



Designation: D7599 – 16

# Standard Test Method for Determination of Diethanolamine, Triethanolamine, *N*-Methyldiethanolamine and *N*-Ethyldiethanolamine in Water by Single Reaction Monitoring Liquid Chromatography/ Tandem Mass Spectrometry (LC/MS/MS)<sup>1</sup>

This standard is issued under the fixed designation D7599; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This procedure covers the determination of diethanolamine, triethanolamine, *N*-methyldiethanolamine and *N*-ethyldiethanolamine (referred to collectively as ethanolamines in this test method) in surface water by direct injection using liquid chromatography (LC) and detected with tandem mass spectrometry (MS/MS). These analytes are qualitatively and quantitatively determined by this test method. This test method adheres to single reaction monitoring (SRM) mass spectrometry.

1.2 This test method has been developed by US EPA Region 5 Chicago Regional Laboratory (CRL).

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 The Detection Verification Level (DVL) and Reporting Range for the ethanolamines are listed in [Table 1](#).

1.4.1 The DVL is required to be at a concentration at least 3 times below the Reporting Limit (RL) and have a signal/noise ratio greater than 3:1. [Fig. 1](#) displays the signal/noise ratios at the DVLs and at higher concentrations for *N*-methyldiethanolamine.

1.4.2 The reporting limit is the concentration of the Level 1 calibration standard as shown in [Table 2](#) for diethanolamine, triethanolamine, and *N*-ethyldiethanolamine and Level 2 for *N*-methyldiethanolamine. The reporting limit for *N*-methyldiethanolamine is set at 50  $\mu\text{g/L}$  due to poor sensitivity at a 5  $\mu\text{g/L}$  concentration which did not meet the DVL criteria. The DVL for *N*-methyldiethanolamine is at 10  $\mu\text{g/L}$ , which forces a raised reporting limit (chromatograms are shown in [Fig. 1](#)). However, the multi-laboratory validation required a spike of all target analytes at 25  $\mu\text{g/L}$ . The mean

recovery for *N*-methyldiethanolamine at this level was 88 % as shown in [Table 3](#). If your instrument's sensitivity can meet the requirements in this test method, *N*-methyldiethanolamine may have a 25  $\mu\text{g/L}$  reporting limit.

1.5 *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*:<sup>2</sup>

- D1129 Terminology Relating to Water
- D1193 Specification for Reagent Water
- D2777 Practice for Determination of Precision and Bias of Applicable Test Methods of Committee D19 on Water
- D3856 Guide for Management Systems in Laboratories Engaged in Analysis of Water
- D3694 Practices for Preparation of Sample Containers and for Preservation of Organic Constituents
- D5847 Practice for Writing Quality Control Specifications for Standard Test Methods for Water Analysis
- E2554 Practice for Estimating and Monitoring the Uncertainty of Test Results of a Test Method Using Control Chart Techniques

2.2 *Other Documents*:

- EPA publication SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods<sup>3</sup>

## 3. Terminology

3.1 *Definitions*:

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.06 on Methods for Analysis for Organic Substances in Water.

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<sup>2</sup> 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.

<sup>3</sup> Available from National Technical Information Service (NTIS), U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA, 22161 or at <http://www.epa.gov/epawaste/hazard/testmethods/index.htm>.

**TABLE 1 Detection Verification Level and Reporting Range**

Analyte	DVL (µg/L)	Reporting Range (µg/L)
Diethanolamine	5	25-500
Triethanolamine	5	25-500
N-Ethyldiethanolamine	5	25-500
N-Methyldiethanolamine	10	50-500

3.1.1 For definitions of terms used in this standard, refer to Terminology **D1129**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *detection verification level, DVL, n*—a concentration that has a signal/noise ratio greater than 3:1 and is at least 3 times below the reporting limit (RL).

3.2.2 *ethanolamines, n*—in this test method, diethanolamine, triethanolamine, *N*-methyldiethanolamine and *N*-ethyldiethanolamine collectively.

3.2.3 *independent reference material, IRM, n*—a material of known purity and concentration obtained either from the National Institute of Standards and Technology (NIST) or other reputable supplier. The IRM shall be obtained from a different lot of material than is used for calibration.

3.3 *Acronyms:*

- 3.3.1 *CCC, n*—Continuing Calibration Check
- 3.3.2 *IC, n*—Initial Calibration
- 3.3.3 *LC, n*—Liquid Chromatography
- 3.3.4 *LCS/LCSD, n*—Laboratory Control Sample/  
Laboratory Control Sample Duplicate
- 3.3.5 *MDL, n*—Method Detection Limit
- 3.3.6 *MeOH, n*—Methanol
- 3.3.7 *mM, n*—millimolar,  $1 \times 10^{-3}$  moles/L
- 3.3.8 *MRM, n*—Multiple Reaction Monitoring
- 3.3.9 *MS/MSD, n*—Matrix Spike/Matrix Spike Duplicate
- 3.3.10 *NA, adj*—Not Available
- 3.3.11 *ND, n*—non-detect
- 3.3.12 *P&A, n*—Precision and Accuracy
- 3.3.13 *PPB, n*—parts per billion
- 3.3.14 *PPT, n*—parts per trillion
- 3.3.15 *QA, adj*—Quality Assurance
- 3.3.16 *QC, adj*—Quality Control
- 3.3.17 *RL, n*—Reporting Limit
- 3.3.18 *RSD, n*—Relative Standard Deviation
- 3.3.19 *RT, n*—Retention Time
- 3.3.20 *SDS, n*—Safety Data Sheets
- 3.3.21 *SRM, n*—Single Reaction Monitoring
- 3.3.22 *SS, n*—Surrogate Standard
- 3.3.23 *TC, n*—Target Compound
- 3.3.24 *µM, n*—micromolar,  $1 \times 10^{-6}$  moles/L
- 3.3.25 *VOA, n*—Volatile Organic Analysis

## 4. Summary of Test Methods

4.1 This is a performance-based method and modifications are allowed to improve performance.

4.2 For ethanolamines analysis, samples are shipped to the lab between 0°C and 6°C and analyzed within 7 days of collection. In the lab, the samples are spiked with surrogate, filtered using a syringe-driven filter unit and analyzed directly by LC/MS/MS.

4.3 Diethanolamine, triethanolamine, *N*-methyldiethanolamine and *N*-ethyldiethanolamine and diethanolamine-D<sub>8</sub> (surrogate) are identified by retention time and one SRM transition. The target analytes and surrogate are quantitated using the SRM transitions utilizing an external calibration. The final report issued for each sample lists the concentration of diethanolamine, triethanolamine, *N*-methyldiethanolamine and *N*-ethyldiethanolamine and the diethanolamine-D<sub>8</sub> surrogate recovery.

## 5. Significance and Use

5.1 *N*-Ethyldiethanolamine, *N*-methyldiethanolamine and triethanolamine are Schedule 3 compounds under the Chemical Weapons Convention (CWC). Schedule 3 chemicals include those that have been produced, stockpiled or used as a chemical weapon, poses otherwise a risk to the object and purpose of the CWC because they possess such lethal or incapacitating toxicity as well as other properties that might enable it to be used as a chemical weapon, poses otherwise a risk to the object and purpose of the CWC by virtue of its importance in the production of one or more chemicals listed in Schedules 1 or 2, or it may be produced in large commercial quantities for purposes not prohibited under the CWC.<sup>4</sup> Ethanolamines have a broad spectrum of applications. They are used to produce adhesives, agricultural products, cement grinding aids, concrete additives, detergents, specialty cleaners, personal care products, gas treatments, metalwork, oil well chemicals, packaging and printing inks, photographic chemicals, rubber, textile finishing, urethane coatings, textile lubricants, polishes, pesticides, and pharmaceuticals. Ethanolamines are readily dissolved in water, biodegradable and the bio-concentration potential is low.<sup>5</sup>

5.2 This test method has been investigated for use with reagent and surface water.

## 6. Interferences

6.1 Method interferences may be caused by contaminants in solvents, reagents, glassware and other apparatus producing discrete artifacts or elevated baselines. All of these materials are demonstrated to be free from interferences by analyzing laboratory reagent blanks under the same conditions as samples.

6.2 All glassware is washed in hot water with a detergent, rinsed in hot water followed by distilled water. Detergents

<sup>4</sup> Additional information about CWC and ethanolamines are available from the Organisation for the Prohibition of Chemical Weapons, <https://www.opcw.org>.

<sup>5</sup> Additional information can be found on the Dow Chemical Company website at <http://www.dow.com/amines/prod/index.htm>.

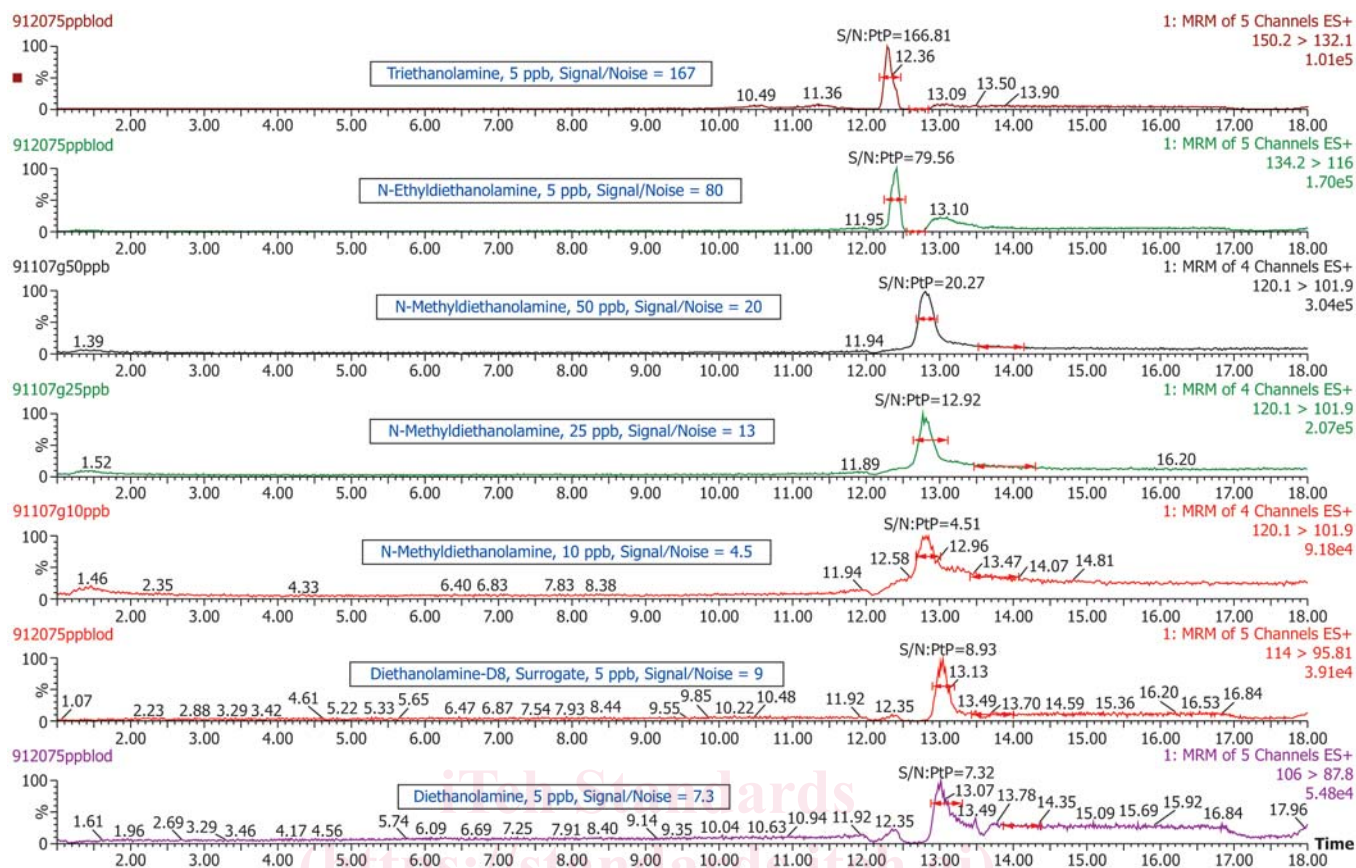


FIG. 1 Example SRM Chromatograms Signal/Noise Ratios

TABLE 2 Concentrations of Calibration Standards (PPB)

Analyte/Surrogate	LV 1	LV 2	LV 3	LV 4	LV 5	LV 6	LV 7
Diethanolamine	25	50	75	150	250	350	500
Triethanolamine	25	50	75	150	250	350	500
N-Ethyl-diethanolamine	25	50	75	150	250	350	500
N-Methyl-diethanolamine	25	50	75	150	250	350	500
Diethanolamine-D <sub>8</sub> (Surrogate)	25	50	75	150	250	350	500

containing ethanolamines must not be used to clean glassware. The glassware is then dried and heated in an oven at 250°C for 15 to 30 minutes. All glassware is subsequently cleaned with acetone, then methanol.

6.3 All reagents and solvents should be pesticide residue purity or higher to minimize interference problems.

6.4 Matrix interferences may be caused by contaminants that are co-extracted from the sample. The extent of matrix interferences can vary considerably from sample source depending on variations of the sample matrix.

## 7. Apparatus

### 7.1 LC/MS/MS System:

7.1.1 *Liquid Chromatography (LC) System*—A complete LC system is needed in order to analyze samples.<sup>6</sup> This should

<sup>6</sup> A Waters Alliance High Performance Liquid Chromatography (HPLC) System (a trademark of the Waters Corporation, Milford, MA), or equivalent, was found suitable for use. The multi-laboratory study included Agilent and Waters LC systems.

include a sample injection system, a solvent pumping system capable of mixing solvents, a sample compartment capable of maintaining required temperature and a temperature controlled column compartment. A system that is capable of performing at the flows, pressures, controlled temperatures, sample volumes and requirements of the standard may be used.

7.1.2 *Analytical Column-Waters*<sup>7</sup>—A HILIC column was used to develop this test method. Any column that achieves adequate resolution may be used. The retention times and order of elution may change depending on the column that is used and need to be monitored.

7.1.3 *Tandem Mass Spectrometer (MS/MS) System*—A MS/MS system capable of MRM analysis.<sup>8</sup> A system that is capable of performing at the requirements in this standard may be used.

### 7.2 Filtration Device:

7.2.1 *Hypodermic syringe*—A luer-lock tip glass syringe capable of holding a syringe-driven filter unit.

7.2.1.1 A 25-mL lock tip glass syringe size is recommended since a 25-mL sample size is used in this test method.

<sup>7</sup> A Waters Atlantis (a trademark of the Waters Corporation, Milford, MA) HILIC Silica, 100 mm × 2.1 mm, 3 μm particle size, or equivalent, has been found suitable for use.

<sup>8</sup> A Waters Quattro (a trademark of the Waters Corporation, Milford, MA) micro API mass spectrometer, or equivalent, was found suitable for use. The multi-laboratory study included Applied Biosystems, Varian and Waters mass spectrometers.



**TABLE 3 Multi-Laboratory Recovery Data in Reagent Water**

Analyte	Spike Conc. (ppb)	# Results	# Labs	Bias			Precision			
				Mean Recovery (%)	Min Recovery (%)	Max Recovery (%)	Overall SD (%)	Pooled within-lab SD (%)	Overall RSD (%)	Pooled within-lab RSD (%)
Diethanolamine	25	24	6	96.34	51.00	156.96	31.31	10.96	32.50	9.49
Diethanolamine	50	24	6	101.41	54.00	154.80	29.54	7.97	29.13	7.91
Diethanolamine	200	24	6	101.57	61.00	138.00	20.98	10.50	20.66	10.85
Diethanolamine	425	24	6	102.06	70.00	138.82	17.98	5.90	17.61	5.70
Triethanolamine	25	24	6	87.70	35.96	157.20	27.00	25.18	30.79	27.48
Triethanolamine	50	24	6	94.95	67.00	121.66	16.39	9.57	17.26	9.66
Triethanolamine	200	22	6	105.00	79.50	132.00	14.06	11.81	13.39	11.52
Triethanolamine	425	24	6	96.94	40.00	144.94	27.56	4.41	28.43	5.76
N-Ethyldiethanolamine	25	24	6	90.61	31.00	132.00	39.42	7.47	43.51	10.42
N-Ethyldiethanolamine	50	23	6	111.88	49.00	146.00	28.71	7.19	25.66	7.56
N-Ethyldiethanolamine	200	24	6	106.20	60.00	134.00	23.09	11.96	21.74	12.23
N-Ethyldiethanolamine	425	24	6	99.67	51.00	130.00	23.07	4.68	23.15	6.01
N-Methyldiethanolamine	25	24	6	88.43	41.72	133.60	25.24	13.29	28.55	16.70
N-Methyldiethanolamine	50	24	6	102.28	56.00	153.80	25.85	8.73	25.27	8.22
N-Methyldiethanolamine	200	24	6	101.02	59.00	136.50	20.07	9.51	19.87	9.54
N-Methyldiethanolamine	425	24	6	94.75	63.00	115.76	15.02	3.34	15.85	3.72
Diethanolamine-D <sub>8</sub> (Surrogate)	200	96	6	103.02	60.00	151.95	21.13	9.40	20.51	9.25

7.2.2 *Filter unit*<sup>9</sup>—PVDF filter units were used to filter the samples.

## 8. Reagents and Materials

8.1 *Purity of Reagents*—High-performance liquid chromatography (HPLC) pesticide residue analysis and spectrophotometry grade chemicals shall be used in all tests. Unless indicated otherwise, it is intended that all reagents shall conform to the Committee on Analytical Reagents of the American Chemical Society.<sup>10</sup> Other reagent grades may be used provided they are first determined to be of sufficiently high purity to permit their use without affecting the accuracy of the measurements.

8.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to Type 1 of Specification **D1193**. It must be demonstrated that this water does not contain contaminants at concentrations sufficient to interfere with the analysis.

8.3 *Gases*—Ultrapure nitrogen and argon.

8.4 Acetonitrile (CAS # 75-05-8).

8.5 Methanol (CAS # 67-56-1).

8.6 Acetone (CAS # 67-64-1).

8.7 Ammonium acetate (CAS # 631-61-8).

8.8 Diethanolamine (CAS # 111-42-2).

8.9 Triethanolamine (CAS # 102-71-6).

8.10 *N*-Ethyldiethanolamine (CAS # 139-87-7).

8.11 *N*-Methyldiethanolamine (CAS # 105-59-9).

8.12 Bis(2-hydroxyethyl)-D<sub>8</sub>-amine; (Diethanolamine-D<sub>8</sub>), where the ethylene moieties contain all <sup>2</sup>H (CAS # 103691-51-6).

8.12.1 Diethanolamine-D<sub>8</sub> is used as a surrogate in this standard.

## 9. Hazards

9.1 Normal laboratory safety applies to this method. Analysts should wear safety glasses, gloves, and lab coats when working in the lab. Analysts should review the Safety Data Sheets (SDS) for all reagents used in this test method.

## 10. Sampling

10.1 *Sampling*—Grab samples must be collected in ≥25-mL pre-cleaned amber glass bottles with Teflon-lined caps demonstrated to be free of interferences. This test method requires a 25-mL sample size per analysis. Conventional sampling practices should be followed. Refer to Guide **D3856** and Practices **D3694**.

10.2 *Preservation*—Store samples between 0°C and 6°C from the time of collection until analysis. Analyze the sample within 7 days of collection.

## 11. Preparation of LC/MS/MS

11.1 *LC Chromatograph Operating Conditions*:<sup>6</sup>

11.1.1 Injection volumes of all calibration standards and samples are 25 μL. The first sample analyzed after the calibration curve is a blank to ensure there is no carry-over. The gradient conditions for the liquid chromatograph are shown in **Table 4**.

11.1.2 *Temperatures*—Column, 30°C; Sample compartment, 15°C.

11.1.3 *Seal Wash*—Solvent: 50 % Acetonitrile/50 % Water; Time: 5 minutes.

11.1.4 *Needle Wash*—Solvent: 50 % Acetonitrile/50 % Water; Normal wash, approximately 13 second wash time.

11.1.5 *Autosampler Purge*—Three loop volumes.

<sup>9</sup> A Millex HV Syringe-Driven Filter Unit PVDF 0.45 μm (Millipore Corporation, Catalog # SLHV033NS; Millex is a trademark of Merck KGAA, Darmstadt, Germany) has been found suitable for use for this test method, any filter unit may be used that meets the performance of this test method may be used.

<sup>10</sup> *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 *Annual Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

TABLE 4 Gradient Conditions for Liquid Chromatography

Time (min)	Flow (μL/min)	Percent CH <sub>3</sub> CN	Percent Water	Percent 200 mmolar Ammonium Acetate
0	400	95	0	5
1	400	95	0	5
2	400	90	0	10
4	300	90	0	10
10	300	60	30	10
13	300	60	30	10
15	300	40	50	10
18	300	30	60	10
20	300	30	60	10
25	300	95	0	5
27	300	95	0	5

11.1.6 Specific instrument manufacturer wash/purge specifications should be followed in order to eliminate sample carry-over in the analysis of ethanolamines.

11.2 Mass Spectrometer Parameters:<sup>8</sup>

11.2.1 In order to acquire the maximum number of data points per SRM channel while maintaining adequate sensitivity, the tune parameters may be optimized according to your instrument. Each peak requires at least 10 scans per peak for adequate quantitation. This standard contains only one surrogate and four target compounds which are located in the same multiple reaction monitoring (MRM) experiment window. Variable parameters regarding retention times, SRM Transitions and cone and collision energies are shown in Table 5.

The instrument is set in the Electrospray (+) positive setting.  
 Capillary Voltage: 0.5 kV  
 Cone: Variable depending on analyte (Table 5)  
 Extractor: 2 Volts  
 RF Lens: 0.2 Volts  
 Source Temperature: 120°C  
 Desolvation Temperature: 300°C  
 Desolvation Gas Flow: 500 L/hr  
 Cone Gas Flow: 25 L/hr  
 Low Mass Resolution 1: 14.5  
 High Mass Resolution 1: 14.5  
 Ion Energy 1: 0.5  
 Entrance Energy: -1  
 Collision Energy: Variable depending on analyte (Table 5)  
 Exit Energy: 2  
 Low Mass Resolution 2: 15  
 High Mass resolution 2: 15  
 Ion Energy 2: 0.5  
 Multiplier: 650  
 Gas Cell Pirani Gauge: 3.3 × 10<sup>-3</sup> Torr  
 Inter-Channel Delay: 0.02 seconds  
 Inter-Scan Delay: 0.1 seconds  
 Repeats: 1  
 Span: 0 Daltons  
 Dwell: 0.1 Seconds

12. Calibration and Standardization

12.1 The mass spectrometer must be calibrated per manufacturer specifications before analysis. In order that analytical values obtained using this test method are valid and accurate within the confidence limits of the test method, the following procedures must be followed when performing the test method.

12.2 Calibration and Standardization—To calibrate the instrument, analyze seven calibration standards containing the seven concentration levels of the ethanolamines and diethanolamine-D<sub>8</sub> surrogate prior to analysis as shown in Table 2. A calibration stock standard solution is prepared from standard materials or purchased as certified solutions. Stock standard solution A (Level 7) containing diethanolamine, triethanolamine, N-methyldiethanolamine and N-ethyldiethanolamine and diethanolamine-D<sub>8</sub> is prepared at Level 7 concentration and aliquots of that solution are diluted to prepare Levels 1 through 6. The following steps will produce standards with the concentration values shown in Table 2. The analyst is responsible for recording initial component weights carefully when working with pure materials and correctly carrying the weights through the dilution calculations.

12.2.1 Prepare stock standard solution A (Level 7) by adding, to a 100 mL volumetric flask, individual methanol solutions of the following: 50 μL of diethanolamine, triethanolamine, N-methyldiethanolamine, N-ethyldiethanolamine and diethanolamine-D<sub>8</sub> each at 1 g/L concentration, dilute to 100 mL with water. The preparation of the Level 7 standard can be accomplished using different volumes and concentrations of stock solutions as is accustomed in the individual laboratory. Depending on stock concentrations prepared, the solubility at that concentration will have to be ensured.

12.2.2 Aliquots of Solution A are then diluted with water to prepare the desired calibration levels in 2-mL amber glass LC vials. The calibration vials must be used within 24 hours to ensure optimum results. Stock calibration standards are routinely replaced every six months if not previously discarded for quality control failure. Calibration standards are not filtered.

12.2.3 Inject each standard and obtain a chromatogram for each one. An external calibration is used monitoring the SRM transition of each analyte. Calibration software is utilized to conduct the quantitation of the target analyte and surrogate. The SRM transition of each analyte is used for quantitation and confirmation. This gives confirmation by isolating the parent ion, fragmenting it to the product ion, and also relating it to the retention time in the calibration standard.

12.2.4 The calibration software manual should be consulted to use the software correctly. The quantitation method is set as

TABLE 5 Retention Times, SRM Ions, and Analyte-Specific Mass Spectrometer Parameters

Analyte	SRM Mass Transition (Parent > Product)	Retention Time (min)	Cone Voltage (Volts)	Collision Energy (eV)
Diethanolamine	106 > 87.8	13.0	25	11
Triethanolamine	150.2 > 132.1	12.3	25	14
N-Ethyldiethanolamine	134.2 > 116	12.4	25	13
N-Methyldiethanolamine	120.1 > 101.9	12.8	25	13
Diethanolamine-D <sub>8</sub> (Surrogate)	114 > 95.8	13.0	25	12

an external calibration using the peak areas in ppb or ppm units as long as the analyst is consistent. Concentrations may be calculated using the data system software to generate linear regression or quadratic calibration curves. Forcing the calibration through the origin is not recommended.

12.2.5 Linear calibration may be used if the coefficient of determination,  $r^2$ , is  $>0.98$  for the analyte. The point of origin is excluded and a fit weighting of  $1/X$  is used in order to give more emphasis to the lower concentrations. If one of the calibration standards other than the high or low point causes the  $r^2$  of the curve to be  $<0.98$ , this point must be re-injected or a new calibration curve must be regenerated. If the low or high (or both) point is excluded, minimally a five point curve is acceptable but the reporting range must be modified to reflect this change.

12.2.6 Quadratic calibration may be used if the coefficient of determination,  $r^2$ , is  $>0.99$  for the analyte. The point of origin is excluded and a fit weighting of  $1/X$  is used in order to give more emphasis to the lower concentrations. If one of the calibration standards, other than the high or low, causes the curve to be  $<0.99$  this point must be re-injected or a new calibration curve must be regenerated. If the low or high point is excluded, a six-point curve is acceptable using a quadratic fit. An initial seven-point curve over the calibration range is suggested in the event that the low or high point must be excluded to obtain a coefficient of determination  $>0.99$ . In this event, the reporting range must be modified to reflect this change. Each calibration point used to generate the curve must have a calculated percent deviation less than 25 % from the generated curve.

12.2.7 The retention time window of the SRM transitions must be within 5 % of the retention time of the analyte in a midpoint calibration standard. If this is not the case, re-analyze the calibration curve to determine if there was a shift in retention time during the analysis and the sample needs to be re-injected. If the retention time is still incorrect in the sample, refer to the analyte as an unknown.

12.2.8 A midpoint calibration check standard must be analyzed at the end of each batch of 20 samples or within 24 hours after the initial calibration curve was generated. This end calibration check should be the same calibration standard that was used to generate the initial curve. The results from the end calibration check standard must have a percent deviation less than 30 % from the calculated concentration for the target analytes and surrogate. If the results are not within these criteria, the problem must be corrected and either: all samples in the batch must be re-analyzed against a new calibration curve, or the affected results must be qualified with an indication that they do not fall within the performance criteria of the test method. If the analyst inspects the vial containing the end calibration check standard and notices that the sample evaporated affecting the concentration, a new end calibration check standard may be made and analyzed. If this new end calibration check standard has a percent deviation less than 30 % from the calculated concentration for the target analyte and surrogate the results may be reported unqualified.

12.3 All samples are prepared using Class A glass volumetric glassware. The sample volume used throughout this test

method is 25 mL. Every sample, the entire 25-mL volume, is filtered through the filtration device described in Section 7.2 only after all required spiking solutions are added and mixed throughout the sample.

12.3.1 A new filter unit is used for each sample. The syringe must be cleaned between each filtration. It is the analyst's responsibility to ensure that the syringe is clean. A possible way of cleaning the syringe between filtrations is first by rinsing with at least 5 syringe volumes of water, followed by at least 3 volumes of acetone, then 3 volumes of methanol and finally rinsed with water to remove any residual solvent.

12.4 If a laboratory has not performed the test before or if there has been a major change in the measurement system, for example, new analyst, new instrument, etc., perform a precision and bias study to demonstrate laboratory capability.

12.4.1 Analyze at least four replicates of a sample solution containing diethanolamine, triethanolamine, *N*-methyl-diethanolamine, *N*-ethyl-diethanolamine and diethanolamine- $D_8$  at a concentration in the calibration range of Levels 3 to 5. The matrix and chemistry should be similar to the solution used in this test method. Each replicate must be taken through the complete analytical test method including any sample preservation and pretreatment steps.

12.4.2 Calculate the mean (average) percent recovery and relative standard deviation (RSD) of the four values and compare to the acceptable ranges of the quality control (QC) acceptance criteria for the Initial Demonstration of Performance in Table 6.

12.4.3 This study should be repeated until the single operator precision and mean recovery are within the limits in Table 6. If a concentration other than the recommended concentration is used, refer to Practice D5847 for information on applying the F test and t test in evaluating the acceptability of the mean and standard deviation.

12.4.3.1 The QC acceptance criteria for the initial demonstration of performance in Table 6 were generated from a multi-laboratory method validation involving six laboratories. The descriptive statistics from this validation are shown in the Precision and Bias Section. The analyst must be aware that the performance data generated from multiple-laboratory data tend to be significantly wider than those generated from single-laboratory data. It is recommended that the laboratory generate their own in-house QC acceptance criteria which meets or exceeds the criteria in this standard. References on how to generate QC acceptance criteria are ASTM Standards Practice D2777, Practice D5847, Practice E2554, or Method 8000B in EPA publication SW-846, which may be helpful.

**TABLE 6 QC Acceptance Criteria**

Analyte	Test Conc. (µg/L)	Initial Demonstration of Performance			Lab Control Sample	
		Recovery (%)		Precision	Recovery (%)	
		Lower Limit	Upper Limit	Maximum % RSD	Lower Limit	Upper Limit
Diethanolamine	200	52	151	19	51	152
Triethanolamine	200	83	127	21	75	135
<i>N</i> -Ethyl-diethanolamine	200	53	160	21	51	161
<i>N</i> -Methyl-diethanolamine	200	53	149	17	52	150
Diethanolamine- $D_8$ (Surrogate)	200	51	156	16	50	156