

CONTENTS

ENVIRONMENTAL HEALTH CRITERIA FOR CHRYBOTILE ASBESTOS

PREAMBLE	ix
ABBREVIATIONS	xix
INTRODUCTION	xx
1. SUMMARY	1
1.1 Identity, physical and chemical properties, sampling and analysis	1
1.2 Sources of occupational and environmental exposure	2
1.3 Occupational and environmental exposure levels	2
1.4 Uptake, clearance, retention and translocation	4
1.5 Effects on animals and cells	5
1.6 Effects on humans	7
1.7 Environmental fate and effects on biota	9
2. IDENTITY, PHYSICAL AND CHEMICAL PROPERTY, SAMPLING AND ANALYSIS	10
2.1 Identity	10
2.1.1 Chemical composition	10
2.1.2 Structure	10
2.1.3 Fibre forms in the ore	11
2.1.4 Fibre properties	11
2.1.5 UICC samples	12
2.1.6 Associated minerals in chrysotile ore	12
2.2 Physical and chemical properties	14
2.2.1 Physical properties	14
2.2.2 Chemical properties	16
2.3 Sampling and analytical methods	16
2.3.1 Workplace sampling	17
2.3.2 Sampling in the general environment	17

2.3.3	Analytical methods	18
2.3.3.1	Fibre identification	18
2.3.3.2	Measurement of airborne fibre concentrations	19
2.3.3.3	Lung tissue analysis	20
2.3.3.4	Gravimetric analysis	20
2.4	Conversion factors	20
2.4.1	Conversion from airborne particle to fibre concentrations	21
2.4.2	Conversion from total mass to fibre number concentrations	22
3.	SOURCES OF OCCUPATIONAL AND ENVIRONMENTAL EXPOSURE	23
3.1	Natural occurrence	23
3.2	Anthropogenic sources	23
3.2.1	Production	24
3.2.2	Manufacture of products	27
3.2.3	Use of products	28
4.	OCCUPATIONAL AND ENVIRONMENTAL EXPOSURE LEVELS	30
4.1	Occupational exposure	30
4.1.1	Mining and milling	31
4.1.2	Textile production	33
4.1.3	Asbestos-cement	39
4.1.4	Friction products	40
4.1.5	Exposure of building maintenance personnel	41
4.1.6	Various industries	45
4.2	Non-occupational exposure	47
4.2.1	Ambient air	47
4.2.2	Indoor air	47
5.	UPTAKE, CLEARANCE, RETENTION AND TRANSLOCATION	51

5.1	Inhalation	51
5.1.1	General principles	51
5.1.2	Fibre deposition	54
5.1.3	Fibre clearance and retention	55
5.1.3.1	Fibre clearance and retention in humans	55
5.1.3.2	Fibre clearance and retention in laboratory animals	55
5.1.4	Fibre translocation	64
5.1.4.1	Fibre translocation in humans	64
5.1.4.2	Fibre translocation in animal models	65
5.1.5	Mechanisms of fibre clearance	66
5.2	Ingestion	68
6.	EFFECTS ON LABORATORY MAMMALS AND <i>IN VITRO</i> TEST SYSTEMS	69
6.1	Introduction	69
6.2	Effects on laboratory mammals	70
6.2.1	Summary of previous studies	70
6.2.2	Recent long-term inhalation studies	71
6.2.3	Intratracheal and intrabronchial injection studies	78
6.2.4	Intraperitoneal and intrapleural injection studies	81
6.2.5	Ingestion studies	91
6.3	Studies on cells	93
6.3.1	Genotoxicity and interactions with DNA	93
6.3.2	Cell proliferation	97
6.3.3	Inflammation	99
6.3.4	Cell death and cytotoxicity	100
6.3.5	Liberation of growth factors and other response of cells of the immune system	101
7.	EFFECTS ON HUMANS	103
7.1	Occupational exposure	103

7.1.1	Pneumoconiosis and other non-malignant respiratory effects	103
7.1.2	Lung cancer and mesothelioma	106
7.1.2.1	Critical occupational cohort studies – chrysotile	107
7.1.2.2	Comparisons of lung cancer exposure-response – critical studies	118
7.1.2.3	Other relevant studies	120
7.1.3	Other malignant diseases	125
7.1.3.1	Critical occupational cohort studies involving chrysotile	126
7.1.3.2	Other relevant studies	127
7.2	Non-occupational exposure	127
8.	ENVIRONMENTAL FATE AND EFFECTS ON BIOTA	129
8.1	Environmental transport and distribution	129
8.1.1	Chrysotile fibres in water	129
8.1.2	Chrysotile fibres in soil	130
8.2	Effects on biota	130
8.2.1	Impact on plants	131
8.2.2	Impact on terrestrial life-forms	132
8.2.3	Impact on aquatic biota	133
9.	EVALUATION OF HEALTH RISKS OF EXPOSURE TO CHRYSOTILE ASBESTOS	136
9.1	Introduction	136
9.2	Exposure	137
9.2.1	Occupational exposure	137
9.2.1.1	Production	137
9.2.1.2	Use	138
9.2.2	General population exposure	139
9.3	Health effects	140
9.3.1	Occupational exposure	140
9.3.1.1	Fibrosis	141
9.3.1.2	Lung cancer	142

9.3.1.3	Mesothelioma	142
9.3.2	General environment	143
9.4	Effects on the environment	143
10.	CONCLUSIONS AND RECOMMENDATIONS FOR PROTECTION OF HUMAN HEALTH	144
11.	FURTHER RESEARCH	145
	REFERENCES	146
	RÉSUMÉ	176
	RESUMEN	187