
Contents

Chapter 17. Microfiltration and Ultrafiltration	1
17.1. UF and MF: cut-off	2
17.2. UF and MF: materials	6
17.2.1. Cellulose acetate.	6
17.2.2. Polypropylene	7
17.2.3. Polyacrylonitrile.	7
17.2.4. Polyether sulfone/polysulfone.	7
17.2.5. Polyvinylidene fluoride	8
17.3. UF and MF: membrane types	8
17.4. UF and MF: implementation of membranes under pressure	11
17.4.1. Horizontal-vertical configuration.	13
17.4.2. Submerged membranes.	17
17.5. Filtration modes: frontal or tangential	19
17.5.1. Batch operation: filtration-backwash.	21
17.5.2. Filtration direction	21
17.6. Sizing parameters: membrane selection	22
17.7. Sizing parameters: horizontal or vertical configuration	25
17.8. Sizing parameters: flow	25
17.8.1. Instantaneous flow and net flow	26
17.8.2. Transmembrane pressure.	31
17.8.3. Resistance	33
17.8.4. Permeability	33
17.8.5. Principle of the calculation of the membrane surface and water losses.	35
17.8.6. Pre-filters	37
17.9. Operating parameters	37
17.9.1. Evolution of the permeability	37
17.9.2. Clogging	38

17.9.3. Frequency and conditions of hydraulic and chemical backwashing.	46
17.9.4. Frequency and conditions of CIP.	53
17.9.5. Membrane integrity.	56
17.10. MF and UF's place in a treatment process	62
17.10.1. Turbidity and SS.	63
17.10.2. TOC (and UV254).	63
17.10.3. Algae.	63
17.10.4. Iron and manganese.	63
17.11. Combination of coagulation and UF membranes	71
17.12. Combination of PAC and UF.	75
17.13. Performance and guarantees	76
17.13.1. Turbidity	76
17.13.2. Supplier warranty on the life of the membranes	86
17.14. Advantages of MF and UF	87
17.15. Veolia's experience	87
17.16. Appendix: sheets	92
17.17. References.	107
Chapter 18. Nanofiltration and Reverse Osmosis	111
18.1. Membranes	112
18.1.1. Materials	112
18.1.2. Membrane element configurations	115
18.2. Principles of operation and separation	119
18.2.1. Conceptual principle	119
18.2.2. Molecular weight cut-off.	124
18.3. Treatment process including high-pressure membranes and parameters to be considered.	127
18.3.1. Particulates and SS	127
18.3.2. Particle count	128
18.3.3. Conductivity	128
18.3.4. The SDI or MFI: clogging indices	128
18.3.5. The SDI.	128
18.3.6. The MFI	130
18.3.7. Salts and metals	131
18.3.8. Biological clogging	132
18.3.9. Undesirable substances.	133
18.3.10. Limit values of compounds at the inlet of high-pressure membranes.	133
18.4. Sizing parameters	134
18.4.1. Temperature	134

18.4.2. Implementation configuration	134
18.4.3. Calculation of the osmotic pressure	138
18.4.4. Mass flow diagram	139
18.4.5. Salt passage	140
18.4.6. Concentration factor	140
18.4.7. Hydraulic pressure loss.	140
18.4.8. Pressure tubes and number of modules per tube	141
18.5. Chemical conditioning of pre-treated water	143
18.5.1. Calculation of saturation indices and antiscalant dosage	143
18.5.2. Choice and implementation of the antiscalant	146
18.5.3. pH adjustment at the membrane inlet	147
18.5.4. Choice and application of the acid	148
18.5.5. Influence of sulfates	148
18.6. Design and implementation	148
18.6.1. Pre-treatment.	148
18.6.2. Treatment processes	149
18.6.3. Membrane station	152
18.6.4. Post-treatment	158
18.6.5. Cleaning units in place	159
18.7. Functional and operating parameters	162
18.7.1. Basic principles	162
18.7.2. Permeability (L_p)	166
18.7.3. Longitudinal pressure drop (ΔP_{fc})	166
18.7.4. Hydraulic resistance	167
18.7.5. Energy.	167
18.7.6. SDI	168
18.7.7. Chemical cleaning.	168
18.7.8. The fate of concentrates and used washing solutions	168
18.7.9. Methods for assessing the impact of concentrate discharges in the natural environment.	171
18.8. High-pressure membrane performance	174
18.8.1. Organic matter	175
18.8.2. Pesticides, drug residues, endocrine disruptors and industrial residues	176
18.8.3. Various toxic and undesirable substances.	177
18.8.4. Salts	177
18.8.5. Micro-organisms	178
18.8.6. Overall performance	179
18.9. Lifetime warranties	179
18.10. Parameters affecting the performance of NF membranes	180
18.10.1. Taking clogging into account	181
18.11. Monitoring and control parameters: standardization of raw data	182
18.12. Veolia's experience: examples of treatment processes	184

18.12.1. Surface water No. 1	184
18.12.2. Surface water No. 2	188
18.12.3. Groundwater No. 1	193
18.12.4. Groundwater No. 2	195
18.13. References	200

Chapter 19. Desalination by Reverse Osmosis 205

19.1. Characterization of the water to be treated	205
19.1.1. Physical characteristics	207
19.1.2. Chemical composition: ionic content	214
19.1.3. Chemical composition: organic substances	224
19.2. Fields of application	234
19.3. Operating principle of RO	234
19.4. The membranes used in desalination	237
19.5. Sizing parameters	238
19.5.1. Flow	239
19.5.2. Concentration polarization	240
19.5.3. Conversion rate	240
19.5.4. Passage rate and rejection rate in salts	241
19.5.5. Influence of the temperature	242
19.5.6. Determining the number of modules and pressure tubes	243
19.6. Implementation	244
19.6.1. Membranes	244
19.6.2. Pressure tube	245
19.6.3. Pass	246
19.7. Pre-treatment	246
19.7.1. Pre-treatment selection	246
19.7.2. Pre-treatment systems	250
19.8. Pre-chlorination	254
19.8.1. Pre-chlorination and development of micro- and macro-organisms	254
19.8.2. Implementation of chlorination	257
19.8.3. pH adjustment	263
19.8.4. Direct filtration	263
19.8.5. Chemical conditions of implementation	273
19.8.6. Flotation	276
19.8.7. Settling	281
19.8.8. Membranes (UF and MF)	282
19.8.9. Conclusions on pre-treatment with UF membranes	291
19.9. Energy consumption	292
19.9.1. Energy consumption without recovery	292

19.9.2. Energy consumption with recovery	293
19.9.3. Hydraulic exchanger systems	293
19.10. Operating parameters	305
19.10.1. Relationship between conductivity and salt concentration	305
19.10.2. Controlling RO membrane clogging	306
19.11. Performance of RO membranes used in desalination.	307
19.11.1. Boron removal	307
19.12. Post-treatment.	315
19.12.1. Indicators characterizing the aggressiveness or corrosiveness of the water.	317
19.12.2. Application to desalinated water	320
19.12.3. Treatments	322
19.13. Monitoring and control parameters	336
19.13.1. Standardization of raw data	336
19.13.2. Bromates	338
19.14. Veolia's new processes applied to seawater desalination	339
19.14.1. Flotation with the Spidflow® process	339
19.14.2. Spidflow® filter process applied to seawater desalination	344
19.14.3. BiopROtector.	349
19.14.4. Barrel (SIDEM Veolia).	353
19.14.5. Hiprode	355
19.15. Packaged solutions in desalination.	358
19.16. Veolia's experience (HP membranes).	360
19.17. References.	374
Index	385
Summaries of other volumes	387