



*NSF International Standard /
American National Standard*

NSF/ANSI 44 - 2015 Residential Cation Exchange Water Softeners



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NSF International Standard/
American National Standard
for Drinking Water Treatment Units —
**Residential cation exchange
water softeners**

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Foreword²

The purpose of this Standard is to establish minimum requirements for materials, design, construction, and performance of drinking water treatment units that are designed to reduce specific aesthetic-related contaminants in public or private water supplies. This Standard specifies the minimum product literature and labeling information that a manufacturer must supply to authorized representatives and system owners. Lastly, the Standard provides minimum service-related obligations that the manufacturer must extend to system owners.

This edition of the Standard contains the following revisions:

Issue 37

This revision harmonized the structural integrity requirements in Table 5 of NSF/ANSI 42, NSF/ANSI 44 and NSF/ANSI 53.

Issue 38

This revision added clarification regarding the maximum number of samples exposed in the Materials evaluation under section 4.

Issue 39

This revision added criteria for utilizing a treatment train approach for the evaluation of a system containing multiple, sequential treatment technologies.

This Standard was developed by the NSF Joint Committee on Drinking Water Treatment Units using the consensus process described by the American National Standards Institute.

Suggestions for improvement of this Standard are welcome. This Standard is maintained on a Continuous Maintenance schedule and can be opened for comment at any time. Comments should be sent to Chair, Joint Committee on Drinking Water Treatment Units at standards@nsf.org or c/o NSF International, Standards Department, P.O. Box 130140, Ann Arbor, Michigan 48113-0140, USA.

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NSF/ANSI Standard for Drinking Water Treatment Units — Residential cation exchange water softeners

1 General

1.1 Purpose

The purpose of this Standard is to establish minimum requirements for materials, design and construction, and performance of residential cation exchange water softeners. This Standard also specifies the minimum product literature that manufacturers shall supply to authorized representatives and owners, as well as the minimum service-related obligations that manufacturers shall extend to owners.

1.2 Scope

The manual, autoinitiated, and demand-initiated regeneration residential cation exchange water softeners addressed by this Standard are designed to be used for the removal of hardness and the reduction of specific contaminants from drinking water supplies (public or private) considered to be microbiologically safe and of known quality. Systems with components or functions covered under other NSF or NSF/ANSI Standards or Criteria shall conform to the applicable requirements therein.

1.3 Alternate materials, design, and construction

While specific materials, design, and construction may be stipulated in this Standard, systems that incorporate alternate materials, designs, and construction may be acceptable when it is verified that such systems meet the applicable requirements.

1.4 Treatment train

A system that contains multiple, sequential treatment technologies for a performance claim under this Standard shall meet the applicable requirements as described in Annex C.

2 Normative references

The following documents contain requirements that, by reference in this text, constitute requirements of this Standard. At the time of publication, the indicated editions were valid. All of the documents are subject to revision and parties are encouraged to investigate the possibility of applying the recent editions of the documents indicated below. The most recent published edition of the document shall be used for undated references.

NSF/ANSI 53 – *Drinking water treatment units – Health effects*

NSF/ANSI 61 – *Drinking water system components – Health effects*

USEPA-600/4-79-020, *Methods for the Chemical Analysis of Water and Wastes*, March 1983³

³ USEPA, Environmental Monitoring and Support Laboratory, Cincinnati, OH 45268 <www.epa.org>.

USEPA-600/4-88-039, *Methods for the Determination of Organic Compounds in Drinking Water*, December 1988 (Revised July 1991)⁴

USEPA-600/4-90-020, *Methods for the Determination of Organic Compounds in Drinking Water*, Supplement I, July 1990⁴

USEPA-600/R-92-129, *Methods for the Determination of Organic Compounds in Drinking Water* Supplement II, August 1992⁴

USEPA-600/R-94-111, *Methods for the Determination of Metals in Environmental Samples*, Supplement 1, May 1994⁴

USEPA-600/R-95-131, *Method for the Determination of Organic Compounds in Drinking Water* Supplement III, August 1995⁵

USEPA *National Primary Drinking Water Regulations*, 40 CFR Part 141, July 1, 2002⁵

USEPA *National Secondary Drinking Water Regulations*, 40 CFR Part 143, July 1, 2002⁵

USFDA Code of Federal Regulations, Title 21, (*Food and Drugs*) *Direct Food Additive Substances Parts 170 through 199*, April 1, 2002⁵

3 Definitions

Terms used in this Standard that have a specific technical meaning are defined in NSF/ANSI 330.

4 Materials

4.1 Materials in contact with drinking water

4.1.1 POE drinking water treatment units shall conform to the protocol and criteria in NSF/ANSI 61.

4.1.2 POU drinking water treatment units shall conform to the protocol and criteria in this section.

4.1.3 Acceptance criteria

4.1.3.1 Materials in contact with drinking water shall not impart levels of target compounds or Tentatively Identified Compounds (TICs) that exceed the Total Allowable Concentration (TAC), Maximum Contaminant Levels (MCL), or Maximum Acceptable Concentration (MAC) criteria specified in tables 1, 2 and 3 or specified in NSF/ANSI 61 Annex D and E. Any extractable contaminants not listed in the referenced tables shall be reviewed and shall not exceed criteria developed in accordance with NSF/ANSI 61 Annex A.

4.1.3.2 TIC identification and quantitation shall be conducted in accordance with section 4.3.1.2. Additional TIC identification and quantitation should be verified using a standard of the compound in question or an alternate approved analytical method. Additional TIC identification and quantitation is recommended when the contaminant is a health risk or when the “Probability Based Matching” process in section 4.3.1.2 is inconclusive. When possible, the product manufacturer should assist and support the testing laboratory in the identification of a standard for the compound and an appropriate analytical method, if applicable, so that confirmatory identification and quantification can be performed. If a standard and an adequate alternative analytical method are not available to verify the identification and quantitation of the compound, the TIC shall be evalu-

⁴ USEPA, Office of Research and Development, Washington, DC 20460 <www.epa.gov>.

⁵ Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402 <www.gpo.gov>.

ated according to section 4.3.1.2.

NOTE – Manufacturers may not be privy to formulation information, so they may not be able to assist a testing laboratory to identify a standard for the compound that extracted. Refer to Section 4.3.1.2 when the manufacturer does not have material formulation information.

4.1.3.3 Unknown contaminants detected by GC/MS analysis for which identification is unable to be made after performing the steps in 4.3.1 shall be reported in accordance to 4.1.4.2.

4.1.3.4 Whole-system or component assembly extraction testing may be waived if components, when separately tested, meet the requirements of this Standard and are assembled in a manner that does not introduce any new components or materials, increase the surface area-to-volume ratio of previously evaluated components, or present potential concern based on cumulative factors. The reported extractable concentrations for components shall be arithmetically added to ensure that the whole-system or component assembly meets the allowable levels in accordance with tables 1, 2, and 3 and Annex A, D, and E of NSF/ANSI 61.

4.1.4 Data reporting

4.1.4.1 All contaminants identified and detected at or above the reporting limit shall be reported with the identification of the contaminant, the concentration, and whether it exceeds the acceptance criteria as required in Section 4.1.3. Contaminants detected below the reporting limit shall be reported to the manufacturer as less than the reporting limit's value.

Example: If the lab's reporting limit is 1.0 mg/L for analyte "X" and the concentration was detected at 0.5 mg/L, the lab shall report less than 1.0 mg/L or <1.0 mg/L.

4.1.4.2 If the extractable contaminant cannot be identified following the procedures in 4.3.1 the laboratory shall supply the manufacturer with the approximate molecular weight along with any additional information about the compound.

4.2 Materials evaluation

Complete formulation information on any material not certified as specifically compliant with the sections of the U. S. Code of Federal Regulations, Title 21, listed in table 4, shall be reviewed to determine whether the material presents a health effects concern in contact with drinking water and to assess the material's potential for contributing contaminants to the drinking water. As a minimum level of information for those materials requiring submission of formulation information, the complete chemical identity and proportion by weight (in some cases approximate weights or proportions may suffice) and ingredient sources of supply shall be provided.

The following additional information is required when available:

- a list of the known or suspected impurities within the product or material and the maximum percent or parts by weight of each impurity;
- the water solubility, hydrolysis products, and extraction rates of chemicals within the product or material; and
- a list of toxicological studies relevant to the chemicals and impurities present in the product, component, or material.

4.2.1 Analytical methods

All analyses shall be conducted in accordance with the applicable method(s) referred to in 2.

4.2.1.1 The laboratory shall validate the analytical method to the reporting limit (RL) concentration following the procedures established in the referenced method. The laboratory shall evaluate its method detection limit (MDL) in reference to the RL. In all cases, the RL shall be equal or greater than the MDL. When preparing its calibration standards, the lowest calibration point shall be at or less than the RL.

4.2.1.2 For extracted techniques (e.g., USEPA Method 625), regarding the concentration of the lowest calibration point, the laboratory shall apply the concentration factor due to sample preparation. For example, a sample one liter extracted, and the extract concentrated to 1.0 milliliter, for a factor of 1000, if the RL is set to 0.2 ug/L, then the lowest calibration point would be at or less than 0.2 mg/L.

NOTE – See Annex B for additional information on GC/MS and other alternative methods.

4.2.2 Exposure water

Systems and components shall be exposed to locally available tap water that has been adjusted to contain 50 ± 5 mg/L total dissolved solids and to have a pH of 6.75 ± 0.25 . Any existing concentrations of extraction testing parameters listed in tables 1, 2, and 3 found to be present in the exposure water shall be subtracted from the values obtained in the analysis of the extractant water.

4.2.3 System exposure procedure

4.2.3.1 The system or component(s) of a system shall be installed, flushed, and conditioned in accordance with the manufacturer's instructions using the exposure water specified in 4.2.2 at an initial inlet static pressure of 340 kPa (50 psig).

4.2.3.2 After flushing and conditioning in accordance with 4.2.3.1, the system or component(s) shall be refilled with exposure water as specified in 4.2.2 and maintained for 24 h at a temperature of 23 ± 2 °C (73 ± 3 °F). A 2-L water sample shall then be collected in accordance with 4.2.3.3. The product(s) shall then be flushed with five unit volumes and maintained for another 24 h at an ambient temperature of 23 ± 2 °C (73 ± 3 °F). A second 2-L water sample shall be collected in accordance with 4.2.3.3. The product(s) shall then be flushed with five unit volumes, refilled, and maintained for a third period of 24 h at a temperature of 23 ± 2 °C (73 ± 3 °F). A third 2-L water sample shall be collected in accordance with 4.2.3.3.

4.2.3.3 A minimum sample volume of 2 L shall be collected at each sample point. If the water-holding volume of the product is greater than 2 L, the entire volume shall be collected in a suitable collection vessel, and a 2-L subsample obtained from this volume. If the water-holding volume of the product is less than 2 L, sufficient products shall be exposed to provide the required 2 L volume of extractant water. The maximum number of samples exposed shall not exceed 16 with 125 mL of extractant water drawn from each sample. If the components with a water-holding volume that is less than 250 mL and is able to be identified as one that will only occur once in the flow path of dispensed treated water (such as diverters, faucets, RO shutoff valves, or specialty components) then a volume of 250 mL shall be drawn from each sample using a maximum number of 8 samples.

4.2.3.4 All samples collected shall be composited and analyzed in accordance with 4.2.1.

4.2.3.5 Systems with adsorptive or absorptive media shall be tested with and without the media. Testing without media shall include removal of any granular adsorptive or absorptive media, and removal of any adsorptive or absorptive replacement elements.

4.3 Gas chromatography/mass spectroscopy (GC/MS) analysis

4.3.1 General requirements for GC/MS analysis

When determined to be required following a product-specific formulation review, USEPA Analytical Methods for semi-volatiles and volatiles that include mass spectral libraries shall be performed on products or components, and shall include full-range mass spectral libraries to monitor for non-target compounds.

Testing for semi-volatiles (e.g. USEPA Method 625 or 528 or 525.2) and volatiles (e.g. USEPA Method 524.2 or 524.3) shall be conducted using the required target compounds in Tables 2 and 3 and the laboratory's RL shall be no greater than the RL's listed in Tables 2 and 3.

4.3.1.1 Target compounds shall be validated in accordance with the requirements of the referenced method. USEPA Methods 524.2 and 625 have specific validation requirements including precision and accuracy requirements as well as demonstration of sensitivity (Method Detection Limit Study or MDL).

For USEPA Method 625, the minimum instrument operation requirements for GC/MS analysis shall be in accordance with those protocols as defined by the method with the following modifications:

- To guard against significant drift from an initial instrument calibration to subsequent instrument batches, the average chromatographic peak area of each internal standard in the calibration curve shall be determined. The chromatographic peak area of each internal standard in the continuing calibration shall be greater than 50% and not more than 200% of that average;
- Due to the number of characteristics of the analytes associated with method 625, while a continuing calibration check (CCC) is performed, concentrations of 10% of the target compounds for each analysis (e. g., base/neutral, base/neutral/acid, acid) shall be allowed to fall outside the range of 70% to 130% (outlier) of the true value. None of the concentrations shall be allowed to fall below 50% or above 200% of the true value. If a positive sample analyte result is identified for any outlier, a second CCC shall be performed. If the second CCC determines the sample analyte result no longer to be an outlier, the sample shall be reanalyzed. However, if the second CCC also determines the analyte to be an outlier, a new calibration curve shall be determined and the sample shall be reanalyzed; and

NOTE – At the laboratory's discretion, a calibration may be performed specifically for the compound in question, with the reporting of its data from this second calibration. It should be understood, that if the laboratory utilizes this approach (calibrating for the specific analyte) all method requirements as specified by 625 shall be achieved.

4.3.1.2 TICs are identified by comparison of the spectrum of the unknown to the mass-spectral reference library utilizing "Probability Based Matching" (as available from instrument manufacturers) as well as interpretation by the analyst. The laboratory shall report the TIC with the best match factor (the match factor shall not be reported) except in the following circumstances:

- a) Due to the complex nature of GCMS interpretation and identification, when reviewing the list of possible matches for any particular TIC peak, the laboratory has the authority to assign the identification to a compound "hit" with a lower numeric match factor from the library search algorithm.
- b) The laboratory may determine that none of the returned compounds by the automated search algorithm is a good match for the unknown peak. In this case the compound is reported as an "Unknown."
- c) The laboratory may utilize manual spectral interpretation to identify the peak in question.
- d) All TICs detected at a concentration greater than or equal to 3.0 ppb shall be reported.

The library used during the analysis shall be NIST 2007 or most current version. Additional spectra libraries may be used to assist in the identification of unknown compounds. For TICs, the concentration is estimated by comparison of its total ion area response to the total ion area response of the nearest internal standard.

For TICs, a response factor of “1” (one) shall be utilized for the purposes of calculating the TICs estimated concentration.

NOTE – It should be understood that when utilizing mass-spectrometer library searches to identify unknown chromatographic peaks (sometimes called “TICs”) that the concentration is estimated assuming that the response of the TIC is the same as the internal standard. However, for example, when analyzing for traditional semi volatile compounds by USEPA method 625, the range of response factors is typically 0.1 to 2. Because the response factor is used as a reciprocal, and assuming that the response for the TIC falls within the range of the compounds for which the system is typically calibrated, the true concentration for this TIC would range up to 10 times greater to one half the reported TIC concentration.

4.3.1.3 Unknown Compounds - contaminants detected by GC/MS analysis but are not identified and quantified against a known mass spectrum or standard shall be evaluated as follows:

- a) The molecular weight shall be reported or, if no molecular ion is identifiable, a minimum value for the molecular weight (for example, if the highest mass ion for the TIC has a m/z of 143, then report $MW \geq 143$).
- b) The chemical class information shall be reported if this determination is possible.
- c) The laboratory shall report the presence of the common halogens chlorine and bromine utilizing their characteristic “M+2” patterns.
- d) The product material formulation(s) shall be reviewed for potential identification of the unknown contaminant(s) as an ingredient or byproduct;
- e) The manufacturer shall be notified and requested to provide supporting information that enables identification of the unknown contaminant(s);
- f) Structure activity relationships (SAR) shall be utilized when sufficient structural identification of the unknown contaminant(s) can be made; and
- g) Alternative methods of analysis that may identify the unknown contaminant(s) shall be considered, such as classifying the unknown into a chemical class.

Contaminants that are identified after performing one or more of the above steps shall be evaluated in accordance with 4.1.3.2 and 4.1.3.3. The product manufacturer, laboratory toxicologist and laboratory chemist shall assist the testing laboratory in the identification of a standard for the compound and an appropriate analytical method, if applicable, so that confirmatory identification and quantification can be performed when needed. Standard validation is needed when the identified compound is not reported in the formulation review conducted in 4.2

NOTE – Items “b” and “c” above may be automated utilizing software available from NIST with their mass-spectral database.

4.3.1.4 Contaminants detected by GC/MS analysis for which no identification can be made after performing the above steps shall not be considered in the determination of product compliance to this Standard. When unknown contaminants are detected in the extractant water, the testing laboratory shall report the analytical results.

Table 1 – Extraction testing parameters

Parameter	Total Allowable Concentration (TAC) mg/L	Drinking water regulatory level (MCL/MAC) mg/L	Maximum Reporting Limit (RL) mg/L	USEPA method(s)
aluminum	0.5		0.1	200.7, 200.8
antimony		0.006	0.001	200.8, 200.9
arsenic		0.010	0.001	200.8, 200.9
barium		2	0.2	200.7, 200.8
beryllium		0.004	0.001	200.7, 200.8, 200.9
cadmium		0.005	0.001	200.8, 200.9
chromium		0.1	0.01	200.7, 200.8, 200.9
copper		1.3	0.1	200.7, 200.8
lead		0.010	0.001	200.8, 200.9
manganese	0.3		0.01	200.7, 200.8
mercury		0.002	0.001	200.8, 245.1
nickel	0.1		0.01	200.7, 200.8
selenium		0.05	0.005	200.8, 200.9
thallium		0.002	0.001	200.8, 200.9

– concluded –

Table 2 – Extraction testing parameters (Semi-Volatiles)

Analyte	CAS Number	TAC ¹ (mg/L)	Drinking water regulatory level (MCL/MAC) (mg/L)	Maximum Reporting Limit (RL) (mg/L)	Reference Method(s)
2,4,6-Trichlorophenol	88-06-2	0.005		0.001	525.2, 528, 625
2,4-Dichlorophenol	120-83-2	0.003		0.001	525.2, 528, 625
2,4-Dimethylphenol	105-67-9	0.1		0.01	525.2, 528, 625
2,6-Di-tert-butyl-4-methoxyphenol	489-01-0	0.003		0.003	525.2, 528, 625
2-Methylnaphthalene	91-57-6	0.03		0.003	525.2, 528, 625
2-Nitrophenol	88-75-5	0.003*		0.001	525.2, 528, 625
2-Phenyl-2-propanol	617-94-7	0.05		0.005	525.2, 528, 625
3,3-Dichlorobenzidine	91-94-1	0.0008		0.001	525.2, 528, 625
3-and 4-Methylphenol, m&p-cresol	106-44-5 108-39-4	0.003*		0.001	525.2, 528, 625
4-Chloro-3-methylphenol	59-50-7	0.7		0.07	525.2, 528, 625
4-tert-Butylphenol or p-tert-Butylphenol	98-54-4	0.5		0.05	525.2, 528, 625
Acenaphthene	83-32-9	0.003*		0.004	525.2, 528, 625
Acenaphthylene	208-96-8	0.003		0.0004	525.2, 528, 625
Acetophenone	98-86-2	0.2		0.02	525.2, 528, 625
Anthracene	120-12-7	0.003*		0.0003	525.2, 528, 625
Benzo(a)pyrene	50-32-8		0.002	0.0002	525.2, 528, 625
Benzothiazole	95-16-9	0.003		0.003	525.2, 528, 625
Bis(2-ethylhexyl)adipate	103-23-1		0.4	0.04	525.2, 528, 625
Bis(2-ethylhexyl)phthalate	117-81-7		0.006	0.001	525.2, 528, 625
Butyl benzyl phthalate	85-68-7	1*		0.1	525.2, 528, 625
Chrysene	218-01-9	0.003*		0.003	525.2, 528, 625
Diethyl phthalate	84-66-2	6		0.6	525.2, 528, 625
Dimethyl phthalate	131-11-3	0.003		0.001	525.2, 528, 625
Di-n-butyl phthalate	84-74-2	0.7		.07	525.2, 528, 625
Fluoranthene	206-44-0	0.003		0.0003	525.2, 528, 625
Isophorone	78-59-1	0.4		0.04	525.2, 528, 625

Table 2 – Extraction testing parameters (Semi-Volatiles)

Analyte	CAS Number	TAC ¹ (mg/L)	Drinking water regulatory level (MCL/MAC) (mg/L)	Maximum Reporting Limit (RL) (mg/L)	Reference Method(s)
Naphthalene	91-20-3	0.4		0.04	525.2, 528, 625
N-Nitroso-di-n-butylamine	924-16-3	0.00006		0.0006	525.2, 528, 625
N-Nitroso-di-n-propylamine	621-64-7	0.00005		0.0005	525.2, 528, 625
N-Nitrosodiphenylamine	86-30-6	0.07		0.007	525.2, 528, 625
o-Cresol or 2-methylphenol	95-48-7	0.003*		0.001	525.2, 528, 625
Pentachlorophenol	87-86-5		0.001	0.0005	525.2, 528, 625
Phenanthrene	85-01-8	0.003		0.0003	525.2, 528, 625
Phenol	108-95-2	2		0.2	525.2, 528, 625
Phenyl sulfone	127-63-9	0.003*		0.002	525.2, 528, 625
Pyrene	129-00-0	0.003		0.0006	525.2, 528, 625
¹ TAC values have been evaluated using qualitative or quantitative risk assessment methods. If contaminants extract above these levels, an evaluation in accordance of with Annex A of NSF/ANSI 61 may be used to determine a higher allowable level.					

– concluded –

Table 3 – Extraction testing parameters (Volatiles)

Analyte	CAS Number	TAC ¹ (mg/L)	Drinking water regulatory level (MCL/MAC) (mg/L)	Maximum Reporting Limit (RL) (mg/L)	Reference Method(s)
1,1,1,2-Tetrachloroethane	630-20-6	0.01		0.001	524.2, 524.3
1,1,1-Trichloroethane	71-55-6		0.2	0.02	524.2, 524.3
1,1,2,2-Tetrachloroethane	79-34-5	0.002		0.0005	524.2, 524.3
1,1,2-Trichloroethane	79-00-5		0.005	0.0005	524.2, 524.3
1,1-Dichloroethene	75-35-4		0.007*	0.0007	524.2, 524.3
1,1-Dichloropropene	563-58-6	0.003*		0.0005	524.2, 524.3
1,2,3-Trichlorobenzene	87-61-6	0.003		0.0005	524.2, 524.3
1,2,3-Trichloropropane	96-18-4	0.04		0.004	524.2, 524.3
1,2,4-Trichlorobenzene	120-82-1		0.07	0.007	524.2, 524.3
1,2-Dibromo-3-chloropropane	96-12-8		0.0002	0.0002	524.2, 524.3
1,2-Dibromoethane	106-93-4	0.0002		0.0002	524.2, 524.3
1,2-Dichlorobenzene	95-50-1		0.6	0.06	524.2, 524.3
1,2-Dichloroethane	107-06-2		0.005	0.0005	524.2, 524.3
1,2-Dichloropropane	78-87-5		0.005	0.0005	524.2, 524.3
1,3,5-Trimethylbenzene	108-67-8	0.003*		0.0005	524.2, 524.3
1,3-Dichlorobenzene	541-73-1		0.6	0.06	524.2, 524.3
1,4-Dichlorobenzene	106-46-7		0.075	0.007	524.2, 524.3
2-Butanone	78-93-3	4		0.4	524.2, 524.3
2-Chlorotoluene	95-49-8	0.1*		0.01	524.2, 524.3
2-ethyl-1-hexanol	104-76-7	0.05		0.005	524.2, 524.3
4-Chlorotoluene	106-43-4	0.003		0.0005	524.2, 524.3
4-Isopropyltoluene	99-87-6	0.003		0.0005	524.2, 524.3
4-Methyl-2-pentanone	108-10-1	7		0.7	524.2, 524.3
Acetone	67-64-1	6		0.6	524.2, 524.3
Acetophenone	98-86-2	0.2		0.02	524.2, 524.3
Acrylonitrile	107-13-1	0.0006*		0.0006	524.2 SIM
Benzene	71-43-2		0.005	0.0005	524.2, 524.3
bis(2-Chloroethyl)ether or Di-(2-chloroethyl) ether	111-44-4	0.0003		0.0003	524.2, 524.3
Bromobenzene	108-86-1	0.003		0.0005	524.2, 524.3
Bromochloromethane	74-97-5		0.09	0.009	524.2, 524.3