

Contents

<i>Foreword</i>	ix
<i>Acknowledgements</i>	xiii
<i>Acronyms and abbreviations used in the text</i>	xv
<i>Executive summary</i>	xvii
1 Introduction	1
1.1 Purpose and scope	1
1.2 Multiple barriers	2
1.3 Process control measures	3
2 Removal processes	5
2.1 Pretreatment	6
2.1.1 Roughing filters	6
2.1.2 Microstrainers	7
2.1.3 Off-stream storage	8
2.1.4 Bank infiltration	10

2.2	Coagulation, flocculation and sedimentation.....	12
2.2.1	Conventional clarification	13
2.2.2	High-rate clarification	17
2.2.3	Dissolved air flotation	18
2.2.4	Lime softening.....	19
2.2.5	In-line coagulation.....	19
2.3	Ion exchange.....	20
2.4	Filtration	20
2.5	Granular high-rate filtration.....	21
2.5.1	Design of granular filtration	22
2.5.2	Mechanism of action of granular filtration.....	23
2.5.3	Importance of chemical coagulation pretreatment	23
2.5.4	Effect of filter media design	24
2.5.5	Importance of filter backwash.....	25
2.6	Slow sand filtration.....	26
2.6.1	Design and action of slow sand filters.....	26
2.6.2	Protection provided by slow sand filtration.....	30
2.7	Precoat filtration	32
2.7.1	Removal of microbes.....	32
2.7.2	Importance of chemical pretreatment	33
2.8	Membrane filtration.....	33
2.8.1	Microfiltration	35
2.8.2	Ultrafiltration.....	36
2.8.3	Nanofiltration and reverse osmosis	37
2.9	Bag, cartridge and fibrous filters	39
3	Inactivation (disinfection) processes.....	41
3.1	Factors affecting disinfection	41
3.2	Pretreatment oxidation.....	43
3.3	Primary disinfection	44
3.3.1	Chlorine.....	44
3.3.2	Monochloramine	50
3.3.3	Chlorine dioxide.....	52
3.3.4	Ozone	54
3.3.5	Ultraviolet light	58
3.3.6	Mixed oxidants.....	61

3.4	Secondary disinfection.....	62
3.4.1	Maintenance of water quality in the distribution system	62
3.4.2	Factors affecting microbial occurrence	62
3.4.3	Other non-chlorine disinfectants	65
4	Performance models	67
4.1	Removal process models	67
4.1.1	Transport	68
4.1.2	Attachment	68
4.1.3	Effects of process variables on removal efficiency	68
4.2	Disinfection models	72
4.2.1	Integrated disinfection design framework	74
5	Treatment variability	75
5.1	Effects of process variability	76
5.2	Relationships between treatment processes	76
5.3	Dynamic nature of treatment processes	77
5.4	Effects of changes in raw water quality	78
5.5	Variability due to process measurements	78
6	Process control	81
6.1	Risk assessment and process control	82
6.2	Source water protection	83
6.3	Coagulation, flocculation and clarification.....	85
6.4	Filtration	88
6.5	Disinfection	90
6.6	Distribution system.....	91
7	Reference list	93
	Index	107