

POU RO Systems: Claims Testing Under NSF/ANSI 58

By Rick Andrew

Initially developed in the 1950s, by the 1980s, RO residential water treatment was beginning to become popular. The introduction of NSF/ANSI 58—*Reverse osmosis drinking water systems* in 1981, as well as the development of automatic shut-off valves, helped to bring RO to the mainstream as a consumer drinking water treatment technology.

RO systems today are sold through water treatment dealers, with a considerable number also marketed through big-box stores in the US. Internationally, RO is one of the leading technologies in consumer drinking water treatment.

In order to function properly, RO systems require a significant number of components. Typically, pre- and post-filters, membranes, automatic shut-off valves, storage tanks and faucets are all integral parts of modern POU RO systems. The test methodologies developed for evaluation of contaminant reduction capabilities of these systems have been developed based on specific functionality of the technology.

Membranes

RO membranes reject ionic contaminants dissolved in water, while allowing water to pass through. The rejection efficiency depends on chemical properties of the membrane, net driving pressure of the system, electrical charge of the ions, size of the ions, system crossflow, water temperature, water chemistry and other factors.

Ions that have less electrical charge and are smaller in size may more easily pass through the membrane than those that have more charge or are larger. With this in mind, NSF/ANSI 58 requires that all RO systems be evaluated for ionic rejection capability. The test uses deionized water to which 750 mg/L sodium chloride is added.

Sodium chloride is used for testing because sodium is monovalent (Na⁺), as is chloride (Cl⁻), when dissolved and dissociated in water. Also, the ions are relatively small in ionic size. Given these properties, the use of sodium chloride creates conservative and repeatable tests. All RO systems conforming to *Standard 58* must reject at least 75 percent of sodium chloride ions, with the resulting claim being total dissolved solids (TDS) reduction.

Additional Claims

There are many ionic contaminants in water. These ions can be effectively rejected by RO membranes. Some of these ions, such as chromium, lead and perchlorate, are health concerns at high concentrations. NSF/ANSI 58 includes requirements for testing contaminant reduction performance of a number of these contaminants (See Figure 1).

Note that requirements for testing reduction of pentavalent arsenic are included, but there is no mention of trivalent arsenic. RO has only limited effectiveness in rejecting trivalent arsenic, which is not sufficient to make a claim under the standard.

Accordingly, there is no claim of trivalent arsenic reduction under *Standard 58*. The standard requires that RO systems with pentavalent arsenic reduction claims may be operated on water known to contain only pentavalent arsenic, or used in combination with preoxidation technology to convert any trivalent arsenic to pentavalent prior to RO treatment.

Keeping in mind that RO can also serve as an effective mechanical barrier, NSF/ANSI 58 includes requirements for testing for claims of asbestos, cysts and turbidity reduction.

Testing duration

With proper prefilter maintenance, and on the right water supply, RO membranes can last for several years. This long life makes testing an RO system through the entire replacement cycle of the membrane impractical.

Instead, RO systems are evaluated according to a seven-day protocol that subjects the system to a variety of usage patterns. Complete tank draws, partial tank draws and a stagnation period are all incorporated into the evaluation. A complete description of the protocol is included in Figure 2. Systems that do not

Figure 2. Contaminant reduction test sampling requirements under NSF/ANSI 58

Day	Sample point (hours)	Sampling conditions
1	4	Complete tank emptied
1	12	Complete tank emptied
1	16	Complete tank emptied (Note: this sample point excluded except for TDS reduction testing)
2	24	5% of daily production rate withdrawn
2	30	5% of daily production rate withdrawn
2	36	5% of daily production rate withdrawn
3	48	5% of daily production rate withdrawn
3	54	5% of daily production rate withdrawn
3	60	5% of daily production rate withdrawn
4	72	5% of daily production rate withdrawn
4	78	5% of daily production rate withdrawn
4	84	5% of daily production rate withdrawn
5	None	Stagnation period—no samples, no water withdrawn
6	None	Stagnation period—no samples, no water withdrawn
7	144	Sample collected, followed by complete emptying of the tank
7	148	Sample collected, followed by complete emptying of the tank

Figure 1. Ionic contaminant reduction requirements of NSF/ANSI 58 (excluding nitrate and nitrite)

Contaminant	Individual influent sample points limits ¹ mg/L	Average influent challenge level mg/L	Maximum allowable product water level mg/L	US EPA method(s)	Compounds
Arsenic (pentavalent) ²	0.30 ±20%, 0.30 ±25% ³	0.30 ± 10%	0.010	200.7 ⁴ , 200.8	Na ₂ HAsO ₄ · 7H ₂ O
Arsenic (pentavalent) ²	0.050 ±20%, 0.050 ±25% ³	0.050 ± 10%	0.010	200.7 ⁴ , 200.8	Na ₂ HAsO ₄ · 7H ₂ O
Barium	10.0 ±20%, 10.0 ±25% ³	10.0 ± 10%	2.0	200.7, 200.8	BaCl ₂ · 2H ₂ O
Cadmium	0.03 ±25%	0.03 ± 10%	0.005	200.8, 200.9	CdCl ₂ · 2.5 H ₂ O or Cd(NO ₃) ₂
Chromium (hexavalent) ⁵	0.3 ± 20%, 0.3 ± 25% ⁶	0.3 ± 10% (added as hexavalent)	0.1	200.7, 200.8, 200.9	Na ₂ Cr ₂ O ₇ · 2 H ₂ O
Chromium (trivalent) ⁵	0.3 ± 30% ⁷	0.3 ± 10% (added as trivalent)	0.1	—	CrCl ₃ · 6 H ₂ O
Chromium (hexavalent and trivalent)	0.3 ±25%	0.3 ± 10% (added as 0.15 mg/L hexavalent and 0.15 mg/L trivalent)	0.05 (for each species)	SM3500-CrD and 200.8	—
Copper	3.0 ± 20%, 3.0 ± 25% ³	3.0 ± 10%	1.3	200.7, 200.8	CuSO ₄ · 5 H ₂ O
Fluoride	8.0 ± 25%	8.0 ± 10%	1.5	340.2	NaF
Lead	0.15 ± 25%	0.15 ± 10%	0.010	200.8, 200.9	PbCl ₂ or Pb (NO ₃) ₂
Mercury	0.006 ±25%	0.006 ± 10% (added as mercuric chloride)	0.002	200.8, 245.1	HgCl ₂
Perchlorate	0.13 ± 25%	0.13 ± 10%	0.004	314.0	NaClO ₄
Selenium	0.10 ± 25%	0.10 ± 10% (added as 0.05 mg/L selenite and 0.05 mg/L selenate)	0.05	200.8, 200.9	50/50 mix of Na ₂ SeO ₃ and Na ₂ SeO ₄
Radium 226/228 ⁸	N/ A	25 pCi/L	5 pCi/L	—	—

1. Equals average influent challenge concentration variability plus one of the following, in order of availability: 1) Acceptable Continuing Calibration Verification (CCV) limits stated in the appropriate US EPA method. 2) Acceptable spike recoveries as stated in the appropriate US EPA method. 3) Opinion of laboratory professionals—no guidance available in US EPA method.

2. Arsenic shall be added in the pentavalent form and analyzed for total arsenic. Arsenic reduction is species- dependent, therefore, reduction claims shall only be made on chlorinated water supplies where trivalent arsenic has been oxidized to the pentavalent form, as indicated by the presence of a detectable residual of free chlorine at the system inlet.

3. The first limits apply to analysis conducted according to the first US EPA method, and the second limits apply to analysis conducted according to the second US EPA method.

4. For arsenic, US EPA Method 200.7 shall be used for analysis of influent sample concentrations only.

5. Chromium shall be added as chromate for hexavalent chromium reduction and measured as total chromium. Trivalent chromium reduction may be claimed only after additional testing.

6. The first limits apply to analysis conducted according to US EPA Method 200.7, and the second limits apply to analysis conducted according to US EPA method 200.8 or 200.9.

7. Trivalent chromium is a calculated parameter. The range is based on the propagated error of two analyses.

8. For test purposes, barium shall be added to the influent challenge water and shall be analyzed in the influent challenge water and product water. The reduction of radium is not concentration dependent, therefore, barium shall be added at 10 mg/L with a maximum product water level of 2.0 mg/L. Barium is used as a surrogate based on its relationship with radium on the periodic table and the difficulty in using radium for routine testing.

include a storage tank are evaluated under an adapted version of the protocol.

The system production rate is measured during a complete tank fill, and when filling the tank from the point where the automatic shut-off valve first turns on. The 750-mg/L sodium chloride TDS reduction test water is used. Daily production rate is calculated as an average value based on these two operational conditions, expressed as volume per 24 hours. For systems that do not include a storage tank, the measurement is similar but adapted to systems without a tank.

Membrane isolation

NSF conducted studies in the late 1990s to determine the influence of carbon prefilters and/or postfilters on RO system contaminant reduction performance. These studies indicated that in some cases, there was significant influence. Most notable of these was mercury.

The test protocol in *Standard 58*, however, is a weeklong protocol designed to evaluate membrane performance only, and is not at all appropriate for evaluation of the contaminant reduction performance of media filters. Accordingly, in 1999,

Figure 3. NSF/ANSI 58 requirements for nitrate/nitrite reduction

Contaminant	Individual influent sample points limits ¹ mg/L	Average influent challenge level mg/L	Maximum allowable product water level mg/L	US EPA method(s)	Compounds
Nitrate plus nitrite (as N) ²	30.0 ± 20%	30.0 ± 10% (added as 27 mg/L NO ₃ and 3 mg/L NO ₂)	10.0 ³	300	NaNO ₃ NaNO ₂

1. Equals average influent challenge concentration variability plus one of the following, in order of availability: 1) Acceptable Continuing Calibration Verification (CCV) limits stated in the appropriate US EPA method. 2) Acceptable spike recoveries as stated in the appropriate US EPA method. 3) Opinion of laboratory professionals—no guidance available in US EPA method.
2. Some public and private water supplies will exceed 30 mg/L of NO₃ and may contain nitrite (NO₂), which is more toxic. Additional treatment or individual design, or both, shall be applied to assure the product water level consistently meets the MCLs for such water supplies.
3. Of the 10 mg/L maximum product water level, no more than 1.0 mg/L shall be in the form of NO₂ as N.

Standard 58 was revised so that all pre- and postfilters are removed from the system prior to testing for contaminant reduction performance.

Subsequent to this change, there are no RO systems certified by NSF for reduction of mercury.

Unique nature of nitrate/nitrite

Nitrate and nitrite exist in chemical equilibrium—there is always some of each present. The balance of the equilibrium depends on water chemistry. US EPA regulates the two contaminants together because of this equilibrium. Likewise, *NSF/ANSI 58* requires that the two must be tested together, and testing must be successful for both in order to make a single claim of nitrate/nitrite reduction. Details of this claim are included in Figure 3.

Technology-driven test methods

RO is a unique water treatment technology, with specific

advantages, capabilities and limitations. The NSF Joint Committee on Drinking Water Treatment Units recognizes these, and specifically developed the test protocols in *Standard 58* to reflect the technology and its mode of action in water treatment. By specifying inlet pressures, operational requirements, product configurations and sampling schedules, the protocols create appropriate tests of these systems to conservatively verify their performance when used to treat residential drinking water.

About the author

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