

CONTENTS

NOTE TO THE READER.....	1
LIST OF PARTICIPANTS.....	3
PREAMBLE.....	9
A. GENERAL PRINCIPLES AND PROCEDURES	9
1. Background.....	9
2. Objective and scope.....	10
3. Selection of agents for review	11
4. Data for the <i>Monographs</i>	11
5. Meeting participants	12
6. Working procedures.....	13
B. SCIENTIFIC REVIEW AND EVALUATION	14
1. Exposure data.....	15
2. Studies of cancer in humans.....	16
3. Studies of cancer in experimental animals.....	20
4. Mechanistic and other relevant data.....	23
5. Summary	26
6. Evaluation and rationale.....	27
References.....	31
GENERAL REMARKS	33

DIESEL AND GASOLINE ENGINE EXHAUSTS

1. EXPOSURE DATA.....	39
1.1 Diesel and gasoline engines and the chemical composition of their exhausts.....	39
1.1.1 Diesel engine technology	40
1.1.2 Levels of diesel engine exhaust emissions	44
1.1.3 Biodiesel	55

1.1.4 Spark ignition (gasoline) engines	56
1.1.5 Levels of gasoline exhaust emissions	57
1.1.6 Comparison of levels of emissions from current technology	60
1.2 Sampling and analysis	65
1.2.1 Sampling	65
1.2.2 Analysis	66
1.2.3 Biomarkers of exposure	73
1.3 Regulations and guidelines	75
1.3.1 Structure and progression of emission standards	75
1.3.2 Representative emission standards worldwide	76
1.3.3 Availability of engines with new emission control technologies	77
1.3.4 In-use emission verification programmes	78
1.4 Occurrence and exposure	79
1.4.1 Occupational exposure of workers predominantly exposed to diesel exhaust	79
1.4.2 Occupational exposure of workers predominantly exposed to gasoline engine exhaust ..	95
1.4.3 Exposure of the general population	118
References	134
2. CANCER IN HUMANS	147
2.1 Introduction	147
2.1.1 General aspects	147
2.1.2 Aspects of exposure assessment methods	148
2.1.3 Studies of environmental air pollution	149
2.2 Cohort studies	149
2.2.1 Railroad workers	149
2.2.2 Bus garage workers	174
2.2.3 Professional drivers	174
2.2.4 Miners	181
2.2.5 Other groups exposed to vehicle exhausts	184
2.3 Case-control studies	188
2.3.1 Cancer of the lung	188
2.3.2 Cancer of the urinary bladder	199
2.3.3 Cancer at other and multiple sites	231
2.4 Meta-analyses	245
2.4.1 Cancer of the lung	245
2.4.2 Cancer of the urinary bladder	249
2.4.3 Cancer of the pancreas	250
2.4.4 Summary of meta-analyses	251
2.5 Studies of childhood cancer	251
References	260
3. CANCER IN EXPERIMENTAL ANIMALS	267
3.1 Diesel engine exhaust	267
3.1.1 Mouse	267
3.1.2 Rat	275
3.1.3 Hamster	291
3.1.4 Monkey	293

3.2 Gasoline engine exhaust.....	293
3.2.1 Mouse.....	293
3.2.2 Rat.....	301
3.2.3 Hamster.....	305
3.2.4 Dog.....	308
References.....	309
4. MECHANISTIC AND OTHER RELEVANT DATA	313
4.1 Overview of the mechanisms of carcinogenesis of polycyclic aromatic hydrocarbons.....	313
4.1.1 Mechanistic data to support the role of benzo[<i>a</i>]pyrene as a human carcinogen.....	313
4.2 Deposition, clearance, retention and metabolism	323
4.2.1 Humans	323
4.2.2 Experimental systems.....	327
4.3 Genetic and related effects	338
4.3.1 Humans	338
4.3.2 Experimental systems.....	345
4.4 Other data relevant to carcinogenicity.....	410
4.4.1 Diesel engine exhaust.....	410
4.4.2 Gasoline engine exhaust	415
4.5 Susceptibility in humans	416
4.5.1 Genetic polymorphisms.....	416
4.5.2 Vulnerable populations.....	418
4.5.3 Underlying lung disease	418
4.5.4 Respiratory tract microbiome	418
4.6 Mechanistic considerations.....	418
4.6.1 Diesel engine exhaust.....	418
4.6.2 Gasoline engine exhaust	423
References.....	423
5. SUMMARY OF DATA REPORTED	451
5.1 Exposure data.....	451
5.2 Human carcinogenicity data.....	453
5.2.1 Diesel engine exhaust.....	453
5.2.2 Gasoline engine exhaust	457
5.3 Animal carcinogenicity data.....	457
5.3.1 Diesel engine exhaust.....	457
5.3.2 Gasoline engine exhaust	459
5.4 Mechanistic and other relevant data.....	460
5.4.1 Diesel engine exhaust.....	460
5.4.2 Gasoline engine exhaust	464
6. EVALUATION.....	467
6.1 Cancer in humans.....	467
6.2 Cancer in experimental animals.....	467
6.3 Overall evaluation	467

ANNEX: EMISSION STANDARDS FOR LIGHT- AND HEAVY-DUTY VEHICLES	469
1. Europe	469
2. USA	472
3. Other countries	484
3,7-DINITROFLUORANTHENE	487
1. Exposure Data	487
2. Cancer in Humans	488
3. Cancer in Experimental Animals	488
4. Mechanistic and Other Relevant Data	489
5. Summary of Data Reported	491
6. Evaluation	491
References	492
3,9-DINITROFLUORANTHENE	493
1. Exposure Data	493
2. Cancer in Humans	494
3. Cancer in Experimental Animals	494
4. Mechanistic and Other Relevant Data	496
5. Summary of Data Reported	498
6. Evaluation	498
References	499
1,3-DINITROPYRENE	501
1. Exposure Data	501
2. Cancer in Humans	510
3. Cancer in Experimental Animals	510
4. Mechanistic and Other Relevant Data	515
5. Summary of Data Reported	516
6. Evaluation	517
References	517
1,6-DINITROPYRENE	521
1. Exposure Data	521
2. Cancer in Humans	525
3. Cancer in Experimental Animals	525
4. Mechanistic and Other Relevant Data	531
5. Summary of Data Reported	533
6. Evaluation	534
References	534
1,8-DINITROPYRENE	537
1. Exposure Data	537
2. Cancer in Humans	541
3. Cancer in Experimental Animals	541
4. Mechanistic and Other Relevant Data	546
5. Summary of Data Reported	551
6. Evaluation	552
References	552

3-NITROBENZANTHRONE	557
1. Exposure Data	557
2. Cancer in Humans	561
3. Cancer in Experimental Animals	561
4. Mechanistic and Other Relevant Data	562
5. Summary of Data Reported	572
6. Evaluation	573
References	573
6-NITROCHRYSENE	577
1. Exposure Data	577
2. Cancer in Humans	580
3. Cancer in Experimental Animals	580
4. Mechanistic and Other Relevant Data	588
5. Summary of Data Reported	594
6. Evaluation	595
References	596
2-NITROFLUORENE	601
1. Exposure Data	601
2. Cancer in Humans	604
3. Cancer in Experimental Animals	604
4. Mechanistic and Other Relevant Data	607
5. Summary of Data Reported	615
6. Evaluation	616
References	616
1-NITROPYRENE	621
1. Exposure Data	621
2. Cancer in Humans	645
3. Cancer in Experimental Animals	645
4. Mechanistic and Other Relevant Data	657
5. Summary of Data Reported	674
6. Evaluation	677
References	677
4-NITROPYRENE	689
1. Exposure Data	689
2. Cancer in Humans	691
3. Cancer in Experimental Animals	691
4. Mechanistic and Other Relevant Data	694
5. Summary of Data Reported	697
6. Evaluation	697
References	698
LIST OF ABBREVIATIONS	701