

CONTENTS

SECTION I. INTRODUCTION	1
Background	1
Objective	1
Scope	1
Reference to Section I	3
SECTION II. DEFINITIONS	5
References to Section II	28
SECTION III. GENERAL PROVISIONS	29
Radiation protection	29
Emergency response	34
Quality assurance	35
Compliance assurance	36
Special arrangement	38
References to Section III	39
SECTION IV. ACTIVITY LIMITS AND MATERIAL RESTRICTIONS	41
Basic radionuclide values	41
Determination of basic radionuclide values	43
Contents limits for packages	44
References to Section IV	48
SECTION V. REQUIREMENTS AND CONTROLS FOR TRANSPORT	51
Requirements before the first shipment	51
Requirements before each shipment	53
Transport of other goods	55
Other dangerous properties of contents	56
Requirements and controls for contamination and for leaking packages	57
Requirements and controls for transport of excepted packages	63

Requirements and controls for transport of LSA material and SCO in industrial packages or unpackaged	67
Determination of transport index	68
Determination of criticality safety index	70
Limits on transport index, criticality safety index and radiation levels for packages and overpacks	71
Categories	71
Marking, labelling and placarding	73
Consignor's responsibilities	79
Transport and storage in transit	82
Customs operations	93
Undeliverable consignments	94
References to Section V	94
 SECTION VI. REQUIREMENTS FOR RADIOACTIVE MATERIALS AND FOR PACKAGINGS AND PACKAGES	97
Requirements for radioactive materials	97
General requirements for all packagings and packages	101
Additional requirements for packages transported by air	104
Requirements for excepted packages	105
Requirements for industrial packages	105
Requirements for packages containing uranium hexafluoride	110
Requirements for Type A packages	113
Requirements for Type B(U) packages	119
Requirements for Type B(M) packages	134
Requirements for Type C packages	136
Requirements for packages containing fissile material	137
References to Section VI	148
 SECTION VII. TEST PROCEDURES	153
Demonstration of compliance	153
Tests for special form radioactive material	160
Tests for low dispersible radioactive material	162
Tests for packages	163
References to Section VII	194

SECTION VIII. APPROVAL AND ADMINISTRATIVE REQUIREMENTS	199
General aspects	199
Approval of special form radioactive material and low dispersible radioactive material	200
Approval of package designs	200
Transitional arrangements	202
Notification and registration of serial numbers	206
Approval of shipments	207
Approval of shipments under special arrangement	208
Competent authority approval certificates	209
Contents of approval certificates	210
Validation of certificates	213
Reference to Section VIII	214
APPENDIX I: THE Q SYSTEM FOR THE CALCULATION AND APPLICATION OF A₁ AND A₂ VALUES	215
Introduction	215
Background	216
Basis of the Q system	217
Dosimetric models and assumptions	219
Special considerations	229
Applications	233
Tabulation of Q values	237
Decay chains used in the Q system	252
Conclusions	252
References to Appendix I	255
APPENDIX II: HALF-LIFE AND SPECIFIC ACTIVITY OF RADIONUCLIDES, DOSE AND DOSE RATE COEFFICIENTS OF RADIONUCLIDES AND SPECIFIC ACTIVITY	259
Reference to Appendix II	285
APPENDIX III: EXAMPLE CALCULATIONS FOR ESTABLISHING MINIMUM SEGREGATION DISTANCE REQUIREMENTS	287

Introduction	287
Below main deck stowage of one group of packages	
in passenger aircraft	289
Below main deck stowage of multiple groups of packages	
in passenger aircraft	292
Main deck stowage on combi or cargo aircraft	294
Segregation distances for undeveloped film	295
References to Appendix III	295
 APPENDIX IV: QUALITY ASSURANCE IN THE SAFE TRANSPORT OF RADIOACTIVE MATERIAL	297
Introduction	297
Quality assurance programmes	301
Organization	302
Document control	303
Design control	304
Procurement control	306
Material control	307
Process control	307
Inspection and test control	308
Non-conformity control	310
Corrective actions	310
Records	310
Staff and training	311
Servicing	311
Audits	311
Definitions of terms used in Appendix IV	312
References to Appendix IV	313
 APPENDIX V: PACKAGE STOWAGE AND RETENTION DURING TRANSPORT	315
Introduction	315
Types of retention system	315
Package acceleration factor considerations	317
Demonstrating compliance through testing	319
Examples of retention system designs and assessments	320
Definitions of terms used in Appendix V	326
References to Appendix V	327

APPENDIX VI: GUIDELINES FOR SAFE DESIGN OF SHIPPING PACKAGES AGAINST BRITTLE FRACTURE	329
Introduction	329
General consideration of evaluation methods	330
Considerations for fracture mechanics	334
Safety factors for Method 3	337
Evaluation procedure for Method 3	339
References to Appendix VI	344
APPENDIX VII: CRITICALITY SAFETY ASSESSMENTS	347
Introduction	347
Package description	347
Criticality safety analysis models	348
Method of analysis	350
Validation of calculational method	352
Calculations and results	358
Special issues	365
Design and operational issues	368
References to Appendix VII	370
CONTRIBUTORS TO DRAFTING AND REVIEW	375
BODIES FOR THE ENDORSEMENT OF SAFETY STANDARDS	380
INDEX	382

LIST OF TABLES

Table I	Correction factors for package and detector sizes	22
Table II	Sample segregation between classes of dangerous goods ..	85
Table III	Comparison of the four volumetric leak test methods recommended by Aston et al. [3]	98
Table IV	List of VRI codes by country	211
Table I.1	Dose coefficients for submersion	229
Table I.2	Type A package contents limits	238
Table I.3	Decay chains used in the Q system	253
Table II.1	Half-life and specific activity of radionuclides	259
Table II.2	Dose and dose rate coefficients of radionuclides	272

Table II.3	Specific activity values for uranium at various levels of enrichment	286
Table III.1	Transmission factors	290
Table III.2	Variation of segregation distance with transport index for a single group of packages stowed below main deck on a passenger aircraft	291
Table III.3	Variation of segregation distance with transport index for main deck stowage on a combi or cargo aircraft	294
Table IV.1	Basic elements of quality assurance programmes that should be considered and addressed in the safe transport of radioactive material	300
Table V.1	Acceleration factors for package retention system design	318
Table V.2	Acceleration factors for package retention system design for specific packages	319
Table V.3	Symbols used in calculation of a rectangular package with baseplate flange bolted to the conveyance	325