Designation: D5090 – 20

Standard Practice for Standardizing Ultrafiltration Permeate Flow Performance Data[1]

This standard is issued under the fixed designation D5090; 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 (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the standardization of permeate flow for ultrafiltration (UF) systems.

1.2 This practice is applicable to natural waters including brackish waters, seawaters, and ultrapure waters including those used in power generation and microelectronics and pharmaceuticals production. It is not necessarily applicable to waste waters.

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1129 Terminology Relating to Water

D6161 Terminology Used for Microfiltration, Ultrafiltration, Nanofiltration, and Reverse Osmosis Membrane Processes

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this standard, refer to Terminologies D1129 and D6161.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *concentrate, reject, or brine, n*—that portion of feed which does not pass through the membrane.

3.2.2 *device pressure drop (ΔP), n*—the difference between the feed pressure and the concentrate pressure.

3.2.3 *feed, n*—the fluid that enters the device.

3.2.4 *permeate, n*—that portion of the feed which passes through the membrane.

3.2.5 *permeate flow rate, n*—the quantity of permeate produced per unit time.

3.2.6 *recovery or conversion, n*—the ratio of permeate flow rate to total feed flow rate, expressed as a percent.

3.2.7 *stage, n*—a device or group of devices, several of which may be included in a system, which share common manifolds on the feed, concentrate and permeate stream plumbing.

3.2.7.1 *Discussion*—The concentrate from one stage becomes the feed to the following stage.

3.2.8 *ultrafiltration device, n*—a single housing (vessel), comprising or containing an ultrafiltration element or multiple elements and supporting materials.

4. Summary of Practice

4.1 This practice consists of calculating the permeate flow of UF systems at a standard set of conditions using data obtained at actual operating conditions.

5. Significance and Use

5.1 During the operation of a UF system, conditions including pressure and temperature can vary, causing permeate flow to change (see Note 1). To effectively evaluate system performance, it is necessary to compare permeate flow data at the same conditions. Since data may not always be obtained at the same conditions, it is necessary to convert the UF data obtained at actual conditions to a set of constant conditions, thereby standardizing the data. The user of this practice determines the standard conditions. This practice gives the procedure to standardize UF data on pure water only.

NOTE 1—Feed concentration, crossflow velocity, and both device and total system recovery will also influence permeate rate, especially when operating on other than pure water. This practice does not address those system conditions.

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[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.

5.2 This practice can be used for systems which contain spiral-wound, tubular, plate and frame, and hollow fiber devices.

5.3 This practice can be used for a single-element or a multi-element system. However, if the UF system is staged, standardize the permeate flow and salt passage for each stage separately. This requires pressure readings at the feed inlet and concentrate outlet of each stage.

5.4 This practice is applicable for UF systems with no significant leaks between the feed/concentrate and permeate streams.

5.5 This practice assumes no significant osmotic pressure differential ($\Delta\pi$) exists in the UF system under the actual operating conditions. Differential osmotic pressure will reduce the permeate rate relative to operation on pure water.

5.6 The user of this practice should be aware that fouled UF devices will produce less permeate flow than nonfouled devices, and may wish to perform flushing, chemical, or mechanical cleaning, or combination thereof, prior to determining the permeate flow performance of the device.

6. Procedure

6.1 *Standardization of Permeate Flow:*

6.1.1 Calculate the permeate flow at standard conditions using Eq 1:

$$Q_{ps} = \frac{\left[P_{fs} - \frac{\Delta P_{fbs}}{2} - P_{ps} \right] (TCF_s)}{\left[P_{fa} - \frac{\Delta P_{fba}}{2} - P_{pa} \right] (TCF_a)} (Q_{pa}) \quad (1)$$

where:

Q_{ps} = permeate flow at standard conditions,
P_{fs} = feed pressure at standard conditions, kPa,
$\Delta P_{fbs}/2$ = one half device pressure drop at standard conditions, kPa,
P_{ps} = permeate pressure at standard conditions, kPa,
TCF_s = temperature correction factor at standard conditions,
Q_{pa} = permeate flow at actual conditions,
P_{fa} = feed pressure at actual conditions, kPa,
$\Delta P_{fba}/2$ = one half device pressure drop at actual conditions, kPa,
P_{pa} = permeate pressure at actual conditions, kPa, and
TCF_a = temperature correction factor at actual conditions.

6.1.2 Whenever possible, the user of this practice should obtain temperature correction factors, TCF_s and TCF_a from the device supplier. If unavailable, use Eq 2 and Eq 3.

$$TCF_s = 1.03^{(T_s - 25)} \quad (2)$$

$$TCF_a = 1.03^{(T_a - 25)} \quad (3)$$

where:

T_s = temperatures at standard conditions, °C, and
T_a = temperature at actual conditions, °C.

6.1.3 The value for $\Delta P_{fbs}/2$ in Eq 1 is a selected and constant value. A realistic value can be obtained from the UF device supplier, or obtained from careful measurement at standard operating conditions with a new, unfouled device.

6.1.4 Proper calibration and reading of instrumentation is critical for accurate permeate flow data.

6.1.5 To obtain the most accurate standardization, set the standard conditions close to the average actual conditions. The device recovery and crossflow velocity should also be set as close to actual conditions as possible.

7. Use of Computers for Standardization

7.1 The calculations in this practice are adaptable to simple computer analysis.

8. Keywords

8.1 nanofiltration; particulates; permeate; UF; ultrafiltration