

CONTENTS

CHAPTER 1. INTRODUCTION	1
1.1. From screen–film radiography to digital techniques	1
1.2. Patient exposures in radiology	3
1.3. Quality assurance and dose management	4
1.4. Need for dosimetry	5
CHAPTER 2. FRAMEWORK	7
2.1. Introduction	7
2.2. Clinical needs	7
2.2.1. Dosimetry requirements	8
2.2.2. Goals of the Code of Practice	9
2.3. The international measurement system (IMS)	10
2.3.1. SSDLs	11
2.3.2. Diagnostic radiology standards	12
2.3.3. Mutual recognition arrangement (MRA)	14
CHAPTER 3. DOSIMETRIC QUANTITIES AND UNITS	19
3.1. Basic dosimetric quantities	19
3.1.1. Fluence	19
3.1.2. Energy fluence	19
3.1.3. Kerma and kerma rate	20
3.1.4. Energy imparted	20
3.1.5. Absorbed dose	21
3.2. Application specific dosimetric quantities	21
3.2.1. Rationale for choice of quantities	21
3.2.2. Incident air kerma	23
3.2.3. Entrance surface air kerma	24
3.2.4. X ray tube output	24
3.2.5. Air kerma–area product	25
3.2.6. Air kerma–length product	25
3.2.7. Quantities for CT dosimetry	26
3.3. Quantities related to stochastic and deterministic effects	28
3.3.1. Organ and tissue dose	28
3.3.2. Equivalent dose	29
3.3.3. Effective dose	29

3.4.	Conversion coefficients for the assessment of organ and tissue doses	29
CHAPTER 4. DOSIMETRY FORMALISM		
4.1.	N_k based formalism	33
4.1.1.	Reference conditions	33
4.1.2.	Influence quantities	34
4.2.	Cross-calibration of dosimeters	37
CHAPTER 5. SELECTION OF INSTRUMENTATION		
5.1.	Introduction	41
5.2.	Dosimeters	42
5.2.1.	Ionization chambers	42
5.2.2.	Solid state dosimeters	45
5.2.3.	Dosimeter energy dependence	48
5.2.4.	Other considerations	50
5.3.	Requirements on user dosimetric equipment	51
5.4.	Requirements on the dosimetric equipment of SSDLs	51
CHAPTER 6. ESTABLISHMENT OF A DIAGNOSTIC SSDL CALIBRATION FACILITY		
6.1.	Introduction	55
6.2.	General considerations	55
6.3.	Environmental conditions	56
6.4.	Apparatus	57
6.4.1.	Dosimetry equipment	57
6.4.2.	X ray equipment	62
6.4.3.	Shutter and apertures	63
6.4.4.	Monitor chamber	65
6.4.5.	Filters and attenuators	65
6.4.6.	X ray tube voltage measuring devices	66
6.4.7.	Equipment for the calibration of CT chambers	67
6.4.8.	Equipment for the calibration of KAP chambers	67
6.5.	Establishing radiation qualities	69
6.5.1.	General	69
6.5.2.	Standard radiation qualities RQR	70
6.5.3.	Standard radiation qualities RQA and RQT	73

6.5.4.	Standard radiation qualities RQR-M and RQA-M	75
6.5.5.	Other radiation qualities for mammography	76
6.6.	Calibration of non-invasive X ray tube voltage measuring instruments	77
6.6.1.	Establishing the value for the practical peak voltage	77
6.7.	Calibration uncertainties at the SSDL	80
6.8.	Quality management system	82
CHAPTER 7. CODE OF PRACTICE FOR DIAGNOSTIC CALIBRATIONS AT SSDLs		
7.1.	Introduction	87
7.2.	General considerations	87
7.3.	Use of detectors	89
7.3.1.	Secondary standard	89
7.3.2.	Instrument to be calibrated	90
7.4.	Calibration procedures	91
7.4.1.	Generalized protocol for calibration	91
7.4.2.	Procedures preceding calibration	92
7.4.3.	Procedures during calibration	92
7.4.4.	Calibration by the substitution method using a monitor chamber	94
7.4.5.	Determination of the correction factor k_Q using a monitor chamber	95
7.4.6.	CT	95
7.4.7.	KAP meters	97
7.5.	Calibration of non-invasive X ray tube voltage measuring instruments	98
7.5.1.	Use of a voltage divider to calibrate a non-invasive device	99
7.5.2.	Use of non-invasive devices to calibrate non-invasive devices	99
7.6.	Procedures following calibration	100
7.6.1.	Uncertainty budget	100
7.6.2.	Calibration certificate	100
CHAPTER 8. CODE OF PRACTICE FOR CLINICAL MEASUREMENTS		
8.1.	Introduction	105
8.2.	Selection of patients	107

8.3.	Dosimetry formalism	108
8.3.1.	Determination of application specific quantities	108
8.3.2.	Uncertainties in quantities directly measured by diagnostic dosimeters	109
8.3.3.	Uncertainties in quantities derived from directly measured quantities	111
8.3.4.	Uncertainties in thermoluminescence measurements	112
8.4.	General radiography	113
8.4.1.	Choice of dosimetric quantities	113
8.4.2.	Measurements using phantoms	113
8.4.3.	Patient dosimetry	125
8.5.	Fluoroscopy	139
8.5.1.	Choice of dosimetric quantities	139
8.5.2.	Measurements using phantoms	139
8.5.3.	Patient dosimetry	150
8.6.	Mammography	155
8.6.1.	Choice of dosimetric quantities	155
8.6.2.	Measurements using phantoms	155
8.6.3.	Measurements on patients	173
8.7.	CT	188
8.7.1.	Choice of dosimetric quantities	188
8.7.2.	Measurements using phantoms and free in air	188
8.7.3.	Measurements on patients	202
8.8.	Dental radiography	209
8.8.1.	Choice of dosimetric quantities	209
8.8.2.	Measurements using phantoms	209
8.8.3.	Patient dosimetry	209
APPENDIX I:	UNCERTAINTY OF MEASUREMENT	231
APPENDIX II:	EXAMPLE OF UNCERTAINTY ANALYSIS FOR THE CALIBRATION OF A USER DOSIMETER IN TERMS OF AIR KERMA FOR RADIATION QUALITY, Q_0	240
APPENDIX III:	EXAMPLE OF DATA SHEET FOR CALIBRATIONS AT AN SSDL	253
APPENDIX IV:	DETERMINATION OF THE PRACTICAL PEAK VOLTAGE	256

APPENDIX V:	DETERMINATION OF THE HVL	261
APPENDIX VI:	APPLICATION OF PATIENT DOSE MEASUREMENTS	265
APPENDIX VII:	BACKGROUND TO THE CODE OF PRACTICE FOR CLINICAL MEASUREMENTS	291
APPENDIX VIII:	BACKSCATTER FACTORS FOR GENERAL RADIOGRAPHY AND FLUOROSCOPY	330
APPENDIX IX:	FIELD CALIBRATIONS	335
GLOSSARY		347
CONTRIBUTORS TO DRAFTING AND REVIEW		357