



Designation: E50 – 24

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 E01. 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 E01 methods of chemical analysis of metals, ores and related materials when definite reference is made to these practices, as covered in Section 4.

1.3 The values stated in SI units are regarded as 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 the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Specific hazards are given in Section 8.

NOTE 1—The use of the verbs “shall” and “must” (with their 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.

1.5 *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.*

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. Referenced Documents

2.1 ASTM Standards:²

- D1193 Specification for Reagent Water
 - 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
 - E135 Terminology Relating to Analytical Chemistry for Metals, Ores, and Related Materials
 - E287 Specification for Laboratory Glass Graduated Burets
 - E288 Specification for Laboratory Glass Volumetric Flasks
 - E438 Specification for Glasses in Laboratory Apparatus
 - E542 Practice for Gravimetric Calibration of Laboratory Volumetric Instruments
 - 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
- ### 2.2 ISO Standards:³
- DIN EN ISO 1042 Laboratory glassware -- One-mark volumetric flasks

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

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

TABLE 1 Chemical Reagents Specified in E01 Methods for Chemical Analysis of Metals

Name	Formula
* Acetic acid ^A	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 chloride	AlCl ₃
Aluminum nitrate nonahydrate	Al(NO ₃) ₃ ·9H ₂ O
Aluminum sulfate octadecahydrate	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 (diammonium hydrogen 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 monohydrate	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)	
Ascorbic Acid	C ₆ H ₈ O ₆
Barium chloride dihydrate	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
Benzene	C ₆ H ₆
α-Benzoin oxime (benzoin anti-oxime)	C ₆ H ₅ CHOHC:NOHC ₆ H ₅
Beryllium sulfate tetrahydrate	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 hemi(pentahydrate)	CdCl ₂ ·2½ H ₂ O
Cadmium chloride, anhydrous	CdCl ₂
Cadmium metal	Cd
* † 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 COC ₆ H-5-COOH-6-OH-8-CH ₃ CO
Cerium ammonium nitrate	(NH ₄) ₂ Ce(NO ₃) ₆
* Chloroform	CHCl ₃
Cinchonine	C ₁₉ H ₂₂ N ₂ O
Citric acid	HOC(COOH)(CH ₂ COOH) ₂



TABLE 1 Continued

Name	Formula
Cobalt metal	Co
Cobalt sulfate	CoSO ₄
Coke	
Congo red test paper	
Copper metal (99.9 % min)	Cu
* Copper metal (powder or turnings)	Cu
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 ₆ H ₄ SO ₂ OC(C ₆ H ₃ -2-CH ₃ -4-OH) ₂ (see Metacresol purple)
Cupferron	C ₆ H ₅ N(NO)ONH ₄
Cupric chloride dihydrate	CuCl ₂ ·2H ₂ O
* Cupric nitrate trihydrate	Cu(NO ₃) ₂ ·3H ₂ O
* Cupric oxide (powder)	CuO
Cupric potassium chloride dihydrate	CuCl ₂ ·2KCl·2H ₂ O
* Cupric sulfate pentahydrate	CuSO ₄ ·5H ₂ O
Curcumin	(2-CH ₃ OC ₆ H ₃ -1-OH-4-CH:CHCO) ₂ CH ₂
Devarda's alloy	50Cu-45Al-5Zn
Diantipyrilmethane monohydrate	C ₂₃ H ₂₄ N ₄ O ₂ ·H ₂ O
Diethylenetriamine pentaacetic acid ([[(carboxymethyl)imino]bis(ethylenenitrilo)] tetraacetic acid)	((HOCOCH ₂) ₂ NCH ₂ CH ₂) ₂ NCH ₂ COOH
* Dimethylglyoxime	CH ₃ C:NOHC:NOHCH ₃
N,N' Diphenylbenzidine	C ₆ H ₅ NHC ₆ H ₄ C ₆ H ₄ NHC ₆ H ₅
Diphenylcarbazine (1,5-diphenylcarbohydrazide)	C ₆ H ₅ NHNHCONHNHC ₆ H ₅
* Disodium (ethylenedinitrilo) tetraacetate dihydrate	See (ethylenedinitrilo) tetraacetic acid disodium salt
Dithiol (toluene-3,4-dithiol)	CH ₃ C ₆ H ₃ (SH) ₂
Dithizone (diphenylthiocarbazon)	C ₆ H ₅ NHNHCSN:NC ₆ H 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 ₃ Na-6- NO ₂
* EDTA (Disodium salt)	See (ethylenedinitrilo) tetraacetic acid disodium salt dihydrate
* Ethanol	C ₂ H ₅ OH
* Ethyl ether (diethyl ether)	C ₂ H ₅ OC ₂ H ₅
* (Ethylenedinitrilo) tetraacetic acid disodium salt dihydrate	HOCOCH ₂ (NaOCOCH ₂)NCH ₂ N(CH ₂ COONa)CH ₂ COOH·2H ₂ O
Ethylene glycol monomethyl ether (2-methoxy- ethanol)	CH ₃ OCH ₂ CH ₂ OH
* Ferric chloride hexahydrate	FeCl ₃ ·6H ₂ O
* Ferric nitrate nonahydrate	Fe(NO ₃) ₃ ·9H ₂ O
Ferric sulfate hydrated	Fe ₂ (SO ₄) ₃ · <i>n</i> H ₂ O
* Ferrous ammonium sulfate hexahydrate	Fe(NH ₄) ₂ (SO ₄) ₂ ·6H ₂ O
* Ferrous sulfate heptahydrate	FeSO ₄ ·7H ₂ O
Fluoroboric acid	HBF ₄
Fluorescein, sodium salt	2NaOCOC ₆ H ₄ C:C ₆ H ₃ -3(:O)OC ₆ H ₃ -6-ONa
Formaldehyde	HCHO
* Formic acid ^A	HCOOH
Gelatin	
Graphite	C
Glass wool	
Glycerol	CH ₂ OHCHOHCH ₂ OH
Hydrazine sulfate	NH ₂ NH ₂ ·H ₂ SO ₄
* Hydrobromic acid ^A	HBr
* Hydrochloric acid ^A	HCl
* Hydrofluoric acid ^A	HF
Hydrogen chloride gas	HCl
* Hydrogen peroxide ^A	H ₂ O ₂
Hydrogen sulfide gas	H ₂ S
Hydroquinone	1,4-(OH) ₂ C ₆ H ₄
* Hydroxylamine hydrochloride	NH ₂ OH·HCl
* Hypophosphorous acid ^B	H ₃ PO ₂
Invert sugar	
* Iodine	I ₂
Iron metal or wire (99.8 % min)	Fe
Isopropyl ether	(CH ₃) ₂ CHOCH(CH ₃) ₂



TABLE 1 Continued

Name	Formula
Lanthanum oxide	La_2O_3
Lead metal	Pb
* Lead acetate	$\text{Pb}(\text{CH}_3\text{COO})_2$
Lead chloride	PbCl_2
* Lead nitrate	$\text{Pb}(\text{NO}_3)_2$
Litmus	
Lithium fluoride	LiF
Magnesium metal (Sn-free)	Mg
Magnesium perchlorate, anhydrous	$\text{Mg}(\text{ClO}_4)_2$
* Magnesium sulfate heptahydrate	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
Manganese metal (99.8 % min)	Mn
Manganous nitrate	$\text{Mn}(\text{NO}_3)_2$
Manganous sulfate monohydrate	$\text{MnSO}_4 \cdot \text{H}_2\text{O}$
Mannitol	$\text{CH}_2\text{OH}(\text{CHOH})_4\text{CH}_2\text{OH}$
Marble chips	
* Mercuric chloride	HgCl_2
Mercuric nitrate	$\text{Hg}(\text{NO}_3)_2$
* Mercury	Hg
Metacresol purple (<i>m</i> -Cresol purple), (<i>m</i> -cresolsulfonephthalein)	$\text{C}_6\text{H}_4\text{SO}_2\text{OC}(\text{C}_6\text{H}_3-2-\text{CH}_3-4-\text{OH})_2$
* Methanol	CH_3OH
Methyl isobutyl ketone (4-methyl-2-pentanone)	$\text{CH}_3\text{COCH}_2\text{CH}(\text{CH}_3)_2$
* Methyl orange (<i>p</i> [[<i>p</i> -dimethylamino]phenyl]azo]benzenesulfonic acid sodium salt)	$4\text{-NaOSO}_2\text{C}_6\text{H}_4\text{N}:\text{NC}_6\text{H}_4-4\text{-N}(\text{CH}_3)_2$
Methyl purple	formula unknown, patented
* Methyl red (<i>o</i> -[[<i>p</i> -dimethylamino]phenyl]azo]benzoic acid)	$4\text{-(CH}_3)_2\text{NC}_6\text{H}_4\text{N}:\text{NC}_6\text{H}_4-2\text{-COOH}$
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)	$5,7\text{-(HO)}_2\text{C}_6\text{H}_2\text{OC}(\text{C}_6\text{H}_3-2,4\text{-(OH)}_2\text{):C(OH)CO}$
β -Naphthoquinoline (5,6-benzoquinoline)	$\text{C}_{10}\text{H}_6\text{CH}:\text{CHCH}:\text{N}$
Neocuproine (2,9-dimethyl-1,10-phenanthroline) docecahydrate	$(\text{CH}_3)_2\text{C}_{12}\text{H}_6\text{N}_2 \cdot 12\text{H}_2\text{O}$
Nickel metal (99.8 % min)	Ni
Nickel metal (sheet)	Ni
Nickelous nitrate hexahydrate	$\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$
Nickelous sulfate hexahydrate	$\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$
* Nitric acid ^A	HNO_3
Nitrogen gas (oxygen-free)	N_2
Nitrogen, liquid	N_2
<i>m</i> -Nitrophenol	$\text{NO}_2\text{C}_6\text{H}_4\text{OH}$
1-Nitroso-2-naphthol(α -nitroso- β -naphthol)	$\text{NOC}_{10}\text{H}_6\text{OH}$
Nitroso-R-salt (1-nitroso-2-naphthol-3,6-disulfonic acid disodium salt)	$1\text{-NOC}_{10}\text{H}_4-2\text{-(OH)-3,6-(SO}_3\text{Na)}_2$
Osmium tetroxide	OsO_4
Oxalic acid	$(\text{COOH})_2$
Oxalic acid dihydrate	$\text{HO}_2\text{CCO}_2\text{H} \cdot 2\text{H}_2\text{O}$
Oxygen gas	O_2
* Perchloric acid ^A	HClO_4
1,10-Phenanthroline (<i>o</i> -phenanthroline) monohydrate	$\text{CH}:\text{CHCH}:\text{NC}:\text{CCH}:\text{CHC}:\text{CN}:\text{CHCH}:\text{CH} \cdot \text{H}_2\text{O}$
* Phenolphthalein	$\text{C}_6\text{H}_4\text{COOC}(\text{C}_6\text{H}_4-4\text{-OH})_2$
* Phosphoric acid ^A	H_3PO_4
Piperidine	$\text{NH}(\text{CH}_2)_4\text{CH}_2$
Platinized quartz	
Platinized silica gel	
Platinum gauze and sheet	Pt
* Potassium biphthalate	$1\text{-KOCOC}_6\text{H}_4-2\text{-COOH}$
Potassium bisulfate	KHSO_4
* Potassium bromate	KBrO_3
* Potassium bromide	KBr
* Potassium chlorate	KClO_3
* Potassium chloride	KCl
* Potassium chromate	K_2CrO_4
Potassium niobate hexadecahydrate	$4\text{K}_2\text{O} \cdot 3\text{Nb}_2\text{O}_5 \cdot 16\text{H}_2\text{O}$
* Potassium cyanide	KCN
* Potassium dichromate	$\text{K}_2\text{Cr}_2\text{O}_7$
* Potassium ferricyanide	$\text{K}_3\text{Fe}(\text{CN})_6$