



Designation: D 3739 – 05

Standard Practice for Calculation and Adjustment of the Langelier Saturation Index for Reverse Osmosis¹

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1. Scope

1.1 This practice covers the calculation and adjustment of the Langelier saturation index for the concentrate stream of a reverse osmosis device. This index is used to determine the need for calcium carbonate scale control in the operation and design of reverse osmosis installations. This practice is applicable for concentrate streams containing xx 10 mg/L to 10 000 mg/L of total dissolved solids. For concentrate containing over 10,000 mg/L see Practice D 4582.

1.2 *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:²

- D 511 Test Methods for Calcium and Magnesium in Water
- D 1067 Test Methods for Acidity or Alkalinity of Water
- D 1129 Terminology Relating to Water
- D 1293 Test Method for pH of Water
- D 1888 Test Methods for Particulate and Dissolved Matter in Water³
- D 4194 Test Methods for Operating Characteristics of Reverse Osmosis and Nanofiltration Devices
- D 4195 Guide for Water Analysis for Reverse Osmosis Application

¹ This practice is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.08 on Membranes and Ion Exchange Materials.

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² 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.

³ Withdrawn.

D 4582 Practice for Calculation and Adjustment of the Stiff and Davis Stability Index for Reverse Osmosis

D 6161 Terminology Used for Microfiltration, Ultrafiltration, Nanofiltration, and Reverse Osmosis Membrane Processes

3. Terminology

3.1 For definitions of terms used in this practice, refer to Terminology D 1129 and Terminology D 6161.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 For descriptions of terms relating to reverse osmosis, refer to Test Methods D 4194.

3.2.2 *Langelier Saturation Index*—an index calculated from total dissolved solids, calcium concentration, total alkalinity, pH, and solution temperature that shows the tendency of a water solution to precipitate or dissolve calcium carbonate.

4. Summary of Practice

4.1 This practice consists of calculating the Langelier Saturation Index for a reverse osmosis concentrate stream from the total dissolved solids, calcium ion content, total alkalinity, pH, and temperature of the feed solution, and the recovery of the reverse osmosis system.

4.2 This practice also presents techniques to lower the Langelier Saturation Index by decreasing the recovery, by decreasing the calcium content of the feedwater, or by changing the ratio of total alkalinity to free carbon dioxide in the feedwater.

5. Significance and Use

5.1 In the design and operation of reverse osmosis installations, it is important to predict the calcium carbonate scaling properties of the concentrate stream. Because of the increase in total dissolved solids in the concentrate stream and the difference in passages for calcium ion, bicarbonate ion, and free CO₂, the calcium carbonate scaling properties of the concentrate stream will generally be quite different from those of the feed solution. This practice permits the calculation of the

Langelier Saturation Index for the concentrate stream from the feed water analyses and the reverse osmosis operating parameters.

5.2 A positive Langelier Saturation Index indicates the tendency to form a calcium carbonate scale, which can be damaging to reverse osmosis performance. This practice gives various procedures for the adjustment of the Langelier saturation index.

5.3 The tendency to form CaCO₃ scale can be suppressed by the addition of antiscalents or crystal modifiers. Suppliers of antiscalents and crystal modifiers can provide information on the scale inhibition performance of these types of chemical. Their use may be appropriate for reducing scale formation in RO systems. The RO system supplier should be consulted prior to the use of antiscalents and crystal modifiers to ensure they will not have a negative impact on the RO system.

6. Procedure

6.1 Determine the calcium concentration in the feed solution in accordance with Test Methods D 511 and express as CaCO₃ as demonstrated in section 6.6.

6.2 Determine the total dissolved solids of the feed solution using Test Methods D 1888.

6.3 Determine the total alkalinity of the feed solution using Test Methods D 1067, and express as CaCO₃.

6.4 Measure the pH of the feed solution using Test Method D 1293.

6.5 Measure the temperature of the feed solution.

6.6 Convert feed water alkalinity and calcium as mg/L CaCO₃:

$$Ca_f = [Ca^{+2}] \times \frac{100gCaCO_3}{mol} \times \frac{1000mg}{g} \times \frac{1eqCaCO_3}{1eqCa^{+2}} \quad (1)$$

$$Alk_f = [HCO_3^-] \times \frac{100gCaCO_3}{mol} \times \frac{1000mg}{g} \times \frac{1eqCaCO_3}{2eqHCO_3^-} \quad (2)$$

where:

Ca_c = calcium concentration in concentrate as CaCO₃, mg/L,

Ca_f = calcium concentration in feed as CaCO₃, mg/L,

Alk_c = alkalinity in concentrate as CaCO₃, mg/L, and

Alk_f = alkalinity in feed as CaCO₃, mg/L.

6.7 Measure the concentration of all major ions using the methods cited in Guide D 4195. At a minimum, measure the concentration of Mg⁺, Na⁺, K⁺, SO₄⁼, and Cl⁻.

7. Calculation

7.1 Calculate the calcium concentration in the concentrate stream from the calcium concentration in the feed solution, the recovery of the reverse osmosis system, and the calcium ion passage as follows:

$$Ca_c = Ca_f \times \frac{1 - Y(SP_{Ca})}{1 - Y} \quad (3)$$

where:

Ca_c = calcium concentration in concentrate, as CaCO₃, mg/L,

Ca_f = calcium concentration in feed, as CaCO₃, mg/L,

Y = recovery of the reverse osmosis system, expressed as a decimal, and

SP_{Ca} = calcium ion passage, expressed as a decimal.

NOTE 1— SP_{Ca} can be obtained from the supplier of the specific reverse osmosis system. For most reverse osmosis devices SP_{Ca} can be considered to be zero, in which case the equation simplifies to:

$$Ca_c = Ca_f \times (1/1 - Y) \quad (4)$$

This assumption will introduce only a small error.

7.2 Calculate the total dissolved solids (TDS) in the concentrate stream from the total dissolved solids in the feed solution, the recovery of the reverse osmosis system, and the passage of total dissolved solids as follows:

$$TDS_c = TDS_f \times \frac{1 - Y(SP_{TDS})}{1 - Y} \quad (5)$$

where:

TDS_c = concentration of total dissolved solids in concentrate, mg/L,

TDS_f = concentration of total dissolved solids in the feed, mg/L,

Y = recovery of the reverse osmosis system, expressed as a decimal, and

SP_{TDS} = passage of total dissolved solids, expressed as a decimal.

NOTE 2— SP_{TDS} can be obtained from the supplier of the specific reverse osmosis system. For most reverse osmosis devices SP_{TDS} can be assumed to be zero, in which case the equation simplifies to:

$$TDS_c = TDS_f \times (1/1 - Y) \quad (6)$$

The error introduced will usually be negligible.

7.3 Calculate the alkalinity in the concentrate stream from the alkalinity in the feed solution, the recovery of the reverse osmosis system, and the passage of alkalinity, by:

$$Alk_c = Alk_f \times \frac{1 - Y(SP_{alk})}{1 - Y} \quad (7)$$

where:

Alk_c = alkalinity in concentrate, as CaCO₃, mg/L,

Alk_f = alkalinity in feed, as CaCO₃, mg/L,

Y = recovery of the reverse osmosis system, expressed as a decimal, and

SP_{alk} = alkalinity passage, expressed as a decimal.

NOTE 3— SP_{alk} is dependent on the pH of the feed solution and its value should be obtained from the supplier of the specific reverse osmosis system.

7.4 Calculate the free carbon dioxide content (C) in the concentrate stream by assuming that the CO₂ concentration in the concentrate is equal to the CO₂ concentration in the feed: $C_c = C_f$. The concentration of free carbon dioxide in the feed solution is obtained from Fig. 1 as a function of the alkalinity, temperature, and the pH of the feed solution.