



ANALYSIS OF ULTRAPURE WATER SYSTEMS

TRACE METALS, VOLATILE AND SEMI VOLATILE ORGANICS, TOC, RNASE, DNASE, ENDOTOXINS, BACTERIA

Independent laboratory tests were conducted on Evoqua ultrapure water systems. New cartridges and a final filter were installed in the system and flushed to remove any entrained air. The system was allowed to circulate for approximately 2.5 hours prior to collecting initial samples for analyses. Tests were conducted to determine: volatile organic compounds, semi-volatile organic compounds, trace metals, TOC, bacterial endotoxins and RNase/DNase enzymes. Test results show each parameter tested to be below the detection level of the instrument or method utilized.

ANALYSIS OF VOLATILE ORGANIC COMPOUNDS

Volatile organic compounds by GC/MS Result (ppb)

Acetone	< 4.62
Acrylonitrile	< 1.28
Benzene	< 0.160
Bromobenzene	< 0.170
Bromochloromethane	< 0.310
Bromodichloromethane	< 0.120
Bromoform	< 0.150
Bromomethane	< 0.480
2-Butanone (MEK)	< 0.910
n-Butylbenzene	< 0.0900
Sec-Butylbenzene	< 0.120
Tert-Butylbenzene	< 0.140
Carbon Disulfide	< 0.140
Carbon Tetrachloride	< 0.130
Chlorobenzene	< 0.0800
Chlorodibromomethane	< 0.250
Chloroethane	< 0.500
Chloroform	< 0.0800
Chloromethane	< 0.200
2-Chlorotoluene	< 0.200
4-Chlorotoluene	< 0.150
1,2-Dibromo-3-Chloropropane	< 0.750
1,2-Dibromoethane (EDB)	< 0.130
Dibromomethane	< 0.220
1,2-Dichlorobenzene	< 0.150
1,3-Dichlorobenzene	< 0.130
1,4-Dichlorobenzene	< 0.120
Dichlorodifluoromethane	< 0.170
1,1-Dichloroethane	< 0.0900
1,2-Dichloroethane	< 0.160
1,1-Dichloroethene	< 0.190
cis-1,2-Dichloroethane	< 0.200

Volatile organic compounds by GC/MS Result (ppb)

trans-1,2-Dichloroethane	< 0.150
1,2-Dichloropropane	< 0.400
1,3-Dichloropropane	< 0.190
2,2-Dichloropropane	< 0.240
1,1-Dichloropropene	< 0.170
cis-1,3-Dichloropropene	< 0.160
trans-1,3-Dichloropropene	< 0.160
Ethylbenzene	< 0.180
Hexachlorobutadiene	< 0.390
Hexane	< 0.440
Isopropylbenzene	< 0.190
p-Isopropyltoluene	< 0.130
Methyl tert-Butyl Ether	< 0.120
Naphthalene	< 0.350
n-Propylbenzene	< 0.140
Styrene	< 0.100
1,1,1,2-Tetrachloroethane	< 0.16
1,1,2,2-Tetrachloroethane	< 0.230
Tetrachloroethene	< 0.240
Toluene	< 0.100
1,2,3-Trichlorobenzene	< 2.15
1,2,4-Trichlorobenzene	< 0.490
1,1,1-Trichloroethane	< 0.150
1,1,2-Trichloroethane	< 0.300
Trichloroethene	< 0.170
Trichlorofluoromethane	< 0.150
1,2,3-Trichloropropane	< 0.180
1,2,4-Trimethylbenzene	< 0.160
1,3,5-Trimethylbenzene	< 0.140
Vinyl chloride	< 0.160
Xylenes, total	< 0.170

Results shown as < limit of detection. VOC and SVOC were performed by TestAmerica Laboratories, Inc.

ENDOTOXINS

Ultrapure water system	<0.001 EU/ml
Sterile filter with retention of endotoxins	<0.001 EU/ml
RO system	<0.001 EU/ml

Bacterial endotoxin tests were performed by Nachtmann Enterprises Inc. utilizing a Lonza® ELX808 micro-plate reader and certified Kinetic-QCL® Limulus Amebocyte Lysate (LAL) assay.

DNASE/ RNASE BY MICROMED LABORATORIES

The water was free of any detectable RNase or DNase.

The detection limit for RNase assay is equivalent to about 0.5 pg RNase A, for DNase 10 pg DNase 1. Test was performed for ultrapure water system and separate sterile filter.


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ANALYSIS OF SEMI-VOLATILE ORGANIC COMPOUNDS

Semivolatile organics by GC/MS	Result (ppb)
Acenaphthene	< 0.756
Acenaphthylene	< 0.956
Anthracene	< 1.22
Benzidine	< 36.7
Benzo (a) anthracene	< 0.889
Benzo (b) fluoranthene	< 1.09
Benzo (k) fluoranthene	< 1.22
Benzoic acid	< 14.4
Benzo (a) pyrene	< 1.02
Benzo (g,h,i) perylene	< 1.11
Benzyl alcohol	< 0.811
Butyl benzyl phthalate	< 1.22
Bis(2-chloroethyl) ether	< 0.967
Bis(2-chloroethoxy) methane	< 0.933
Bis(2-ethylhexyl) phthalate	< 1.89
Bis(2-chloroisopropyl) ether	< 1.10
4-Bromophenyl phenyl ether	< 0.800
Carbazole	< 1.11
4-Chloroaniline	< 1.56
4-Chloro-3-methylphenol	< 0.567
2-Chloronaphthalene	< 1.02
2-Chlorophenol	< 0.856
4-Chlorophenyl phenyl ether	< 0.833
Chrysene	< 0.700
Cresol(s)	< 0.967
Dibenzo (a,h) anthracene	< 1.44
Dibenzofuran	< 0.922
1,2-Dichlorobenzene	< 0.967
1,3-Dichlorobenzene	< 1.00
1,4-Dichlorobenzene	< 1.00
3,3'-Dichlorobenzidine	< 2.44
2,4-Dichlorophenol	< 0.856
2,4-Dimethylphenol	< 8.78
Diethyl phthalate	< 0.844
Dimethyl phthalate	< 0.867

Semivolatile organics by GC/MS	Result (ppb)
4,6-Dinitro-2-Methylphenol	< 0.467
2,4-Dinitrophenol	< 0.544
2,4-Dinitrotoluene	< 0.800
2,6-dinitrotoluene	< 0.789
Di-n-octyl phthalate	< 1.44
Fluoranthene	< 0.778
Fluorene	< 0.844
Hexachlorobenzene	< 0.744
Hexachlorobutadiene	< 0.822
Hexachlorocyclopentadiene	< 0.689
Hexachloroethane	< 0.689
Ideno (1,2,3-cd) pyrene	< 0.989
Isophorone	< 0.822
2-Methylnaphthalene	< 0.756
2-Methylphenol (o-Cresol)	< 0.967
4-Methylphenol (p-Cresol)	< 1.01
Naphthalene	< 0.811
2-Nitroaniline	< 0.989
3-Nitroaniline	< 1.09
4-Nitroaniline	< 0.767
Nitrobenzene	< 1.04
2-Nitrophenol	< 0.800
4-Nitrophenol	< 0.400
N-Nitrosodimethylamine	< 0.711
N-Nitrosodiphenylamine	< 1.09
N-Nitrosodi-n-propylamine	< 0.756
Pentachlorophenol	< 0.856
Phenanthrene	< 0.811
Phenol	< 0.433
Pyrene	< 0.978
Pyridine	< 1.22
1,2,4-Trichlorobenzene	< 0.889
2,4,5-Trichlorophenol	< 0.744
2,4,6-Trichlorophenol	< 0.767

BACTERIA

HPC/SPC media for stressed bacterial was used, incubation time 48h, triplicate control measurements were done.

Culture (viable) Bacterial (cfu) < 1 / 1000 ml

Analyzed by Metron Analytical Test Services.
Results shown as < limit of detection.


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TRACE METALS ANALYSIS BY ICP-MS

Elements		Result ppb	Elements		Result ppb
Aluminium	Al	< 0.003	Nickel	Ni	< 0.003
Antimony	Sb	< 0.002	Niobium	Nb	< 0.001
Arsenic	As	< 0.005	Osmium	Os	< 0.002
Barium	Ba	< 0.0005	Palladium	Pd	< 0.002
Beryllium	Be	< 0.003	Platinum	Pt	< 0.005
Bismuth	Bi	< 0.001	Potassium	K	< 0.02
Cadmium	Cd	< 0.002	Praseodymium	Pr	< 0.001
Calcium	Ca	< 0.02	Rhenium	Re	< 0.003
Cerium	Ce	< 0.001	Rhodium	Rh	< 0.001
Cesium	Cs	< 0.001	Rubidium	Rb	< 0.001
Chromium	Cr	< 0.003	Ruthenium	Ru	< 0.002
Cobalt	Co	< 0.001	Samarium	Sm	< 0.002
Copper	Cu	< 0.003	Scandium	Sc	< 0.005
Dysprosium	Dy	< 0.001	Selenium	Se	< 0.5
Erbium	Er	< 0.001	Silicon	Si	< 0.5
Europium	Eu	< 0.001	Silver	Ag	< 0.001
Gadolinium	Gd	< 0.001	Sodium	Na	< 0.005
Gallium/ Gallium	Ga	< 0.0005	Strontium	Sr	< 0.0005
Germanium	Ge	< 0.003	Tantalum	Ta	< 0.003
Gold	Au	< 0.005	Tellurium	Te	< 0.001
Hafnium	Hf	< 0.001	Terbium	Tb	< 0.001
Holmium	Ho	< 0.001	Thallium	Tl	< 0.001
Indium	In	< 0.001	Thorium	Th	< 0.001
Iridium	Ir	< 0.002	Thulium	Tm	< 0.0005
Iron	Fe	< 0.02	Tin	Sn	< 0.003
Lanthanum	La	< 0.001	Titanium	Ti	< 0.002
Lead	Pb	< 0.002	Tungsten	W	< 0.002
Lithium	Li	< 0.002	Uranium	U	< 0.002
Lutetium	Lu	< 0.001	Vanadium	V	< 0.001
Magnesium	Mg	< 0.002	Ytterbium	Yb	< 0.001
Manganese	Mn	< 0.002	Yttrium	Y	< 0.001
Mercury	Hg	< 0.005	Zinc	Zn	< 0.005
Molybdenum	Mo	< 0.002	Zirconium	Zr	< 0.005
Neodymium	Nd	< 0.001			

Results shown as < limit of detection. Si was analyzed by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). Na was analyzed by using Dionex® DX-500 Ion Chromatography. Trace metals analysis where performed by Metron Analytical Test Services.

TOTAL OXIDIZABLE ORGANIC CARBON (TOC)

Detection Limit (ppb)	Result (ppb)
1,0	< 1

TOC was analyzed by Metron Analytical Test Services on a Sievers® 800 TOC analyzer. Results shown as < limit of detection. A Sievers® 900 portable analyzer showed online results < 0.5 ppb as performed by Nachtman Enterprises Inc. Results are not, or cannot, be guaranteed in all cases due to variations in feedwater, preventative maintenance, user operating conditions and lab environments. nalyzed by Metron Analytical Test Services.


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