cinchonine	C ₁₉ H ₂₂ N ₂ O
Citric acid	HOC(COOH)(CH ₂ COOH) ₂
Cobalt metal	Co
Cobalt sulfate	CoSO ₄
Coke	
Congo red test paper	
Copper metal (99.9 % min)	Cu
* Copper metal (powder or turnings)	Cu



TABLE 1 Continued

Name	Formula
Copper metal (P-free)	Cu
Copper metal (Mn, Ni, and Co-free, less than 0.001 % of each)	Cu
Copper-rare earth oxide mixture	
<i>m</i> -Cresol purple (<i>m</i> -cresolsulfonephthalein)	$C_6H_4SO_2OC(C_6H_3-2-CH_3-4-OH)_2$
Cupferron	$C_6H_5N(NO)ONH_4$
Cupric chloride	$CuCl_2 \cdot 2H_2O$
* Cupric nitrate	$Cu(NO_3)_2 \cdot 3H_2O$
* Cupric oxide (powder)	CuO
Cupric potassium chloride	$CuCl_2 \cdot 2KCl \cdot 2H_2O$
* Cupric sulfate	$CuSO_4 \cdot 5H_2O$
Curcumin	$(2-CH_3OC_6H_3-1-OH-4-CH:CHCO)_2CH_2$
Devarda's alloy	50Cu-45Al-5Zn
Diethylenetriamine pentaacetic acid	$((HOCOCH_2)_2NCH_2CH_2)_2NCH_2COOH$
([[[(carboxymethyl)imino]bis(ethylenenitrilo)] tetraacetic acid)	
* Dimethylglyoxime	$CH_3C:NOHC:NOHCH_3$
N,N' Diphenylbenzidine	$C_6H_5NHC_6H_4C_6H_4NHC_6H_5$
Diphenylcarbazine (1,5-diphenylcarbohydrazide)	$C_6H_5NHNHCONHNHC_6H_5$
* Disodium (ethylenedinitrilo) tetraacetate dihydrate	See (ethylenedinitrilo) tetraacetic acid disodium salt
Dithiol (toluene-3,4-dithiol)	$CH_3C_6H_3(SH)_2$
Dithizone (diphenylthiocarbazone)	$C_6H_5NHNHCSN:NC_6H_5$
Eriochrome black-T (1(1-hydroxy-2-naphthylazo)-6-nitro-2-naphthol-4-sulfonic acid sodium salt)	$1-HOC_{10}H_6-2-N:N-1-C_{10}H_4-2-OH-4-SO_3Na-6-NO_2$
* EDTA (Disodium salt)	See (ethylenedinitrilo) tetraacetic acid disodium salt
* Ethanol	C_2H_5OH
* Ethyl ether (diethyl ether)	$C_2H_5OC_2H_5$
* (Ethylenedinitrilo) tetraacetic acid disodium salt	$HOCOCH_2(NaOCOCH_2)NCH_2N(CH_2COONa)CH_2COOH \cdot 2H_2O$
Ethylene glycol monomethyl ether (2-methoxy-ethanol)	$CH_3OCH_2CH_2OH$
* Ferric chloride	$FeCl_3 \cdot 6H_2O$
* Ferric nitrate	$Fe(NO_3)_3 \cdot 9H_2O$
Ferric sulfate	$Fe_2(SO_4)_3 \cdot nH_2O$
* Ferrous ammonium sulfate	$Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$
* Ferrous sulfate	$FeSO_4 \cdot 7H_2O$
Fluoroboric acid	$HBFe_4$
Fluorescein, sodium salt	$2NaOCOC_6H_4C:C_6H_3-3(:O)OC_6H_3-6-ONa$
Formaldehyde	HCHO
* Formic acid ^A	HCOOH
Gelatin	
Graphite	C
Glass wool	
Glycerol	$CH_2OHCHOHCH_2OH$
Hydrazine sulfate	$NH_2NH_2 \cdot H_2SO_4$
* Hydrobromic acid ^A	HBr
* Hydrochloric acid ^A	HCl
* Hydrofluoric acid ^A	HF
Hydrogen chloride gas	HCl
* Hydrogen peroxide	H_2O_2
Hydrogen sulfide gas	H_2S
Hydroquinone	$1,4-(OH)_2C_6H_4$
* Hydroxylamine hydrochloride	$NH_2OH \cdot HCl$
* Hypophosphorous acid ^B	H_3PO_2
Invert sugar	
* Iodine	I_2
Iron metal or wire (99.8 % min)	Fe
Isopropyl ether	$(CH_3)_2CHOCH(CH_3)_2$
Lead metal	Pb
* Lead acetate	$Pb(CH_3COO)_2$
Lead chloride	$PbCl_2$
* Lead nitrate	$Pb(NO_3)_2$
Litmus	
Lithium fluoride	LiF
Magnesium metal (Sn-free)	Mg
Magnesium perchlorate, anhydrous	$Mg(ClO_4)_2$



TABLE 1 Continued

Name	Formula
* Magnesium sulfate	MgSO ₄ ·7H ₂ O
Manganese metal (99.8 % min)	Mn
Manganous nitrate	Mn(NO ₃) ₂
Manganous sulfate	MnSO ₄ ·H ₂ O
Mannitol	CH ₂ OH(CHOH) ₄ CH ₂ OH
Marble chips	
* Mercuric chloride	HgCl ₂
* Mercury	Hg
* Methanol	CH ₃ OH
Methyl isobutyl ketone (4-methyl-2-pentanone)	CH ₃ COCH ₂ CH(CH ₃) ₂
* Methyl orange (<i>p</i> [[<i>p</i> -dimethylamino)phenyl]azo]benzenesulfonic acid sodium salt)	4-NaOSO ₂ C ₆ H ₄ N:NC ₆ H ₄ -4-N(CH ₃) ₂
Methyl purple	formula unknown, patented
* Methyl red (<i>o</i> -[[<i>p</i> -dimethylamino)phenyl]azo]benzoic acid)	4-(CH ₃) ₂ NC ₆ H ₄ N:NC ₆ H ₄ -2-COOH
Molybdenum metal (99.8 % min)	Mo
Molybdic acid, anhydride (molybdenum trioxide)	MoO ₃
Molybdic acid (ammonium paramolybdate)	Assay: as MoO ₃ —85 %
Morin, anhydrous (2',3,4',7-penta hydroxyflavone)	5,7-(HO) ₂ C ₆ H ₂ OC(C ₆ H ₃ -2,4-(OH) ₂):C(OH)CO
β-Naphthoquinoline (5,6-benzoquinoline)	C ₁₀ H ₆ CH:CHCH:N
Neocuproine (2,9-dimethyl-1,10-phenanthroline)	(CH ₃) ₂ C ₁₂ H ₆ N ₂ ·12H ₂ O
Nickel metal (99.8 % min)	Ni
Nickel metal (sheet)	Ni
Nickelous nitrate	Ni(NO ₃) ₂ ·6H ₂ O
Nickelous sulfate	NiSO ₄ ·6H ₂ O
* Nitric acid ^A	HNO ₃
Nitrogen gas (oxygen-free)	N ₂
Nitrogen, liquid	N ₂
<i>m</i> -Nitrophenol	NO ₂ C ₆ H ₄ OH
1-Nitroso-2-naphthol (α-nitroso-β-naphthol)	NOC ₁₀ H ₆ OH
Nitroso-R-salt (1-nitroso-2-naphthol-3,6-disulfonic acid disodium salt)	1-NOC ₁₀ H ₄ -2-(OH)-3,6-(SO ₃ Na) ₂
Osmium tetroxide	OsO ₄
Oxalic acid	(COOH) ₂
Oxygen gas	O ₂
* Perchloric acid ^A	HClO ₄
1,10-Phenanthroline (<i>o</i> -phenanthroline)	CH:CHCH:NC:CH:CHC:CN:CHCH:CH·H ₂ O
* Phenolphthalein	C ₆ H ₄ COOC(C ₆ H ₄ -4-OH) ₂
* Phosphoric acid	H ₃ PO ₄
Piperidine	NH(CH ₂) ₄ CH ₂
Platinized quartz	
Platinized silica gel	
Platinum gauze	Pt
* Potassium biphthalate	1-KOCOC ₆ H ₄ -2-COOH
Potassium bisulfate	KHSO ₄
* Potassium bromate	KBrO ₃
* Potassium bromide	KBr
* Potassium chlorate	KClO ₃
* Potassium chloride	KCl
* Potassium chromate	K ₂ CrO ₄
Potassium columbate	4K ₂ O·3Cb ₂ O ₅ ·16H ₂ O
* Potassium cyanide	KCN
* Potassium dichromate	K ₂ Cr ₂ O ₇
* Potassium ferricyanide	K ₃ Fe(CN) ₆
Potassium ferrocyanide	K ₄ Fe(CN) ₆ ·3H ₂ O
* Potassium fluoride	KF·2H ₂ O
* Potassium hydroxide	KOH
* Potassium iodate	KIO ₃
* Potassium iodide	KI
Potassium iodide starch paper	
* Potassium nitrate	KNO ₃
* Potassium <i>m</i> -periodate	KIO ₄
* Potassium permanganate	KMnO ₄
Potassium persulfate	K ₂ S ₂ O ₈
Potassium phosphate, monobasic	KH ₂ PO ₄
* Potassium pyrosulfate	K ₂ S ₂ O ₇
* Potassium sulfate	K ₂ SO ₄
Potassium tantalum fluoride	K ₂ TaF ₇
Potassium thiocarbonate	K ₂ CS ₃
* Potassium thiocyanate	KSCN