

Verification of RESRAD-RDD

Version 2.01

Environmental Science Division

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CONTENTS

NOTATION.....	xxi
ABSTRACT.....	1
1 INTRODUCTION.....	1
2 COMPARISON OF NUCLIDE-SPECIFIC DATA USED IN CALCULATIONS.....	5
2.1 Radiological Half-Lives.....	5
2.2 DCFs for Submersion, Inhalation, and Ingestion.....	5
2.3 DCFs for External Radiation and Radon.....	5
2.4 Planning Values.....	6
3 INPUT PARAMETERS USED IN THE VERIFICATION.....	7
4 RESULTS OF COMPARISON FOR GROUP A.....	11
4.1 Comparison of General Guidelines.....	11
4.1.1 Results Based on ICRP-30 DCFs.....	11
4.1.2 Results Based on ICRP-60 DCFs.....	24
4.2 Comparison of Measurement-Based Guidelines.....	35
4.2.1 Results Based on ICRP-30 DCFs.....	36
4.2.2 Results Based on ICRP-60 DCFs.....	37
5 RESULTS OF COMPARISON FOR GROUP B.....	41
5.1 Comparison of General Guidelines.....	41
5.1.1 Results Based on ICRP-30 DCFs.....	41
5.1.2 Results Based on ICRP-60 DCFs.....	42
5.2 Comparison of Measurement-Based Results.....	43
5.2.1 Results Based on ICRP-30 DCFs.....	43
5.2.2 Results Based on ICRP-60 DCFs.....	44
6 RESULTS OF COMPARISON FOR GROUP C.....	45
6.1 Comparison of General Guidelines.....	45
6.1.1 Results Based on ICRP-30 DCFs.....	45
6.1.2 Results Based on ICRP-60 DCFs.....	47
6.2 Comparison of Measurement-Based Results.....	49
6.2.1 Results Based on ICRP-30 DCFs.....	49
6.2.2 Results Based on ICRP-60 DCFs.....	51

CONTENTS (CONT.)

7	RESULTS OF COMPARISON FOR GROUP D	55
7.1	Comparison of General Guidelines.....	55
7.1.1	Results Based on ICRP-30 DCFs	55
7.1.2	Results Based on ICRP-60 DCFs	61
7.2	Comparison of Measurement-Based Results	68
7.2.1	Results Based on ICRP-30 DCFs	68
7.2.2	Results Based on ICRP-60 DCFs	71
8	RESULTS OF COMPARISON FOR GROUP E.....	75
8.1	Comparison of General Guidelines.....	75
8.1.1	Results Based on ICRP-30 DCFs	75
8.1.2	Results Based on ICRP-60 DCFs	77
8.2	Comparison of Measurement-Based Results	78
8.2.1	Results Based on ICRP-30 DCFs	78
8.2.2	Results Based on ICRP-60 DCFs	79
9	RESULTS OF COMPARISON FOR GROUP F.....	81
10	RESULTS OF COMPARISON FOR GROUP G	83
10.1	Comparison of General Guidelines.....	83
10.1.1	Results Based on ICRP-30 DCFs	83
10.1.2	Results Based on ICRP-60 DCFs	85
10.2	Comparison of Measurement-Based Results	86
10.2.1	Results Based on ICRP-30 DCFs	86
10.2.2	Results Based on ICRP-60 DCFs	88
11	COMPARISONS OF RESULTS IN DIFFERENT UNITS GENERATED BY RESRAD-RDD VERSION 2.01	91
11.1	Comparison of Group A Results.....	91
11.2	Comparison of Group B Results	92
11.3	Comparison of Group C Results	94
11.4	Comparison of Group D Results.....	95
11.5	Comparison of Group E Results	97
11.6	Comparison of Group F Results	98
11.7	Comparison of Group G Results.....	99
12	CONCLUSIONS	103

FIGURES

1	Total Dose versus Stay Times Based on Measured Radionuclide Concentrations Obtained with RESRAD-RDD Version 1.7.....	69
2	Total Dose versus Stay Times Based on Measured Radionuclide Concentrations Obtained with RESRAD-RDD Version 2.01.....	70
3	Total Dose versus Stay Times Based on Measured Radionuclide Concentrations Obtained with RESRAD-RDD Version 1.7.....	70
4	Total Dose versus Stay Times Based on Measured Radionuclide Concentrations Obtained with RESRAD-RDD Version 2.01.....	71
5	Total Dose versus Stay Times Based on Measured Radionuclide Concentrations Obtained with RESRAD-RDD Version 1.7.....	72
6	Total Dose versus Stay Times Based on Measured Radionuclide Concentrations Obtained with RESRAD-RDD Version 2.0.....	73
7	Total Dose versus Stay Times Based on Measured Radionuclide Concentrations Obtained with RESRAD-RDD Version 1.7.....	73
8	Total Dose versus Stay Times Based on Measured Radionuclide Concentrations Obtained with RESRAD-RDD Version 2.01.....	74

TABLES

3.1	Input Datasets with Parameter Values Used for the RESRAD-RDD Verification	8
4.1	Group A General Guidelines without Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 1.7.....	11
4.2	Group A General Guidelines without Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 2.01.....	12
4.3	Group A General Guidelines without Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 1.7.....	12

TABLES (CONT.)

4.4	Group A General Guidelines without Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 2.01	12
4.5	Group A General Guidelines without Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 1.7.....	13
4.6	Group A General Guidelines without Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 2.01	13
4.7	Group A General Guidelines without Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 1.7.....	13
4.8	Group A General Guidelines without Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 2.01	14
4.9	Group A Radionuclide Correction Factors for Stay Times without a Respirator Obtained with RESRAD-RDD Version 1.7.....	14
4.10	Group A Radionuclide Correction Factors for Stay Times without a Respirator Obtained with RESRAD-RDD Version 2.01.....	15
4.11	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 1.7	15
4.12	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 2.01	15
4.13	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 1.7	16
4.14	Group A General Guidelines Results with Full-Face Air-Purifying Respirators Based on Beta-Gamma Ground Surface Measurement Obtained with RESRAD-RDD Version 2.01	16
4.15	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 1.7.....	17
4.16	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 2.01	17

TABLES (CONT.)

4.17	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 1.7	17
4.18	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 2.01	18
4.19	Group A Radionuclide Correction Factors for Stay Times with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 1.7	18
4.20	Group A Radionuclide Correction Factors for Stay Times with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 2.01	19
4.21	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 1.7	19
4.22	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 2.01	20
4.23	Group A General Guidelines with Full-Face Continuous Flow Air Supply Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 1.7	20
4.24	Group A General Guidelines with Full-Face Continuous Flow Air Supply Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 2.01	20
4.25	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 1.7	21
4.26	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 2.01	21
4.27	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 1.7	22

TABLES (CONT.)

4.28	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 2.01	22
4.29	Group A Radionuclide Correction Factors for Stay Times with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 1.7	23
4.30	Group A Radionuclide Correction Factors for Stay Times with a Full-Face continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 2.01	23
4.31	Group A General Guidelines without Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 1.7.....	24
4.32	Group A General Guidelines without Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 2.01.....	24
4.33	Group A General Guidelines without Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 1.7.....	25
4.34	Group A General Guidelines without Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 2.01.....	25
4.35	Group A General Guidelines without Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 1.7.....	25
4.36	Group A General Guidelines without Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 2.01.....	26
4.37	Group A General Guidelines without Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 1.7	26
4.38	Group A General Guidelines without Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 2.01	26
4.39	Group A Radionuclide Correction Factors for Stay Times without a Respirator Obtained with RESRAD-RDD Version 1.7.....	27
4.40	Group A Radionuclide Correction Factors for Stay Times without a Respirator Obtained with RESRAD-RDD Version 2.01.....	27

TABLES (CONT.)

4.41	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 1.7	28
4.42	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 2.01	28
4.43	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 1.7	28
4.44	Group A General Guidelines Results with Full-Face Air-Purifying Respirators Based on Beta-Gamma Ground Surface Measurement Obtained with RESRAD Version 2.01	29
4.45	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 1.7.....	29
4.46	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 2.01	29
4.47	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 1.7.....	30
4.48	Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 2.01	30
4.49	Group A Radionuclide Correction Factors for Stay Times with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 1.7	31
4.50	Group A Radionuclide Correction Factors for Stay Times with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 2.01	31
4.51	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 1.7	32
4.52	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 2.01	32

TABLES (CONT.)

4.53	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 1.7	32
4.54	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 2.01	33
4.55	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 1.7	33
4.56	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 2.01	33
4.57	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 1.7	34
4.58	Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 2.01	34
4.59	Group A Radionuclide Correction Factors for Stay Times with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 1.7	35
4.60	Group A Radionuclide Correction Factors for Stay Times with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 2.01	35
4.61	Group A Measurement-Based Stay Time Results without a Respirator Obtained with RESRAD-RDD Version 1.7	36
4.62	Group A Measurement-Based Stay Time Results without a Respirator Obtained with RESRAD-RDD Version 2.01	36
4.63	Group A Measurement-Based Stay Time Results with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 1.7	36

TABLES (CONT.)

4.64	Group A Measurement-Based Stay Time Results with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 2.01	37
4.65	Group A Measurement-Based Stay Time Results with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 1.7	37
4.66	Group A Measurement-Based Stay Time Results with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 2.01	37
4.67	Group A Measurement-Based Stay Time Results without a Respirator Obtained with RESRAD-RDD Version 1.7	38
4.68	Group A Measurement-Based Stay Time Results without a Respirator Obtained with RESRAD-RDD Version 2.01	38
4.69	Group A Measurement-Based Stay Time Results with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 1.7	38
4.70	Group A Measurement-Based Stay Time Results with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 2.01	38
4.71	Group A Measurement-Based Stay Time Results with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 1.7	39
4.72	Group A Measurement-Based Stay Time Results with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 2.01	39
5.1	Group B General Operational Guidelines Results Based on FRMAC Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 1.7	41
5.2	Group B General Operational Guidelines Results Based on FRMAC Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 2.01	42
5.3	Group B General Operational Guidelines Results Based on OGT Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 1.7	42
5.4	Group B General Operational Guidelines Results Based on OGT Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 2.01	43
5.5	Group B Measurement-Based Dose Results Based on FRMAC Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 1.7	43

TABLES (CONT.)

5.6	Group B Measurement-Based Dose Results Based on FRMAC Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 2.01	44
5.7	Group B Measurement-Based Dose Results Based on OGT Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 1.7.....	44
5.8	Group B Measurement-Based Dose Results Based on OGT Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 2.01	44
6.1	Most Restrictive Operational Guidelines for Subgroup C1 Obtained with RESRAD-RDD Version 1.7	45
6.2	Most Restrictive Operational Guidelines for Subgroup C1 Obtained with RESRAD-RDD Version 2.01	46
6.3	Most Restrictive Operational Guidelines for Subgroup C2 Obtained with RESRAD-RDD Version 1.7	46
6.4	Most Restrictive Operational Guidelines for Subgroup C2 Obtained with RESRAD-RDD Version 2.01	47
6.5	Most Restrictive Operational Guidelines for Subgroup C4 Obtained with RESRAD-RDD Version 1.7	47
6.6	Most Restrictive Operational Guidelines for Subgroup C4 Obtained with RESRAD-RDD Version 2.01	48
6.7	Most Restrictive Operational Guidelines for Subgroup C5 Obtained with RESRAD-RDD Version 1.7	48
6.8	Most Restrictive Operational Guidelines for Subgroup C5 Obtained with RESRAD-RDD Version 2.01	49
6.9	Total Doses Based on Measurement Data for Subgroup C1 Obtained with RESRAD-RDD Version 2.01	50
6.10	Total Doses Based on Measurement Data for Subgroup C1 Obtained with RESRAD-RDD Version 2.01	50
6.11	Total Doses Based on Measurement Data for Subgroup C3 Obtained with RESRAD-RDD Version 1.7	50

TABLES (CONT.)

6.12	Total Doses Based on Measurement Data for Subgroup C3 Obtained with RESRAD-RDD Version 2.01	51
6.13	Total Doses Based on Measurement Data for Subgroup C4 Obtained with RESRAD-RDD Version 1.7	51
6.14	Total Doses Based on Measurement Data for Subgroup C4 Obtained with RESRAD-RDD Version 2.01	51
6.15	Total Doses Based on Measurement Data for Subgroup C6 Obtained with RESRAD-RDD Version 1.7	52
6.16	Total Doses Based on Measurement Data for Subgroup C6 Obtained with RESRAD-RDD Version 2.01	52
6.17	Total Doses Based on Measurement Data for Subgroup C7 Obtained with RESRAD-RDD Version 1.7	53
6.18	Total Doses Based on Measurement Data for Subgroup C7 Obtained with RESRAD-RDD Version 2.01	53
7.1	General Guidelines in Terms of Stay Time for Subgroup D1-1 Obtained with RESRAD-RDD Version 1.7	55
7.2	General Guidelines in Terms of Stay Time for Subgroup D1-1 Obtained with RESRAD-RDD Version 2.01	55
7.3	General Guidelines in Terms of Stay Time for Subgroup D1-2 Obtained with RESRAD-RDD Version 1.7	56
7.4	General Guidelines in Terms of Stay Time for Subgroup D1-2 Obtained with RESRAD-RDD Version 2.01	56
7.5	General Guidelines in Terms of Stay Time for Subgroup D2-1 Obtained with RESRAD-RDD Version 1.7	56
7.6	General Guidelines in Terms of Stay Time for Subgroup D2-1 Obtained with RESRAD-RDD Version 2.01	57
7.7	General Guidelines in Terms of Stay Time for Subgroup D2-2 Obtained with RESRAD-RDD Version 1.7	57

TABLES (CONT.)

7.8	General Guidelines in Terms of Stay Time for Subgroup D2-2 Obtained with RESRAD-RDD Version 2.01	57
7.9	General Operational Guidelines for Four Selected Exposure Durations for Subgroup D1-1 Obtained with RESRAD-RDD Version 1.7	58
7.10	General Operational Guidelines for Four Selected Exposure Durations for Subgroup D1-1 Obtained with RESRAD-RDD Version 2.01	58
7.11	General Operational Guidelines for Four Selected Exposure Durations for Subgroup D1-2 Obtained with RESRAD-RDD Version 1.7	59
7.12	General Operational Guidelines for Four Selected Exposure Durations for Subgroup D1-2 Obtained with RESRAD-RDD Version 2.01	59
7.13	General Operational Guidelines for Three Selected Exposure Durations for Subgroup D2-1 Obtained with RESRAD-RDD Version 1.7	60
7.14	General Operational Guidelines for Three Selected Exposure Durations for Subgroup D2-2 Obtained with RESRAD-RDD Version 2.01	60
7.15	General Operational Guidelines for Three Selected Exposure Durations for Subgroup D2-2 Obtained with RESRAD-RDD Version 1.7	61
7.16	General Operational Guidelines for Three Selected Exposure Durations for Subgroup D2-2 Obtained with RESRAD-RDD Version 2.01	61
7.17	General Operational Guidelines in Terms of Stay Time for Subgroup D1-1 Obtained with RESRAD-RDD Version 1.7	62
7.18	General Operational Guidelines in Terms of Stay Time for Subgroup D1-1 Obtained with RESRAD-RDD Version 2.01	62
7.19	General Operational Guidelines in Terms of Stay Time for Subgroup D1-2 Obtained with RESRAD-RDD Version 1.7	62
7.20	General Operational Guidelines in Terms of Stay Time for Subgroup D1-2 Obtained with RESRAD-RDD Version 2.01	62
7.21	General Operational Guidelines in Terms of Stay Time for Subgroup D2-1 Obtained with RESRAD-RDD Version 1.7	63

TABLES (CONT.)

7.22	General Operational Guidelines in Terms of Stay Time for Subgroup D2-1 Obtained with RESRAD-RDD Version 2.01.....	63
7.23	General Operational Guidelines in Terms of Stay Time for Subgroup D2-2 Obtained with RESRAD-RDD Version 1.7.....	63
7.24	General Operational Guidelines in Terms of Stay Time for Subgroup D2-2 Obtained with RESRAD-RDD Version 2.01.....	64
7.25	General Operational Guidelines for Four Exposure Durations for Subgroup D1-1 Obtained with RESRAD-RDD Version 1.7.....	64
7.26	General Operational Guidelines for Four Exposure Durations for Subgroup D1-1 Obtained with RESRAD-RDD Version 2.01.....	65
7.27	General Operational Guidelines for Four Selected Exposure Durations for Subgroup D1-2 Obtained with RESRAD-RDD Version 1.7.....	65
7.28	General Operational Guidelines for Four Selected Exposure Durations for Subgroup D1-2 Obtained with RESRAD-RDD Version 2.01.....	66
7.29	General Operational Guidelines for Three Exposure Durations for Subgroup D2-1 Obtained with RESRAD-RDD Version 1.7.....	66
7.30	General Operational Guidelines for Three Exposure Durations for Subgroup D2-1 Obtained with RESRAD-RDD Version 2.01.....	67
7.31	General Operational Guidelines for Three Exposure Durations for Subgroup D2-2 Obtained with RESRAD-RDD Version 1.7.....	67
7.32	General Operational Guidelines for Three Exposure Durations for Subgroup D2-2 Obtained with RESRAD-RDD Version 2.01.....	68
7.33	Group D Stay Times Based on Measurement Data Obtained with RESRAD-RDD Version 1.7.....	68
7.34	Group D Stay Times Based on Measurement Data Obtained with RESRAD-RDD Version 2.01.....	69
7.35	Group D Stay Times Based on Measurement Data Obtained with RESRAD-RDD Version 1.7.....	71

TABLES (CONT.)

7.36	Group D Stay Times Based on Measurement Data Obtained with RESRAD-RDD Version 2.01	72
8.1	General Operational Guidelines for Subgroup E1 Obtained with RESRAD-RDD Version 1.7	75
8.2	General Operational Guidelines for Subgroup E1 Obtained with RESRAD-RDD Version 2.01	76
8.3	General Operational Guidelines for Subgroup E2 Obtained with RESRAD-RDD Version 1.7	76
8.4	General Operational Guidelines for Subgroup E2 Obtained with RESRAD-RDD Version 2.01	77
8.5	General Operational Guidelines for Subgroup E3 Obtained with RESRAD-RDD Version 1.7	77
8.6	General Operational Guidelines for Subgroup E3 Obtained with RESRAD-RDD Version 2.01	78
8.7	Measurement-Based Total Dose Results for Subgroup E3 Obtained with RESRAD-RDD Version 1.7	79
8.8	Measurement-Based Total Dose Results for Subgroup E3 Obtained with RESRAD-RDD Version 2.01	79
8.9	Measurement-Based Total Dose Results for Subgroups E1 and E2 Obtained with RESRAD-RDD Version 1.7	80
8.10	Measurement-Based Total Dose Results for Subgroups E1 and E2 Obtained with RESRAD-RDD Version 2.01	80
10.1	General Operational Guidelines for Subgroup G2 Obtained with RESRAD-RDD Version 1.7	83
10.2	General Operational Guidelines for Subgroup G2 Obtained with RESRAD-RDD Version 2.01	84
10.3	General Operational Guidelines for Subgroup G3 Obtained with RESRAD-RDD Version 1.7	84

TABLES (CONT.)

10.4	Group G Operational Guidelines for Subgroup G3 Obtained with RESRAD-RDD Version 2.01	85
10.5	General Operational Guidelines for Subgroup G4 Obtained with RESRAD-RDD Version 1.7	85
10.6	General Operational Guidelines for Subgroup G4 Obtained with RESRAD-RDD Version 2.01	86
10.7	Group G Measurement-Based Results for Radionuclide Concentrations in Food Types Obtained with RESRAD-RDD Version 1.7	86
10.8	Group G Measurement-Based Results for Radionuclide Concentrations in Food Types Obtained with RESRAD-RDD Version 2.01	87
10.9	Group G Measurement-Based Dose Results for Different Food Types Obtained with RESRAD-RDD Version 1.7	87
10.10	Group G Measurement-Based Dose Results for Different Food Types Obtained with RESRAD-RDD Version 2.01	87
10.11	Group G Measurement-Based Results for Radionuclide Concentrations in Food Types Obtained with RESRAD-RDD Version 1.7	88
10.12	Group G Measurement-Based Results for Radionuclide Concentrations in Food Types Obtained with RESRAD-RDD Version 2.01	88
10.13	Group G Measurement-Based Dose Results for Different Food Types Obtained with RESRAD-RDD Version 1.7	89
10.14	Group G Measurement-Based Dose Results for Different Food Types Obtained with RESRAD-RDD Version 2.01	89
11.1	Group A General Guidelines without Respirators Based on Gross Alpha Surface Measurement in the Traditional Unit	91
11.2	Group A General Guidelines without Respirators Based on Gross Alpha Surface Measurement in the SI Unit	92
11.3	Group A Measurement-Based Stay Time Results without a Respirator in the Traditional Unit	92

TABLES (CONT.)

11.4	Group A Measurement-Based Stay Time Results without a Respirator in the SI Unit.....	92
11.5	Group B General Operational Guidelines Results Based on FRMAC Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 2.01	93
11.6	Worksheet Results Obtained by Dividing the Results Shown in Table 5.2 by 27.027.....	93
11.7	Group B Measurement-Based Dose Results Based on OGT Methodology for Early Phase of Response in the SI Unit	94
11.8	Group B Measurement-Based Dose Results Based on OGT Methodology for Early Phase of Response in the Traditional Unit.....	94
11.9	Total Doses Based on Measurement Data for Subgroups C4–C7 in the SI Unit	95
11.10	Total Doses Based on Measurement Data for Subgroups C4–C7 in the Traditional Unit	95
11.11	General Guidelines in Terms of Stay Time for Subgroup D2-1 in the SI Unit	96
11.12	General Guidelines in Terms of Stay Time for Subgroup D2-1 in the Traditional Unit	96
11.13	Group D Stay Times Based on Measurement Data in the SI Unit.....	96
11.14	Group D Stay Times Based on Measurement Data in the Traditional Unit	96
11.15	General Operational Guidelines for Subgroup E1 in the SI Unit	97
11.16	Worksheet Results Obtained by Dividing the Results Shown in Table 8.2 by 27.027.....	97
11.17	Measurement-Based Total Dose Results for Subgroups E1 and E2 in the SI Unit	09
11.18	Measurement-Based Total Dose Results for Subgroups E1 and E2 in the Traditional Unit.....	98
11.19	General Soil Guidelines for Group F in the SI Unit	99

TABLES (CONT.)

11.20	Worksheet Results Obtained by Dividing the General Soil Guidelines for Group F in the Traditional Unit by 27.027.....	99
11.21	General Operational Guidelines for Subgroup G2 in the SI Unit.....	100
11.22	Worksheet Results Obtained by Dividing the Results Shown in Table 10.2 by 27.027.....	100
11.23	Group G Measurement-Based Results for Radionuclide Concentrations in Food Types in the SI Unit.....	101
11.24	Worksheet Results Obtained by Dividing the Results Shown in Table 10.12 by 27.027.....	101

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NOTATION

The following is a list of the acronyms and units of measure used in this document.

ACRONYMS, INITIALISMS, AND ABBREVIATIONS

DCF	Dose Conversion Factor
DHS	U.S. Department of Homeland Security
DIL	derived intervention level
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FDA	U.S. Food and Drug Administration
FRMAC	Federal Radiological Monitoring and Assessment Center
GUI	graphical user interface
ICRP	International Commission on Radiological Protection
NRC	U.S. Nuclear Regulatory Commission
OGT	Operational Guidelines Task Group
PAG	Protective Action Guide
PV	Planning Value
RAM	random-access memory
RDD	Radiological Dispersal Device
WCF	Weathering Correction Factor

UNITS OF MEASURE

Bq	becquerel(s)
Ci	curie(s)
cm	centimeter(s)
cm ²	square centimeter(s)
cm ³	cubic centimeter(s)
d	day(s)
dpm	disintegration(s) per minute

GB	gigabyte(s)
GHz	gigahertz
h	hour(s)
kg	kilogram(s)
m	meter(s)
m ²	square meter(s)
m ³	cubic meter(s)
mrem	millirem(s)
mSv	millisievert(s)
R	roentgen(s)
rem	rem(s)
s	second(s)
Sv	sievert(s)
yr	year(s)

VERIFICATION OF RESRAD-RDD VERSION 2.01

by

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ABSTRACT

In this report, the results generated by RESRAD-RDD version 2.01 are compared with those produced by RESRAD-RDD version 1.7 for different scenarios with different sets of input parameters. RESRAD-RDD version 1.7 is spreadsheet-driven, performing calculations with Microsoft Excel spreadsheets. RESRAD-RDD version 2.01 revamped version 1.7 by using command-driven programs designed with Visual Basic.NET to direct calculations with data saved in Microsoft Access database, and re-facing the graphical user interface (GUI) to provide more flexibility and choices in guideline derivation. Because version 1.7 and version 2.01 perform the same calculations, the comparison of their results serves as verification of both versions. The verification covered calculation results for 11 radionuclides included in both versions: Am-241, Cf-252, Cm-244, Co-60, Cs-137, Ir-192, Po-210, Pu-238, Pu-239, Ra-226, and Sr-90. At first, all nuclide-specific data used in both versions were compared to ensure that they are identical. Then generic operational guidelines and measurement-based radiation doses or stay times associated with a specific operational guideline group were calculated with both versions using different sets of input parameters, and the results obtained with the same set of input parameters were compared. A total of 12 sets of input parameters were used for the verification, and the comparison was performed for each operational guideline group, from A to G, sequentially. The verification shows that RESRAD-RDD version 1.7 and RESRAD-RDD version 2.01 generate almost identical results; the slight differences could be attributed to differences in numerical precision with Microsoft Excel and Visual Basic.NET. RESRAD-RDD version 2.01 allows the selection of different units for use in reporting calculation results. The results of SI units were obtained and compared with the base results (in traditional units) used for comparison with version 1.7. The comparison shows that RESRAD-RDD version 2.01 correctly reports calculation results in the unit specified in the GUI.

1 INTRODUCTION

RESRAD-RDD is a software tool developed by Argonne National Laboratory (Argonne) for the Operational Guideline Task Group (OGT) established by the U.S. Department of Energy (DOE) to derive operational guidelines for use in emergency planning and response associated with a radiological dispersal device (RDD) incident. The operational guidelines are expressed in terms of ground surface radioactivity concentrations or stay times and correspond to the

protection action guides (PAGs) in terms of radiation doses established by the U.S. Environmental Protection Agency (EPA 400-R-92-001).

The operational guidelines are organized into seven groups that are generally characterized by the phase of emergency response in which they would be implemented or used. Individual groups are further categorized into subgroups, as appropriate. The operational guideline groups considered in RESRAD-RDD are (A) access control during emergency response operations, for life- and property-saving measures and emergency worker demarcation, (B) early-phase protective action, concerning evacuation or sheltering of the general public, (C) relocation from different areas, including residential areas, commercial and industrial areas, and other areas such as parks and monuments, and utilization of critical infrastructure in relocation areas, including hospitals and other healthcare facilities, critical transport facilities, water and sewer facilities, and power and fuel facilities, (D) temporary access to relocation areas for essential services, concerning worker access to business or public access to residences, (E) transportation and access routes, determining access control to bridges, streets and thoroughfares, and sidewalks and walkways, (F) release of real property, such as lands and buildings, from radiologically controlled areas, and (G) food consumption, concerning ingestion of food in early phase, intermediate, and intermediate-to-late phase.

For each group or subgroup, RESRAD-RDD considers multiple exposure scenarios representing likely receptors and their exposure conditions and estimates the unit radiation doses that could be incurred by the receptors, that is, the radiation doses associated with a unit radioactivity concentration for the individual radionuclide on the ground surface, with corresponding radioactivity in the surrounding media. The estimated unit dose results are then scaled with the applicable PAG to derive operational guidelines for the individual radionuclide. The most conservative, that is, the smallest, operational guidelines among the scenarios considered for the same group or subgroup are selected as the general operational guidelines for that group or subgroup. In cases in which radioactivity measurement data are available, RESRAD-RDD also calculates measurement-based stay times corresponding to the applicable PAG or total radiation doses for comparison with the PAG value.

RESRAD-RDD version 1.7 and previous versions are spreadsheet-driven, performing calculations with Microsoft Excel spreadsheets. In version 2.01, the code was revamped and no longer restricted by the Excel setting; that is, Microsoft Excel does not need to be installed on the target computer for the code to run. Command-driven programs designed with Visual Basic were employed to direct all the calculations with data saved in Microsoft Access database. In version 2.01, the operational guideline calculations are streamlined and redundant calculations are minimized. In addition, interactions between the calculation programs and the database are more efficient than those among multiple spreadsheets. As a result, the calculation speed is greatly improved with version 2.01 over the previous versions, especially for the operational guideline group D. The other advantage of the revamp is that the database that accompanies the executable program can be easily expanded to include additional radionuclides in the future. In addition to the improvement in calculations, in version 2.01, the graphical user interface (GUI) was redesigned to provide more flexibility and choices for users when specifying input data and viewing calculation results.

Note that in version 1.7, operational guidelines are also derived for Cs-134, in addition to the 11 radionuclides considered in this benchmarking, for groups A, B, C, and E, but not for groups D, F, and G. Because the derivation of guidelines for Cs-134 is not performed for all operational guideline groups in version 1.7, it was decided not to include Cs-134 in version 2.01. However, expansion of the radionuclide database is being planned for a future version in which Cs-134 will be included.

Although the design of version 2.01 is different from that of version 1.7, the principles and equations governing the derivation of operational guidelines as implemented in the two versions are the same. This report documents the comparisons of the calculation results obtained with both versions; the comparisons serve as a means of verifying that the principles and equations were correctly implemented in both versions and that version 2.01 will produce the same results as version 1.7 with the same input data.

Chapter 2 presents the comparison of nuclide-specific data used in version 1.7 and version 2.01. Chapter 3 describes the 12 different input parameter sets used for different operational guideline groups in the comparison. The comparison results are provided in Chapters 4 through 10 for operational guideline groups A through G, respectively, which are followed by verification of the calculation results expressed in SI units for version 2.01 in Chapter 11 (version 1.7 is not equipped with this function). Finally, in Chapter 12, conclusions drawn from the comparison are presented.

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2 COMPARISON OF NUCLIDE-SPECIFIC DATA USED IN CALCULATIONS

While RESRAD-RDD allows users to change the values of parameters used to consider exposure conditions and model environmental partitioning of radionuclides, there are some nuclide-specific data used in the code that cannot be modified (but some can be viewed) by the user. These nuclide-specific data would not change with exposure conditions and environmental settings; they include radiological half-lives, radiation dose conversion factors (DCFs), and planning values (PVs) for food. Because these data are used in the calculations to derive operational guidelines, the verification effort started with the comparison of their values between RESRAD-RDD version 1.7 and version 2.01 to ensure consistent values are used in both versions.

2.1 RADIOLOGICAL HALF-LIVES

The half-lives of the 11 radionuclides—Am-241, Cf-252, Cm-244, Co-60, Cs-137, Ir-192, Po-210, Pu-238, Pu-239, Ra-226, and Sr-90—included in both versions were compared. No discrepancies were found.

2.2 DCFS FOR SUBMERSION, INHALATION, AND INGESTION

Two sets of DCFs are included in RESRAD-RDD, based on (International Commission on Radiological Protection Publication 30 (ICRP-30) and ICRP-60. The default set is based on ICRP-60, but the user can choose whether to change this default setting. The selected DCFs are used in the calculations. The DCF selection is saved between RESRAD-RDD runs.

RESRAD-RDD considers radiation exposures from different pathways, including external exposure from the groundshine and air submersion pathways, and internal exposure from the inhalation of airborne dust particles, inhalation of radon, ingestion of soil/dust, and ingestion of food (for group G only) pathways. For the air submersion, inhalation, and ingestion pathways, the DCFs (both ICRP-30 and -60 based) stored in version 1.7 and version 2.01 were compared and no discrepancies were found.

2.3 DCFS FOR EXTERNAL RADIATION AND RADON

RESRAD-RDD considers multiple contaminated surfaces when unit radiation doses for an exposure scenario are being calculated. The contaminated surfaces considered for all the different scenarios modeled by RESRAD-RDD include the outside ground surface, the 10 surfaces (roof, four exterior walls, four interior walls, and floor) of an enclosed space, the ground area of a street, and the ground area and two side walls of a bridge. Eight different geometries developed to represent (1) a rural house, (2) a suburban house, (3) an urban apartment, (4) a store, (5) a warehouse, (6) a monument, (7) a subway station, and (8) a rail car are included in the code. Users are given the option of choosing the geometry for the enclosed space involved in

the scenario that they are considering for guideline derivation. The dimensions of the contaminated surfaces are predetermined. The unit external radiation dose (equivalent to the external radiation DCF in RESRAD-RDD) that a receptor would incur from each of the contaminated surfaces was precalculated and saved in the code. There are two sets of external radiation DCFs (one based on ICRP-30 and the other based on ICRP-60, and both were calculated with RESRAD-Build) for each surface. The saved DCFs are retrieved according to the geometry selection made by the user and used for dose calculations. The external radiation DCFs saved in version 1.7 and version 2.01 were compared, and no discrepancies were found.

The inhalation-of-radon pathway is valid only when Ra-226 is present in a contaminated surface. As Ra-226 decays, radon would be generated and could escape the contaminated surface and get into the air, resulting in radiation exposure through the inhalation of radon pathway. Only indoor radon exposure is modeled in RESRAD-RDD, because in an outdoor environment, the radon concentration tends to be greatly diluted by uncontaminated air. Like the external radiation DCFs, the unit radon inhalation dose, equivalent to the radon DCF in RESRAD-RDD, for each of the contaminated surface of the predetermined geometries for an enclosed space was precalculated (also obtained with RESRAD-Build) and saved in the code. The saved radon DCFs in version 1.7 and version 2.01 were compared, and no discrepancies were found.

2.4 PLANNING VALUES

The PV for each radionuclide was prederived using the U.S. Food and Drug Administration (FDA) methodology for calculating Derived Intervention Levels (DILs) for food and the updated ingestion dose coefficients for different age groups from ICRP-72. The derived PVs are saved in the code and used for group G scenarios.

The PVs for the 11 radionuclides considered in RESRAD-RDD version 2.01 were compared against those in version 1.7 and no discrepancies were found.

3 INPUT PARAMETERS USED IN THE VERIFICATION

The calculation results for different scenarios obtained with RESRAD-RDD version 1.7 and version 2.01 were compared as a means of verifying the results. Table 3-1 lists the 12 sets of input parameters used for the various scenarios under different operational guideline groups to obtain the calculation results. A dash in the table indicates that the default value was used; NA indicates that the parameter is not used for the scenarios under the specific operational guideline group(s).

TABLE 3.1 Input Datasets with Parameter Values Used for the RESRAD-RDD Verification

	Input Data Set Number											
	1	2	3	4	5	6	7	8	9	10	11	12
Guideline Group	A	A	A	A	B, C, D, E	B, C, D, E	B, C, D, E	B, C, D, E	G	G	G	G
Subgroup	NA	NA	NA	NA	Various ^a	Various ^b	Various ^c	Various ^d	2, 3	4	2, 3	4
Guidelines for Comparison	General	General	Measurement	Measurement	General	General	Measurement	Measurement	General	General	Measurement	Measurement
DCF and Geometry	Input Parameter Values											
DCF Basis	ICRP-30	ICRP-60	ICRP-30	ICRP-60	ICRP-30	ICRP-60	ICRP-30	ICRP-60	ICRP-30	ICRP-60	ICRP-30	ICRP-60
Geometry Number	NA	NA	NA	NA	- ^e / NA ^f	- / NA	3 (all applicable scenarios)	-	NA	NA	NA	NA
Protection/Conversion Factors												
Full-Face Air-Purifying Respirator Protection Factor	150	-	-	50	NA	NA	NA	NA	NA	NA	NA	NA
Full-Face Continuous-Flow Air Supply Respirator Protection Factor	-	725	1030	-	NA	NA	NA	NA	NA	NA	NA	NA
Exposure Rate to Dose Conversion Factor	0.5	-	0.75	0.9	NA	NA	NA	NA	NA	NA	NA	NA
General Parameters												
Roughness Correction	0.25	0.5	0.75	0.9	0.5 (street/soil)	0.5 (street/soil)	-	-	NA	NA	NA	NA
External Shielding	NA	NA	NA	NA	-	0.5 (all structures)	0.5 (all structures)	-	NA	NA	NA	NA
Initial Partitioning	NA	NA	NA	NA	0.5 (roofs)	-	0.5 (roofs)	0.2 (exterior walls)	NA	NA	NA	NA
Dust Filtration (Indoor/Outdoor)	NA	NA	NA	NA	0.4	-	-	0.7	NA	NA	NA	NA
Outdoor Resuspension coefficient (d/m or 1/m)	-	-	-	-	-	-	-	-	1E-4 (R _o)	-	-	1E-4 (R _o)
Indoor Resuspension (1/m)	NA	NA	NA	NA	1E-5	1E-5	- / NA	- / NA	NA	NA	NA	NA
Weathering Correction	NA	NA	NA	NA	0.75 (street, mobile fraction)	1 (soil, shorter half-life)	5 (floor, longer half-life)	0.5 (street, shorter half-life)	NA	-	-	NA
Exposure Parameters												
Multiplication Factor for Resuspension	NA	NA	NA	NA	5 (C1, C2, E1, and E2 scenarios)	20 (B2, C4, C5, and E3 scenarios)	0.5 (C1, C3, and E3 scenarios)	-	NA	NA	NA	NA
Exposure Frequency (d/y)	NA	NA	NA	NA	- / NA	- / NA	- / NA	350 (C6, C7, E1, and E2 scenarios)	NA	NA	NA	NA
Dust Ingestion (m ³ /h)	0.01	1.25E-4	0	-	2E-5 (B1, C1, C2, D1, and D2)	2E-5	-	-	NA	NA	NA	NA
Indoor Exposure Duration (h/d)	NA	NA	NA	NA	-	-	NA	-	NA	NA	NA	NA
Outdoor Exposure Duration (h/d)	NA	NA	NA	NA	-	-	NA	-	NA	NA	NA	NA
Indoor Inhalation Rate (m ³ /h)	NA	NA	NA	NA	0.7	0.7	-	-	NA	NA	NA	NA
Outdoor Inhalation Rate (m ³ /h)	2.28	-	-	1	1.5	1.5	-	-	NA	NA	NA	NA
Food Consumption Parameters												
Deposition Velocity (m/s)	NA	NA	NA	NA	NA	NA	NA	NA	-	-	-	0.01
Foliage to Food Transfer Factor	NA	NA	NA	NA	NA	NA	NA	NA	-	0.25 (all plant types)	-	0.75 (all plant types)
Fraction of Foliage Deposition Retained	NA	NA	NA	NA	NA	NA	NA	NA	0.8 (OGT and FRMAC, all plant types)	-	-	-
Productivity of Plants (kg/m ²)	NA	NA	NA	NA	NA	NA	NA	NA	-	-	1 (all plant types, OGT and FRMAC)	1 (all plant types, OGT and FRMAC)

TABLE 3.1 (Cont.)

	Input Data Set Number											
	1	2	3	4	5	6	7	8	9	10	11	12
Weathering Removal Constant for Plants (1/yr)	NA	NA	NA	NA	NA	NA	NA	NA	15	10	–	–
Growing Period for Plants (y)	NA	NA	NA	NA	NA	NA	NA	NA	–	0.1 (all plant types)	–	–
Mixing Depth of Soil (m)	NA	NA	NA	NA	NA	NA	NA	NA	–	–	–	0.25
Depth of Roots (m)	NA	NA	NA	NA	NA	NA	NA	NA	0.3 (OGT and FRMAC)	–	0.3 (OGT and FRMAC)	–
Density of Soil (kg/m ³)	NA	NA	NA	NA	NA	NA	NA	NA	1,800 (OGT and FRMAC)	–	–	–
Livestock Fodder Ingestion Rate (kg/d)	NA	NA	NA	NA	NA	NA	NA	NA	–	–	–	–
Contamination Fraction of Fodder	NA	NA	NA	NA	NA	NA	NA	NA	–	0.2	–	0.5
Storage Time of Produce/Meat/Milk (d)	NA	NA	NA	NA	NA	NA	NA	NA	10 (meat, OGT)	–	3 (milk, OGT and FRMAC)	7 (all vegetables, OGT and FRMAC)
Human Ingestion Rate of Produce/Meat/Milk (kg/y or L/y)	NA	NA	NA	NA	NA	NA	NA	NA	130 (milk)	10 (meat)	–	–
Contamination Fraction of Produce/Meat/Milk	NA	NA	NA	NA	NA	NA	NA	NA	0.5	–	0.1	0.25
Measurement Data												
Ground Surface Concentration (pCi/m ²)	NA	NA	5.00E+9 Co-60, 1.30E+7 Ra-226	–	NA	NA	4.5E+7 Pu-238, 1.0E+7 Ra-226	7.25E+8 Ir-192, 9.50E+6 Po-210	NA	NA	6.75E+7 Sr-90	7.5E+7 Pu-239, 1.0E+7 Po-210
Air Concentration (pCi/m ³)	NA	NA	5E+5 Co-60	–	NA	NA	NA	NA	NA	NA	NA	NA
Gross Alpha (dpm/100 cm ² , Bq/cm ² , or pCi/cm ²)	NA	NA	–	–	NA	NA	NA	NA	NA	NA	NA	NA
β-γ (dpm/100 cm ² , Bq/cm ² , or pCi/cm ²)	NA	NA	–	–	NA	NA	NA	NA	NA	NA	NA	NA
Total Air Concentration (dpm/m ³ , Bq/m ³ , or pCi/m ³)	NA	NA	–	–	NA	NA	NA	NA	NA	NA	NA	NA
γ Exposure Rate (μR/h)	NA	NA	–	3.75E+1	NA	NA	NA	NA	NA	NA	NA	NA
PAGs												
PAG (mrem)	NA	NA	NA	NA	–	2,000 (all groups, 1 st year)	–	1,000 (all groups, 2 nd year)	NA	NA	NA	100

^a With input dataset 5, calculation results of the following subgroups were obtained and compared – B1, C1, C2, D1, D2, E1, and E2.

^b With input dataset 6, calculation results of the following subgroups were obtained and compared – B2, C4, C5, D1, D2, and E3.

^c With input dataset 7, calculation results of the following subgroups were obtained and compared – B1, C1, C3, D2, and E3.

^d With input dataset 8, calculation results of the following subgroups were obtained and compared – B2, C4, C6/C7, D1, E1, and E2.

^e “–” indicates that the default value is used for the parameter.

^f “NA” denotes the parameter is not applicable, i.e., it is not used in calculation for the group/subgroup under consideration.

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4 RESULTS OF COMPARISON FOR GROUP A

The Group A calculation results obtained with RESRAD-RDD version 1.7 and version 2.01 are compared in this chapter.

4.1 COMPARISON OF GENERAL GUIDELINES

Input datasets one and two as shown in Table 3.1 were used to obtain Group A general guidelines for comparison. Input dataset one used ICRP-30-based DCFs, while input dataset two used ICRP-60-based DCFs. With either set of input data, RESRAD-RDD version 2.01 took a total of 0.4 s to finish calculations and generate reports, while version 1.7 took a total of about 23 s to accomplish the same tasks. The execution times were based on running the two versions of RESRAD-RDD on a computer with an Intel Core i7 processor of 2.80 gigahertz (GHz), an 8.00-gigabyte (GB) random-access memory (RAM), and installed with the Windows 7 Enterprise 64-bit operating system. The same computer was used to generate the results documented in the remaining sections of this report.

4.1.1 Results Based on ICRP-30 DCFs

Tables 4.1 and 4.2 show the general operational guidelines without respirators based on gross alpha ground surface measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.1 Group A General Guidelines without Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 1.7

Activity per Unit Area			Stay Time ^a for Given Dose, h							
pCi/cm ²	Bq/ cm ²	dpm/100 cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,220	2.67E+01	1.34E+02	2.67E+02	5.35E+02	1.34E+03	2.67E+03	6.68E+03	---
100	3.7	22,200	2.67E+00	1.34E+01	2.67E+01	5.35E+01	1.34E+02	2.67E+02	6.68E+02	2.67E+03
1,000	37	2.22 x 10 ⁵	2.67E-01	1.34E+00	2.67E+00	5.35E+00	1.34E+01	2.67E+01	6.68E+01	2.67E+02
10,000	370	2.22 x 10 ⁶	2.67E-02	1.34E-01	2.67E-01	5.35E-01	1.34E+00	2.67E+00	6.68E+00	2.67E+01
100,000	3,700	2.22 x 10 ⁷	2.67E-03	1.34E-02	2.67E-02	5.35E-02	1.34E-01	2.67E-01	6.68E-01	2.67E+00
1 x 10 ⁶	37,000	2.22 x 10 ⁸	2.67E-04	1.34E-03	2.67E-03	5.35E-03	1.34E-02	2.67E-02	6.68E-02	2.67E-01
1 x 10 ⁷	370,000	2.22 x 10 ⁹	2.67E-05	1.34E-04	2.67E-04	5.35E-04	1.34E-03	2.67E-03	6.68E-03	2.67E-02

TABLE 4.2 Group A General Guidelines without Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 2.01

Activity per Unit Area			Stay Time ¹ for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	2.67E+1	1.34E+2	2.67E+2	5.35E+2	1.34E+3	2.67E+3	6.68E+3	>8.76E+3
100	3.7	22,000	2.67E+0	1.34E+1	2.67E+1	5.35E+1	1.34E+2	2.67E+2	6.68E+2	2.67E+3
1,000	37	220,000	2.67E-1	1.34E+0	2.67E+0	5.35E+0	1.34E+1	2.67E+1	6.68E+1	2.67E+2
10,000	370	2,200,000	2.67E-2	1.34E-1	2.67E-1	5.35E-1	1.34E+0	2.67E+0	6.68E+0	2.67E+1
100,000	3,700	22,000,000	2.67E-3	1.34E-2	2.67E-2	5.35E-2	1.34E-1	2.67E-1	6.68E-1	2.67E+0
1,000,000	37,000	220,000,000	2.67E-4	1.34E-3	2.67E-3	5.35E-3	1.34E-2	2.67E-2	6.68E-2	2.67E-1
10,000,000	370,000	2,200,000,000	2.67E-5	1.34E-4	2.67E-4	5.35E-4	1.34E-3	2.67E-3	6.68E-3	2.67E-2

Tables 4.3 and 4.4 show the general operational guidelines without respirators based on beta-gamma ground surface measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.3 Group A General Guidelines without Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 1.7

Activity per Unit Area			Stay Time ^a for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100 cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,220	3.61E+03	---	---	---	---	---	---	---
100	3.7	22,200	3.61E+02	1.80E+03	3.61E+03	7.21E+03	---	---	---	---
1,000	37	2.22 x 10 ⁵	3.61E+01	1.80E+02	3.61E+02	7.21E+02	1.80E+03	3.61E+03	---	---
10,000	370	2.22 x 10 ⁶	3.61E+00	1.80E+01	3.61E+01	7.21E+01	1.80E+02	3.61E+02	9.01E+02	3.61E+03
100,000	3,700	2.22 x 10 ⁷	3.61E-01	1.80E+00	3.61E+00	7.21E+00	1.80E+01	3.61E+01	9.01E+01	3.61E+02
1 x 10 ⁶	37,000	2.22 x 10 ⁸	3.61E-02	1.80E-01	3.61E-01	7.21E-01	1.80E+00	3.61E+00	9.01E+00	3.61E+01
1 x 10 ⁷	370,000	2.22 x 10 ⁹	3.61E-03	1.80E-02	3.61E-02	7.21E-02	1.80E-01	3.61E-01	9.01E-01	3.61E+00

TABLE 4.4 Group A General Guidelines without Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 2.01

Activity per Unit Area			Stay Time ^{1 2} for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	3.61E+3	>8.76E+3						
100	3.7	22,000	3.61E+2	1.80E+3	3.61E+3	7.21E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3
1,000	37	220,000	3.61E+1	1.80E+2	3.61E+2	7.21E+2	1.80E+3	3.61E+3	>8.76E+3	>8.76E+3
10,000	370	2,200,000	3.61E+0	1.80E+1	3.61E+1	7.21E+1	1.80E+2	3.61E+2	9.01E+2	3.61E+3
100,000	3,700	22,000,000	3.61E-1	1.80E+0	3.61E+0	7.21E+0	1.80E+1	3.61E+1	9.01E+1	3.61E+2
1,000,000	37,000	220,000,000	3.61E-2	1.80E-1	3.61E-1	7.21E-1	1.80E+0	3.61E+0	9.01E+0	3.61E+1
10,000,000	370,000	2,200,000,000	3.61E-3	1.80E-2	3.61E-2	7.21E-2	1.80E-1	3.61E-1	9.01E-1	3.61E+0

Tables 4.5 and 4.6 show the general operational guidelines without respirators based on air concentration measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.5 Group A General Guidelines without Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 1.7

Air Concentration			Stay Time for Given Dose							
pCi/m ³	Bq/m ³	dpm/m ³	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
0.1	0.0037	0.222	2.67E+01	1.34E+02	2.67E+02	5.35E+02	1.34E+03	2.67E+03	6.68E+03	---
1	0.037	2.22	2.67E+00	1.34E+01	2.67E+01	5.35E+01	1.34E+02	2.67E+02	6.68E+02	2.67E+03
10	0.37	22.2	2.67E-01	1.34E+00	2.67E+00	5.35E+00	1.34E+01	2.67E+01	6.68E+01	2.67E+02
100	3.7	222	2.67E-02	1.34E-01	2.67E-01	5.35E-01	1.34E+00	2.67E+00	6.68E+00	2.67E+01
1,000	37	2,220	2.67E-03	1.34E-02	2.67E-02	5.35E-02	1.34E-01	2.67E-01	6.68E-01	2.67E+00
10,000	370	22,200	2.67E-04	1.34E-03	2.67E-03	5.35E-03	1.34E-02	2.67E-02	6.68E-02	2.67E-01
100,000	3,700	222,000	2.67E-05	1.34E-04	2.67E-04	5.35E-04	1.34E-03	2.67E-03	6.68E-03	2.67E-02

TABLE 4.6 Group A General Guidelines without Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 2.01

Air Concentration			Stay Time ¹ for Given Dose, h							
pCi/m ³	Bq/m ³	dpm/m ³	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
0.1	0.0037	0.222	2.67E+1	1.34E+2	2.67E+2	5.35E+2	1.34E+3	2.67E+3	6.68E+3	>8.76E+3
1	0.037	2.22	2.67E+0	1.34E+1	2.67E+1	5.35E+1	1.34E+2	2.67E+2	6.68E+2	2.67E+3
10	0.37	22.2	2.67E-1	1.34E+0	2.67E+0	5.35E+0	1.34E+1	2.67E+1	6.68E+1	2.67E+2
100	3.7	222	2.67E-2	1.34E-1	2.67E-1	5.35E-1	1.34E+0	2.67E+0	6.68E+0	2.67E+1
1,000	37	2,220	2.67E-3	1.34E-2	2.67E-2	5.35E-2	1.34E-1	2.67E-1	6.68E-1	2.67E+0
10,000	370	22,200	2.67E-4	1.34E-3	2.67E-3	5.35E-3	1.34E-2	2.67E-2	6.68E-2	2.67E-1
100,000	3,700	222,000	2.67E-5	1.34E-4	2.67E-4	5.35E-4	1.34E-3	2.67E-3	6.68E-3	2.67E-2

Tables 4.7 and 4.8 show the general operational guidelines without respirators based on gamma exposure rate measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.7 Group A General Guidelines without Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 1.7

Exposure Rate		Stay Time ³ for Given Dose, h							
μR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.01	2.91E-05	1.45E-04	2.91E-04	5.81E-04	1.45E-03	2.91E-03	7.26E-03	2.91E-02
100	0.1	2.91E-06	1.45E-05	2.91E-05	5.81E-05	1.45E-04	2.91E-04	7.26E-04	2.91E-03
1,000	1	2.91E-07	1.45E-06	2.91E-06	5.81E-06	1.45E-05	2.91E-05	7.26E-05	2.91E-04
10,000	10	2.91E-08	1.45E-07	2.91E-07	5.81E-07	1.45E-06	2.91E-06	7.26E-06	2.91E-05
100,000	100	2.91E-09	1.45E-08	2.91E-08	5.81E-08	1.45E-07	2.91E-07	7.26E-07	2.91E-06
1 x 10 ⁶	1,000	2.91E-10	1.45E-09	2.91E-09	5.81E-09	1.45E-08	2.91E-08	7.26E-08	2.91E-07
1 x 10 ⁷	10,000	2.91E-11	1.45E-10	2.91E-10	5.81E-10	1.45E-09	2.91E-09	7.26E-09	2.91E-08

TABLE 4.8 Group A General Guidelines without Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 2.01

Exposure Rate		Stay Time ¹ for Given Dose, h							
microR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.01	2.91E-5	1.45E-4	2.91E-4	5.81E-4	1.45E-3	2.91E-3	7.26E-3	2.91E-2
100	0.1	2.91E-6	1.45E-5	2.91E-5	5.81E-5	1.45E-4	2.91E-4	7.26E-4	2.91E-3
1,000	1	2.91E-7	1.45E-6	2.91E-6	5.81E-6	1.45E-5	2.91E-5	7.26E-5	2.91E-4
10,000	10	2.91E-8	1.45E-7	2.91E-7	5.81E-7	1.45E-6	2.91E-6	7.26E-6	2.91E-5
100,000	100	2.91E-9	1.45E-8	2.91E-8	5.81E-8	1.45E-7	2.91E-7	7.26E-7	2.91E-6
1,000,000	1,000	2.91E-10	1.45E-9	2.91E-9	5.81E-9	1.45E-8	2.91E-8	7.26E-8	2.91E-7
10,000,000	10,000	2.91E-11	1.45E-10	2.91E-10	5.81E-10	1.45E-9	2.91E-9	7.26E-9	2.91E-8

Tables 4.9 and 4.10 show the radionuclide correction factors for stay times without a respirator obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. Essentially, there is no discrepancy in the results when the different ways of number rounding as implemented in the two versions are taken into account.

TABLE 4.9 Group A Radionuclide Correction Factors for Stay Times without a Respirator Obtained with RESRAD-RDD Version 1.7

Radionuclide	Correction Factor for Stay Times based on			
	Surface Concentration Measurement			Exposure Rate Measurement ^d
	Air Concentration Measurement ^a	Alpha Emitters ^b	β - γ Emitters ^c	
Am-241	1	1	0.007	1700
Cf-252	3	3	-	150
Cm-244	2	2	-	97
Co-60	130	-	1	19415000
Cs-137	75	-	0.6	2537000
Ir-192	620	-	5	30647000
Po-210	2	2	-	1
Pu-238	1	1	-	58
Pu-239	1	1	-	23
Ra-226	3	3	0.02	286000
Sr-90	24	-	0.2	8400
Cs-134	51	-	0.4	4725000

Am-241 is used as the reference radionuclide for air concentration measurement.
 Am-241 is used as the reference radionuclide for alpha emitters.
 Co-60 is used as the reference radionuclide for β - γ emitters.
 Po-210 is used as the reference radionuclide for exposure rate measurement.

TABLE 4.10 Group A Radionuclide Correction Factors for Stay Times without a Respirator Obtained with RESRAD-RDD Version 2.01

Radionuclide	Air Concentration Measurement ¹	Surface Alpha Emitters ²	Beta-Gamma Surface Measurement ³	Exposure Rate Measurement ⁴
Am-241	1	1	0.01	1,696
Cf-252	3	3	-	148
Cm-244	2	2	-	97
Co-60	135	-	1	19,415,215
Cs-137	75	-	0.55	2,536,907
Ir-192	622	-	5	30,647,284
Po-210	2	2	-	1
Pu-238	1	1	-	58
Pu-239	1	1	-	23
Ra-226	3	3	0.02	286,091
Sr-90	24	-	0.18	8,395

¹ Am-241 is used as the reference radionuclide for the air concentration measurement.
² Am-241 is used as the reference radionuclide for the surface alpha measurement.
³ Co-60 is used as the reference radionuclide for the beta-gamma measurement.
⁴ Po-210 is used as the reference radionuclide for the exposure rate measurement.

Tables 4.11 and 4.12 show the general operational guidelines with full-face air-purifying respirators based on gross alpha ground surface measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.11 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 1.7

Activity per Unit Area			Stay Time ^a for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100 cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,220	---	---	---	---	---	---	---	---
100	3.7	22,200	---	---	---	---	---	---	---	---
1,000	37	2.22 x 10 ⁵	1.46E+03	7.31E+03	---	---	---	---	---	---
10,000	370	2.22 x 10 ⁶	1.46E+02	7.31E+02	1.46E+03	2.92E+03	7.31E+03	---	---	---
100,000	3,700	2.22 x 10 ⁷	1.46E+01	7.31E+01	1.46E+02	2.92E+02	7.31E+02	1.46E+03	3.65E+03	---
1 x 10 ⁶	37,000	2.22 x 10 ⁸	1.46E+00	7.31E+00	1.46E+01	2.92E+01	7.31E+01	1.46E+02	3.65E+02	1.46E+03
1 x 10 ⁷	370,000	2.22 x 10 ⁹	1.46E-01	7.31E-01	1.46E+00	2.92E+00	7.31E+00	1.46E+01	3.65E+01	1.46E+02

TABLE 4.12 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 2.01

Activity per Unit Area			Stay Time ¹ for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	22,000	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
1,000	37	220,000	1.46E+03	7.31E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
10,000	370	2,200,000	1.46E+02	7.31E+02	1.46E+03	2.92E+03	7.31E+03	>8.76E+03	>8.76E+03	>8.76E+03
100,000	3,700	22,000,000	1.46E+01	7.31E+01	1.46E+02	2.92E+02	7.31E+02	1.46E+03	3.65E+03	>8.76E+03
1,000,000	37,000	220,000,000	1.46E+00	7.31E+00	1.46E+01	2.92E+01	7.31E+01	1.46E+02	3.65E+02	1.46E+03
10,000,000	370,000	2,200,000,000	1.46E-01	7.31E-01	1.46E+00	2.92E+00	7.31E+00	1.46E+01	3.65E+01	1.46E+02
100,000,000	3,700,000	22,000,000,000	1.46E-02	7.31E-02	1.46E-01	2.92E-01	7.31E-01	1.46E+00	3.65E+00	1.46E+01

Tables 4.13 and 4.14 show the general operational guidelines with full-face air-purifying respirators based on beta-gamma ground surface measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.13 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 1.7

Activity per Unit Area			Stay Time ^a for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100 cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,220	---	---	---	---	---	---	---	---
100	3.7	2.22 x 10 ⁴	---	---	---	---	---	---	---	---
1,000	37	2.22 x 10 ⁵	1.28E+03	6.39E+03	---	---	---	---	---	---
10,000	370	2.22 x 10 ⁶	1.28E+02	6.39E+02	1.28E+03	2.56E+03	6.39E+03	---	---	---
100,000	3,700	2.22 x 10 ⁷	1.28E+01	6.39E+01	1.28E+02	2.56E+02	6.39E+02	1.28E+03	3.20E+03	---
1 x 10 ⁶	37,000	2.22 x 10 ⁸	1.28E+00	6.39E+00	1.28E+01	2.56E+01	6.39E+01	1.28E+02	3.20E+02	1.28E+03
1 x 10 ⁷	370,000	2.22 x 10 ⁹	1.28E-01	6.39E-01	1.28E+00	2.56E+00	6.39E+00	1.28E+01	3.20E+01	1.28E+02

TABLE 4.14 Group A General Guidelines Results with Full-Face Air-Purifying Respirators Based on Beta-Gamma Ground Surface Measurement Obtained with RESRAD-RDD Version 2.01

Activity per Unit Area			Stay Time ^{1 2} for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	22,000	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
1,000	37	220,000	1.28E+03	6.39E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
10,000	370	2,200,000	1.28E+02	6.39E+02	1.28E+03	2.56E+03	6.39E+03	>8.76E+03	>8.76E+03	>8.76E+03
100,000	3,700	22,000,000	1.28E+01	6.39E+01	1.28E+02	2.56E+02	6.39E+02	1.28E+03	3.20E+03	>8.76E+03
1,000,000	37,000	220,000,000	1.28E+00	6.39E+00	1.28E+01	2.56E+01	6.39E+01	1.28E+02	3.20E+02	1.28E+03
10,000,000	370,000	2,200,000,000	1.28E-01	6.39E-01	1.28E+00	2.56E+00	6.39E+00	1.28E+01	3.20E+01	1.28E+02
100,000,000	3,700,000	22,000,000,000	1.28E-02	6.39E-02	1.28E-01	2.56E-01	6.39E-01	1.28E+00	3.20E+00	1.28E+01

Tables 4.15 and 4.16 show the general operational guidelines with full-face air-purifying respirators based on air concentration measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.15 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 1.7

Air Concentration			Stay Time for Given Dose							
pCi/m ³	Bq/m ³	dpm/m ³	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
0.1	0.0037	0.222	---	---	---	---	---	---	---	---
1	0.037	2.22	---	---	---	---	---	---	---	---
10	0.37	22.2	1.28E+03	6.39E+03	---	---	---	---	---	---
100	3.7	222	1.28E+02	6.39E+02	1.28E+03	2.56E+03	6.39E+03	---	---	---
1,000	37	2,220	1.28E+01	6.39E+01	1.28E+02	2.56E+02	6.39E+02	1.28E+03	3.20E+03	---
10,000	370	22,200	1.28E+00	6.39E+00	1.28E+01	2.56E+01	6.39E+01	1.28E+02	3.20E+02	1.28E+03
100,000	3,700	222,000	1.28E-01	6.39E-01	1.28E+00	2.56E+00	6.39E+00	1.28E+01	3.20E+01	1.28E+02

TABLE 4.16 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 2.01

Air Concentration			Stay Time ¹ for Given Dose, h							
pCi/cm ³	Bq/cm ³	dpm/100 cm ³	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
0	0	0	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
1	0.04	2	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
10	0.37	22	1.28E+03	6.39E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	222	1.28E+02	6.39E+02	1.28E+03	2.56E+03	6.39E+03	>8.76E+03	>8.76E+03	>8.76E+03
1,000	37	2,220	1.28E+01	6.39E+01	1.28E+02	2.56E+02	6.39E+02	1.28E+03	3.20E+03	>8.76E+03
10,000	370	22,200	1.28E+00	6.39E+00	1.28E+01	2.56E+01	6.39E+01	1.28E+02	3.20E+02	1.28E+03
100,000	3,700	222,000	1.28E-01	6.39E-01	1.28E+00	2.56E+00	6.39E+00	1.28E+01	3.20E+01	1.28E+02
1,000,000	37,000	2,220,000	1.28E-02	6.39E-02	1.28E-01	2.56E-01	6.39E-01	1.28E+00	3.20E+00	1.28E+01

Tables 4.17 and 4.18 show the general operational guidelines with full-face air-purifying respirators based on gamma exposure rate measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.17 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 1.7

Exposure Rate		Stay Time ^a for Given Dose, h							
μR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.01	3.75E+00	1.88E+01	3.75E+01	7.51E+01	1.88E+02	3.75E+02	9.39E+02	3.75E+03
100	0.1	3.75E-01	1.88E+00	3.75E+00	7.51E+00	1.88E+01	3.75E+01	9.39E+01	3.75E+02
1,000	1	3.75E-02	1.88E-01	3.75E-01	7.51E-01	1.88E+00	3.75E+00	9.39E+00	3.75E+01
10,000	10	3.75E-03	1.88E-02	3.75E-02	7.51E-02	1.88E-01	3.75E-01	9.39E-01	3.75E+00
100,000	100	3.75E-04	1.88E-03	3.75E-03	7.51E-03	1.88E-02	3.75E-02	9.39E-02	3.75E-01
1 x 10 ⁶	1,000	3.75E-05	1.88E-04	3.75E-04	7.51E-04	1.88E-03	3.75E-03	9.39E-03	3.75E-02
1 x 10 ⁷	10,000	3.75E-06	1.88E-05	3.75E-05	7.51E-05	1.88E-04	3.75E-04	9.39E-04	3.75E-03

TABLE 4.18 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 2.01

Exposure Rate		Stay Time ¹ for Given Dose, h							
microR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.01	3.75E+00	1.88E+01	3.75E+01	7.51E+01	1.88E+02	3.75E+02	9.39E+02	3.75E+03
100	0.1	3.75E-01	1.88E+00	3.75E+00	7.51E+00	1.88E+01	3.75E+01	9.39E+01	3.75E+02
1,000	1	3.75E-02	1.88E-01	3.75E-01	7.51E-01	1.88E+00	3.75E+00	9.39E+00	3.75E+01
10,000	10	3.75E-03	1.88E-02	3.75E-02	7.51E-02	1.88E-01	3.75E-01	9.39E-01	3.75E+00
100,000	100	3.75E-04	1.88E-03	3.75E-03	7.51E-03	1.88E-02	3.75E-02	9.39E-02	3.75E-01
1,000,000	1,000	3.75E-05	1.88E-04	3.75E-04	7.51E-04	1.88E-03	3.75E-03	9.39E-03	3.75E-02
10,000,000	10,000	3.75E-06	1.88E-05	3.75E-05	7.51E-05	1.88E-04	3.75E-04	9.39E-04	3.75E-03
100,000,000	100,000	3.75E-07	1.88E-06	3.75E-06	7.51E-06	1.88E-05	3.75E-05	9.39E-05	3.75E-04

Tables 4.19 and 4.20 show the radionuclide correction factors for stay times with a full-face air-purifying respirator obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. Essentially, there is no discrepancy in the results when the different ways of number rounding as implemented in the two versions are taken into account.

TABLE 4.19 Group A Radionuclide Correction Factors for Stay Times with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 1.7

Radionuclide	Correction Factor for Stay Times based			
	Air Concentration Measurement ^a	Surface Concentration Measurement		Exposure Rate Measurement ^d
		Alpha Emitters ^b	β-γ Emitters ^c	
Am-241	1	1	1	71
Cf-252	3	3	-	5
Cm-244	2	2	-	4
Co-60	1	-	1	5300
Cs-137	4	-	4	5300
Ir-192	3	-	3	5300
Po-210	55	48	-	1
Pu-238	1	1	-	2
Pu-239	1	1	-	1
Ra-226	1	1	1	5200
Sr-90	200	-	200	2600
Cs-134	2	-	2	5300

Co-60 is used as the reference radionuclide for air concentration measurement.

Am-241 is used as the reference radionuclide for alpha emitters.

Co-60 is used as the reference radionuclide for β-γ emitters.

Pu-239 is used as the reference radionuclide for exposure rate measurement.

TABLE 4.20 Group A Radionuclide Correction Factors for Stay Times with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 2.01

Radionuclide	Air Concentration Measurement ¹	Surface Alpha Emitters ²	Beta-Gamma Surface Measurement ³	Exposure Rate Measurement ⁴
Am-241	1	1	1	71
Cf-252	3	3	-	5
Cm-244	2	2	-	4
Co-60	1	-	1	5,325
Cs-137	4	-	4	5,325
Ir-192	3	-	3	5,326
Po-210	55	48	-	1
Pu-238	1	1	-	2
Pu-239	1	1	-	1
Ra-226	1	1	1	5,204
Sr-90	203	-	203	2,579

¹ Co-60 is used as the reference radionuclide for the air concentration measurement.

² Am-241 is used as the reference radionuclide for the surface alpha measurement.

³ Co-60 is used as the reference radionuclide for the beta-gamma measurement.

⁴ Pu-239 is used as the reference radionuclide for the exposure rate measurement.

Tables 4.21 and 4.22 show the general operational guidelines with full-face continuous-flow air supply respirators based on gross alpha ground surface measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.21 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 1.7

Activity per Unit Area			Stay Time ^a for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100 cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,220	---	---	---	---	---	---	---	---
100	3.7	22,200	---	---	---	---	---	---	---	---
1,000	37	222,200	1.80E+03	---	---	---	---	---	---	---
		2.22 x								
10,000	370	10 ⁶ i _c ^{1/2} i _c ^{1/2}	1.80E+02	9.00E+02	1.80E+03	3.60E+03	---	---	---	---
100,000	3,700	2.22 x 10 ⁷	1.80E+01	9.00E+01	1.80E+02	3.60E+02	9.00E+02	1.80E+03	4.50E+03	---
1 x 10 ⁶	37,000	2.22 x 10 ⁸	1.80E+00	9.00E+00	1.80E+01	3.60E+01	9.00E+01	1.80E+02	4.50E+02	1.80E+03
1 x 10 ⁷	370,000	2.22 x 10 ⁹	1.80E-01	9.00E-01	1.80E+00	3.60E+00	9.00E+00	1.80E+01	4.50E+01	1.80E+02

TABLE 4.22 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 2.01

Activity per Unit Area			Stay Time ¹ for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	22,000	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
1,000	37	220,000	1.80E+03	>8.76E+03						
10,000	370	2,200,000	1.80E+02	9.00E+02	1.80E+03	3.60E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100,000	3,700	22,000,000	1.80E+01	9.00E+01	1.80E+02	3.60E+02	9.00E+02	1.80E+03	4.50E+03	>8.76E+03
1,000,000	37,000	220,000,000	1.80E+00	9.00E+00	1.80E+01	3.60E+01	9.00E+01	1.80E+02	4.50E+02	1.80E+03
10,000,000	370,000	2,200,000,000	1.80E-01	9.00E-01	1.80E+00	3.60E+00	9.00E+00	1.80E+01	4.50E+01	1.80E+02
100,000,000	3,700,000	22,000,000,000	1.80E-02	9.00E-02	1.80E-01	3.60E-01	9.00E-01	1.80E+00	4.50E+00	1.80E+01

Tables 4.23 and 4.24 show the general operational guidelines with full-face continuous-flow air supply respirators based on beta-gamma ground surface measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.23 Group A General Guidelines with Full-Face Continuous Flow Air Supply Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 1.7

Activity per Unit Area			Stay Time ³ for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100 cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,220	---	---	---	---	---	---	---	---
100	3.7	22,200	---	---	---	---	---	---	---	---
1,000	37	222,200	1.28E+03	6.39E+03	---	---	---	---	---	---
10,000	370	2.22 x 10 ⁶	1.28E+02	6.39E+02	1.28E+03	2.56E+03	6.39E+03	---	---	---
100,000	3,700	2.22 x 10 ⁷	1.28E+01	6.39E+01	1.28E+02	2.56E+02	6.39E+02	1.28E+03	3.20E+03	---
1 x 10 ⁶	37,000	2.22 x 10 ⁸	1.28E+00	6.39E+00	1.28E+01	2.56E+01	6.39E+01	1.28E+02	3.20E+02	1.28E+03
1 x 10 ⁷	370,000	2.22 x 10 ⁹	1.28E-01	6.39E-01	1.28E+00	2.56E+00	6.39E+00	1.28E+01	3.20E+01	1.28E+02

TABLE 4.24 Group A General Guidelines with Full-Face Continuous Flow Air Supply Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 2.01

Activity per Unit Area			Stay Time ^{1 2} for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	22,000	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
1,000	37	220,000	1.28E+03	6.39E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
10,000	370	2,200,000	1.28E+02	6.39E+02	1.28E+03	2.56E+03	6.39E+03	>8.76E+03	>8.76E+03	>8.76E+03
100,000	3,700	22,000,000	1.28E+01	6.39E+01	1.28E+02	2.56E+02	6.39E+02	1.28E+03	3.20E+03	>8.76E+03
1,000,000	37,000	220,000,000	1.28E+00	6.39E+00	1.28E+01	2.56E+01	6.39E+01	1.28E+02	3.20E+02	1.28E+03
10,000,000	370,000	2,200,000,000	1.28E-01	6.39E-01	1.28E+00	2.56E+00	6.39E+00	1.28E+01	3.20E+01	1.28E+02
100,000,000	3,700,000	22,000,000,000	1.28E-02	6.39E-02	1.28E-01	2.56E-01	6.39E-01	1.28E+00	3.20E+00	1.28E+01

Tables 4.25 and 4.26 show the general operational guidelines with full-face continuous-flow air supply respirators based on air concentration measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.25 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 1.7

Air Concentration			Stay Time for Given Dose							
pCi/m ³	Bq/m ³	Dpm/m ³	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
0.1	0.0037	0.222	---	---	---	---	---	---	---	---
1	0.037	2.22	---	---	---	---	---	---	---	---
10	0.37	22.2	1.28E+03	6.39E+03	---	---	---	---	---	---
100	3.7	222	1.28E+02	6.39E+02	1.28E+03	2.56E+03	6.39E+03	---	---	---
1,000	37	2,220	1.28E+01	6.39E+01	1.28E+02	2.56E+02	6.39E+02	1.28E+03	3.20E+03	---
10,000	370	22,200	1.28E+00	6.39E+00	1.28E+01	2.56E+01	6.39E+01	1.28E+02	3.20E+02	1.28E+03
100,000	3,700	222,000	1.28E-01	6.39E-01	1.28E+00	2.56E+00	6.39E+00	1.28E+01	3.20E+01	1.28E+02

TABLE 4.26 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 2.01

Air Concentration			Stay Time ¹ for Given Dose, h							
pCi/cm ³	Bq/cm ³	dpm/100 cm ³	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
0	0	0	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
1	0.04	2	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
10	0.37	22	1.28E+03	6.39E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	222	1.28E+02	6.39E+02	1.28E+03	2.56E+03	6.39E+03	>8.76E+03	>8.76E+03	>8.76E+03
1,000	37	2,220	1.28E+01	6.39E+01	1.28E+02	2.56E+02	6.39E+02	1.28E+03	3.20E+03	>8.76E+03
10,000	370	22,200	1.28E+00	6.39E+00	1.28E+01	2.56E+01	6.39E+01	1.28E+02	3.20E+02	1.28E+03
100,000	3,700	222,000	1.28E-01	6.39E-01	1.28E+00	2.56E+00	6.39E+00	1.28E+01	3.20E+01	1.28E+02
1,000,000	37,000	2,220,000	1.28E-02	6.39E-02	1.28E-01	2.56E-01	6.39E-01	1.28E+00	3.20E+00	1.28E+01

Tables 4.27 and 4.28 show the general operational guidelines with full-face continuous-flow air supply respirators based on gamma exposure rate measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.27 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 1.7

Exposure Rate		Stay Time ^a for Given Dose, h							
$\mu\text{R/h}$	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.01	2.50E+01	1.25E+02	2.50E+02	5.00E+02	1.25E+03	2.50E+03	6.25E+03	---
100	0.1	2.50E+00	1.25E+01	2.50E+01	5.00E+01	1.25E+02	2.50E+02	6.25E+02	2.50E+03
1,000	1	2.50E-01	1.25E+00	2.50E+00	5.00E+00	1.25E+01	2.50E+01	6.25E+01	2.50E+02
10,000	10	2.50E-02	1.25E-01	2.50E-01	5.00E-01	1.25E+00	2.50E+00	6.25E+00	2.50E+01
100,000	100	2.50E-03	1.25E-02	2.50E-02	5.00E-02	1.25E-01	2.50E-01	6.25E-01	2.50E+00
1 x 10 ⁶	1,000	2.50E-04	1.25E-03	2.50E-03	5.00E-03	1.25E-02	2.50E-02	6.25E-02	2.50E-01
1 x 10 ⁷	10,000	2.50E-05	1.25E-04	2.50E-04	5.00E-04	1.25E-03	2.50E-03	6.25E-03	2.50E-02

TABLE 4.28 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 2.01

Exposure Rate		Stay Time ¹ for Given Dose, h							
microR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.01	2.50E+01	1.25E+02	2.50E+02	5.00E+02	1.25E+03	2.50E+03	6.25E+03	>8.76E+03
100	0.1	2.50E+00	1.25E+01	2.50E+01	5.00E+01	1.25E+02	2.50E+02	6.25E+02	2.50E+03
1,000	1	2.50E-01	1.25E+00	2.50E+00	5.00E+00	1.25E+01	2.50E+01	6.25E+01	2.50E+02
10,000	10	2.50E-02	1.25E-01	2.50E-01	5.00E-01	1.25E+00	2.50E+00	6.25E+00	2.50E+01
100,000	100	2.50E-03	1.25E-02	2.50E-02	5.00E-02	1.25E-01	2.50E-01	6.25E-01	2.50E+00
1,000,000	1,000	2.50E-04	1.25E-03	2.50E-03	5.00E-03	1.25E-02	2.50E-02	6.25E-02	2.50E-01
10,000,000	10,000	2.50E-05	1.25E-04	2.50E-04	5.00E-04	1.25E-03	2.50E-03	6.25E-03	2.50E-02
100,000,000	100,000	2.50E-06	1.25E-05	2.50E-05	5.00E-05	1.25E-04	2.50E-04	6.25E-04	2.50E-03

Tables 4.29 and 4.30 show the radionuclide correction factors for stay times with a full-face continuous-flow air supply respirator obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. Essentially, there is no discrepancy in the results when the different ways of number rounding as implemented in the two versions are taken into account.

TABLE 4.29 Group A Radionuclide Correction Factors for Stay Times with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 1.7

Radionuclide	Correction Factor for Stay Times based on			
	Air Concentration Measurement ^a	Surface Concentration Measurement		Exposure Rate Measurement ^d
		Alpha Emitters ^b	β-γ Emitters ^c	
Am-241	7	5	7	66
Cf-252	22	15	-	5
Cm-244	14	10	-	4
Co-60	1	-	1	800
Cs-137	4	-	4	800
Ir-192	3	-	3	800
Po-210	360	260	-	1
Pu-238	9	6	-	2
Pu-239	8	6	-	1
Ra-226	1	1	1	800
Sr-90	360	-	360	690
Cs-134	2	-	2	800

Co-60 is used as the reference radionuclide for air concentration measurement.

Ra-226 is used as the reference radionuclide for alpha emitters.

Co-60 is used as the reference radionuclide for β-γ emitters.

Pu-239 is used as the reference radionuclide for exposure rate measurement.

TABLE 4.30 Group A Radionuclide Correction Factors for Stay Times with a Full-Face continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 2.01

Radionuclide	Air Concentration Measurement ¹	Surface Alpha Emitters ²	Beta-Gamma Surface Measurement ³	Exposure Rate Measurement ⁴
Am-241	7	5	7	66
Cf-252	22	15	-	5
Cm-244	14	10	-	4
Co-60	1	-	1	800
Cs-137	4	-	4	800
Ir-192	3	-	3	800
Po-210	364	259	-	1
Pu-238	9	6	-	2
Pu-239	8	6	-	1
Ra-226	1	1	1	797
Sr-90	361	-	361	690

¹ Co-60 is used as the reference radionuclide for the air concentration measurement.

² Ra-226 is used as the reference radionuclide for the surface alpha measurement.

³ Co-60 is used as the reference radionuclide for the beta-gamma measurement.

⁴ Pu-239 is used as the reference radionuclide for the exposure rate measurement.

4.1.2 Results Based on ICRP-60 DCFs

Tables 4.31 and 4.32 show the general operational guidelines without respirators based on gross alpha ground surface measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.31 Group A General Guidelines without Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 1.7

Activity per Unit Area			Stay Time ^a for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100 cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,220	1.36E+03	6.78E+03	---	---	---	---	---	---
100	3.7	22,200	1.36E+02	6.78E+02	1.36E+03	2.71E+03	6.78E+03	---	---	---
1,000	37	2.22 x 10 ⁵	1.36E+01	6.78E+01	1.36E+02	2.71E+02	6.78E+02	1.36E+03	3.39E+03	---
10,000	370	2.22 x 10 ⁶	1.36E+00	6.78E+00	1.36E+01	2.71E+01	6.78E+01	1.36E+02	3.39E+02	1.36E+03
100,000	3,700	2.22 x 10 ⁷	1.36E-01	6.78E-01	1.36E+00	2.71E+00	6.78E+00	1.36E+01	3.39E+01	1.36E+02
1 x 10 ⁶	37,000	2.22 x 10 ⁸	1.36E-02	6.78E-02	1.36E-01	2.71E-01	6.78E-01	1.36E+00	3.39E+00	1.36E+01
1 x 10 ⁷	370,000	2.22 x 10 ⁹	1.36E-03	6.78E-03	1.36E-02	2.71E-02	6.78E-02	1.36E-01	3.39E-01	1.36E+00

TABLE 4.32 Group A General Guidelines without Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 2.01

Activity per Unit Area			Stay Time ¹ for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	1.36E+03	6.78E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	22,000	1.36E+02	6.78E+02	1.36E+03	2.71E+03	6.78E+03	>8.76E+03	>8.76E+03	>8.76E+03
1,000	37	220,000	1.36E+01	6.78E+01	1.36E+02	2.71E+02	6.78E+02	1.36E+03	3.39E+03	>8.76E+03
10,000	370	2,200,000	1.36E+00	6.78E+00	1.36E+01	2.71E+01	6.78E+01	1.36E+02	3.39E+02	1.36E+03
100,000	3,700	22,000,000	1.36E-01	6.78E-01	1.36E+00	2.71E+00	6.78E+00	1.36E+01	3.39E+01	1.36E+02
1,000,000	37,000	220,000,000	1.36E-02	6.78E-02	1.36E-01	2.71E-01	6.78E-01	1.36E+00	3.39E+00	1.36E+01
10,000,000	370,000	2,200,000,000	1.36E-03	6.78E-03	1.36E-02	2.71E-02	6.78E-02	1.36E-01	3.39E-01	1.36E+00
100,000,000	3,700,000	22,000,000,000	1.36E-04	6.78E-04	1.36E-03	2.71E-03	6.78E-03	1.36E-02	3.39E-02	1.36E-01

Tables 4.33 and 4.34 show the general operational guidelines without respirators based on beta-gamma ground surface measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.33 Group A General Guidelines without Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 1.7

Activity per Unit Area			Stay Time ^a for Given Dose, h							
pCi/cm ²	Bq/ cm ²	dpm/100 cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,220	---	---	---	---	---	---	---	---
100	3.7	22,200	5.85E+03	---	---	---	---	---	---	---
1,000	37	2.22 x 10 ⁵	5.85E+02	2.93E+03	5.85E+03	---	---	---	---	---
10,000	370	2.22 x 10 ⁶	5.85E+01	2.93E+02	5.85E+02	1.17E+03	2.93E+03	5.85E+03	---	---
100,000	3,700	2.22 x 10 ⁷	5.85E+00	2.93E+01	5.85E+01	1.17E+02	2.93E+02	5.85E+02	1.46E+03	5.85E+03
1 x 10 ⁶	37,000	2.22 x 10 ⁸	5.85E-01	2.93E+00	5.85E+00	1.17E+01	2.93E+01	5.85E+01	1.46E+02	5.85E+02
1 x 10 ⁷	370,000	2.22 x 10 ⁹	5.85E-02	2.93E-01	5.85E-01	1.17E+00	2.93E+00	5.85E+00	1.46E+01	5.85E+01

TABLE 4.34 Group A General Guidelines without Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 2.01

Activity per Unit Area			Stay Time ^{1 2} for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	22,000	5.85E+03	>8.76E+03						
1,000	37	220,000	5.85E+02	2.93E+03	5.85E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
10,000	370	2,200,000	5.85E+01	2.93E+02	5.85E+02	1.17E+03	2.93E+03	5.85E+03	>8.76E+03	>8.76E+03
100,000	3,700	22,000,000	5.85E+00	2.93E+01	5.85E+01	1.17E+02	2.93E+02	5.85E+02	1.46E+03	5.85E+03
1,000,000	37,000	220,000,000	5.85E-01	2.93E+00	5.85E+00	1.17E+01	2.93E+01	5.85E+01	1.46E+02	5.85E+02
10,000,000	370,000	2,200,000,000	5.85E-02	2.93E-01	5.85E-01	1.17E+00	2.93E+00	5.85E+00	1.46E+01	5.85E+01
100,000,000	3,700,000	22,000,000,000	5.85E-03	2.93E-02	5.85E-02	1.17E-01	2.93E-01	5.85E-01	1.46E+00	5.85E+00

Tables 4.35 and 4.36 show the general operational guidelines without respirators based on air concentration measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.35 Group A General Guidelines without Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 1.7

Air Concentration			Stay Time for Given Dose							
pCi/m ³	Bq/m ³	dpm/m ³	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
0.1	0.0037	0.222	1.36E+03	6.78E+03	---	---	---	---	---	---
1	0.037	2.22	1.36E+02	6.78E+02	1.36E+03	2.71E+03	6.78E+03	---	---	---
10	0.37	22.2	1.36E+01	6.78E+01	1.36E+02	2.71E+02	6.78E+02	1.36E+03	3.39E+03	---
100	3.7	222	1.36E+00	6.78E+00	1.36E+01	2.71E+01	6.78E+01	1.36E+02	3.39E+02	1.36E+03
1,000	37	2,220	1.36E-01	6.78E-01	1.36E+00	2.71E+00	6.78E+00	1.36E+01	3.39E+01	1.36E+02
10,000	370	22,200	1.36E-02	6.78E-02	1.36E-01	2.71E-01	6.78E-01	1.36E+00	3.39E+00	1.36E+01
100,000	3,700	222,000	1.36E-03	6.78E-03	1.36E-02	2.71E-02	6.78E-02	1.36E-01	3.39E-01	1.36E+00

TABLE 4.36 Group A General Guidelines without Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 2.01

Air Concentration			Stay Time ¹ for Given Dose, h							
pCi/m ³	Bq/m ³	dpm/ m ³	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
0	0	0	1.36E+03	6.78E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
1	0.04	2	1.36E+02	6.78E+02	1.36E+03	2.71E+03	6.78E+03	>8.76E+03	>8.76E+03	>8.76E+03
10	0.37	22	1.36E+01	6.78E+01	1.36E+02	2.71E+02	6.78E+02	1.36E+03	3.39E+03	>8.76E+03
100	3.7	222	1.36E+00	6.78E+00	1.36E+01	2.71E+01	6.78E+01	1.36E+02	3.39E+02	1.36E+03
1,000	37	2,220	1.36E-01	6.78E-01	1.36E+00	2.71E+00	6.78E+00	1.36E+01	3.39E+01	1.36E+02
10,000	370	22,200	1.36E-02	6.78E-02	1.36E-01	2.71E-01	6.78E-01	1.36E+00	3.39E+00	1.36E+01
100,000	3,700	222,000	1.36E-03	6.78E-03	1.36E-02	2.71E-02	6.78E-02	1.36E-01	3.39E-01	1.36E+00
1,000,000	37,000	2,220,000	1.36E-04	6.78E-04	1.36E-03	2.71E-03	6.78E-03	1.36E-02	3.39E-02	1.36E-01

Tables 4.37 and 4.38 show the general operational guidelines without respirators based on gamma exposure rate measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.37 Group A General Guidelines without Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 1.7

Exposure Rate		Stay Time ³ for Given Dose, h							
μR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.01	1.33E-03	6.66E-03	1.33E-02	2.66E-02	6.66E-02	1.33E-01	3.33E-01	1.33E+00
100	0.1	1.33E-04	6.66E-04	1.33E-03	2.66E-03	6.66E-03	1.33E-02	3.33E-02	1.33E-01
1,000	1	1.33E-05	6.66E-05	1.33E-04	2.66E-04	6.66E-04	1.33E-03	3.33E-03	1.33E-02
10,000	10	1.33E-06	6.66E-06	1.33E-05	2.66E-05	6.66E-05	1.33E-04	3.33E-04	1.33E-03
100,000	100	1.33E-07	6.66E-07	1.33E-06	2.66E-06	6.66E-06	1.33E-05	3.33E-05	1.33E-04
1 x 10 ⁶	1,000	1.33E-08	6.66E-08	1.33E-07	2.66E-07	6.66E-07	1.33E-06	3.33E-06	1.33E-05
1 x 10 ⁷	10,000	1.33E-09	6.66E-09	1.33E-08	2.66E-08	6.66E-08	1.33E-07	3.33E-07	1.33E-06

TABLE 4.38 Group A General Guidelines without Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 2.01

Exposure Rate		Stay Time ¹ for Given Dose, h							
microR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.01	1.33E-03	6.66E-03	1.33E-02	2.66E-02	6.66E-02	1.33E-01	3.33E-01	1.33E+00
100	0.1	1.33E-04	6.66E-04	1.33E-03	2.66E-03	6.66E-03	1.33E-02	3.33E-02	1.33E-01
1,000	1	1.33E-05	6.66E-05	1.33E-04	2.66E-04	6.66E-04	1.33E-03	3.33E-03	1.33E-02
10,000	10	1.33E-06	6.66E-06	1.33E-05	2.66E-05	6.66E-05	1.33E-04	3.33E-04	1.33E-03
100,000	100	1.33E-07	6.66E-07	1.33E-06	2.66E-06	6.66E-06	1.33E-05	3.33E-05	1.33E-04
1,000,000	1,000	1.33E-08	6.66E-08	1.33E-07	2.66E-07	6.66E-07	1.33E-06	3.33E-06	1.33E-05
10,000,000	10,000	1.33E-09	6.66E-09	1.33E-08	2.66E-08	6.66E-08	1.33E-07	3.33E-07	1.33E-06
100,000,000	100,000	1.33E-10	6.66E-10	1.33E-09	2.66E-09	6.66E-09	1.33E-08	3.33E-08	1.33E-07

Tables 4.39 and 4.40 show the radionuclide correction factors for stay times without a respirator obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. Essentially,

TABLE 4.39 Group A Radionuclide Correction Factors for Stay Times without a Respirator Obtained with RESRAD-RDD Version 1.7

Radionuclide	Correction Factor for Stay Times based on			
	Air Concentration Measurement ^a	Surface Concentration Measurement		Exposure Rate Measurement ^d
		Alpha Emitters ^b	β-γ Emitters ^c	
Am-241	1	1	0.03	2800
Cf-252	5	5	-	206000
Cm-244	2	2	-	130
Co-60	43	-	1	9637000
Cs-137	75	-	2	3978000
Ir-192	130	-	3	9475000
Po-210	1	1	-	1
Pu-238	1	1	-	66
Pu-239	1	1	-	28
Ra-226	4	4	0.09	634000
Sr-90	47	-	1	504000
Cs-134	39	-	0.9	5643000

Pu-239 is used as the reference radionuclide for air concentration measurement.
 Pu-239 is used as the reference radionuclide for alpha emitters.
 Co-60 is used as the reference radionuclide for β-γ emitters.
 Po-210 is used as the reference radionuclide for exposure rate measurement.

TABLE 4.40 Group A Radionuclide Correction Factors for Stay Times without a Respirator Obtained with RESRAD-RDD Version 2.01

Radionuclide	Air Concentration Measurement ¹	Surface Alpha Emitters ²	Beta-Gamma Surface Measurement ³	Exposure Rate Measurement ⁴
Am-241	1	1	0.03	2,822
Cf-252	5	5	-	205,894
Cm-244	2	2	-	131
Co-60	43	-	1	9,636,527
Cs-137	75	-	2	3,978,141
Ir-192	126	-	3	9,475,209
Po-210	1	1	-	1
Pu-238	1	1	-	66
Pu-239	1	1	-	28
Ra-226	4	4	0.09	633,941
Sr-90	47	-	1	504,323

¹ Pu-239 is used as the reference radionuclide for the air concentration measurement.
² Pu-239 is used as the reference radionuclide for the surface alpha measurement.
³ Co-60 is used as the reference radionuclide for the beta-gamma measurement.
⁴ Po-210 is used as the reference radionuclide for the exposure rate measurement.

there is no discrepancy in the results when the different ways of number rounding as implemented in the two versions are taken into account.

Tables 4.41 and 4.42 show the general operational guidelines with full-face air-purifying respirators based on gross alpha ground surface measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.41 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 1.7

Activity per Unit Area			Stay Time ^a for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100 cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,220	---	---	---	---	---	---	---	---
100	3.7	22,200	8.52E+03	---	---	---	---	---	---	---
1,000	37	2.22 x 10 ⁵	8.52E+02	4.26E+03	8.52E+03	---	---	---	---	---
10,000	370	2.22 x 10 ⁶	8.52E+01	4.26E+02	8.52E+02	1.70E+03	4.26E+03	8.52E+03	---	---
100,000	3,700	2.22 x 10 ⁷	8.52E+00	4.26E+01	8.52E+01	1.70E+02	4.26E+02	8.52E+02	2.13E+03	8.52E+03
1 x 10 ⁶	37,000	2.22 x 10 ⁸	8.52E-01	4.26E+00	8.52E+00	1.70E+01	4.26E+01	8.52E+01	2.13E+02	8.52E+02
1 x 10 ⁷	370,000	2.22 x 10 ⁹	8.52E-02	4.26E-01	8.52E-01	1.70E+00	4.26E+00	8.52E+00	2.13E+01	8.52E+01

TABLE 4.42 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 2.01

Activity per Unit Area			Stay Time ^a for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	22,000	8.52E+03	>8.76E+03						
1,000	37	220,000	8.52E+02	4.26E+03	8.52E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
10,000	370	2,200,000	8.52E+01	4.26E+02	8.52E+02	1.70E+03	4.26E+03	8.52E+03	>8.76E+03	>8.76E+03
100,000	3,700	22,000,000	8.52E+00	4.26E+01	8.52E+01	1.70E+02	4.26E+02	8.52E+02	2.13E+03	8.52E+03
1,000,000	37,000	220,000,000	8.52E-01	4.26E+00	8.52E+00	1.70E+01	4.26E+01	8.52E+01	2.13E+02	8.52E+02
10,000,000	370,000	2,200,000,000	8.52E-02	4.26E-01	8.52E-01	1.70E+00	4.26E+00	8.52E+00	2.13E+01	8.52E+01
100,000,000	3,700,000	22,000,000,000	8.52E-03	4.26E-02	8.52E-02	1.70E-01	4.26E-01	8.52E-01	2.13E+00	8.52E+00

Tables 4.43 and 4.44 show the general operational guidelines with full-face air-purifying respirators based on beta-gamma ground surface measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.43 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 1.7

Activity per Unit Area			Stay Time ^a for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100 cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,220	---	---	---	---	---	---	---	---
100	3.7	2.22 x 10 ⁴	6.51E+03	---	---	---	---	---	---	---
1,000	37	2.22 x 10 ⁵	6.51E+02	3.26E+03	6.51E+03	---	---	---	---	---
10,000	370	2.22 x 10 ⁶	6.51E+01	3.26E+02	6.51E+02	1.30E+03	3.26E+03	6.51E+03	---	---
100,000	3,700	2.22 x 10 ⁷	6.51E+00	3.26E+01	6.51E+01	1.30E+02	3.26E+02	6.51E+02	1.63E+03	6.51E+03
1 x 10 ⁶	37,000	2.22 x 10 ⁸	6.51E-01	3.26E+00	6.51E+00	1.30E+01	3.26E+01	6.51E+01	1.63E+02	6.51E+02
1 x 10 ⁷	370,000	2.22 x 10 ⁹	6.51E-02	3.26E-01	6.51E-01	1.30E+00	3.26E+00	6.51E+00	1.63E+01	6.51E+01

TABLE 4.44 Group A General Guidelines Results with Full-Face Air-Purifying Respirators Based on Beta-Gamma Ground Surface Measurement Obtained with RESRAD Version 2.01

Activity per Unit Area			Stay Time ^{1 2} for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	22,000	6.51E+03	>8.76E+03						
1,000	37	220,000	6.51E+02	3.26E+03	6.51E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
10,000	370	2,200,000	6.51E+01	3.26E+02	6.51E+02	1.30E+03	3.26E+03	6.51E+03	>8.76E+03	>8.76E+03
100,000	3,700	22,000,000	6.51E+00	3.26E+01	6.51E+01	1.30E+02	3.26E+02	6.51E+02	1.63E+03	6.51E+03
1,000,000	37,000	220,000,000	6.51E-01	3.26E+00	6.51E+00	1.30E+01	3.26E+01	6.51E+01	1.63E+02	6.51E+02
10,000,000	370,000	2,200,000,000	6.51E-02	3.26E-01	6.51E-01	1.30E+00	3.26E+00	6.51E+00	1.63E+01	6.51E+01
100,000,000	3,700,000	22,000,000,000	6.51E-03	3.26E-02	6.51E-02	1.30E-01	3.26E-01	6.51E-01	1.63E+00	6.51E+00

Tables 4.45 and 4.46 show the general operational guidelines with full-face air-purifying respirators based on air concentration measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.45 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 1.7

Air Concentration			Stay Time for Given Dose							
pCi/m ³	Bq/m ³	dpm/m ³	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
0.1	0.0037	0.222	---	---	---	---	---	---	---	---
1	0.037	2.22	6.51E+03	---	---	---	---	---	---	---
10	0.37	22.2	6.51E+02	3.26E+03	6.51E+03	---	---	---	---	---
100	3.7	222	6.51E+01	3.26E+02	6.51E+02	1.30E+03	3.26E+03	6.51E+03	---	---
1,000	37	2,220	6.51E+00	3.26E+01	6.51E+01	1.30E+02	3.26E+02	6.51E+02	1.63E+03	6.51E+03
10,000	370	22,200	6.51E-01	3.26E+00	6.51E+00	1.30E+01	3.26E+01	6.51E+01	1.63E+02	6.51E+02
100,000	3,700	222,000	6.51E-02	3.26E-01	6.51E-01	1.30E+00	3.26E+00	6.51E+00	1.63E+01	6.51E+01

TABLE 4.46 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 2.01

Air Concentration			Stay Time ¹ for Given Dose, h							
pCi/cm ³	Bq/cm ³	dpm/100 cm ³	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
0	0	0	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
1	0.04	2	6.51E+03	>8.76E+03						
10	0.37	22	6.51E+02	3.26E+03	6.51E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	222	6.51E+01	3.26E+02	6.51E+02	1.30E+03	3.26E+03	6.51E+03	>8.76E+03	>8.76E+03
1,000	37	2,220	6.51E+00	3.26E+01	6.51E+01	1.30E+02	3.26E+02	6.51E+02	1.63E+03	6.51E+03
10,000	370	22,200	6.51E-01	3.26E+00	6.51E+00	1.30E+01	3.26E+01	6.51E+01	1.63E+02	6.51E+02
100,000	3,700	222,000	6.51E-02	3.26E-01	6.51E-01	1.30E+00	3.26E+00	6.51E+00	1.63E+01	6.51E+01
1,000,000	37,000	2,220,000	6.51E-03	3.26E-02	6.51E-02	1.30E-01	3.26E-01	6.51E-01	1.63E+00	6.51E+00

Tables 4.47 and 4.48 show the general operational guidelines with full-face air-purifying respirators based on gamma exposure rate measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.47 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 1.7

Exposure Rate		Stay Time ^a for Given Dose, h							
μR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.01	3.45E+00	1.73E+01	3.45E+01	6.90E+01	1.73E+02	3.45E+02	8.63E+02	3.45E+03
100	0.1	3.45E-01	1.73E+00	3.45E+00	6.90E+00	1.73E+01	3.45E+01	8.63E+01	3.45E+02
1,000	1	3.45E-02	1.73E-01	3.45E-01	6.90E-01	1.73E+00	3.45E+00	8.63E+00	3.45E+01
10,000	10	3.45E-03	1.73E-02	3.45E-02	6.90E-02	1.73E-01	3.45E-01	8.63E-01	3.45E+00
100,000	100	3.45E-04	1.73E-03	3.45E-03	6.90E-03	1.73E-02	3.45E-02	8.63E-02	3.45E-01
1 x 10 ⁶	1,000	3.45E-05	1.73E-04	3.45E-04	6.90E-04	1.73E-03	3.45E-03	8.63E-03	3.45E-02
1 x 10 ⁷	10,000	3.45E-06	1.73E-05	3.45E-05	6.90E-05	1.73E-04	3.45E-04	8.63E-04	3.45E-03

TABLE 4.48 Group A General Guidelines with Full-Face Air-Purifying Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 2.01

Exposure Rate		Stay Time ¹ for Given Dose, h							
microR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.01	3.45E+00	1.73E+01	3.45E+01	6.90E+01	1.73E+02	3.45E+02	8.63E+02	3.45E+03
100	0.1	3.45E-01	1.73E+00	3.45E+00	6.90E+00	1.73E+01	3.45E+01	8.63E+01	3.45E+02
1,000	1	3.45E-02	1.73E-01	3.45E-01	6.90E-01	1.73E+00	3.45E+00	8.63E+00	3.45E+01
10,000	10	3.45E-03	1.73E-02	3.45E-02	6.90E-02	1.73E-01	3.45E-01	8.63E-01	3.45E+00
100,000	100	3.45E-04	1.73E-03	3.45E-03	6.90E-03	1.73E-02	3.45E-02	8.63E-02	3.45E-01
1,000,000	1,000	3.45E-05	1.73E-04	3.45E-04	6.90E-04	1.73E-03	3.45E-03	8.63E-03	3.45E-02
10,000,000	10,000	3.45E-06	1.73E-05	3.45E-05	6.90E-05	1.73E-04	3.45E-04	8.63E-04	3.45E-03
100,000,000	100,000	3.45E-07	1.73E-06	3.45E-06	6.90E-06	1.73E-05	3.45E-05	8.63E-05	3.45E-04

Tables 4.49 and 4.50 show the radionuclide correction factors for stay times with a full-face air-purifying respirator obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. Essentially, there is no discrepancy in the results when the different ways of number rounding as implemented in the two versions are taken into account.

TABLE 4.49 Group A Radionuclide Correction Factors for Stay Times with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 1.7

Radionuclide	Correction Factor for Stay Times based			
	Air Concentration Measurement ^a	Surface Concentration Measurement		Exposure Rate Measurement ^d
		Alpha Emitters ^b	β-γ Emitters ^c	
Am-241	3	2	3	130
Cf-252	4	3	-	3000
Cm-244	5	4	-	6
Co-60	1	-	1	4100
Cs-137	4	-	4	4100
Ir-192	3	-	3	4100
Po-210	69	53	-	1
Pu-238	3	2	-	3
Pu-239	2	2	-	1
Ra-226	1	1	1	4000
Sr-90	20	-	20	4100
Cs-134	2	-	2	4100

Co-60 is used as the reference radionuclide for air concentration measurement.

Ra-226 is used as the reference radionuclide for alpha emitters.

Co-60 is used as the reference radionuclide for β-γ emitters.

Po-210 is used as the reference radionuclide for exposure rate measurement.

TABLE 4.50 Group A Radionuclide Correction Factors for Stay Times with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 2.01

Radionuclide	Air Concentration Measurement ¹	Surface Alpha Emitters ²	Beta-Gamma Surface Measurement ³	Exposure Rate Measurement ⁴
Am-241	3	2	3	125
Cf-252	4	3	-	3,033
Cm-244	5	4	-	6
Co-60	1	-	1	4,138
Cs-137	4	-	4	4,137
Ir-192	3	-	3	4,139
Po-210	69	53	-	1
Pu-238	3	2	-	3
Pu-239	2	2	-	1
Ra-226	1	1	1	3,965
Sr-90	20	-	20	4,093

¹ Co-60 is used as the reference radionuclide for the air concentration measurement.

² Ra-226 is used as the reference radionuclide for the surface alpha measurement.

³ Co-60 is used as the reference radionuclide for the beta-gamma measurement.

⁴ Po-210 is used as the reference radionuclide for the exposure rate measurement.

Tables 4.51 and 4.52 show the general operational guidelines with full-face continuous-flow air supply respirators based on gross alpha ground surface measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.51 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 1.7

Activity per Unit Area			Stay Time ^a for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100 cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,220	---	---	---	---	---	---	---	---
100	3.7	22,200	---	---	---	---	---	---	---	---
1,000	37	222,200	8.84E+02	4.42E+03	---	---	---	---	---	---
		2.22 x								
10,000	370	10 ⁶ i _C ^{1/2} i _C ^{1/2}	8.84E+01	4.42E+02	8.84E+02	1.77E+03	4.42E+03	---	---	---
100,000	3,700	2.22 x 10 ⁷	8.84E+00	4.42E+01	8.84E+01	1.77E+02	4.42E+02	8.84E+02	2.21E+03	---
1 x 10 ⁶	37,000	2.22 x 10 ⁸	8.84E-01	4.42E+00	8.84E+00	1.77E+01	4.42E+01	8.84E+01	2.21E+02	8.84E+02
1 x 10 ⁷	370,000	2.22 x 10 ⁹	8.84E-02	4.42E-01	8.84E-01	1.77E+00	4.42E+00	8.84E+00	2.21E+01	8.84E+01

TABLE 4.52 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gross Alpha Surface Measurement Obtained with RESRAD-RDD Version 2.01

Activity per Unit Area			Stay Time ¹ for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	22,000	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
1,000	37	220,000	8.84E+02	4.42E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
10,000	370	2,200,000	8.84E+01	4.42E+02	8.84E+02	1.77E+03	4.42E+03	>8.76E+03	>8.76E+03	>8.76E+03
100,000	3,700	22,000,000	8.84E+00	4.42E+01	8.84E+01	1.77E+02	4.42E+02	8.84E+02	2.21E+03	>8.76E+03
1,000,000	37,000	220,000,000	8.84E-01	4.42E+00	8.84E+00	1.77E+01	4.42E+01	8.84E+01	2.21E+02	8.84E+02
10,000,000	370,000	2,200,000,000	8.84E-02	4.42E-01	8.84E-01	1.77E+00	4.42E+00	8.84E+00	2.21E+01	8.84E+01
100,000,000	3,700,000	22,000,000,000	8.84E-03	4.42E-02	8.84E-02	1.77E-01	4.42E-01	8.84E-01	2.21E+00	8.84E+00

Tables 4.53 and 4.54 show the general operational guidelines with full-face continuous-flow air supply respirators based on beta-gamma ground surface measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.53 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 1.7

Activity per Unit Area			Stay Time ^a for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100 cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,220	---	---	---	---	---	---	---	---
100	3.7	22,200	6.51E+03	---	---	---	---	---	---	---
1,000	37	222,200	6.51E+02	3.26E+03	6.51E+03	---	---	---	---	---
		2.22 x								
10,000	370	10 ⁶ i _C ^{1/2} i _C ^{1/2}	6.51E+01	3.26E+02	6.51E+02	1.30E+03	3.26E+03	6.51E+03	---	---
100,000	3,700	2.22 x 10 ⁷	6.51E+00	3.26E+01	6.51E+01	1.30E+02	3.26E+02	6.51E+02	1.63E+03	6.51E+03
1 x 10 ⁶	37,000	2.22 x 10 ⁸	6.51E-01	3.26E+00	6.51E+00	1.30E+01	3.26E+01	6.51E+01	1.63E+02	6.51E+02
1 x 10 ⁷	370,000	2.22 x 10 ⁹	6.51E-02	3.26E-01	6.51E-01	1.30E+00	3.26E+00	6.51E+00	1.63E+01	6.51E+01

TABLE 4.54 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Beta-Gamma Surface Measurement Obtained with RESRAD-RDD Version 2.01

Activity per Unit Area			Stay Time ^{1 2} for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	22,000	6.51E+03	>8.76E+03						
1,000	37	220,000	6.51E+02	3.26E+03	6.51E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
10,000	370	2,200,000	6.51E+01	3.26E+02	6.51E+02	1.30E+03	3.26E+03	6.51E+03	>8.76E+03	>8.76E+03
100,000	3,700	22,000,000	6.51E+00	3.26E+01	6.51E+01	1.30E+02	3.26E+02	6.51E+02	1.63E+03	6.51E+03
1,000,000	37,000	220,000,000	6.51E-01	3.26E+00	6.51E+00	1.30E+01	3.26E+01	6.51E+01	1.63E+02	6.51E+02
10,000,000	370,000	2,200,000,000	6.51E-02	3.26E-01	6.51E-01	1.30E+00	3.26E+00	6.51E+00	1.63E+01	6.51E+01
100,000,000	3,700,000	22,000,000,000	6.51E-03	3.26E-02	6.51E-02	1.30E-01	3.26E-01	6.51E-01	1.63E+00	6.51E+00

Tables 4.55 and 4.56 show the general operational guidelines with full-face continuous-flow air supply respirators based on air concentration measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.55 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 1.7

Air Concentration			Stay Time for Given Dose							
pCi/m ³	Bq/m ³	Dpm/m ³	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
0.1	0.0037	0.222	---	---	---	---	---	---	---	---
1	0.037	2.22	6.51E+03	---	---	---	---	---	---	---
10	0.37	22.2	6.51E+02	3.26E+03	6.51E+03	---	---	---	---	---
100	3.7	222	6.51E+01	3.26E+02	6.51E+02	1.30E+03	3.26E+03	6.51E+03	---	---
1,000	37	2,220	6.51E+00	3.26E+01	6.51E+01	1.30E+02	3.26E+02	6.51E+02	1.63E+03	6.51E+03
10,000	370	22,200	6.51E-01	3.26E+00	6.51E+00	1.30E+01	3.26E+01	6.51E+01	1.63E+02	6.51E+02
100,000	3,700	222,000	6.51E-02	3.26E-01	6.51E-01	1.30E+00	3.26E+00	6.51E+00	1.63E+01	6.51E+01

TABLE 4.56 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Air Concentration Measurement Obtained with RESRAD-RDD Version 2.01

Air Concentration			Stay Time ¹ for Given Dose, h							
pCi/cm ³	Bq/cm ³	dpm/100 cm ³	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
0	0	0	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
1	0.04	2	6.51E+03	>8.76E+03						
10	0.37	22	6.51E+02	3.26E+03	6.51E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03	>8.76E+03
100	3.7	222	6.51E+01	3.26E+02	6.51E+02	1.30E+03	3.26E+03	6.51E+03	>8.76E+03	>8.76E+03
1,000	37	2,220	6.51E+00	3.26E+01	6.51E+01	1.30E+02	3.26E+02	6.51E+02	1.63E+03	6.51E+03
10,000	370	22,200	6.51E-01	3.26E+00	6.51E+00	1.30E+01	3.26E+01	6.51E+01	1.63E+02	6.51E+02
100,000	3,700	222,000	6.51E-02	3.26E-01	6.51E-01	1.30E+00	3.26E+00	6.51E+00	1.63E+01	6.51E+01
1,000,000	37,000	2,220,000	6.51E-03	3.26E-02	6.51E-02	1.30E-01	3.26E-01	6.51E-01	1.63E+00	6.51E+00

Tables 4.57 and 4.58 show the general operational guidelines with full-face continuous-flow air supply respirators based on gamma exposure rate measurement obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 4.57 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 1.7

Exposure Rate		Stay Time ^a for Given Dose, h							
μR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.01	2.50E+01	1.25E+02	2.50E+02	5.00E+02	1.25E+03	2.50E+03	6.25E+03	---
100	0.1	2.50E+00	1.25E+01	2.50E+01	5.00E+01	1.25E+02	2.50E+02	6.25E+02	2.50E+03
1,000	1	2.50E-01	1.25E+00	2.50E+00	5.00E+00	1.25E+01	2.50E+01	6.25E+01	2.50E+02
10,000	10	2.50E-02	1.25E-01	2.50E-01	5.00E-01	1.25E+00	2.50E+00	6.25E+00	2.50E+01
100,000	100	2.50E-03	1.25E-02	2.50E-02	5.00E-02	1.25E-01	2.50E-01	6.25E-01	2.50E+00
1 x 10 ⁶	1,000	2.50E-04	1.25E-03	2.50E-03	5.00E-03	1.25E-02	2.50E-02	6.25E-02	2.50E-01
1 x 10 ⁷	10,000	2.50E-05	1.25E-04	2.50E-04	5.00E-04	1.25E-03	2.50E-03	6.25E-03	2.50E-02

TABLE 4.58 Group A General Guidelines with Full-Face Continuous-Flow Air Supply Respirators Based on Gamma Exposure Rate Measurement Obtained with RESRAD-RDD Version 2.01

Exposure Rate		Stay Time ¹ for Given Dose, h							
microR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.01	2.50E+01	1.25E+02	2.50E+02	5.00E+02	1.25E+03	2.50E+03	6.25E+03	>8.76E+03
100	0.1	2.50E+00	1.25E+01	2.50E+01	5.00E+01	1.25E+02	2.50E+02	6.25E+02	2.50E+03
1,000	1	2.50E-01	1.25E+00	2.50E+00	5.00E+00	1.25E+01	2.50E+01	6.25E+01	2.50E+02
10,000	10	2.50E-02	1.25E-01	2.50E-01	5.00E-01	1.25E+00	2.50E+00	6.25E+00	2.50E+01
100,000	100	2.50E-03	1.25E-02	2.50E-02	5.00E-02	1.25E-01	2.50E-01	6.25E-01	2.50E+00
1,000,000	1,000	2.50E-04	1.25E-03	2.50E-03	5.00E-03	1.25E-02	2.50E-02	6.25E-02	2.50E-01
10,000,000	10,000	2.50E-05	1.25E-04	2.50E-04	5.00E-04	1.25E-03	2.50E-03	6.25E-03	2.50E-02
100,000,000	100,000	2.50E-06	1.25E-05	2.50E-05	5.00E-05	1.25E-04	2.50E-04	6.25E-04	2.50E-03

Tables 4.59 and 4.60 show the radionuclide correction factors for stay times with a full-face continuous-flow air supply respirator obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. Essentially, there is no discrepancy in the results when the different ways of number rounding as implemented in the two versions are taken into account.

TABLE 4.59 Group A Radionuclide Correction Factors for Stay Times with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 1.7

Radionuclide	Correction Factor for Stay Times based on			
	Air Concentration Measurement ^a	Surface Concentration Measurement		Exposure Rate Measurement ^d
		Alpha Emitters ^b	β - γ Emitters ^c	
Am-241	18	13	18	110
Cf-252	5	4	-	540
Cm-244	37	27	-	6
Co-60	1	-	1	570
Cs-137	4	-	4	570
Ir-192	3	-	3	570
Po-210	500	370	-	1
Pu-238	19	14	-	3
Pu-239	18	13	-	1
Ra-226	1	1	1	570
Sr-90	21	-	21	570
Cs-134	2	-	2	570

Co-60 is used as the reference radionuclide for air concentration measurement.

Ra-226 is used as the reference radionuclide for alpha emitters.

Co-60 is used as the reference radionuclide for β - γ emitters.

Po-210 is used as the reference radionuclide for exposure rate measurement.

TABLE 4.60 Group A Radionuclide Correction Factors for Stay Times with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 2.01

Radionuclide	Air Concentration Measurement ¹	Surface Alpha Emitters ²	Beta-Gamma Surface Measurement ³	Exposure Rate Measurement ⁴
Am-241	18	13	18	106
Cf-252	5	4	-	544
Cm-244	37	27	-	6
Co-60	1	-	1	572
Cs-137	4	-	4	572
Ir-192	3	-	3	572
Po-210	499	368	-	1
Pu-238	19	14	-	3
Pu-239	18	13	-	1
Ra-226	1	1	1	568
Sr-90	21	-	21	571

¹ Co-60 is used as the reference radionuclide for the air concentration measurement.

² Ra-226 is used as the reference radionuclide for the surface alpha measurement.

³ Co-60 is used as the reference radionuclide for the beta-gamma measurement.

⁴ Po-210 is used as the reference radionuclide for the exposure rate measurement.

4.2 COMPARISON OF MEASUREMENT-BASED GUIDELINES

Input datasets three and four, as shown in Table 3.1, were used to obtain group A measurement-based guidelines for comparison. Input dataset three used ICRP-30-based DCFs, while input dataset four used ICRP-60-based DCFs.

4.2.1 Results Based on ICRP-30 DCFs

With input dataset three, RERAD-RDD version 2.01 took a total of 0.4 s to finish calculations and generate reports, while version 1.7 took a total of about 24 s to accomplish the same tasks. The measurement data included ground surface concentrations of $5.00\text{E}+9$ pCi/m² for Co-60 and $1.30\text{E}+7$ pCi/m² for Ra-226 and an air concentration of $5.00\text{E}+4$ pCi/m³ for Co-60.

Tables 4.61 and 4.62 show the measurement-based stay times without a respirator obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results calculated by both versions were almost the same; minor deviations could be attributed to the difference in rounding numerical values in the two versions.

TABLE 4.61 Group A Measurement-Based Stay Time Results without a Respirator Obtained with RESRAD-RDD Version 1.7

Dose (rem)	0.1	0.5	1	2	5	10	25	100
Stay Time (h)	3.68E-01	1.84E+00	3.68E+00	7.36E+00	1.84E+01	3.68E+01	9.20E+01	3.68E+02

TABLE 4.62 Group A Measurement-Based Stay Time Results without a Respirator Obtained with RESRAD-RDD Version 2.01

Dose (rem)	0.1	0.5	1	2	5	10	25	100
Stay Time (h)	3.69E-1	1.85E+0	3.69E+0	7.38E+0	1.85E+1	3.69E+1	9.23E+1	3.69E+2

Tables 4.63 and 4.64 show the measurement-based stay times with a full-face air-purifying respirator obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results were very close; minor deviations could be attributed to the difference in rounding numerical values in the two versions.

TABLE 4.63 Group A Measurement-Based Stay Time Results with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 1.7

Dose (rem)	0.1	0.5	1	2	5	10	25	100
Stay Time (h)	8.34E-01	4.17E+00	8.34E+00	1.67E+01	4.17E+01	8.34E+01	2.09E+02	8.34E+02

TABLE 4.64 Group A Measurement-Based Stay Time Results with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 2.01

Dose (rem)	0.1	0.5	1	2	5	10	25	100
Stay Time (h)	8.40E-1	4.20E+0	8.40E+0	1.68E+1	4.20E+1	8.40E+1	2.10E+2	8.40E+2

Tables 4.65 and 4.66 show the measurement-based stay times with a full-face continuous-flow air supply respirator obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results were very close; minor deviations could be attributed to the difference in rounding numerical values in the two versions.

TABLE 4.65 Group A Measurement-Based Stay Time Results with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 1.7

Dose (rem)	0.1	0.5	1	2	5	10	25	100
Stay Time (h)	8.44E-01	4.22E+00	8.44E+00	1.69E+01	4.22E+01	8.44E+01	2.11E+02	8.44E+02

TABLE 4.66 Group A Measurement-Based Stay Time Results with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 2.01

Dose (rem)	0.1	0.5	1	2	5	10	25	100
Stay Time (h)	8.50E-1	4.25E+0	8.50E+0	1.70E+1	4.25E+1	8.50E+1	2.12E+2	8.50E+2

4.2.2 Results Based on ICRP-60 DCFs

With input dataset four, RESRAD-RDD version 2.01 took a total of less than 0.2 s to finish calculations and generate reports, while version 1.7 took a total of about 20 s to accomplish the same tasks. The measured gamma exposure rate was 3.75E+1 μ R/h.

Tables 4.67 and 4.68 show the measurement-based stay times without a respirator obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results were identical.

TABLE 4.67 Group A Measurement-Based Stay Time Results without a Respirator Obtained with RESRAD-RDD Version 1.7

Stay Times without a Respirator based on Exposure Rate Measurement

Exposure Rate		Stay Time for Given Dose, h							
$\mu\text{R/h}$	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
3.75E+01	3.75E-02	4.02E-03	2.01E-02	4.02E-02	8.04E-02	2.01E-01	4.02E-01	1.01E+00	4.02E+00

TABLE 4.68 Group A Measurement-Based Stay Time Results without a Respirator Obtained with RESRAD-RDD Version 2.01

Exposure Rate		Stay Time for Given Dose, h							
microR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
3.75E+01	3.75E-02	4.02E-03	2.01E-02	4.02E-02	8.04E-02	2.01E-01	4.02E-01	1.01E+00	4.02E+00

Tables 4.69 and 4.70 show the measurement-based stay times with a full-face air-purifying respirator obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results were identical.

TABLE 4.69 Group A Measurement-Based Stay Time Results with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 1.7

Exposure Rate		Stay Time for Given Dose, h							
$\mu\text{R/h}$	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
3.75E+01	3.75E-02	9.02E-01	4.51E+00	9.02E+00	1.80E+01	4.51E+01	9.02E+01	2.25E+02	9.02E+02

TABLE 4.70 Group A Measurement-Based Stay Time Results with a Full-Face Air-Purifying Respirator Obtained with RESRAD-RDD Version 2.01

Exposure Rate		Stay Time for Given Dose, h							
microR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
3.75E+01	3.75E-02	9.02E-01	4.51E+00	9.02E+00	1.80E+01	4.51E+01	9.02E+01	2.25E+02	9.02E+02

Tables 4.71 and 4.72 show the measurement-based stay times with a full-face continuous-flow air supply respirator, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results were identical.

TABLE 4.71 Group A Measurement-Based Stay Time Results with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 1.7

Exposure Rate		Stay Time for Given Dose, h							
$\mu\text{R/h}$	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
3.75E+01	3.75E-02	1.79E+01	8.97E+01	1.79E+02	3.59E+02	8.97E+02	1.79E+03	4.48E+03	---

TABLE 4.72 Group A Measurement-Based Stay Time Results with a Full-Face Continuous-Flow Air Supply Respirator Obtained with RESRAD-RDD Version 2.01

Exposure Rate		Stay Time for Given Dose, h							
microR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
3.75E+01	3.75E-02	1.79E+01	8.97E+01	1.79E+02	3.59E+02	8.97E+02	1.79E+03	4.48E+03	>8.76E+03

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5 RESULTS OF COMPARISON FOR GROUP B

The group B calculation results obtained with RESRAD-RDD version 1.7 and version 2.01 are compared in this chapter.

5.1 COMPARISON OF GENERAL GUIDELINES

Input datasets five and six as shown in Table 3.1 were used to obtain group B general guidelines for comparison. Input dataset five used ICRP-30-based DCFs, while input dataset six used ICRP-60-based DCFs. With either set of input data, RESRAD-RDD version 2.01 took a total of 0.3 s to finish calculations and generate reports, while version 1.7 took a total of about 33 s to accomplish the same tasks.

5.1.1 Results Based on ICRP-30 DCFs

Tables 5.1 and 5.2 show the general operational guidelines results (pCi/m^2) for the early phase of response after an radiological dispersal device (RDD) event, based on Federal Radiological Monitoring and Assessment Center (FRMAC) methodology and ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 5.1 Group B General Operational Guidelines Results (pCi/m^2) Based on FRMAC Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 1.7

Radionuclide	Receptor spending 100% time indoors	Receptor spending some time outdoors	Receptor spending 100% time outdoors
	Protective action guide (PAG) =		
	1000	mrem	
Am-241	1.40E+08	5.22E+07	2.22E+07
Cf-252	3.98E+08	1.51E+08	6.43E+07
Cm-244	2.51E+08	9.35E+07	3.97E+07
Co-60	3.30E+09	1.42E+09	6.37E+08
Cs-137	1.40E+10	5.20E+09	2.21E+09
Ir-192	9.88E+09	4.29E+09	1.93E+09
Po-210	6.68E+09	6.67E+08	2.27E+08
Pu-238	1.59E+08	5.92E+07	2.51E+07
Pu-239	1.45E+08	5.40E+07	2.29E+07
Ra-226	2.85E+09	6.18E+08	2.30E+08
Sr-90	4.60E+10	6.92E+09	2.44E+09
Cs-134	5.14E+09	2.06E+09	8.98E+08

TABLE 5.2 Group B General Operational Guidelines Results (pCi/m²) Based on FRMAC Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 2.01

Radionuclide	Receptor Spending 100% Time Indoors	Receptor Spending Some Time Outdoors	Receptor Spending 100% Time Outdoors
	Protective Action Guide (PAG) = 1000 mrem/yr		
Am-241	1.40E+8	5.22E+7	2.22E+7
Cf-252	3.98E+8	1.51E+8	6.43E+7
Cm-244	2.51E+8	9.35E+7	3.97E+7
Co-60	3.30E+9	1.42E+9	6.37E+8
Cs-137	1.40E+10	5.20E+9	2.21E+9
Ir-192	9.88E+9	4.29E+9	1.93E+9
Po-210	6.68E+9	6.67E+8	2.27E+8
Pu-238	1.59E+8	5.92E+7	2.51E+7
Pu-239	1.45E+8	5.40E+7	2.29E+7
Ra-226	2.85E+9	6.18E+8	2.30E+8
Sr-90	4.60E+10	6.92E+9	2.44E+9

5.1.2 Results Based on ICRP-60 DCFs

Tables 5.3 and 5.4 show the general operational guidelines results (pCi/m²) for the early phase of response after an RDD event, based on OGT methodology and ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 5.3 Group B General Operational Guidelines Results (pCi/m²) Based on OGT Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 1.7

Radionuclide	Receptor spending 100% time indoors	Receptor spending some time outdoors	Receptor spending 100% time outdoors
	Protective action guide (PAG) = 2000 mrem		
Am-241	1.29E+07	6.70E+06	3.29E+06
Cf-252	6.16E+07	3.21E+07	1.58E+07
Cm-244	2.17E+07	1.13E+07	5.55E+06
Co-60	2.36E+09	2.01E+09	1.53E+09
Cs-137	8.35E+09	5.66E+09	3.33E+09
Ir-192	8.83E+09	7.59E+09	5.82E+09
Po-210	2.89E+08	1.26E+08	5.67E+07
Pu-238	1.12E+07	5.85E+06	2.88E+06
Pu-239	1.03E+07	5.36E+06	2.64E+06
Ra-226	1.25E+08	6.48E+07	3.18E+07
Sr-90	6.96E+09	3.31E+09	1.55E+09
Cs-134	3.93E+09	3.06E+09	2.07E+09

TABLE 5.4 Group B General Operational Guidelines Results (pCi/m²) Based on OGT Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 2.01

Radionuclide	Receptor Spending 100% Time Indoors	Receptor Spending Some Time Outdoors	Receptor Spending 100% Time Outdoors
Protective Action Guide (PAG) = 2000 mrem/yr			
Am-241	1.29E+7	6.70E+6	3.29E+6
Cf-252	6.16E+7	3.21E+7	1.58E+7
Cm-244	2.17E+7	1.13E+7	5.55E+6
Co-60	2.36E+9	2.01E+9	1.53E+9
Cs-137	8.35E+9	5.66E+9	3.34E+9
Ir-192	8.83E+9	7.59E+9	5.83E+9
Po-210	2.89E+8	1.26E+8	5.67E+7
Pu-238	1.12E+7	5.85E+6	2.88E+6
Pu-239	1.03E+7	5.36E+6	2.64E+6
Ra-226	1.25E+8	6.48E+7	3.18E+7
Sr-90	6.96E+9	3.31E+9	1.55E+9

5.2 COMPARISON OF MEASUREMENT-BASED RESULTS

Input datasets seven and eight, as shown in Table 3.1, were used to obtain group B measurement-based guidelines for comparison. Input dataset seven used ICRP-30-based DCFs, while input dataset eight used ICRP-60-based DCFs.

5.2.1 Results Based on ICRP-30 DCFs

With input dataset seven, RESRAD-RDD version 2.01 took a total of 0.2 s to finish calculations and generate reports, while version 1.7 took a total of about 42 s to accomplish the same tasks. The measurement data available were ground surface concentrations of 4.50E+7 pCi/m² for Pu-238 and 1.00E+7 pCi/m² for Ra-226.

Tables 5.5 and 5.6 show the estimated total doses (mrem) from a 4-day exposure based on FRMAC methodology obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results calculated by both versions were identical.

TABLE 5.5 Group B Measurement-Based Dose Results Based on FRMAC Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 1.7

Group-Receptor No.	Group description	Receptor description	Total dose (mrem)
B1-1	Evacuation - FRMAC Method	Receptor spending 100% time indoors	5.22E+02
B1-2	Evacuation - FRMAC Method	Receptor spending time working outdoors	7.18E+02
B1-3	Evacuation - FRMAC Method	Receptor spending 100% time outdoors	1.14E+03

TABLE 5.6 Group B Measurement-Based Dose Results Based on FRMAC Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 2.01

Group-Receptor No.	Group Description	Receptor Description	Total Dose (mrem)
B1-1	Evacuation - FRMAC Method	Receptor Spending 100% Time Indoors	5.22E+2
B1-2	Evacuation - FRMAC Method	Receptor Spending Time Working Outdoors	7.18E+2
B1-3	Evacuation - FRMAC Method	Receptor Spending 100% Time Outdoors	1.14E+3

5.2.2 Results Based on ICRP-60 DCFs

With input dataset eight, RERAD-RDD version 2.01 took a total of 0.2 s to finish calculations and generate reports, while version 1.7 took a total of about 41 s to accomplish the same tasks. The measurement data available were ground surface concentrations of $7.25E+8$ pCi/m² for Ir-192 and $9.50E+7$ pCi/m² for Po-210.

Tables 5.7 and 5.8 show the estimated total doses (mrem) from a 4-day exposure based on OGT methodology obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results calculated by both versions were almost the same; minor deviation could be attributed to the difference in numerical precision with Microsoft Excel and Visual Basic.NET.

TABLE 5.7 Group B Measurement-Based Dose Results Based on OGT Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 1.7

Group-Receptor No.	Group description	Receptor description	Total dose (mrem)
B2-1	Evacuation - OGT Method	Receptor spending 100% time indoors	1.73E+02
B2-2	Evacuation - OGT Method	Receptor spending time working outdoors	2.82E+02
B2-3	Evacuation - OGT Method	Receptor spending 100% time outdoors	5.19E+02

TABLE 5.8 Group B Measurement-Based Dose Results Based on OGT Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 2.01

Group-Receptor No.	Group Description	Receptor Description	Total Dose (mrem)
B2-1	Evacuation - OGT Method	Receptor Spending 100% Time Indoors	1.73E+2
B2-2	Evacuation - OGT Method	Receptor Spending Time Working Outdoors	2.82E+2
B2-3	Evacuation - OGT Method	Receptor Spending 100% Time Outdoors	5.18E+2

6 RESULTS OF COMPARISON FOR GROUP C

The group C calculation results obtained with RESRAD-RDD version 1.7 and version 2.01 are compared in this chapter.

6.1 COMPARISON OF GENERAL GUIDELINES

Input datasets five and six, as shown in Table 3.1, were used to obtain group C general guidelines for comparison. Input dataset five used ICRP-30-based DCFs, while input dataset six used ICRP-60-based DCFs. With either set of input data, RESRAD-RDD version 2.01 took a total of 0.1 s to finish calculations and generate reports, while version 1.7 took a total of about 26 s to accomplish the same tasks.

6.1.1 Results Based on ICRP-30 DCFs

Tables 6.1 and 6.2 show the most restrictive operational guidelines for subgroup C1 (relocation from residential areas) based on ICRP-30 DCFs obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 6.1 Most Restrictive Operational Guidelines for Subgroup C1 (relocation from residential areas) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Street/Soil Contamination (pCi/m ³)			
	Urban		Rural	
	First Year	After First Year	First Year	After First Year
Am-241	1.59E-06	4.78E+05	7.63E+05	2.35E-05
Cf-252	4.94E-06	2.00E-06	2.44E-06	9.83E-05
Cm-244	2.89E-06	9.05E+05	1.39E+06	4.45E-05
Co-60	6.25E-07	3.19E+07	2.49E+07	8.25E-06
Cs-137	2.31E-08	1.20E+08	8.62E+07	2.57E-07
Ir-192	4.99E-08	9.82E+09	2.20E+08	1.98E-09
Po-210	4.51E-07	1.86E+08	2.64E+07	5.19E-07
Pu-238	1.81E-06	5.47E+05	8.68E+05	2.69E-05
Pu-239	1.65E-06	4.94E+05	7.90E+05	2.43E-05
Ra-226	2.50E-07	1.24E+07	1.12E+07	3.37E+06
Sr-90	2.77E-08	1.39E+08	1.33E+08	4.23E+07
Cs-134	1.04E-08	7.51E+07	3.95E+07	1.61E+07

TABLE 6.2 Most Restrictive Operational Guidelines for Subgroup C1 (relocation from residential areas) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Street/Soil Contamination (pCi/m ²)			
	Urban		Rural	
	First Year	After First Year	First Year	After First Year
Am-241	1.59E+06	4.79E+05	7.63E+05	2.35E+05
Cf-252	4.94E+06	2.00E+06	2.44E+06	9.83E+05
Cm-244	2.89E+06	9.05E+05	1.39E+06	4.46E+05
Co-60	8.25E+07	3.19E+07	2.49E+07	8.25E+06
Cs-137	2.31E+08	1.20E+08	8.62E+07	2.57E+07
Ir-192	4.99E+08	9.82E+09	2.20E+08	1.98E+09
Po-210	4.51E+07	1.88E+08	2.64E+07	5.19E+07
Pu-238	1.81E+06	5.47E+05	8.68E+05	2.69E+05
Pu-239	1.65E+06	4.94E+05	7.90E+05	2.43E+05
Ra-226	2.50E+07	1.24E+07	1.12E+07	3.38E+06
Sr-90	2.77E+08	1.39E+08	1.33E+08	4.23E+07

Tables 6.3 and 6.4 show the most restrictive operational guidelines for subgroup C2 (relocation from industrial/commercial areas), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 6.3 Most Restrictive Operational Guidelines for Subgroup C2 (relocation from industrial/commercial areas) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Street Contamination (pCi/m ²)	
	First Year	After First Year
Am-241	6.99E+06	2.09E+06
Cf-252	2.16E+07	8.74E+06
Cm-244	1.27E+07	3.96E+06
Co-60	2.03E+08	1.55E+08
Cs-137	6.29E+08	4.36E+08
Ir-192	1.35E+09	3.65E+10
Po-210	9.84E+07	5.34E+08
Pu-238	7.93E+06	2.40E+06
Pu-239	7.22E+06	2.16E+06
Ra-226	6.37E+07	4.57E+07
Sr-90	6.97E+08	5.34E+08
Cs-134	2.93E+08	2.86E+08

TABLE 6.4 Most Restrictive Operational Guidelines for Subgroup C2 (relocation from industrial/commercial areas) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Street Contamination (pCi/m ²)	
	First Year	After First Year
Am-241	6.99E+06	2.09E+06
Cf-252	2.16E+07	8.74E+06
Cm-244	1.27E+07	3.96E+06
Co-60	2.03E+08	1.55E+08
Cs-137	6.29E+08	4.36E+08
Ir-192	1.35E+09	3.65E+10
Po-210	9.84E+07	5.34E+08
Pu-238	7.93E+06	2.40E+06
Pu-239	7.22E+06	2.16E+06
Ra-226	6.37E+07	4.57E+07
Sr-90	6.97E+08	5.34E+08

6.1.2 Results Based on ICRP-60 DCFs

Tables 6.5 and 6.6 show the most restrictive operational guidelines for subgroup C4 (utilization of hospitals and other healthcare facilities), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 6.5 Most Restrictive Operational Guidelines for Subgroup C4 (utilization of hospitals and other healthcare facilities) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Street/Soil Contamination (pCi/m ²)	
	Occupational Worker	General Public (Patient)
Am-241	5.99E+06	6.34E+06
Cf-252	2.76E+07	3.02E+07
Cm-244	1.01E+07	1.07E+07
Co-60	2.50E+08	6.07E+08
Cs-137	7.38E+08	2.29E+09
Ir-192	1.66E+09	2.36E+09
Po-210	3.58E+07	1.21E+08
Pu-238	5.23E+06	5.53E+06
Pu-239	4.79E+06	5.07E+06
Ra-226	3.81E+07	5.84E+07
Sr-90	8.01E+08	2.79E+09
Cs-134	3.46E+08	9.84E+08

TABLE 6.6 Most Restrictive Operational Guidelines for Subgroup C4 (utilization of hospitals and other healthcare facilities) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Street/Soil Contamination (pCi/m ²)	
	Occupational Worker	General Public (Patient)
Am-241	5.99E+6	6.34E+6
Cf-252	2.76E+7	3.02E+7
Cm-244	1.01E+7	1.07E+7
Co-60	2.50E+8	6.07E+8
Cs-137	7.38E+8	2.29E+9
Ir-192	1.66E+9	2.36E+9
Po-210	3.58E+7	1.21E+8
Pu-238	5.23E+6	5.53E+6
Pu-239	4.79E+6	5.07E+6
Ra-226	3.81E+7	5.84E+7
Sr-90	8.01E+8	2.79E+9

Tables 6.7 and 6.8 show the most restrictive operational guidelines for subgroup C5 (utilization of transport facilities), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 6.7 Most Restrictive Operational Guidelines for Subgroup C5 (utilization of transport facilities) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Street/Soil Contamination (pCi/m ²)	
	Occupational Worker	General Public
Am-241	5.43E+06	3.47E+07
Cf-252	2.54E+07	1.73E+08
Cm-244	9.26E+06	5.92E+07
Co-60	1.33E+08	6.09E+08
Cs-137	4.67E+08	2.33E+09
Ir-192	1.40E+09	6.56E+09
Po-210	3.02E+07	5.02E+08
Pu-238	4.75E+06	3.04E+07
Pu-239	4.34E+06	2.78E+07
Ra-226	3.00E+07	2.24E+08
Sr-90	5.39E+08	7.38E+09
Cs-134	2.27E+08	1.01E+09

TABLE 6.8 Most Restrictive Operational Guidelines for Subgroup C5 (utilization of transport facilities) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Street/Soil Contamination (pCi/m ²)	
	Occupational Worker	General Public
Am-241	5.43E+06	3.47E+07
Cf-252	2.54E+07	1.73E+08
Cm-244	9.26E+06	5.92E+07
Co-60	1.33E+08	6.09E+08
Cs-137	4.67E+08	2.33E+09
Ir-192	1.40E+09	6.56E+09
Po-210	3.02E+07	5.02E+08
Pu-238	4.75E+06	3.04E+07
Pu-239	4.34E+06	2.78E+07
Ra-226	3.00E+07	2.24E+08
Sr-90	5.39E+08	7.38E+09

6.2 COMPARISON OF MEASUREMENT-BASED RESULTS

Input datasets seven and eight as shown in Table 3.1 were used to obtain group C measurement-based guidelines for comparison. Input dataset seven used ICRP-30-based DCFs, while input dataset eight used ICRP-60 based DCFs.

6.2.1 Results Based on ICRP-30 DCFs

The measurement data included in input dataset seven are ground surface concentrations of $4.50E+7$ pCi/m² for Pu-238 and $1.00E+7$ pCi/m² for Ra-226.

Tables 6.9 and 6.10 show the total doses based on measurement data for subgroup C1 (relocation from residential areas), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results calculated by both versions were almost the same; minor deviations could be attributed to the difference in numerical precision with Microsoft Excel and Visual Basic.NET.

TABLE 6.9 Total Doses Based on Measurement Data for Subgroup C1 (relocation from residential areas) Obtained with RESRAD-RDD Version 2.01

Group-Receptor No.	Group Description	Receptor Description	1st year dose (mrem/yr)	2nd year dose (mrem/yr)
C1-1	Relocation from Residential Areas (urban setting)	Resident spending 100% of the time indoors	9.90E+03	6.10E+03
C1-2	Relocation from Residential Areas (urban setting)	Adults working outside	1.05E+04	5.93E+03
C1-3	Relocation from Residential Areas (rural)	Resident spending 100% of the time indoors	1.56E+04	1.25E+04
C1-4	Relocation from Residential Areas (rural)	Adults working outside	1.64E+04	1.30E+04

TABLE 6.10 Total Doses Based on Measurement Data for Subgroup C1 (relocation from residential areas) Obtained with RESRAD-RDD Version 2.01

Group	Group Description	Receptor Description	First Year Dose (mrem/yr)	After First Year Dose (mrem/yr)
C1-1	Relocation from Residential Areas (Urban)	Resident Spending 100% of Time Indoors	9.89E+03	6.09E+03
C1-2	Relocation from Residential Areas (Urban)	Adults Working Outside	1.05E+04	5.93E+03
C1-3	Relocation from Residential Areas (Rural)	Resident Spending 100% of Time Indoors	1.56E+04	1.25E+04
C1-4	Relocation from Residential Areas (Rural)	Adults Working Outside	1.64E+04	1.30E+04

Tables 6.11 and 6.12 show the total doses based on measurement data for subgroup C3 (relocation from other areas), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results calculated by both versions were identical.

TABLE 6.11 Total Doses Based on Measurement Data for Subgroup C3 (relocation from other areas) Obtained with RESRAD-RDD Version 1.7

Group-Receptor No.	Group Description	Receptor Description	1st year dose (mrem/yr)	2nd year dose (mrem/yr)
C3-1	Relocation from Other Areas	Indoor worker at a monument or park	4.57E+03	3.65E+03
C3-2	Relocation from Other Areas	Outdoor worker at a monument or park	4.31E+03	3.21E+03

TABLE 6.12 Total Doses Based on Measurement Data for Subgroup C3 (relocation from other areas) Obtained with RESRAD-RDD Version 2.01

Group	Group Description	Receptor Description	First Year Dose (mrem/yr)	After First Year Dose (mrem/yr)
C3-1	Relocation from Other Areas	Indoor Worker at a Monument or Park	4.57E+3	3.65E+3
C3-2	Relocation from Other Areas	Outdoor Worker at a Monument or Park	4.31E+3	3.21E+3

6.2.2 Results Based on ICRP-60 DCFs

The measurement data included in input dataset eight are ground surface concentrations of $7.25E+8$ pCi/m² for Ir-192 and $9.50E+6$ pCi/m² for Po-210.

Tables 6.13 and 6.14 show the total doses for subgroup C4 (utilization of hospitals and other healthcare facilities), based on measurement data and ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. There were no discrepancies observed in the results.

TABLE 6.13 Total Doses Based on Measurement Data for Subgroup C4 (utilization of hospitals and other healthcare facilities) Obtained with RESRAD-RDD Version 1.7

Group-Receptor No.	Group Description	Receptor Description	Total dose (mrem/yr)
C4-1 ^a	Hospital and Other Health Care Facilities	Hospital outdoor worker	1.94E+03
C4-2 ^a	Hospital and Other Health Care Facilities	Hospital indoor worker	7.33E+02
C4-3 ^a	Hospital and Other Health Care Facilities	Patient staying in hospital	5.41E+02

TABLE 6.14 Total Doses Based on Measurement Data for Subgroup C4 (utilization of hospitals and other healthcare facilities) Obtained with RESRAD-RDD Version 2.01

Group	Group Description	Receptor Description	Total Dose (mrem/yr)
C4-1 ^a	Hospital and Other Health Care Facilities	Hospital Outdoor Worker	1.94E+3
C4-2 ^a	Hospital and Other Health Care Facilities	Hospital Indoor Worker	7.33E+2
C4-3 ^a	Hospital and Other Health Care Facilities	Patient Staying in Hospital	5.41E+2

Tables 6.15 and 6.16 show the total doses for subgroup C6 (utilization of water and sewer facilities), based on measurement data and ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results calculated by both versions were the same.

TABLE 6.15 Total Doses Based on Measurement Data for Subgroup C6 (utilization of water and sewer facilities) Obtained with RESRAD-RDD Version 1.7

Group-Receptor No.	Group Description	Receptor Description	Total dose (mrem/yr)
C6-1	Water and Sewer Facilities	Facility outdoor worker	3.09E+03
C6-2	Water and Sewer Facilities	Facility indoor worker	1.17E+03
C6-3	Water and Sewer Facilities	Contractor works indoors	2.92E+02
C6-4	Water and Sewer Facilities	Contractor works outdoors	7.72E+02

TABLE 6.16 Total Doses Based on Measurement Data for Subgroup C6 (utilization of water and sewer facilities) Obtained with RESRAD-RDD Version 2.01

Group	Group Description	Receptor Description	Total Dose (mrem/yr)
C6-1	Water and Sewer Facilities	Facility Outdoor Worker	3.09E+03
C6-2	Water and Sewer Facilities	Facility Indoor Worker	1.17E+03
C6-3	Water and Sewer Facilities	Contractor Works Indoors	2.92E+02
C6-4	Water and Sewer Facilities	Contractor Works Outdoors	7.72E+02

Tables 6.17 and 6.18 show the total doses for subgroup C7 (utilization of power and fuel), based on measurement data and ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results calculated by both versions were the same.

TABLE 6.17 Total Doses Based on Measurement Data for Subgroup C7 (utilization of power and fuel facilities) Obtained with RESRAD-RDD Version 1.7

Group-Receptor No.	Group Description	Receptor Description	Total dose (mrem/yr)
C7-1	Power and Fuel Facilities	Facility outdoor worker	3.09E+03
C7-2	Power and Fuel Facilities	Facility indoor worker	1.17E+03
C7-3	Power and Fuel Facilities	Contractor works indoors	2.92E+02
C7-4	Power and Fuel Facilities	Contractor works outdoors	7.72E+02

TABLE 6.18 Total Doses Based on Measurement Data for Subgroup C7 (utilization of power and fuel facilities) Obtained with RESRAD-RDD Version 2.01

Group	Group Description	Receptor Description	Total Dose (mrem/yr)
C7-1	Power and Fuel Facilities	Facility Outdoor Worker	3.09E+03
C7-2	Power and Fuel Facilities	Facility Indoor Worker	1.17E+03
C7-3	Power and Fuel Facilities	Contractor Works Indoors	2.92E+02
C7-4	Power and Fuel Facilities	Contractor Works Outdoors	7.72E+02

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7 RESULTS OF COMPARISON FOR GROUP D

The group D calculation results obtained with RESRAD-RDD version 1.7 and version 2.01 are compared in this chapter.

7.1 COMPARISON OF GENERAL GUIDELINES

Input datasets five and six, as shown in Table 3.1, were used to obtain group D general guidelines for comparison. Input dataset five used ICRP-30-based DCFs, while input dataset six used ICRP-60-based DCFs. With either set of input data, RESRAD-RDD version 2.01 took a total of 15.6 s to finish calculations and generate reports, while version 1.7 took a total of about 28 s to accomplish the same tasks.

7.1.1 Results Based on ICRP-30 DCFs

Tables 7.1 and 7.2 show the general guidelines in terms of stay time for subgroup D1-1 (workers accessing businesses, outdoor exposure), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.1 General Guidelines in Terms of Stay Time for Subgroup D1-1 (workers accessing businesses, outdoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide Concentration				Stay Time (continuous exposure time in hours) to Receive 500 mrem										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+01	1.00E+05	3.70E-01	2.22E+03	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+02	1.00E+06	3.70E+00	2.22E+04	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+03	1.00E+07	3.70E+01	2.22E+05	1.21E+02	1.36E+03	4.33E+02	> 8760	> 8760	> 8760	2.03E+03	1.59E+02	1.30E+02	1.78E+03	> 8760
1.00E+04	1.00E+08	3.70E+02	2.22E+06	6.79E+00	1.95E+01	1.22E+01	4.37E+02	1.66E+03	2.36E+03	1.13E+02	7.70E+00	7.03E+00	1.22E+02	2.05E+03
1.00E+05	1.00E+09	3.70E+03	2.22E+07	6.79E-01	1.95E+00	1.22E+00	4.04E+01	1.33E+02	1.22E+02	9.66E+00	7.70E-01	7.03E-01	1.05E+01	1.24E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	6.79E-02	1.95E-01	1.22E-01	4.01E+00	1.30E+01	1.18E+01	9.66E-01	7.70E-02	7.03E-02	1.05E+00	9.93E+00
1.00E+07	1.00E+11	3.70E+05	2.22E+09	6.79E-03	1.95E-02	1.22E-02	4.01E-01	1.30E+00	1.18E+00	9.66E-02	7.70E-03	7.03E-03	1.05E-01	9.93E-01

TABLE 7.2 General Guidelines in Terms of Stay Time for Subgroup D1-1 (workers accessing businesses, outdoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide Concentration				Stay Time (h) for 500 mrem										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+01	1.00E+05	3.70E-01	2.22E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+02	1.00E+06	3.70E+00	2.22E+04	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+03	1.00E+07	3.70E+01	2.22E+05	1.21E+02	1.36E+03	4.33E+02	>8.76E+00	>8.76E+00	>8.76E+00	2.03E+03	1.59E+02	1.30E+02	1.78E+03	>8.76E+00
1.00E+04	1.00E+08	3.70E+02	2.22E+06	6.79E+00	1.95E+01	1.22E+01	4.37E+02	1.66E+03	2.36E+03	1.13E+02	7.70E+00	7.03E+00	1.22E+02	2.05E+03
1.00E+05	1.00E+09	3.70E+03	2.22E+07	6.79E-01	1.95E+00	1.22E+00	4.04E+01	1.33E+02	1.22E+02	9.66E+00	7.70E-01	7.03E-01	1.05E+01	1.24E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	6.79E-02	1.95E-01	1.22E-01	4.01E+00	1.30E+01	1.18E+01	9.66E-01	7.70E-02	7.03E-02	1.05E+00	9.93E+00
1.00E+07	1.00E+11	3.70E+05	2.22E+09	6.79E-03	1.95E-02	1.22E-02	4.01E-01	1.30E+00	1.18E+00	9.66E-02	7.70E-03	7.03E-03	1.05E-01	9.93E-01
1.00E+08	1.00E+12	3.70E+06	2.22E+10	6.79E-04	1.95E-03	1.22E-03	4.01E-02	1.30E-01	1.18E-01	9.66E-03	7.70E-04	7.03E-04	1.05E-02	9.93E-02

Tables 7.3 and 7.4 show the general guidelines in terms of stay time for subgroup D1-2 (workers accessing businesses, indoor exposure), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.3 General Guidelines in Terms of Stay Time for Subgroup D1-2 (workers accessing businesses, indoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide Concentration				Stay Time (continuous exposure time in hours) to Receive 500 mrem										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+02	1.00E+06	3.70E+00	2.22E+04	2.02E+03	> 8760	4.84E+03	> 8760	> 8760	> 8760	> 8760	2.40E+03	2.11E+03	> 8760	> 8760
1.00E+03	1.00E+07	3.70E+01	2.22E+05	1.35E+02	4.42E+02	2.61E+02	> 8760	> 8760	> 8760	> 8760	1.55E+02	1.40E+02	7.62E+03	> 8760
1.00E+04	1.00E+08	3.70E+02	2.22E+06	1.13E+01	3.30E+01	2.03E+01	9.80E+02	6.34E+03	> 8760	5.22E+02	1.28E+01	1.17E+01	4.03E+02	8.37E+03
1.00E+05	1.00E+09	3.70E+03	2.22E+07	1.13E+00	3.22E+00	2.03E+00	8.79E+01	3.86E+02	3.14E+02	3.98E+01	1.28E+00	1.17E+00	3.40E+01	4.03E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	1.13E-01	3.22E-01	2.03E-01	8.68E+00	3.68E+01	2.86E+01	3.87E+00	1.28E-01	1.17E-01	3.35E+00	3.20E+01
1.00E+07	1.00E+11	3.70E+05	2.22E+09	1.13E-02	3.22E-02	2.03E-02	8.68E-01	3.67E+00	2.86E+00	3.87E-01	1.28E-02	1.17E-02	3.35E-01	3.13E+00

TABLE 7.4 General Guidelines in Terms of Stay Time for Subgroup D1-2 (workers accessing businesses, indoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide Concentration				Stay Time (h) for 500 mrem										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+01	1.00E+05	3.70E-01	2.22E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+02	1.00E+06	3.70E+00	2.22E+04	2.02E+03	>8.76E+00	4.84E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	2.40E+03	2.11E+03	>8.76E+00	>8.76E+00
1.00E+03	1.00E+07	3.70E+01	2.22E+05	1.35E+02	4.42E+02	2.61E+02	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	1.55E+02	1.40E+02	7.65E+03	>8.76E+00
1.00E+04	1.00E+08	3.70E+02	2.22E+06	1.13E+01	3.30E+01	2.03E+01	9.80E+02	6.34E+03	>8.76E+00	5.22E+02	1.28E+01	1.17E+01	4.04E+02	8.37E+03
1.00E+05	1.00E+09	3.70E+03	2.22E+07	1.13E+00	3.22E+00	2.03E+00	8.79E+01	3.86E+02	3.14E+02	3.98E+01	1.28E+00	1.17E+00	3.41E+01	4.03E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	1.13E-01	3.22E-01	2.03E-01	8.68E+00	3.68E+01	2.86E+01	3.87E+00	1.28E-01	1.17E-01	3.35E+00	3.20E+01
1.00E+07	1.00E+11	3.70E+05	2.22E+09	1.13E-02	3.22E-02	2.03E-02	8.68E-01	3.67E+00	2.86E+00	3.87E-01	1.28E-02	1.17E-02	3.35E-01	3.13E+00
1.00E+08	1.00E+12	3.70E+06	2.22E+10	1.13E-03	3.22E-03	2.03E-03	8.68E-02	3.67E-01	2.86E-01	3.87E-02	1.28E-03	1.17E-03	3.35E-02	3.13E-01

Tables 7.5 and 7.6 show the general guidelines in terms of stay time for subgroup D2-1 (residents accessing houses, outdoor exposure), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.5 General Guidelines in Terms of Stay Time for Subgroup D2-1 (residents accessing houses, outdoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide Concentration				Stay Time (continuous exposure time in hours) to Receive 500 mrem										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+00	1.00E+04	3.70E-02	2.22E+02	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+01	1.00E+05	3.70E-01	2.22E+03	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+02	1.00E+06	3.70E+00	2.22E+04	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+03	1.00E+07	3.70E+01	2.22E+05	1.21E+02	1.36E+03	4.33E+02	> 8760	> 8760	> 8760	2.03E+03	1.59E+02	1.30E+02	1.78E+03	> 8760
1.00E+04	1.00E+08	3.70E+02	2.22E+06	6.79E+00	1.95E+01	1.22E+01	4.37E+02	1.66E+03	2.36E+03	1.13E+02	7.70E+00	7.03E+00	1.22E+02	2.05E+03
1.00E+05	1.00E+09	3.70E+03	2.22E+07	6.79E-01	1.95E+00	1.22E+00	4.04E+01	1.33E+02	1.22E+02	9.66E+00	7.70E-01	7.03E-01	1.05E+01	1.24E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	6.79E-02	1.95E-01	1.22E-01	4.01E+00	1.30E+01	1.18E+01	9.66E-01	7.70E-02	7.03E-02	1.05E+00	9.93E+00
1.00E+07	1.00E+11	3.70E+05	2.22E+09	6.79E-03	1.95E-02	1.22E-02	4.01E-01	1.30E+00	1.18E+00	9.66E-02	7.70E-03	7.03E-03	1.05E-01	9.93E-01

TABLE 7.6 General Guidelines in Terms of Stay Time for Subgroup D2-1 (residents accessing houses, outdoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide Concentration				Stay Time (h) for 500 mrem										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+01	1.00E+05	3.70E-01	2.22E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+02	1.00E+06	3.70E+00	2.22E+04	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+03	1.00E+07	3.70E+01	2.22E+05	1.21E+02	1.36E+03	4.33E+02	>8.76E+00	>8.76E+00	>8.76E+00	2.03E+03	1.59E+02	1.30E+02	1.78E+03	>8.76E+00
1.00E+04	1.00E+08	3.70E+02	2.22E+06	6.79E+00	1.95E+01	1.22E+01	4.37E+02	1.66E+03	2.36E+03	1.13E+02	7.70E+00	7.03E+00	1.22E+02	2.05E+03
1.00E+05	1.00E+09	3.70E+03	2.22E+07	6.79E-01	1.95E+00	1.22E+00	4.04E+01	1.33E+02	1.22E+02	9.66E+00	7.70E-01	7.03E-01	1.05E+01	1.24E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	6.79E-02	1.95E-01	1.22E-01	4.01E+00	1.30E+01	1.18E+01	9.66E-01	7.70E-02	7.03E-02	1.05E+00	9.93E+00
1.00E+07	1.00E+11	3.70E+05	2.22E+09	6.79E-03	1.95E-02	1.22E-02	4.01E-01	1.30E+00	1.18E+00	9.66E-02	7.70E-03	7.03E-03	1.05E-01	9.93E-01
1.00E+08	1.00E+12	3.70E+06	2.22E+10	6.79E-04	1.95E-03	1.22E-03	4.01E-02	1.30E-01	1.18E-01	9.66E-03	7.70E-04	7.03E-04	1.05E-02	9.93E-02

Tables 7.7 and 7.8 show the general guidelines in terms of stay time for subgroup D2-2 (residents accessing houses, indoor exposure), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.7 General Guidelines in Terms of Stay Time for Subgroup D2-2 (residents accessing houses, indoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide Concentration				Stay Time (continuous exposure time in hours) to Receive 500 mrem										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+00	1.00E+04	3.70E-02	2.22E+02	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+01	1.00E+05	3.70E-01	2.22E+03	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+02	1.00E+06	3.70E+00	2.22E+04	2.02E+03	> 8760	4.84E+03	> 8760	> 8760	> 8760	> 8760	2.40E+03	2.11E+03	> 8760	> 8760
1.00E+03	1.00E+07	3.70E+01	2.22E+05	1.35E+02	4.42E+02	2.61E+02	> 8760	> 8760	> 8760	> 8760	1.55E+02	1.40E+02	7.46E+03	> 8760
1.00E+04	1.00E+08	3.70E+02	2.22E+06	1.13E+01	3.30E+01	2.03E+01	1.01E+03	6.35E+03	> 8760	5.22E+02	1.28E+01	1.17E+01	4.04E+02	8.38E+03
1.00E+05	1.00E+09	3.70E+03	2.22E+07	1.13E+00	3.22E+00	2.03E+00	9.13E+01	4.05E+02	3.35E+02	3.98E+01	1.28E+00	1.17E+00	3.42E+01	4.03E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	1.13E-01	3.22E-01	2.03E-01	9.02E+00	3.86E+01	3.05E+01	3.87E+00	1.28E-01	1.17E-01	3.36E+00	3.20E+01
1.00E+07	1.00E+11	3.70E+05	2.22E+09	1.13E-02	3.22E-02	2.03E-02	9.02E-01	3.85E+00	3.04E+00	3.87E-01	1.28E-02	1.17E-02	3.36E-01	3.14E+00

TABLE 7.8 General Guidelines in Terms of Stay Time for Subgroup D2-2 (residents accessing houses, indoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide Concentration				Stay Time (h) for 500 mrem										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+01	1.00E+05	3.70E-01	2.22E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+02	1.00E+06	3.70E+00	2.22E+04	2.02E+03	>8.76E+00	4.84E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	2.40E+03	2.11E+03	>8.76E+00	>8.76E+00
1.00E+03	1.00E+07	3.70E+01	2.22E+05	1.35E+02	4.42E+02	2.61E+02	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	1.55E+02	1.40E+02	7.46E+03	>8.76E+00
1.00E+04	1.00E+08	3.70E+02	2.22E+06	1.13E+01	3.30E+01	2.03E+01	1.01E+03	6.35E+03	>8.76E+00	5.22E+02	1.28E+01	1.17E+01	4.04E+02	8.38E+03
1.00E+05	1.00E+09	3.70E+03	2.22E+07	1.13E+00	3.22E+00	2.03E+00	9.13E+01	4.05E+02	3.35E+02	3.98E+01	1.28E+00	1.17E+00	3.42E+01	4.03E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	1.13E-01	3.22E-01	2.03E-01	9.02E+00	3.86E+01	3.05E+01	3.87E+00	1.28E-01	1.17E-01	3.36E+00	3.20E+01
1.00E+07	1.00E+11	3.70E+05	2.22E+09	1.13E-02	3.22E-02	2.03E-02	9.02E-01	3.85E+00	3.04E+00	3.87E-01	1.28E-02	1.17E-02	3.36E-01	3.14E+00
1.00E+08	1.00E+12	3.70E+06	2.22E+10	1.13E-03	3.22E-03	2.03E-03	9.02E-02	3.85E-01	3.04E-01	3.87E-02	1.28E-03	1.17E-03	3.36E-02	3.14E-01

Tables 7.9 and 7.10 show the general operational guidelines for four selected exposure durations for subgroup D1-1 (workers accessing businesses, outdoor exposure), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.9 General Operational Guidelines for Four Selected Exposure Durations for Subgroup D1-1 (workers accessing businesses, outdoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Surface Street Concentration pCi/m ²			
	4 Work Days	12 Work Days	4 Work Weeks	12 Work Weeks
Am-241	3.36E+07	2.01E+07	1.36E+07	7.89E+06
Cf-252	9.76E+07	5.97E+07	4.13E+07	2.52E+07
Cm-244	6.03E+07	3.61E+07	2.44E+07	1.42E+07
Co-60	1.28E+09	4.44E+08	2.02E+08	8.16E+07
Cs-137	4.14E+09	1.43E+09	6.48E+08	2.59E+08
Ir-192	3.78E+09	1.35E+09	6.56E+08	3.22E+08
Po-210	3.45E+08	1.33E+08	6.53E+07	3.01E+07
Pu-238	3.81E+07	2.28E+07	1.54E+07	8.98E+06
Pu-239	3.48E+07	2.08E+07	1.40E+07	8.15E+06
Ra-226	3.71E+08	1.40E+08	6.65E+07	2.73E+07
Sr-90	3.72E+09	1.48E+09	7.24E+08	3.04E+08

TABLE 7.10 General Operational Guidelines for Four Selected Exposure Durations for Subgroup D1-1 (workers accessing businesses, outdoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Surface Street Concentration (pCi/m ²)			
	4 Work Days	12 Work Days	4 Work Weeks	12 Work Weeks
Am-241	3.36E+07	2.01E+07	1.36E+07	7.89E+06
Cf-252	9.76E+07	5.97E+07	4.13E+07	2.52E+07
Cm-244	6.03E+07	3.61E+07	2.44E+07	1.42E+07
Co-60	1.28E+09	4.44E+08	2.02E+08	8.16E+07
Cs-137	4.14E+09	1.43E+09	6.48E+08	2.59E+08
Ir-192	3.78E+09	1.35E+09	6.56E+08	3.22E+08
Po-210	3.45E+08	1.33E+08	6.53E+07	3.01E+07
Pu-238	3.81E+07	2.28E+07	1.54E+07	8.98E+06
Pu-239	3.48E+07	2.08E+07	1.40E+07	8.15E+06
Ra-226	3.71E+08	1.40E+08	6.65E+07	2.73E+07
Sr-90	3.72E+09	1.48E+09	7.24E+08	3.04E+08

Tables 7.11 and 7.12 show the general operational guidelines for four selected exposure durations for subgroup D1-2 (workers accessing businesses, indoor exposure), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. Essentially, the results from the two versions are consistent.

TABLE 7.11 General Operational Guidelines for Four Selected Exposure Durations for Subgroup D1-2 (workers accessing businesses, indoor exposure) Obtained with RESRAD-RDD Version 1.7

Surface Street Concentration pCi/m ²				
Radionuclide	4 Work Days	12 Work Days	4 Work Weeks	12 Work Week
Am-241	4.04E+07	1.53E+07	7.29E+06	3.00E+06
Cf-252	1.15E+08	4.37E+07	2.09E+07	8.74E+06
Cm-244	7.23E+07	2.75E+07	1.31E+07	5.39E+06
Co-60	2.75E+09	9.41E+08	4.23E+08	1.62E+08
Cs-137	1.16E+10	3.97E+09	1.78E+09	6.86E+08
Ir-192	9.15E+09	3.24E+09	1.56E+09	7.47E+08
Po-210	1.34E+09	5.02E+08	2.44E+08	1.11E+08
Pu-238	4.58E+07	1.74E+07	8.26E+06	3.40E+06
Pu-239	4.18E+07	1.59E+07	7.54E+06	3.10E+06
Ra-226	1.13E+09	4.08E+08	1.89E+08	7.53E+07
Sr-90	1.09E+10	4.05E+09	1.91E+09	7.80E+08

TABLE 7.12 General Operational Guidelines for Four Selected Exposure Durations for Subgroup D1-2 (workers accessing businesses, indoor exposure) Obtained with RESRAD-RDD Version 2.01

Surface Street Concentration (pCi/m ²)				
Radionuclide	4 Work Days	12 Work Days	4 Work Weeks	12 Work Weeks
Am-241	4.04E+07	1.53E+07	7.29E+06	3.00E+06
Cf-252	1.15E+08	4.37E+07	2.09E+07	8.74E+06
Cm-244	7.23E+07	2.75E+07	1.31E+07	5.39E+06
Co-60	2.75E+09	9.41E+08	4.23E+08	1.62E+08
Cs-137	1.16E+10	3.97E+09	1.78E+09	6.86E+08
Ir-192	9.15E+09	3.24E+09	1.56E+09	7.47E+08
Po-210	1.34E+09	5.02E+08	2.44E+08	1.11E+08
Pu-238	4.58E+07	1.74E+07	8.26E+06	3.40E+06
Pu-239	4.18E+07	1.59E+07	7.54E+06	3.10E+06
Ra-226	1.13E+09	4.09E+08	1.89E+08	7.55E+07
Sr-90	1.09E+10	4.05E+09	1.91E+09	7.80E+08

Tables 7.13 and 7.14 show the general operational guidelines for three selected exposure durations for subgroup D2-1 (residents accessing houses, outdoor exposure), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.13 General Operational Guidelines for Three Selected Exposure Durations for Subgroup D2-1 (residents accessing houses, outdoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Surface Street Concentration (pCi/m ²)		
	1 Day	4 Days	12 Days
Am-241	2.83E+07	1.12E+07	6.71E+06
Cf-252	8.14E+07	3.25E+07	1.99E+07
Cm-244	5.07E+07	2.01E+07	1.20E+07
Co-60	1.67E+09	4.27E+08	1.48E+08
Cs-137	5.43E+09	1.38E+09	4.75E+08
Ir-192	4.90E+09	1.26E+09	4.50E+08
Po-210	4.02E+08	1.15E+08	4.42E+07
Pu-238	3.21E+07	1.27E+07	7.61E+06
Pu-239	2.93E+07	1.16E+07	6.94E+06
Ra-226	4.37E+08	1.24E+08	4.67E+07
Sr-90	4.14E+09	1.24E+09	4.94E+08

TABLE 7.14 General Operational Guidelines for Three Selected Exposure Durations for Subgroup D2-2 (residents accessing houses, outdoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Surface Street Concentration (pCi/m ²)		
	1 Day	4 Days	12 Days
Am-241	2.83E+07	1.12E+07	6.71E+06
Cf-252	8.14E+07	3.25E+07	1.99E+07
Cm-244	5.07E+07	2.01E+07	1.20E+07
Co-60	1.67E+09	4.27E+08	1.48E+08
Cs-137	5.43E+09	1.38E+09	4.75E+08
Ir-192	4.90E+09	1.26E+09	4.50E+08
Po-210	4.02E+08	1.15E+08	4.42E+07
Pu-238	3.21E+07	1.27E+07	7.61E+06
Pu-239	2.93E+07	1.16E+07	6.94E+06
Ra-226	4.37E+08	1.24E+08	4.67E+07
Sr-90	4.14E+09	1.24E+09	4.94E+08

Tables 7.15 and 7.16 show the general operational guidelines for three selected exposure durations for subgroup D2-2 (residents accessing houses, indoor exposure), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.15 General Operational Guidelines for Three Selected Exposure Durations for Subgroup D2-2 (residents accessing houses, indoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Surface Street Concentration (pCi/m ³)		
	1 Day	4 Days	12 Days
Am-241	4.73E+07	1.35E+07	5.11E+06
Cf-252	1.34E+08	3.82E+07	1.46E+07
Cm-244	8.46E+07	2.41E+07	9.15E+06
Co-60	3.76E+09	9.52E+08	3.25E+08
Cs-137	1.61E+10	4.06E+09	1.39E+09
Ir-192	1.27E+10	3.24E+09	1.15E+09
Po-210	1.61E+09	4.46E+08	1.67E+08
Pu-238	5.35E+07	1.53E+07	5.79E+06
Pu-239	4.89E+07	1.39E+07	5.29E+06
Ra-226	1.40E+09	3.78E+08	1.37E+08
Sr-90	1.31E+10	3.64E+09	1.35E+09

TABLE 7.16 General Operational Guidelines for Three Selected Exposure Durations for Subgroup D2-2 (residents accessing houses, indoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Surface Street Concentration (pCi/m ³)		
	1 Day	4 Days	12 Days
Am-241	4.73E+07	1.35E+07	5.11E+06
Cf-252	1.34E+08	3.82E+07	1.46E+07
Cm-244	8.46E+07	2.41E+07	9.15E+06
Co-60	3.76E+09	9.52E+08	3.25E+08
Cs-137	1.61E+10	4.06E+09	1.39E+09
Ir-192	1.27E+10	3.24E+09	1.15E+09
Po-210	1.61E+09	4.46E+08	1.67E+08
Pu-238	5.35E+07	1.53E+07	5.79E+06
Pu-239	4.89E+07	1.39E+07	5.29E+06
Ra-226	1.40E+09	3.78E+08	1.37E+08
Sr-90	1.31E+10	3.64E+09	1.35E+09

7.1.2 Results Based on ICRP-60 DCFs

Tables 7.17 and 7.18 show the general operational guidelines in terms of stay time for subgroup D1-1 (workers accessing businesses, outdoor exposure), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.17 General Operational Guidelines in Terms of Stay Time for Subgroup D1-1 (workers accessing businesses, outdoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide Concentration				Stay Time (continuous exposure time in hours) to Receive 2000 mrem										
pCi/cm ²	pCi/m ³	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+01	1.00E+05	3.70E-01	2.22E+03	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+02	1.00E+06	3.70E+00	2.22E+04	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+03	1.00E+07	3.70E+01	2.22E+05	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	5.01E+03	> 8760	> 8760	> 8760	> 8760
1.00E+04	1.00E+08	3.70E+02	2.22E+06	4.21E+01	9.52E+02	1.11E+02	2.12E+03	> 8760	> 8760	2.15E+02	3.54E+01	3.16E+01	5.41E+02	> 8760
1.00E+05	1.00E+09	3.70E+03	2.22E+07	3.66E+00	1.66E+01	6.17E+00	1.74E+02	5.65E+02	7.70E+02	1.78E+01	3.20E+00	2.93E+00	2.45E+01	7.31E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	3.66E-01	1.66E+00	6.17E-01	1.69E+01	5.16E+01	6.25E+01	1.78E+00	3.20E-01	2.93E-01	2.44E+00	5.73E+01
1.00E+07	1.00E+11	3.70E+05	2.22E+09	3.66E-02	1.66E-01	6.17E-02	1.69E+00	5.09E+00	6.15E+00	1.78E-01	3.20E-02	2.93E-02	2.44E-01	5.40E+00

TABLE 7.18 General Operational Guidelines in Terms of Stay Time for Subgroup D1-1 (workers accessing businesses, outdoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide Concentration				Stay Time (h) for 2000 mrem										
pCi/cm ²	pCi/m ³	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+01	1.00E+05	3.70E-01	2.22E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+02	1.00E+06	3.70E+00	2.22E+04	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+03	1.00E+07	3.70E+01	2.22E+05	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	5.01E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+04	1.00E+08	3.70E+02	2.22E+06	4.21E+01	9.52E+02	1.11E+02	2.12E+03	>8.76E+00	>8.76E+00	2.15E+02	3.54E+01	3.16E+01	5.41E+02	>8.76E+00
1.00E+05	1.00E+09	3.70E+03	2.22E+07	3.66E+00	1.66E+01	6.17E+00	1.74E+02	5.65E+02	7.70E+02	1.78E+01	3.20E+00	2.93E+00	2.45E+01	7.31E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	3.66E-01	1.66E+00	6.17E-01	1.69E+01	5.16E+01	6.25E+01	1.78E+00	3.20E-01	2.93E-01	2.44E+00	5.73E+01
1.00E+07	1.00E+11	3.70E+05	2.22E+09	3.66E-02	1.66E-01	6.17E-02	1.69E+00	5.09E+00	6.15E+00	1.78E-01	3.20E-02	2.93E-02	2.44E-01	5.40E+00
1.00E+08	1.00E+12	3.70E+06	2.22E+10	3.66E-03	1.66E-02	6.17E-03	1.69E-01	5.09E-01	6.15E-01	1.78E-02	3.20E-03	2.93E-03	2.44E-02	5.40E-01

Tables 7.19 and 7.20 show the general operational guidelines in terms of stay time for subgroup D1-2 (workers accessing businesses, indoor exposure), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.19 General Operational Guidelines in Terms of Stay Time for Subgroup D1-2 (workers accessing businesses, indoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide Concentration				Stay Time (continuous exposure time in hours) to Receive 2000 mrem										
pCi/cm ²	pCi/m ³	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+02	1.00E+06	3.70E+00	2.22E+04	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+03	1.00E+07	3.70E+01	2.22E+05	8.07E+02	6.18E+03	1.49E+03	> 8760	> 8760	> 8760	> 8760	6.90E+02	6.25E+02	> 8760	> 8760
1.00E+04	1.00E+08	3.70E+02	2.22E+06	5.64E+01	3.36E+02	1.04E+02	2.45E+03	> 8760	> 8760	1.23E+03	4.79E+01	4.37E+01	5.86E+02	> 8760
1.00E+05	1.00E+09	3.70E+03	2.22E+07	5.18E+00	2.42E+01	8.73E+00	2.06E+02	9.03E+02	9.44E+02	8.51E+01	4.52E+00	4.15E+00	4.42E+01	2.49E+03
1.00E+06	1.00E+10	3.70E+04	2.22E+08	5.18E-01	2.42E+00	8.73E-01	2.02E+01	8.31E+01	7.50E+01	7.69E+00	4.52E-01	4.15E-01	4.23E+00	1.87E+02
1.00E+07	1.00E+11	3.70E+05	2.22E+09	5.18E-02	2.42E-01	8.73E-02	2.02E+00	8.20E+00	7.39E+00	7.69E-01	4.52E-02	4.15E-02	4.23E-01	1.63E+01

TABLE 7.20 General Operational Guidelines in Terms of Stay Time for Subgroup D1-2 (workers accessing businesses, indoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide Concentration				Stay Time (h) for 2000 mrem										
pCi/cm ²	pCi/m ³	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+01	1.00E+05	3.70E-01	2.22E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+02	1.00E+06	3.70E+00	2.22E+04	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+03	1.00E+07	3.70E+01	2.22E+05	8.07E+02	6.18E+03	1.49E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	6.90E+02	6.25E+02	>8.76E+00	>8.76E+00
1.00E+04	1.00E+08	3.70E+02	2.22E+06	5.64E+01	3.36E+02	1.04E+02	2.45E+03	>8.76E+00	>8.76E+00	1.23E+03	4.79E+01	4.37E+01	5.86E+02	>8.76E+00
1.00E+05	1.00E+09	3.70E+03	2.22E+07	5.18E+00	2.42E+01	8.73E+00	2.06E+02	9.03E+02	9.44E+02	8.51E+01	4.52E+00	4.15E+00	4.42E+01	2.49E+03
1.00E+06	1.00E+10	3.70E+04	2.22E+08	5.18E-01	2.42E+00	8.73E-01	2.02E+01	8.31E+01	7.50E+01	7.69E+00	4.52E-01	4.15E-01	4.23E+00	1.87E+02
1.00E+07	1.00E+11	3.70E+05	2.22E+09	5.18E-02	2.42E-01	8.73E-02	2.02E+00	8.20E+00	7.39E+00	7.69E-01	4.52E-02	4.15E-02	4.23E-01	1.63E+01
1.00E+08	1.00E+12	3.70E+06	2.22E+10	5.18E-03	2.42E-02	8.73E-03	2.02E-01	8.20E-01	7.39E-01	7.69E-02	4.52E-03	4.15E-03	4.23E-02	1.63E+00

Tables 7.21 and 7.22 show the general operational guidelines in terms of stay time for subgroup D2-1 (residents accessing houses, outdoor exposure), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.21 General Operational Guidelines in Terms of Stay Time for Subgroup D2-1 (residents accessing houses, outdoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide Concentration				Stay Time (continuous exposure time in hours) to Receive 2000 mrem										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+00	1.00E+04	3.70E-02	2.22E+02	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+01	1.00E+05	3.70E-01	2.22E+03	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+02	1.00E+06	3.70E+00	2.22E+04	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+03	1.00E+07	3.70E+01	2.22E+05	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	5.01E+03	> 8760	> 8760	> 8760	> 8760
1.00E+04	1.00E+08	3.70E+02	2.22E+06	4.21E+01	9.52E+02	1.11E+02	2.12E+03	> 8760	> 8760	2.15E+02	3.54E+01	3.16E+01	5.41E+02	> 8760
1.00E+05	1.00E+09	3.70E+03	2.22E+07	3.66E+00	1.66E+01	6.17E+00	1.74E+02	5.65E+02	7.70E+02	1.78E+01	3.20E+00	2.93E+00	2.45E+01	7.31E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	3.66E-01	1.66E+00	6.17E-01	1.69E+01	5.16E+01	6.25E+01	1.78E+00	3.20E-01	2.93E-01	2.44E+00	5.73E+01
1.00E+07	1.00E+11	3.70E+05	2.22E+09	3.66E-02	1.66E-01	6.17E-02	1.69E+00	5.09E+00	6.15E+00	1.78E-01	3.20E-02	2.93E-02	2.44E-01	5.40E+00

TABLE 7.22 General Operational Guidelines in Terms of Stay Time for Subgroup D2-1 (residents accessing houses, outdoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide Concentration				Stay Time (h) for 2000 mrem										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+01	1.00E+05	3.70E-01	2.22E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+02	1.00E+06	3.70E+00	2.22E+04	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+03	1.00E+07	3.70E+01	2.22E+05	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	5.01E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+04	1.00E+08	3.70E+02	2.22E+06	4.21E+01	9.52E+02	1.11E+02	2.12E+03	>8.76E+00	>8.76E+00	2.15E+02	3.54E+01	3.16E+01	5.41E+02	>8.76E+00
1.00E+05	1.00E+09	3.70E+03	2.22E+07	3.66E+00	1.66E+01	6.17E+00	1.74E+02	5.65E+02	7.70E+02	1.78E+01	3.20E+00	2.93E+00	2.45E+01	7.31E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	3.66E-01	1.66E+00	6.17E-01	1.69E+01	5.16E+01	6.25E+01	1.78E+00	3.20E-01	2.93E-01	2.44E+00	5.73E+01
1.00E+07	1.00E+11	3.70E+05	2.22E+09	3.66E-02	1.66E-01	6.17E-02	1.69E+00	5.09E+00	6.15E+00	1.78E-01	3.20E-02	2.93E-02	2.44E-01	5.40E+00
1.00E+08	1.00E+12	3.70E+06	2.22E+10	3.66E-03	1.66E-02	6.17E-03	1.69E-01	5.09E-01	6.15E-01	1.78E-02	3.20E-03	2.93E-03	2.44E-02	5.40E-01

Tables 7.23 and 7.24 show the general operational guidelines in terms of stay time for subgroup D2-2 (residents accessing houses, indoor exposure), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. Essentially, the results from the two versions are consistent.

TABLE 7.23 General Operational Guidelines in Terms of Stay Time for Subgroup D2-2 (residents accessing houses, indoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide Concentration				Stay Time (continuous exposure time in hours) to Receive 2000 mrem										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+00	1.00E+04	3.70E-02	2.22E+02	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+01	1.00E+05	3.70E-01	2.22E+03	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+02	1.00E+06	3.70E+00	2.22E+04	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760	> 8760
1.00E+03	1.00E+07	3.70E+01	2.22E+05	8.07E+02	6.18E+03	1.49E+03	> 8760	> 8760	> 8760	> 8760	6.90E+02	6.25E+02	> 8760	> 8760
1.00E+04	1.00E+08	3.70E+02	2.22E+06	5.64E+01	3.36E+02	1.04E+02	2.50E+03	> 8760	> 8760	1.23E+03	4.79E+01	4.37E+01	5.87E+02	> 8760
1.00E+05	1.00E+09	3.70E+03	2.22E+07	5.18E+00	2.42E+01	8.73E+00	2.11E+02	9.27E+02	9.70E+02	8.51E+01	4.52E+00	4.15E+00	4.42E+01	2.57E+03
1.00E+06	1.00E+10	3.70E+04	2.22E+08	5.18E-01	2.42E+00	8.73E-01	2.07E+01	8.54E+01	7.68E+01	7.69E+00	4.52E-01	4.15E-01	4.24E+00	1.92E+02
1.00E+07	1.00E+11	3.70E+05	2.22E+09	5.18E-02	2.42E-01	8.73E-02	2.07E+00	8.42E+00	7.56E+00	7.69E-01	4.52E-02	4.15E-02	4.24E-01	1.67E+01

TABLE 7.24 General Operational Guidelines in Terms of Stay Time for Subgroup D2-2 (residents accessing houses, indoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide Concentration				Stay Time (h) for 2000 mrem										
pCi/cm ³	pCi/m ³	Bq/cm ³	dpm/100 cm ³	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+01	1.00E+05	3.70E-01	2.22E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+02	1.00E+06	3.70E+00	2.22E+04	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+03	1.00E+07	3.70E+01	2.22E+05	8.07E+02	6.18E+03	1.49E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	6.90E+02	6.25E+02	>8.76E+00	>8.76E+00
1.00E+04	1.00E+08	3.70E+02	2.22E+06	5.64E+01	3.36E+02	1.04E+02	2.50E+03	>8.76E+00	>8.76E+00	1.23E+03	4.79E+01	4.37E+01	5.87E+02	>8.76E+00
1.00E+05	1.00E+09	3.70E+03	2.22E+07	5.18E+00	2.42E+01	8.73E+00	2.11E+02	9.27E+02	9.70E+02	8.51E+01	4.52E+00	4.15E+00	4.42E+01	2.57E+03
1.00E+06	1.00E+10	3.70E+04	2.22E+08	5.18E-01	2.42E+00	8.73E-01	2.07E+01	8.54E+01	7.68E+01	7.69E+00	4.52E-01	4.15E-01	4.24E+00	1.92E+02
1.00E+07	1.00E+11	3.70E+05	2.22E+09	5.18E-02	2.42E-01	8.73E-02	2.07E+00	8.42E+00	7.56E+00	7.69E-01	4.52E-02	4.15E-02	4.24E-01	1.67E+01
1.00E+08	1.00E+12	3.70E+06	2.22E+10	5.18E-03	2.42E-02	8.73E-03	2.07E-01	8.42E-01	7.56E-01	7.69E-02	4.52E-03	4.15E-03	4.24E-02	1.67E+00

Tables 7.25 and 7.26 show the general operational guidelines for four selected exposure durations for subgroup D1-1 (workers accessing businesses, outdoor exposure), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.25 General Operational Guidelines for Four Exposure Durations for Subgroup D1-1 (workers accessing businesses, outdoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Surface Street Concentration pCi/m ²			
	4 Work Days	12 Work Days	4 Work Weeks	12 Work Weeks
Am-241	1.89E+08	1.25E+08	9.52E+07	6.70E+07
Cf-252	8.33E+08	5.11E+08	3.52E+08	2.09E+08
Cm-244	3.19E+08	2.11E+08	1.60E+08	1.13E+08
Co-60	5.36E+09	1.84E+09	8.22E+08	3.13E+08
Cs-137	1.64E+10	5.68E+09	2.55E+09	9.68E+08
Ir-192	1.97E+10	6.99E+09	3.35E+09	1.57E+09
Po-210	6.19E+08	2.31E+08	1.10E+08	4.81E+07
Pu-238	1.65E+08	1.09E+08	8.32E+07	5.86E+07
Pu-239	1.51E+08	1.00E+08	7.63E+07	5.37E+07
Ra-226	1.04E+09	4.80E+08	2.54E+08	1.09E+08
Sr-90	1.88E+10	6.98E+09	3.24E+09	1.25E+09

TABLE 7.26 General Operational Guidelines for Four Exposure Durations for Subgroup D1-1 (workers accessing businesses, outdoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Surface Street Concentration (pCi/m ²)			
	4 Work Days	12 Work Days	4 Work Weeks	12 Work Weeks
Am-241	1.89E+08	1.25E+08	9.52E+07	6.70E+07
Cf-252	8.33E+08	5.11E+08	3.52E+08	2.09E+08
Cm-244	3.19E+08	2.11E+08	1.60E+08	1.13E+08
Co-60	5.36E+09	1.84E+09	8.22E+08	3.13E+08
Cs-137	1.64E+10	5.68E+09	2.55E+09	9.68E+08
Ir-192	1.97E+10	6.99E+09	3.35E+09	1.57E+09
Po-210	6.19E+08	2.31E+08	1.10E+08	4.81E+07
Pu-238	1.65E+08	1.09E+08	8.32E+07	5.86E+07
Pu-239	1.51E+08	1.00E+08	7.63E+07	5.37E+07
Ra-226	1.04E+09	4.80E+08	2.54E+08	1.09E+08
Sr-90	1.88E+10	6.98E+09	3.24E+09	1.25E+09

Tables 7.27 and 7.28 show the general operational guidelines for four selected exposure durations for subgroup D1-2 (workers accessing businesses, indoor exposure), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.27 General Operational Guidelines for Four Selected Exposure Durations for Subgroup D1-2 (workers accessing businesses, indoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Surface Street Concentration pCi/m ²			
	4 Work Days	12 Work Days	4 Work Weeks	12 Work Week
Am-241	1.90E+08	7.40E+07	3.52E+07	1.39E+07
Cf-252	8.84E+08	3.43E+08	1.64E+08	6.56E+07
Cm-244	3.20E+08	1.25E+08	5.93E+07	2.34E+07
Co-60	6.37E+09	2.16E+09	9.59E+08	3.55E+08
Cs-137	2.60E+10	8.89E+09	3.95E+09	1.46E+09
Ir-192	2.36E+10	8.30E+09	3.93E+09	1.80E+09
Po-210	2.69E+09	1.01E+09	4.87E+08	2.13E+08
Pu-238	1.66E+08	6.46E+07	3.07E+07	1.21E+07
Pu-239	1.52E+08	5.92E+07	2.82E+07	1.11E+07
Ra-226	1.51E+09	5.68E+08	2.65E+08	1.03E+08
Sr-90	5.56E+10	2.01E+10	9.25E+09	3.56E+09

TABLE 7.28 General Operational Guidelines for Four Selected Exposure Durations for Subgroup D1-2 (workers accessing businesses, indoor exposure) Obtained with RESRAD-RDD Version 2.01

Surface Street Concentration (pCi/m ²)				
Radionuclide	4 Work Days	12 Work Days	4 Work Weeks	12 Work Weeks
Am-241	1.90E+08	7.40E+07	3.52E+07	1.39E+07
Cf-252	8.84E+08	3.43E+08	1.64E+08	6.56E+07
Cm-244	3.20E+08	1.25E+08	5.93E+07	2.34E+07
Co-60	6.37E+09	2.16E+09	9.59E+08	3.55E+08
Cs-137	2.60E+10	8.89E+09	3.95E+09	1.46E+09
Ir-192	2.36E+10	8.30E+09	3.93E+09	1.80E+09
Po-210	2.69E+09	1.01E+09	4.87E+08	2.12E+08
Pu-238	1.66E+08	6.46E+07	3.07E+07	1.21E+07
Pu-239	1.52E+08	5.92E+07	2.82E+07	1.11E+07
Ra-226	1.51E+09	5.68E+08	2.65E+08	1.03E+08
Sr-90	5.56E+10	2.01E+10	9.25E+09	3.56E+09

Tables 7.29 and 7.30 show the general operational guidelines for three exposure durations for subgroup D2-1 (residents accessing houses, outdoor exposure), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.29 General Operational Guidelines for Three Exposure Durations for Subgroup D2-1 (residents accessing houses, outdoor exposure) Obtained with RESRAD-RDD Version 1.7

Surface Street Concentration (pCi/m ²)			
Radionuclide	1 Day	4 Days	12 Days
Am-241	1.53E+08	6.31E+07	4.17E+07
Cf-252	6.94E+08	2.78E+08	1.70E+08
Cm-244	2.57E+08	1.06E+08	7.02E+07
Co-60	7.05E+09	1.79E+09	6.12E+08
Cs-137	2.12E+10	5.47E+09	1.89E+09
Ir-192	2.56E+10	6.58E+09	2.33E+09
Po-210	7.43E+08	2.06E+08	7.69E+07
Pu-238	1.33E+08	5.51E+07	3.64E+07
Pu-239	1.22E+08	5.05E+07	3.34E+07
Ra-226	1.02E+09	3.46E+08	1.60E+08
Sr-90	2.25E+10	6.28E+09	2.33E+09

TABLE 7.30 General Operational Guidelines for Three Exposure Durations for Subgroup D2-1 (residents accessing houses, outdoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Surface Street Concentration (pCi/m ²)		
	1 Day	4 Days	12 Days
Am-241	1.53E+08	6.31E+07	4.17E+07
Cf-252	6.94E+08	2.78E+08	1.70E+08
Cm-244	2.57E+08	1.06E+08	7.02E+07
Co-60	7.05E+09	1.79E+09	6.12E+08
Cs-137	2.12E+10	5.47E+09	1.89E+09
Ir-192	2.56E+10	6.58E+09	2.33E+09
Po-210	7.43E+08	2.06E+08	7.69E+07
Pu-238	1.33E+08	5.51E+07	3.64E+07
Pu-239	1.22E+08	5.05E+07	3.34E+07
Ra-226	1.02E+09	3.46E+08	1.60E+08
Sr-90	2.25E+10	6.28E+09	2.33E+09

Tables 7.31 and 7.32 show the general operational guidelines for three exposure durations for subgroup D2-2 (residents accessing houses, indoor exposure), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.31 General Operational Guidelines for Three Exposure Durations for Subgroup D2-2 (residents accessing houses, indoor exposure) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Surface Street Concentration (pCi/m ²)		
	1 Day	4 Days	12 Days
Am-241	2.16E+08	6.34E+07	2.47E+07
Cf-252	1.01E+09	2.95E+08	1.14E+08
Cm-244	3.64E+08	1.07E+08	4.16E+07
Co-60	8.62E+09	2.17E+09	7.37E+08
Cs-137	3.51E+10	8.91E+09	3.04E+09
Ir-192	3.15E+10	8.05E+09	2.83E+09
Po-210	3.20E+09	8.97E+08	3.38E+08
Pu-238	1.88E+08	5.53E+07	2.15E+07
Pu-239	1.73E+08	5.07E+07	1.97E+07
Ra-226	1.77E+09	5.03E+08	1.90E+08
Sr-90	6.94E+10	1.90E+10	6.88E+09

TABLE 7.32 General Operational Guidelines for Three Exposure Durations for Subgroup D2-2 (residents accessing houses, indoor exposure) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Surface Street Concentration (pCi/m ²)		
	1 Day	4 Days	12 Days
Am-241	2.16E+08	6.34E+07	2.47E+07
Cf-252	1.01E+09	2.95E+08	1.14E+08
Cm-244	3.64E+08	1.07E+08	4.16E+07
Co-60	8.62E+09	2.17E+09	7.37E+08
Cs-137	3.51E+10	8.91E+09	3.04E+09
Ir-192	3.15E+10	8.05E+09	2.83E+09
Po-210	3.20E+09	8.97E+08	3.38E+08
Pu-238	1.88E+08	5.53E+07	2.15E+07
Pu-239	1.73E+08	5.07E+07	1.97E+07
Ra-226	1.77E+09	5.04E+08	1.90E+08
Sr-90	6.94E+10	1.90E+10	6.88E+09

7.2 COMPARISON OF MEASUREMENT-BASED RESULTS

Input datasets seven and eight, as shown in Table 3.1, were used to obtain group D measurement-based guidelines for comparison. Input dataset seven used ICRP-30-based DCFs, while input dataset eight used ICRP-60-based DCFs. With either set of input data, RESRAD-RDD version 2.01 took a total of 0.15 s to finish calculations and generate reports, while version 1.7 took a total of about 7 s to accomplish the same tasks.

7.2.1 Results Based on ICRP-30 DCFs

The measurement data included in input dataset seven are ground surface concentrations of 4.50E+7 pCi/m² for Pu-238 and 1.00E+7 pCi/m² for Ra-226.

Tables 7.33 and 7.34 show the stay times based on measurement data for group D (temporary access to relocation areas for essential services), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.33 Group D Stay Times Based on Measurement Data (temporary access to relocation areas for essential services) Obtained with RESRAD-RDD Version 1.7

Stay Time (continuous exposure time in hours) Corresponding to PAG			
Scenario D1-1	Scenario D1-2	Scenario D2-1	Scenario D2-2
1.65E+01	3.95E+01	2.14E+01	3.95E+01

TABLE 7.34 Group D Stay Times Based on Measurement Data (temporary access to relocation areas for essential services) Obtained with RESRAD-RDD Version 2.01

Stay Time (h) for PAG D1 = 500 mrem		Stay Time (h) for PAG D2 = 500 mrem	
Scenario D1-1 ^a	Scenario D1-2 ^b	Scenario D2-1 ^c	Scenario D2-2 ^d
1.65E+01	3.95E+01	2.14E+01	3.95E+01

The figures that showed total dose versus stay time corresponding to the measured radionuclide concentrations as obtained with RESRAD-RDD version 1.7 and version 2.01 were also compared. Figures 1 and 2 show the results for workers accessing business locations. No discrepancy was found in the results.

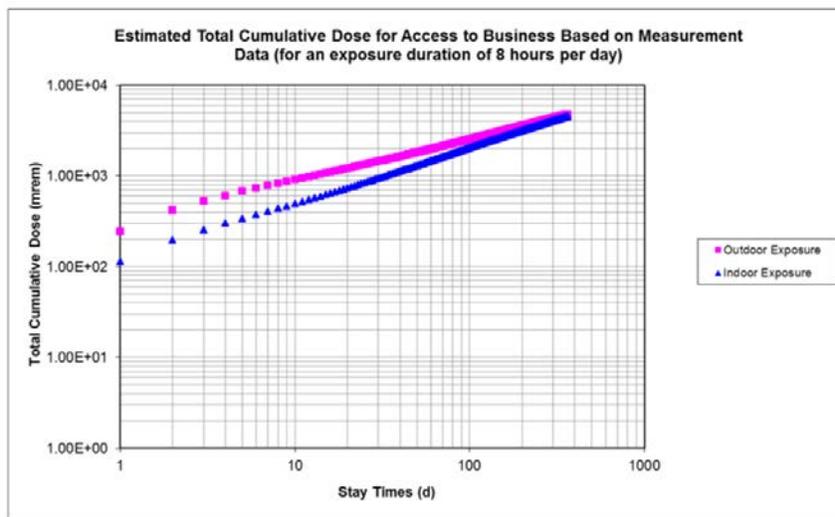


FIGURE 1 Total Dose versus Stay Times Based on Measured Radionuclide Concentrations (workers accessing business locations) Obtained with RESRAD-RDD Version 1.7

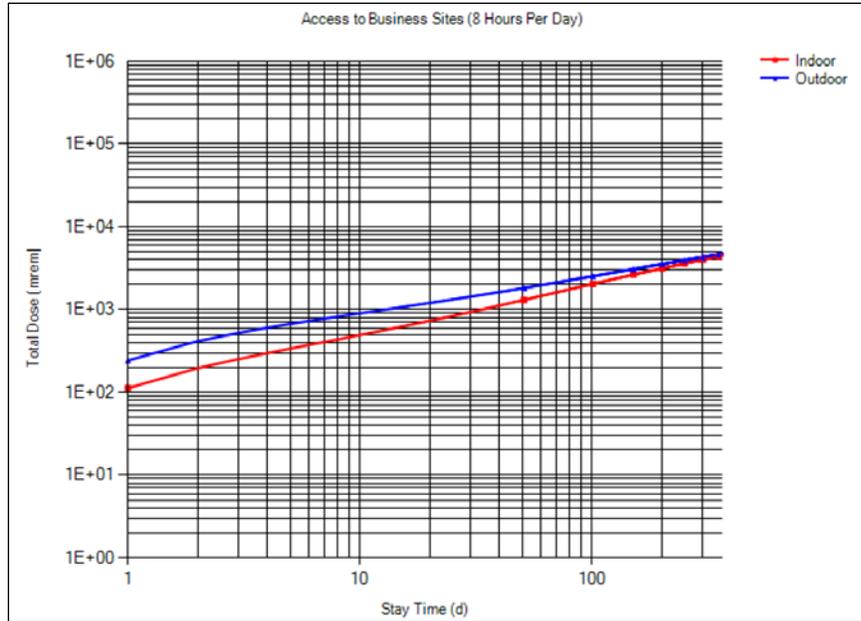


FIGURE 2 Total Dose versus Stay Times Based on Measured Radionuclide Concentrations (workers accessing business locations) Obtained with RESRAD-RDD Version 2.01

Figures 3 and 4 are the results for residents accessing residential sites. The results obtained with RESRAD-RDD version 1.7 and version 2.01 are consistent with each other.

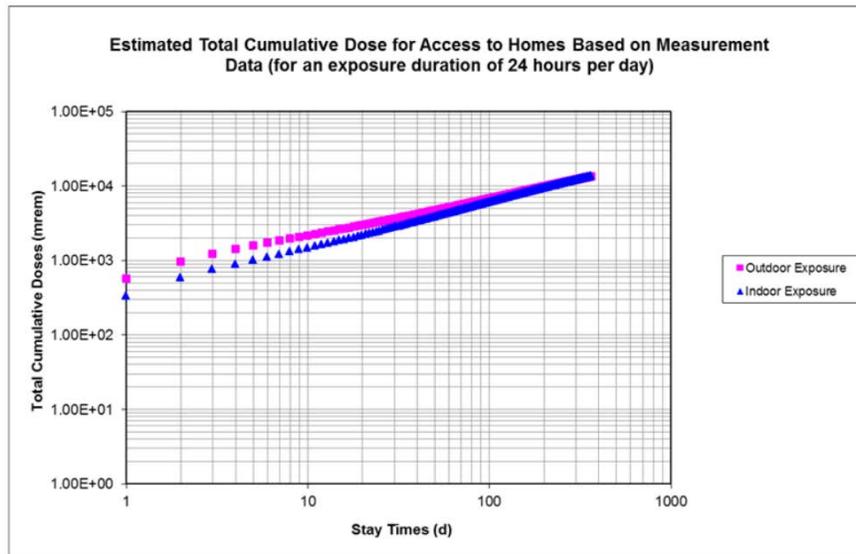


FIGURE 3 Total Dose versus Stay Times Based on Measured Radionuclide Concentrations (residents accessing residential sites) Obtained with RESRAD-RDD Version 1.7

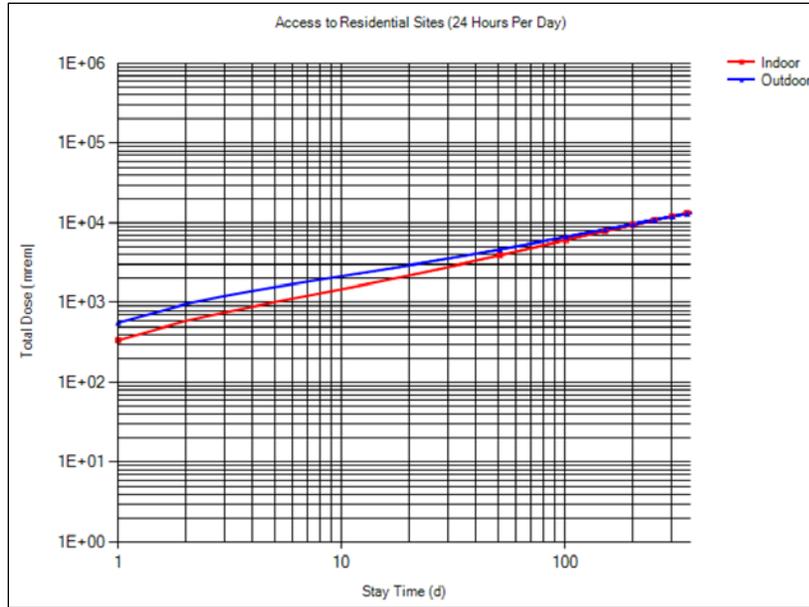


FIGURE 4 Total Dose versus Stay Times Based on Measured Radionuclide Concentrations (residents accessing residential sites) Obtained with RESRAD-RDD Version 2.01

7.2.2 Results Based on ICRP-60 DCFs

The measurement data included in input dataset eight are ground surface concentrations of $7.25E+8$ pCi/m² for Ir-192 and $9.50E+6$ pCi/m² for Po-210.

Tables 7.35 and 7.36 show the stay times based on measurement data for group D (temporary access to relocation areas for essential services), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 7.35 Group D Stay Times Based on Measurement Data (temporary access to relocation areas for essential services) Obtained with RESRAD-RDD Version 1.7

Stay Time (continuous exposure time in hours) Corresponding to PAG			
Scenario D1-1	Scenario D1-2	Scenario D2-1	Scenario D2-2
1.16E+02	3.31E+02	1.17E+02	3.51E+02

TABLE 7.36 Group D Stay Times Based on Measurement Data (temporary access to relocation areas for essential services) Obtained with RESRAD-RDD Version 2.01

Stay Time (h) for PAG D1 = 500 mrem		Stay Time (h) for PAG D2 = 500 mrem	
Scenario D1-1 ^a	Scenario D1-2 ^b	Scenario D2-1 ^c	Scenario D2-2 ^d
1.16E+02	3.31E+02	1.17E+02	3.51E+02

The figures that showed total dose versus stay time corresponding to the measured radionuclide concentrations as obtained with RESRAD-RDD version 1.7 and version 2.01 were also compared. Figures 5 and 6 are the results for workers accessing business locations. No discrepancy was found in the results.

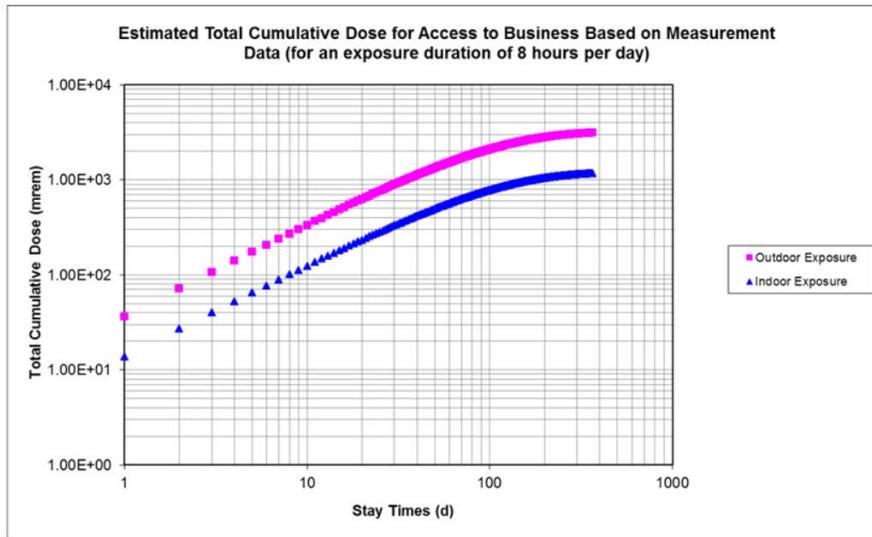


FIGURE 5 Total Dose versus Stay Times Based on Measured Radionuclide Concentrations (workers accessing business locations) Obtained with RESRAD-RDD Version 1.7

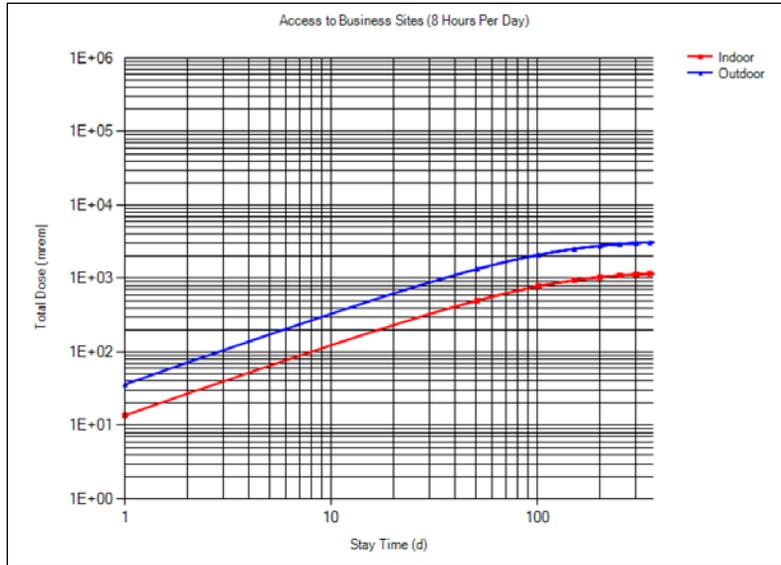


FIGURE 6 Total Dose versus Stay Times Based on Measured Radionuclide Concentrations (workers accessing business locations) Obtained with RESRAD-RDD Version 2.0

Figures 7 and 8 are the results for residents accessing residential sites. The results obtained with RESRAD-RDD version 1.7 and version 2.01 are consistent with each other.

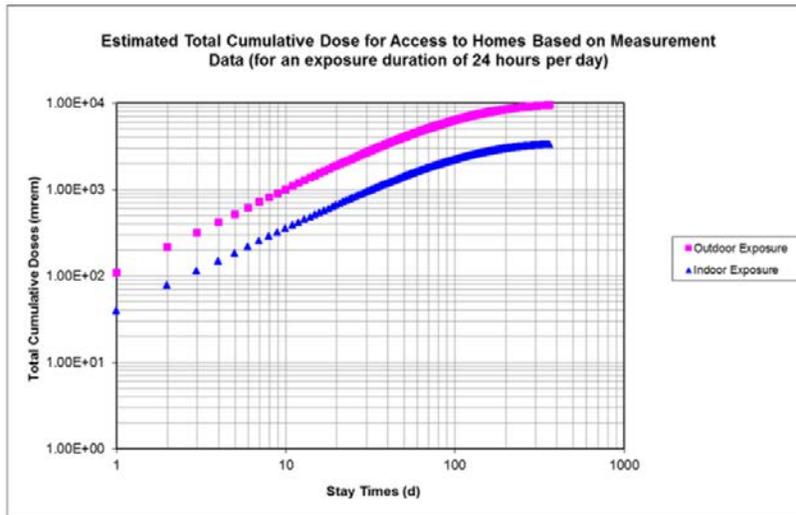


FIGURE 7 Total Dose versus Stay Times Based on Measured Radionuclide Concentrations (residents accessing residential sites) Obtained with RESRAD-RDD Version 1.7

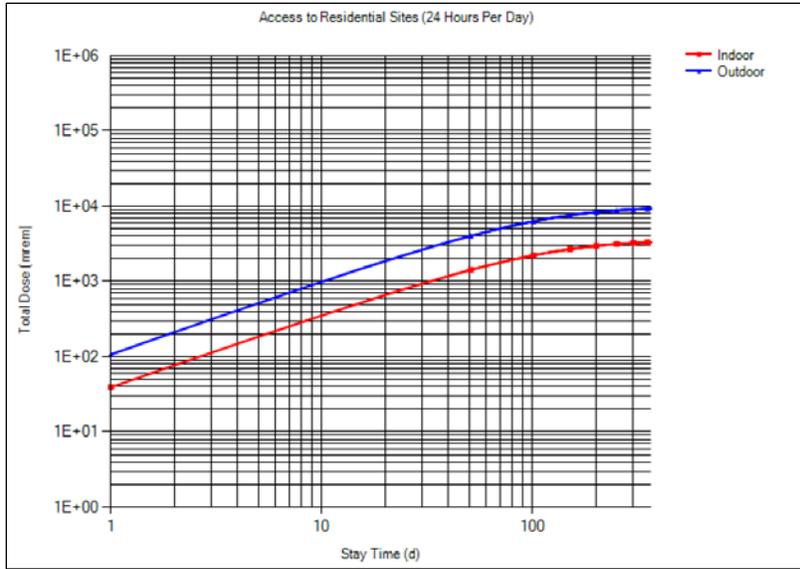


FIGURE 8 Total Dose versus Stay Times Based on Measured Radionuclide Concentrations (residents accessing residential sites) Obtained with RESRAD-RDD Version 2.01

8 RESULTS OF COMPARISON FOR GROUP E

The group E calculation results obtained with RESRAD-RDD version 1.7 and version 2.01 are compared in this chapter.

8.1 COMPARISON OF GENERAL GUIDELINES

Input datasets five and six, as shown in Table 3.1, were used to obtain group E general guidelines for comparison. Input dataset five used ICRP-30-based DCFs, while input dataset six used ICRP-60-based DCFs. With either set of input data, RESRAD-RDD version 2.01 took a total of 0.16 s to finish calculations and generate reports, while version 1.7 took a total of about 6 s to accomplish the same tasks.

8.1.1 Results Based on ICRP-30 DCFs

Tables 8.1 and 8.2 show the operational guidelines for subgroup E1 (initial bridge contamination), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 8.1 General Operational Guidelines for Subgroup E1 (initial bridge contamination) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Operational Guideline (pCi/m ²) for Initial Bridge Contamination following an RDD Event		
	Emergency workers	General public	
	First Year	First Year	After First Year
Am-241	4.02E+08	8.04E+09	9.82E+10
Cf-252	1.16E+09	2.32E+10	4.03E+11
Cm-244	7.22E+08	1.44E+10	1.87E+11
Co-60	3.30E+09	6.60E+10	3.68E+10
Cs-137	1.37E+10	2.75E+11	1.35E+11
Ir-192	2.58E+10	5.17E+11	9.33E+12
Po-210	2.12E+10	4.25E+11	5.39E+13
Pu-238	4.56E+08	9.11E+09	1.13E+11
Pu-239	4.16E+08	8.32E+09	1.02E+11
Ra-226	3.72E+09	7.44E+10	4.29E+10
Sr-90	1.25E+11	2.50E+12	1.04E+13
Cs-134	6.34E+09	1.27E+11	9.24E+10

TABLE 8.2 General Operational Guidelines for Subgroup E1 (initial bridge contamination) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Operational Guideline (pCi/m ²) for Initial Bridge Contamination Following an RDD Event		
	Emergency Workers	General Public	
	First Year	First Year	After First Year
Am-241	4.02E+08	8.04E+09	9.82E+10
Cf-252	1.16E+09	2.32E+10	4.03E+11
Cm-244	7.22E+08	1.44E+10	1.87E+11
Co-60	3.30E+09	6.60E+10	3.68E+10
Cs-137	1.37E+10	2.75E+11	1.35E+11
Ir-192	2.58E+10	5.17E+11	9.33E+12
Po-210	2.12E+10	4.25E+11	5.39E+13
Pu-238	4.56E+08	9.11E+09	1.13E+11
Pu-239	4.16E+08	8.32E+09	1.02E+11
Ra-226	3.72E+09	7.44E+10	4.29E+10
Sr-90	1.25E+11	2.50E+12	1.04E+13

Tables 8.3 and 8.4 show the operational guidelines for subgroup E2 (initial street contamination), based on ICRP-30 DCFS, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. No discrepancies were observed in the results.

TABLE 8.3 General Operational Guidelines for Subgroup E2 (initial street contamination) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Operational Guideline (pCi/m ²) for Initial Street Contamination following an RDD Event		
	Emergency workers	General public	
	First Year	First Year	After First Year
Am-241	4.02E+08	8.04E+09	9.88E+10
Cf-252	1.16E+09	2.32E+10	4.03E+11
Cm-244	7.22E+08	1.44E+10	1.87E+11
Co-60	4.54E+09	9.09E+10	7.12E+10
Cs-137	1.93E+10	3.86E+11	2.68E+11
Ir-192	3.42E+10	6.84E+11	1.85E+13
Po-210	2.12E+10	4.25E+11	5.40E+13
Pu-238	4.56E+08	9.11E+09	1.13E+11
Pu-239	4.16E+08	8.32E+09	1.02E+11
Ra-226	4.87E+09	9.73E+10	8.44E+10
Sr-90	1.28E+11	2.56E+12	1.58E+13
Cs-134	8.20E+09	1.64E+11	1.60E+11

TABLE 8.4 General Operational Guidelines for Subgroup E2 (initial street contamination) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Operational Guideline (pCi/m ²) for Initial Street Contamination Following an RDD Event		
	Emergency Workers	General Public	
	First Year	First Year	After First Year
Am-241	4.02E+08	8.04E+09	9.88E+10
Cf-252	1.16E+09	2.32E+10	4.03E+11
Cm-244	7.22E+08	1.44E+10	1.87E+11
Co-60	4.54E+09	9.09E+10	7.12E+10
Cs-137	1.93E+10	3.86E+11	2.68E+11
Ir-192	3.42E+10	6.84E+11	1.85E+13
Po-210	2.12E+10	4.25E+11	5.40E+13
Pu-238	4.56E+08	9.11E+09	1.13E+11
Pu-239	4.16E+08	8.32E+09	1.02E+11
Ra-226	4.87E+09	9.73E+10	8.44E+10
Sr-90	1.28E+11	2.56E+12	1.58E+13

8.1.2 Results Based on ICRP-60 DCFs

Tables 8.5 and 8.6 show the operational guidelines for subgroup E3 (initial bridge contamination), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. Essentially, the results from the two versions are consistent.

TABLE 8.5 General Operational Guidelines for Subgroup E3 (initial sidewalk/walkway contamination) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Operational Guideline (pCi/m ²) for Initial Sidewalks/Walkways Contamination following an RDD Event		
	Essential Service Worker	General Public	
	First Year	First Year	After First Year
Am-241	4.48E+07	5.60E+06	2.32E+07
Cf-252	2.03E+08	2.54E+07	8.72E+07
Cm-244	7.58E+07	9.47E+06	4.12E+07
Co-60	1.27E+09	1.59E+08	8.55E+07
Cs-137	3.74E+09	4.67E+08	2.29E+08
Ir-192	1.20E+10	1.51E+09	2.51E+10
Po-210	2.42E+08	3.02E+07	1.18E+08
Pu-238	3.91E+07	4.89E+06	2.05E+07
Pu-239	3.59E+07	4.48E+06	1.86E+07
Ra-226	2.40E+08	3.00E+07	2.64E+07
Sr-90	4.31E+09	5.39E+08	2.99E+08
Cs-134	1.83E+09	2.29E+08	1.52E+08

TABLE 8.6 General Operational Guidelines for Subgroup E3 (initial sidewalk/walkway contamination) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Operational Guideline (pCi/m ²) for Initial Sidewalks/Walkways Contamination Following an RDD Event		
	Essential Service Worker	General Public	
	First Year	First Year	After First Year
Am-241	4.48E+07	5.60E+06	2.32E+07
Cf-252	2.03E+08	2.54E+07	8.72E+07
Cm-244	7.58E+07	9.47E+06	4.12E+07
Co-60	1.28E+09	1.60E+08	8.56E+07
Cs-137	3.74E+09	4.67E+08	2.29E+08
Ir-192	1.20E+10	1.51E+09	2.51E+10
Po-210	2.42E+08	3.02E+07	1.18E+08
Pu-238	3.91E+07	4.89E+06	2.05E+07
Pu-239	3.59E+07	4.48E+06	1.86E+07
Ra-226	2.40E+08	3.00E+07	2.64E+07
Sr-90	4.31E+09	5.39E+08	2.99E+08

8.2 COMPARISON OF MEASUREMENT-BASED RESULTS

Input datasets seven and eight, as shown in Table 3.1, were used to obtain group E measurement-based guidelines for comparison. Input dataset seven used ICRP-30-based DCFs, while input dataset eight used ICRP-60-based DCFs. With either set of input data, RESRAD-RDD version 2.01 took a total of 0.05 s to finish calculations and generate reports, while version 1.7 took a total of about 14 s to accomplish the same tasks.

8.2.1 Results Based on ICRP-30 DCFs

The measurement data included in input dataset seven are ground surface concentrations of 4.50E+7 pCi/m² for Pu-238 and 1.00E+7 pCi/m² for Ra-226.

Tables 8.7 and 8.8 show the total doses based on measurement data for subgroup E3 (initial sidewalks/walkways contamination), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results calculated by both versions were the same.

TABLE 8.7 Measurement-Based Total Dose Results for Subgroup E3 (initial sidewalks/walkways contamination) Obtained with RESRAD-RDD Version 1.7

Group-Receptor No.	Group Description	Receptor Description	1st year dose (mrem/yr)	2nd year dose (mrem/yr)
E3-1	Sidewalks and Walkways	Essential service worker under restricted condition	3.37E+02	---
E3-2	Sidewalks and Walkways	Volunteer collecting donations near streets	3.37E+02	1.59E+02
E3-3	Sidewalks and Walkways	Vendor selling merchandise away from streets	2.70E+03	1.28E+03

TABLE 8.8 Measurement-Based Total Dose Results for Subgroup E3 (initial sidewalks/walkways contamination) Obtained with RESRAD-RDD Version 2.01

Group-Receptor No.	Group Description	Receptor Description	1st Year Dose (mrem/yr)	2nd Year Dose (mrem/yr)
E3-1	Sidewalks and Walkways	Essential Service Worker Under Restricted Condition	3.37E+02	---
E3-2	Sidewalks and Walkways	Volunteer Collecting Donations Near Streets	3.37E+02	1.59E+02
E3-3	Sidewalks and Walkways	Vendor Selling Merchandise Away from Streets	2.70E+03	1.28E+03

8.2.2 Results Based on ICRP-60 DCFs

The measurement data included in input dataset eight are ground surface concentrations of $7.25E+8$ pCi/m² for Ir-192 and $9.50E+6$ pCi/m² for Po-210.

Tables 8.9 and 8.10 show the total doses based on measurement data for subgroups E1 (initial bridge contamination) and E2 (initial street contamination), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results calculated by both versions were identical.

TABLE 8.9 Measurement-Based Total Dose Results for Subgroups E1 (initial bridge contamination) and E2 (initial street contamination) Obtained with RESRAD-RDD Version 1.7

Group-Receptor No.	Group Description	Receptor Description	1st year dose (mrem/yr)	2nd year dose (mrem/yr)
E1-1	Bridges	Occupational workers drive through bridges under restricted condition	3.11E+02	----
E1-2	Bridges	Public drive through bridges under unrestricted condition	8.07E+00	1.11E-01
E2-1	Streets and Thoroughfares	Occupational workers drive through streets under restricted condition	2.96E+02	----
E2-2	Streets and Thoroughfares	Public drive through streets under unrestricted condition	7.78E+00	1.03E-01

TABLE 8.10 Measurement-Based Total Dose Results for Subgroups E1 (initial bridge contamination) and E2 (initial street contamination) Obtained with RESRAD-RDD Version 2.01

Group-Receptor No.	Group Description	Receptor Description	1st Year Dose (mrem/yr)	2nd Year Dose (mrem/yr)
E1-1	Bridges	Occupational Workers Drive Through Bridges Under Restricted Conditions	3.11E+02	---
E1-2	Bridges	Public Drive Through Bridges Under Unrestricted Conditions	8.07E+00	1.11E-01
E2-1	Streets and Thoroughfares	Occupational Workers Drive Through Streets Under Restricted Conditions	2.96E+02	---
E2-2	Streets and Thoroughfares	Public Drive Through Streets Under Unrestricted Conditions	7.78E+00	1.03E-01

9 RESULTS OF COMPARISON FOR GROUP F

Group F is unique in RESRAD-RDD because the operational guidelines were precalculated using RESRAD (onsite) and RESRAD-BUILD; therefore, the only applicable input parameter is the selection of DCF library, ICRP-30-based or ICRP-60-based, used to retrieve the corresponding operational guidelines for viewing. The precalculated results for group F saved in RESRAD-RDD versions 1.7 and 2.01 were compared, and no discrepancies were found.

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10 RESULTS OF COMPARISON FOR GROUP G

The group G calculation results obtained with RESRAD-RDD version 1.7 and version 2.01 are compared in this chapter.

10.1 COMPARISON OF GENERAL GUIDELINES

Input datasets nine and ten, as shown in Table 3.1, were used to obtain group G general guidelines for comparison. Input dataset nine used ICRP-30-based DCFs, while input dataset ten used ICRP-60-based DCFs. With either set of input data, RESRAD-RDD version 2.01 took a total of 0.14 s to finish calculations and generate reports, while version 1.7 took a total of about 7 s to accomplish the same tasks.

10.1.1 Results Based on ICRP-30 DCFs

Tables 10.1 and 10.2 show the operational guidelines for subgroup G2 (surface soil operational guidelines for the early phase of response after an RDD event), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results were almost the same.

TABLE 10.1 General Operational Guidelines for Subgroup G2 (surface soil operational guidelines for the early phase of response after an RDD event) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Operational Guideline for Individual Food Category (pCi/m ²)		Final Operational Guideline (pCi/m ²)
	Vegetable	Milk	
Am-241	3.24E+02	1.51E+06	3.24E+02
Cf-252	2.43E+02	8.52E+05	2.43E+02
Cm-244	4.59E+02	1.61E+06	4.59E+02
Co-60	5.00E+04	1.75E+05	5.00E+04
Cs-137	9.45E+04	8.37E+04	8.37E+04
Ir-192	1.91E+05	6.74E+08	1.91E+05
Po-210	1.02E+02	2.11E+03	1.02E+02
Pu-238	3.98E+02	2.53E+06	3.98E+02
Pu-239	3.65E+02	2.32E+06	3.65E+02
Ra-226	1.35E+02	7.27E+02	1.35E+02
Sr-90	7.43E+03	1.86E+04	7.43E+03

TABLE 10.2 General Operational Guidelines for Subgroup G2 (surface soil operational guidelines for the early phase of response after an RDD event) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Operational Guidelines for Individual Food Category (pCi/m ²)		
	Vegetable	Milk	Final Operational Guidelines
Am-241	3.25E+02	1.52E+06	3.25E+02
Cf-252	2.43E+02	8.51E+05	2.43E+02
Cm-244	4.60E+02	1.61E+06	4.60E+02
Co-60	5.00E+04	1.75E+05	5.00E+04
Cs-137	9.45E+04	8.37E+04	8.37E+04
Ir-192	1.89E+05	6.62E+08	1.89E+05
Po-210	1.01E+02	2.08E+03	1.01E+02
Pu-238	3.98E+02	2.53E+06	3.98E+02
Pu-239	3.65E+02	2.32E+06	3.65E+02
Ra-226	1.35E+02	7.27E+02	1.35E+02
Sr-90	7.43E+03	1.86E+04	7.43E+03

Tables 10.3 and 10.4 show the operational guidelines for subgroup G3 (surface soil operational guidelines for the intermediate phase of response after an RDD event), based on ICRP-30 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results were almost the same.

TABLE 10.3 General Operational Guidelines for Subgroup G3 (surface soil operational guidelines for the intermediate phase of response after an RDD event) Obtained with RESRAD-RDD Version 1.7

Radionuclide	Operational Guideline for Individual Food Category (pCi/m ²)				Final Operational Guideline (pCi/m ²)
	Non-leafy Vegetable	Leafy Vegetable	Meat	Milk	
Am-241	7.11E+04	1.97E+04	2.38E+06	7.36E+07	1.97E+04
Cf-252	5.43E+04	1.50E+04	1.51E+06	1.48E+08	1.50E+04
Cm-244	1.01E+05	2.80E+04	8.45E+06	1.04E+08	2.80E+04
Co-60	1.03E+07	3.00E+06	9.15E+05	1.13E+07	9.15E+05
Cs-137	2.00E+07	5.70E+06	1.15E+06	5.34E+06	1.15E+06
Ir-192	5.10E+07	1.32E+07	4.03E+07	4.58E+10	1.32E+07
Po-210	2.52E+04	6.68E+03	8.08E+03	1.40E+05	6.68E+03
Pu-238	8.74E+04	2.43E+04	1.46E+06	1.81E+08	2.43E+04
Pu-239	8.00E+04	2.22E+04	1.34E+06	1.66E+08	2.22E+04
Ra-226	2.85E+04	8.14E+03	4.94E+04	6.10E+04	8.14E+03
Sr-90	1.26E+06	4.18E+05	3.30E+05	1.63E+06	3.30E+05

TABLE 10.4 Group G Operational Guidelines for Subgroup G3 (surface soil operational guidelines for the intermediate phase of response after an RDD event) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Operational Guidelines for Individual Food Category (pCi/m ²)				
	Non-Leafy Vegetable	Leafy Vegetable	Meat	Milk	Final Operational Guideline
Am-241	7.13E+04	1.98E+04	2.39E+06	7.39E+07	1.98E+04
Cf-252	5.43E+04	1.50E+04	1.51E+06	1.48E+08	1.50E+04
Cm-244	1.01E+05	2.81E+04	8.48E+06	1.05E+08	2.81E+04
Co-60	1.03E+07	3.00E+06	9.17E+05	1.13E+07	9.17E+05
Cs-137	2.00E+07	5.70E+06	1.16E+06	5.35E+06	1.16E+06
Ir-192	5.11E+07	1.32E+07	4.04E+07	4.59E+10	1.32E+07
Po-210	2.52E+04	6.69E+03	8.09E+03	1.41E+05	6.69E+03
Pu-238	8.73E+04	2.42E+04	1.46E+06	1.81E+08	2.42E+04
Pu-239	8.01E+04	2.22E+04	1.34E+06	1.66E+08	2.22E+04
Ra-226	2.85E+04	8.14E+03	4.95E+04	6.11E+04	8.14E+03
Sr-90	1.26E+06	4.19E+05	3.31E+05	1.63E+06	3.31E+05

10.1.2 Results Based on ICRP-60 DCFs

Tables 10.5 and 10.6 show the operational guidelines for subgroup G4 (surface soil operational guidelines for the late phase of response after an RDD event), based on ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results were almost the same; minor differences were caused by the different rounding methods used in Microsoft Excel and Visual Basic.NET.

TABLE 10.5 General Operational Guidelines for Subgroup G4 (surface soil operational guidelines for the late phase of response after an RDD event) Obtained with RESRAD-RDD Version 1.7

Radionuclides	Operational Guidelines for Individual Food Category (pCi/m ²)				Final Operational Guideline (all foods combined) (pCi/m ²)	Operational Guideline (leafy and non-leafy vegetable combined) (pCi/m ²)
	Non-leafy Vegetable	Leafy Vegetable	Meat	Milk		
Am-241	1.93E+09	2.90E+10	9.29E+12	2.61E+13	1.81E+09	1.81E+09
Cf-252	4.70E+09	7.11E+10	1.96E+13	1.74E+14	4.41E+09	4.41E+09
Cm-244	3.26E+09	4.90E+10	3.95E+13	4.43E+13	3.06E+09	3.06E+09
Co-60	2.73E+09	3.12E+10	1.48E+11	1.93E+11	2.43E+09	2.51E+09
Cs-137	1.34E+09	1.54E+10	4.47E+10	2.17E+10	1.13E+09	1.23E+09
Ir-192	5.98E+10	6.28E+11	3.08E+13	3.33E+15	5.45E+10	5.46E+10
Po-210	5.45E+08	8.51E+09	3.47E+10	5.25E+10	5.00E+08	5.12E+08
Pu-238	1.68E+09	2.53E+10	4.05E+12	4.55E+13	1.58E+09	1.58E+09
Pu-239	1.54E+09	2.32E+10	3.71E+12	4.17E+13	1.45E+09	1.45E+09
Ra-226	6.12E+07	7.07E+08	6.14E+10	7.96E+09	5.59E+07	5.63E+07
Sr-90	7.68E+07	8.78E+08	1.10E+10	5.89E+09	6.93E+07	7.06E+07

TABLE 10.6 General Operational Guidelines for Subgroup G4 (surface soil operational guidelines for the late phase of response after an RDD event) Obtained with RESRAD-RDD Version 2.01

Radionuclide	Operational Guidelines for Individual Food Category (pCi/m ²)					
	Non-Leafy Vegetable	Leafy Vegetable	Meat	Milk	All Foods	All Vegetables
Am-241	1.93E+09	2.90E+10	9.29E+12	2.61E+13	1.81E+09	1.81E+09
Cf-252	4.70E+09	7.11E+10	1.96E+13	1.74E+14	4.41E+09	4.41E+09
Cm-244	3.26E+09	4.90E+10	3.95E+13	4.43E+13	3.06E+09	3.06E+09
Co-60	2.73E+09	3.12E+10	1.48E+11	1.93E+11	2.43E+09	2.51E+09
Cs-137	1.34E+09	1.54E+10	4.47E+10	2.17E+10	1.13E+09	1.23E+09
Ir-192	6.00E+10	6.29E+11	3.10E+13	3.33E+15	5.47E+10	5.48E+10
Po-210	5.45E+08	8.51E+09	3.47E+10	5.25E+10	5.00E+08	5.12E+08
Pu-238	1.68E+09	2.53E+10	4.05E+12	4.55E+13	1.58E+09	1.58E+09
Pu-239	1.54E+09	2.32E+10	3.71E+12	4.17E+13	1.45E+09	1.45E+09
Ra-226	6.12E+07	7.07E+08	6.14E+10	7.96E+09	5.59E+07	5.63E+07
Sr-90	7.68E+07	8.78E+08	1.10E+10	5.89E+09	6.93E+07	7.06E+07

10.2 COMPARISON OF MEASUREMENT-BASED RESULTS

Input datasets eleven and twelve, as shown in Table 3.1, were used to obtain group G measurement-based guidelines for comparison. Input dataset eleven used ICRP-30-based DCFs, while input dataset twelve used ICRP-60-based DCFs. With either set of input data, RESRAD-RDD version 2.01 took a total of 0.07 s to finish calculations and generate reports, while version 1.7 took a total of about 6 s to accomplish the same tasks.

10.2.1 Results Based on ICRP-30 DCFs

Tables 10.7 and 10.8 show estimated radionuclide concentrations in different foods based on soil measurement data (6.75 pCi/m² for Sr-90) and ICRP-30 DCFs obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results for Sr-90 were almost identical.

TABLE 10.7 Group G Measurement-Based Results for Radionuclide Concentrations in Food Types Obtained with RESRAD-RDD Version 1.7

Radionuclides	PVs for Food (pCi/kg)	Estimated concentrations in plant food and livestock product									
		FRMAC methodology*		OGT methodology*				OGT methodology*			
		Vegetable (pCi/kg)	Milk (pCi/L)	Non-leafy vegetable (pCi/kg)**	Leafy vegetable (pCi/kg)**	Meat (pCi/kg)**	Milk (pCi/L)**	Non-leafy vegetable (pCi/kg)***	Leafy vegetable (pCi/kg)***	Meat (pCi/kg)***	Milk (pCi/L)***
Am-241	1.30E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cf-252	9.72E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cm-244	1.84E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	2.00E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	3.78E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ir-192	7.56E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Po-210	4.05E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-238	1.59E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239	1.46E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-226	5.40E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	2.97E+03	1.35E+07	4.72E+06	4.43E+04	4.53E+04	2.71E+04	5.55E+03	4.03E+04	4.07E+04	2.31E+04	4.74E+03

TABLE 10.8 Group G Measurement-Based Results for Radionuclide Concentrations in Food Types Obtained with RESRAD-RDD Version 2.01

Radionuclide	PVs for Food (pCi/kg)	Estimated Concentrations in Plant Food and Livestock Product									
		FRMAC Methodology*		OGT Methodology*				OGT Methodology*			
		Vegetable (pCi/kg)	Milk (pCi/L)	Non-Leafy Vegetable (pCi/kg)**	Leafy Vegetable (pCi/kg)**	Meat (pCi/kg)**	Milk (pCi/L)**	Non-Leafy Vegetable (pCi/kg)***	Leafy Vegetable (pCi/kg)***	Meat (pCi/kg)***	Milk (pCi/L)***
Sr-90	2.97E+03	1.35E+07	4.72E+06	4.43E+04	4.53E+04	2.72E+04	5.55E+03	4.03E+04	4.07E+04	2.32E+04	4.74E+03

Tables 10.9 and 10.10 show the total doses based on measurement data and ICRP-30 DCFs obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results from the two versions were identical.

TABLE 10.9 Group G Measurement-Based Dose Results for Different Food Types Obtained with RESRAD-RDD Version 1.7

Radionuclides	OGT methodology				Total (mrem/yr)
	Ingestion of non-leafy vegetable (mrem/yr)*	Ingestion of leafy vegetable (mrem/yr)*	Ingestion of meat (mrem/yr)*	Ingestion of milk (mrem/yr)*	
Am-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cf-252	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cm-244	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ir-192	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-226	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	9.85E+01	8.72E+00	2.23E+01	6.67E+00	1.36E+02
Sum	9.85E+01	8.72E+00	2.23E+01	6.67E+00	1.36E+02

TABLE 10.10 Group G Measurement-Based Dose Results for Different Food Types Obtained with RESRAD-RDD Version 2.01

Radionuclide(s)	OGT Methodology				Total (mrem/yr)*
	Ingestion of Non-Leafy Vegetable (mrem/yr)*	Ingestion of Leafy Vegetable (mrem/yr)*	Ingestion of Meat (mrem/yr)*	Ingestion of Milk (mrem/yr)*	
Sr-90	9.85E+01	8.72E+00	2.23E+01	6.67E+00	1.36E+02
Total	9.85E+01	8.72E+00	2.23E+01	6.67E+00	1.36E+02

10.2.2 Results Based on ICRP-60 DCFs

Tables 10.11 and 10.12 show radionuclide concentrations in food groups based on measurement data ($7.5E+7$ pCi/m² for Pu-239 and $1.0E+7$ pCi/m² for Po-210) and ICRP-60 DCFs obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results were almost the same.

TABLE 10.11 Group G Measurement-Based Results for Radionuclide Concentrations in Food Types Obtained with RESRAD-RDD Version 1.7

Radionuclides	PVs for Food (pCi/kg)	Estimated concentrations in plant food and livestock product									
		FRMAC methodology*		OGT methodology*				OGT methodology*			
		Vegetable (pCi/kg)	Milk (pCi/L)	Non-leafy vegetable (pCi/kg)**	Leafy vegetable (pCi/kg)**	Meat (pCi/kg)**	Milk (pCi/L)**	Non-leafy vegetable (pCi/kg)***	Leafy vegetable (pCi/kg)***	Meat (pCi/kg)***	Milk (pCi/L)***
Am-241	1.30E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CF-252	9.72E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cm-244	1.84E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	2.00E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	3.78E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ir-192	7.56E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Po-210	4.05E+01	1.99E+06	8.42E+04	2.14E+05	1.58E+05	5.26E+04	3.18E+03	4.22E+04	4.33E+04	5.56E+03	3.36E+02
Pu-238	1.59E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239	1.46E+02	1.50E+07	2.06E+03	1.76E+06	1.32E+06	9.00E+03	7.28E+01	3.95E+05	4.05E+05	1.11E+03	9.00E+00
Ra-226	5.40E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	2.97E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

TABLE 10.12 Group G Measurement-Based Results for Radionuclide Concentrations in Food Types Obtained with RESRAD-RDD Version 2.01

Radionuclide	PVs for Food (pCi/kg)	Estimated Concentrations in Plant Food and Livestock Product									
		FRMAC Methodology*		OGT Methodology*				OGT Methodology*			
		Vegetable (pCi/kg)	Milk (pCi/L)	Non-Leafy Vegetable (pCi/kg)**	Leafy Vegetable (pCi/kg)**	Meat (pCi/kg)**	Milk (pCi/L)**	Non-Leafy Vegetable (pCi/kg)***	Leafy Vegetable (pCi/kg)***	Meat (pCi/kg)***	Milk (pCi/L)***
Po-210	4.05E+01	2.00E+06	8.50E+04	2.14E+05	1.58E+05	5.25E+04	3.18E+03	4.22E+04	4.33E+04	5.56E+03	3.36E+02
Pu-239	1.46E+02	1.50E+07	2.06E+03	1.76E+06	1.32E+06	8.99E+03	7.27E+01	3.95E+05	4.05E+05	1.11E+03	9.00E+00

Tables 10.13 and 10.14 show the total doses, based on measurement data and ICRP-60 DCFs, obtained with RESRAD-RDD version 1.7 and version 2.01, respectively. The results from the two versions were identical.

TABLE 10.13 Group G Measurement-Based Dose Results for Different Food Types Obtained with RESRAD-RDD Version 1.7

Radionuclides	OGT methodology				Total (mrem/yr)
	Ingestion of non-leafy vegetable (mrem/yr)*	Ingestion of leafy vegetable (mrem/yr)*	Ingestion of meat (mrem/yr)*	Ingestion of milk (mrem/yr)*	
Am-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cf-252	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cm-244	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ir-192	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Po-210	7.49E+03	6.73E+02	3.89E+02	3.44E+01	8.59E+03
Pu-238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239	1.46E+04	1.31E+03	1.62E+01	1.92E-01	1.59E+04
Ra-226	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sum	2.21E+04	1.99E+03	4.05E+02	3.46E+01	2.45E+04

TABLE 10.14 Group G Measurement-Based Dose Results for Different Food Types Obtained with RESRAD-RDD Version 2.01

Radionuclide(s)	OGT Methodology				Total (mrem/yr)
	Ingestion of Non-Leafy Vegetable (mrem/yr)*	Ingestion of Leafy Vegetable (mrem/yr)*	Ingestion of Meat (mrem/yr)*	Ingestion of Milk (mrem/yr)*	
Po-210	7.49E+03	6.73E+02	3.89E+02	3.44E+01	8.59E+03
Pu-239	1.46E+04	1.31E+03	1.62E+01	1.92E-01	1.59E+04
Total	2.21E+04	1.99E+03	4.05E+02	3.46E+01	2.45E+04

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11 COMPARISONS OF RESULTS IN DIFFERENT UNITS GENERATED BY RESRAD-RDD VERSION 2.01

All results generated by RESRAD-RDD version 1.7 are in traditional units, that is, mrem for total doses and pCi/m² for surface contamination operational guidelines. In addition to traditional units, RESRAD-RDD version 2.01 would generate results in SI units, that is, Sv or Bq/m², if the SI units are preferred by users.

The verification of calculation results in SI units was performed by using the input datasets in Table 3.1 to generate calculation results, with the check box for “SI units in Report” checked. The results in SI units were then compared with those in traditional units (as presented in Chapters 4–10) to determine whether they are correlated by a constant factor, for example, 100 (for 1 mSv = 100 mrem) or 27.027 (for 1 Bq = 27.027 pCi). A few examples of the comparison are presented in the following sections. The comparison shows that the results in SI units are correctly correlated to the results in traditional units for all the operational guideline groups.

11.1 COMPARISON OF GROUP A RESULTS

Tables 11.1 (same as Table 4.2) and 11.2 were obtained with input dataset one. They show group A operational guidelines without respirators based on gross alpha surface measurement, in traditional units and SI units, respectively. The results are identical because the operational guidelines are stay time in hours.

TABLE 11.1 Group A General Guidelines without Respirators Based on Gross Alpha Surface Measurement in the Traditional Unit

Activity per Unit Area			Stay Time ¹ for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
10	0.37	2,200	2.67E+1	1.34E+2	2.67E+2	5.35E+2	1.34E+3	2.67E+3	6.68E+3	>8.76E+3
100	3.7	22,000	2.67E+0	1.34E+1	2.67E+1	5.35E+1	1.34E+2	2.67E+2	6.68E+2	2.67E+3
1,000	37	220,000	2.67E-1	1.34E+0	2.67E+0	5.35E+0	1.34E+1	2.67E+1	6.68E+1	2.67E+2
10,000	370	2,200,000	2.67E-2	1.34E-1	2.67E-1	5.35E-1	1.34E+0	2.67E+0	6.68E+0	2.67E+1
100,000	3,700	22,000,000	2.67E-3	1.34E-2	2.67E-2	5.35E-2	1.34E-1	2.67E-1	6.68E-1	2.67E+0
1,000,000	37,000	220,000,000	2.67E-4	1.34E-3	2.67E-3	5.35E-3	1.34E-2	2.67E-2	6.68E-2	2.67E-1
10,000,000	370,000	2,200,000,000	2.67E-5	1.34E-4	2.67E-4	5.35E-4	1.34E-3	2.67E-3	6.68E-3	2.67E-2

TABLE 11.2 Group A General Guidelines without Respirators Based on Gross Alpha Surface Measurement in the SI Unit

Activity per Unit Area			Stay Time ¹ for Given Dose, h							
pCi/cm ²	Bq/cm ²	dpm/100cm ²	0.001 Sv	0.005 Sv	0.01 Sv	0.02 Sv	0.05 Sv	0.1 Sv	0.25 Sv	1 Sv
10	0.37	2,200	2.67E+01	1.34E+02	2.67E+02	5.35E+02	1.34E+03	2.67E+03	6.68E+03	>8.76E+03
100	3.7	22,000	2.67E+00	1.34E+01	2.67E+01	5.35E+01	1.34E+02	2.67E+02	6.68E+02	2.67E+03
1,000	37	220,000	2.67E-01	1.34E+00	2.67E+00	5.35E+00	1.34E+01	2.67E+01	6.68E+01	2.67E+02
10,000	370	2,200,000	2.67E-02	1.34E-01	2.67E-01	5.35E-01	1.34E+00	2.67E+00	6.68E+00	2.67E+01
100,000	3,700	22,000,000	2.67E-03	1.34E-02	2.67E-02	5.35E-02	1.34E-01	2.67E-01	6.68E-01	2.67E+00
1,000,000	37,000	220,000,000	2.67E-04	1.34E-03	2.67E-03	5.35E-03	1.34E-02	2.67E-02	6.68E-02	2.67E-01
10,000,000	370,000	2,200,000,000	2.67E-05	1.34E-04	2.67E-04	5.35E-04	1.34E-03	2.67E-03	6.68E-03	2.67E-02
100,000,000	3,700,000	22,000,000,000	2.67E-06	1.34E-05	2.67E-05	5.35E-05	1.34E-04	2.67E-04	6.68E-04	2.67E-03

Tables 11.3 (same as Table 4.68) and 11.4 were obtained with input dataset four. They show the group A measurement-based stay time results without a respirator, in traditional units and SI units, respectively. The results are identical because the operational guidelines are stay time in hours.

TABLE 11.3 Group A Measurement-Based Stay Time Results without a Respirator in the Traditional Unit

Exposure Rate		Stay Time for Given Dose, h							
microR/h	mR/h	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem
3.75E+01	3.75E-02	4.02E-03	2.01E-02	4.02E-02	8.04E-02	2.01E-01	4.02E-01	1.01E+00	4.02E+00

TABLE 11.4 Group A Measurement-Based Stay Time Results without a Respirator in the SI Unit

Exposure Rate		Stay Time for Given Dose, h							
microR/h	mR/h	0.001 Sv	0.005 Sv	0.01 Sv	0.02 Sv	0.05 Sv	0.1 Sv	0.25 Sv	1 Sv
3.75E+01	3.75E-02	4.02E-03	2.01E-02	4.02E-02	8.04E-02	2.01E-01	4.02E-01	1.01E+00	4.02E+00

11.2 COMPARISON OF GROUP B RESULTS

Table 11.5 was obtained with input dataset five and shows the group B operational guidelines in the SI unit (Bq/m²) based on the FRMAC methodology; the operational guidelines in the traditional unit (pCi/m²) are presented in Table 5.2. To verify that unit conversion is performed correctly, the results in Table 5.2 were transferred to a worksheet, divided by 27.027 (pCi/Bq), and then compared with those in Table 11.5. Table 11.6 shows the division results, which are almost the same as those in Table 11.5.

TABLE 11.5 Group B General Operational Guidelines Results Based on FRMAC Methodology for Early Phase of Response Obtained with RESRAD-RDD Version 2.01

Radionuclide	Receptor Spending 100% Time Indoors	Receptor Spending Some Time Outdoors	Receptor Spending 100% Time Outdoors
	Protective Action Guide (PAG) = 10 mSv		
Am-241	5.19E+06	1.93E+06	8.20E+05
Cf-252	1.47E+07	5.57E+06	2.38E+06
Cm-244	9.30E+06	3.46E+06	1.47E+06
Co-60	1.22E+08	5.25E+07	2.36E+07
Cs-137	5.18E+08	1.92E+08	8.16E+07
Ir-192	3.65E+08	1.59E+08	7.15E+07
Po-210	2.47E+08	2.47E+07	8.39E+06
Pu-238	5.89E+06	2.19E+06	9.29E+05
Pu-239	5.38E+06	2.00E+06	8.48E+05
Ra-226	1.06E+08	2.29E+07	8.50E+06
Sr-90	1.70E+09	2.56E+08	9.03E+07

TABLE 11.6 Worksheet Results Obtained by Dividing the Results Shown in Table 5.2 by 27.027 (pCi/Bq)

Am-241	5.18E+06	1.93E+06	8.21E+05
Cf-252	1.47E+07	5.59E+06	2.38E+06
Cm-244	9.29E+06	3.46E+06	1.47E+06
Co-60	1.22E+08	5.25E+07	2.36E+07
Cs-137	5.18E+08	1.92E+08	8.18E+07
Ir-192	3.66E+08	1.59E+08	7.14E+07
Po-210	2.47E+08	2.47E+07	8.40E+06
Pu-238	5.88E+06	2.19E+06	9.29E+05
Pu-239	5.37E+06	2.00E+06	8.47E+05
Ra-226	1.05E+08	2.29E+07	8.51E+06
Sr-90	1.70E+09	2.56E+08	9.03E+07

Table 11.7 was obtained with input dataset eight and shows the group B measurement-based dose results in the SI unit (mSv) based on the OGT methodology. Table 11.8 (same as Table 5.7) shows the dose results in the traditional unit (mrem). Clearly, the results in Table 11.8 are 100 times those in Table 11.7, demonstrating that unit conversion was performed correctly by RESRAD-RDD version 2.01.

TABLE 11.7 Group B Measurement-Based Dose Results Based on OGT Methodology for Early Phase of Response in the SI Unit

Group-Receptor No.	Group Description	Receptor Description	Total Dose (mSv)
B2-1	Evacuation - OGT Method	Receptor Spending 100% Time Indoors	1.73E+00
B2-2	Evacuation - OGT Method	Receptor Spending Time Working Outdoors	2.82E+00
B2-3	Evacuation - OGT Method	Receptor Spending 100% Time Outdoors	5.18E+00

TABLE 11.8 Group B Measurement-Based Dose Results (mrem) Based on OGT Methodology for Early Phase of Response in the Traditional Unit (same as Table 5.7)

Group-Receptor No.	Group Description	Receptor Description	Total Dose (mrem)
B2-1	Evacuation - OGT Method	Receptor Spending 100% Time Indoors	1.73E+2
B2-2	Evacuation - OGT Method	Receptor Spending Time Working Outdoors	2.82E+2
B2-3	Evacuation - OGT Method	Receptor Spending 100% Time Outdoors	5.18E+2

11.3 COMPARISON OF GROUP C RESULTS

Table 11.9 was obtained with input dataset eight and shows the group C measurement-based dose results in SI units (mSv/yr). Table 11.10 (same as Tables 6-14, 6-16, and 6-18 combined) shows the dose results in traditional units (mrem/yr). Clearly, the results in Table 11.10 are 100 times the results in Table 11.9; this demonstrating that unit conversion was correctly performed by RESRAD-RDD version 2.01.

TABLE 11.9 Total Doses Based on Measurement Data for Subgroups C4–C7 (utilization of critical facilities) in the SI Unit

Group	Group Description	Receptor Description	Total Dose (mSv/yr)
C4-1 ^a	Hospital and Other Health Care Facilities	Hospital Outdoor Worker	1.94E+01
C4-2 ^a	Hospital and Other Health Care Facilities	Hospital Indoor Worker	7.33E+00
C4-3 ^a	Hospital and Other Health Care Facilities	Patient Staying in Hospital	5.41E+00
C5-1	Critical Transport Facilities	Ticket Clerk Staying Inside	8.67E+00
C5-2	Critical Transport Facilities	Baggage Handler Staying Outside	2.21E+01
C5-3	Critical Transport Facilities	Passenger Staying Inside	2.34E+00
C5-4	Critical Transport Facilities	Passenger Staying Both Outside and Inside	2.56E+00
C6-1	Water and Sewer Facilities	Facility Outdoor Worker	3.09E+01
C6-2	Water and Sewer Facilities	Facility Indoor Worker	1.17E+01
C6-3	Water and Sewer Facilities	Contractor Works Indoors	2.92E+00
C6-4	Water and Sewer Facilities	Contractor Works Outdoors	7.72E+00
C7-1	Power and Fuel Facilities	Facility Outdoor Worker	3.09E+01
C7-2	Power and Fuel Facilities	Facility Indoor Worker	1.17E+01
C7-3	Power and Fuel Facilities	Contractor Works Indoors	2.92E+00
C7-4	Power and Fuel Facilities	Contractor Works Outdoors	7.72E+00

TABLE 11.10 Total Doses Based on Measurement Data for Subgroups C4–C7 (utilization of critical facilities) in the Traditional Unit (same as Tables 6-14, 6-16, and 6-18 combined)

Group	Group Description	Receptor Description	Total Dose (mrem/yr)
C4-1 ^a	Hospital and Other Health Care Facilities	Hospital Outdoor Worker	1.94E+03
C4-2 ^a	Hospital and Other Health Care Facilities	Hospital Indoor Worker	7.33E+02
C4-3 ^a	Hospital and Other Health Care Facilities	Patient Staying in Hospital	5.41E+02
C6-1	Water and Sewer Facilities	Facility Outdoor Worker	3.09E+03
C6-2	Water and Sewer Facilities	Facility Indoor Worker	1.17E+03
C6-3	Water and Sewer Facilities	Contractor Works Indoors	2.92E+02
C6-4	Water and Sewer Facilities	Contractor Works Outdoors	7.72E+02
C7-1	Power and Fuel Facilities	Facility Outdoor Worker	3.09E+03
C7-2	Power and Fuel Facilities	Facility Indoor Worker	1.17E+03
C7-3	Power and Fuel Facilities	Contractor Works Indoors	2.92E+02
C7-4	Power and Fuel Facilities	Contractor Works Outdoors	7.72E+02

11.4 COMPARISON OF GROUP D RESULTS

Tables 11.11 and 11.12 (same as Table 7.6) were obtained with input dataset five. They show the general guidelines for subgroup D2-1, corresponding to a PAG expressed in the SI unit

TABLE 11.11 General Guidelines in Terms of Stay Time for Subgroup D2-1 (residents accessing houses, outdoor exposure) in the SI Unit

Radionuclide Concentration				Stay Time (h) for 5 mSv										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+01	1.00E+05	3.70E-01	2.22E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+02	1.00E+06	3.70E+00	2.22E+04	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+03	1.00E+07	3.70E+01	2.22E+05	1.21E+02	1.36E+03	4.33E+02	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	2.03E+03	1.59E+02	1.30E+02	1.78E+03
1.00E+04	1.00E+08	3.70E+02	2.22E+06	6.79E+00	1.95E+01	1.22E+01	4.37E+02	1.66E+03	2.36E+03	1.13E+02	7.70E+00	7.03E+00	1.22E+02	2.05E+03
1.00E+05	1.00E+09	3.70E+03	2.22E+07	6.79E-01	1.95E+00	1.22E+00	4.04E+01	1.33E+02	1.22E+02	9.66E+00	7.70E-01	7.03E-01	1.05E+01	1.24E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	6.79E-02	1.95E-01	1.22E-01	4.01E+00	1.30E+01	1.18E+01	9.66E-01	7.70E-02	7.03E-02	1.05E+00	9.93E+00
1.00E+07	1.00E+11	3.70E+05	2.22E+09	6.79E-03	1.95E-02	1.22E-02	4.01E-01	1.30E+00	1.18E+00	9.66E-02	7.70E-03	7.03E-03	1.05E-01	9.93E-01
1.00E+08	1.00E+12	3.70E+06	2.22E+10	6.79E-04	1.95E-03	1.22E-03	4.01E-02	1.30E-01	1.18E-01	9.66E-03	7.70E-04	7.03E-04	1.05E-02	9.93E-02

TABLE 11.12 General Guidelines in Terms of Stay Time for Subgroup D2-1 (residents accessing houses, outdoor exposure) in the Traditional Unit

Radionuclide Concentration				Stay Time (h) for 500 mrem										
pCi/cm ²	pCi/m ²	Bq/cm ²	dpm/100 cm ²	Am-241	Cf-252	Cm-244	Co-60	Cs-137	Ir-192	Po-210	Pu-238	Pu-239	Ra-226	Sr-90
1.00E+01	1.00E+05	3.70E-01	2.22E+03	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+02	1.00E+06	3.70E+00	2.22E+04	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00	>8.76E+00
1.00E+03	1.00E+07	3.70E+01	2.22E+05	1.21E+02	1.36E+03	4.33E+02	>8.76E+00	>8.76E+00	>8.76E+00	2.03E+03	1.59E+02	1.30E+02	1.78E+03	>8.76E+00
1.00E+04	1.00E+08	3.70E+02	2.22E+06	6.79E+00	1.95E+01	1.22E+01	4.37E+02	1.66E+03	2.36E+03	1.13E+02	7.70E+00	7.03E+00	1.22E+02	2.05E+03
1.00E+05	1.00E+09	3.70E+03	2.22E+07	6.79E-01	1.95E+00	1.22E+00	4.04E+01	1.33E+02	1.22E+02	9.66E+00	7.70E-01	7.03E-01	1.05E+01	1.24E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	6.79E-02	1.95E-01	1.22E-01	4.01E+00	1.30E+01	1.18E+01	9.66E-01	7.70E-02	7.03E-02	1.05E+00	9.93E+00
1.00E+07	1.00E+11	3.70E+05	2.22E+09	6.79E-03	1.95E-02	1.22E-02	4.01E-01	1.30E+00	1.18E+00	9.66E-02	7.70E-03	7.03E-03	1.05E-01	9.93E-01
1.00E+08	1.00E+12	3.70E+06	2.22E+10	6.79E-04	1.95E-03	1.22E-03	4.01E-02	1.30E-01	1.18E-01	9.66E-03	7.70E-04	7.03E-04	1.05E-02	9.93E-02

and the traditional unit, respectively. The results are identical because the operational guidelines are stay time in hours.

Tables 11.13 and 11.14 (same as Table 7.36) were obtained with input dataset eight. They show the calculated stay times-based measurement data (7.25E+8 pCi/m² for Ir-192 and 9.50E+6 pCi/m² for Po-210) for group D, corresponding to a PAG expressed in the SI unit and the traditional unit, respectively. The results are identical because the operational guidelines are stay times in hours.

TABLE 11.13 Group D Stay Times Based on Measurement Data (temporary access to relocation areas for essential services) in the SI Unit

Stay Time (h) for PAG D1 = 5 mSv		Stay Time (h) for PAG D2 = 5 mSv	
Scenario D1-1 ^a	Scenario D1-2 ^b	Scenario D2-1 ^c	Scenario D2-2 ^d
1.16E+02	3.31E+02	1.17E+02	3.51E+02

TABLE 11.14 Group D Stay Times Based on Measurement Data (temporary access to relocation areas for essential services) in the Traditional Unit

Stay Time (h) for PAG D1 = 500 mrem		Stay Time (h) for PAG D2 = 500 mrem	
Scenario D1-1 ^a	Scenario D1-2 ^b	Scenario D2-1 ^c	Scenario D2-2 ^d
1.16E+02	3.31E+02	1.17E+02	3.51E+02

11.5 COMPARISON OF GROUP E RESULTS

Table 11.15 was obtained with input dataset five and shows the subgroup E1 operational guidelines in the SI unit (Bq/m^2); the operational guidelines in the traditional unit (pCi/m^2) are presented in Table 8.2. To verify that unit conversion is correctly performed, the results in Table 8.2 were transferred to a worksheet, divided by 27.027 (pCi/Bq), and then compared with those in Table 11.15. Table 11.16 shows the division results, which are almost the same as those in Table 11.15.

TABLE 11.15 General Operational Guidelines for Subgroup E1 (initial bridge contamination) in the SI Unit

Radionuclide	Operational Guideline (Bq/m^2) for Initial Bridge Contamination Following an RDD Event		
	Emergency Workers	General Public	
	First Year	First Year	After First Year
Am-241	1.49E+07	2.97E+08	3.63E+09
Cf-252	4.29E+07	8.58E+08	1.49E+10
Cm-244	2.67E+07	5.34E+08	6.90E+09
Co-60	1.22E+08	2.44E+09	1.36E+09
Cs-137	5.08E+08	1.02E+10	4.98E+09
Ir-192	9.56E+08	1.91E+10	3.45E+11
Po-210	7.86E+08	1.57E+10	2.00E+12
Pu-238	1.69E+07	3.37E+08	4.19E+09
Pu-239	1.54E+07	3.08E+08	3.78E+09
Ra-226	1.38E+08	2.75E+09	1.59E+09
Sr-90	4.63E+09	9.26E+10	3.84E+11

TABLE 11.16 Worksheet Results Obtained by Dividing the Results Shown in Table 8.2 by 27.027 (pCi/Bq)

Am-241	1.49E+07	2.97E+08	3.63E+09
Cf-252	4.29E+07	8.58E+08	1.49E+10
Cm-244	2.67E+07	5.33E+08	6.92E+09
Co-60	1.22E+08	2.44E+09	1.36E+09
Cs-137	5.07E+08	1.02E+10	5.00E+09
Ir-192	9.55E+08	1.91E+10	3.45E+11
Po-210	7.84E+08	1.57E+10	1.99E+12
Pu-238	1.69E+07	3.37E+08	4.18E+09
Pu-239	1.54E+07	3.08E+08	3.77E+09
Ra-226	1.38E+08	2.75E+09	1.59E+09
Sr-90	4.63E+09	9.25E+10	3.85E+11

Table 11.17 was obtained with input dataset eight and shows the subgroups E1 and E2 measurement-based dose results in the SI unit (mSv). Table 11.18 (same as Table 8.10) shows the dose results in the traditional unit (mrem). Clearly, the results in Table 11.18 are 100 times

TABLE 11.17 Measurement-Based Total Dose Results for Subgroups E1 (initial bridge contamination) and E2 (initial street contamination) in the SI Unit

Group-Receptor No.	Group Description	Receptor Description	1st Year Dose (mSv/yr)	2nd Year Dose (mSv/yr)
E1-1	Bridges	Occupational Workers Drive Through Bridges Under Restricted Conditions	3.11E+00	---
E1-2	Bridges	Public Drive Through Bridges Under Unrestricted Conditions	8.07E-02	1.11E-03
E2-1	Streets and Thoroughfares	Occupational Workers Drive Through Streets Under Restricted Conditions	2.96E+00	---
E2-2	Streets and Thoroughfares	Public Drive Through Streets Under Unrestricted Conditions	7.78E-02	1.03E-03

TABLE 11.18 Measurement-Based Total Dose Results for Subgroups E1 (initial bridge contamination) and E2 (initial street contamination) in the Traditional Unit

Group-Receptor No.	Group Description	Receptor Description	1st Year Dose (mrem/yr)	2nd Year Dose (mrem/yr)
E1-1	Bridges	Occupational Workers Drive Through Bridges Under Restricted Conditions	3.11E+02	---
E1-2	Bridges	Public Drive Through Bridges Under Unrestricted Conditions	8.07E+00	1.11E-01
E2-1	Streets and Thoroughfares	Occupational Workers Drive Through Streets Under Restricted Conditions	2.96E+02	---
E2-2	Streets and Thoroughfares	Public Drive Through Streets Under Unrestricted Conditions	7.78E+00	1.03E-01

the results in Table 11.17, demonstrating that unit conversion was correctly performed by RESRAD-RDD version 2.01.

11.6 COMPARISON OF GROUP F RESULTS

Table 11.19 shows the general guidelines based on ICRP-60 DCFs for soil in the SI unit for group F. The general guidelines in the traditional unit (pCi/g) were obtained, transferred to a worksheet, divided by 27.027 (pCi/Bq), and then compared with those in Table 11.19. Table 11.20 shows the division results, which are almost the same as those in Table 11.19.

TABLE 11.19 General Soil Guidelines for Group F in the SI Unit

Radionuclide	Residential Farmer		Urban Resident		Worker	
	1 mSv/yr	0.04 mSv/yr	1 mSv/yr	0.04 mSv/yr	1 mSv/yr	0.04 mSv/yr
Am-241	9.21E+01	3.69E+00	1.17E+02	4.70E+00	3.10E+02	1.24E+01
Cf-252	3.19E+00	1.27E-01	3.20E+00	1.28E-01	7.22E+00	2.89E-01
Cm-244	3.01E+02	1.20E+01	5.74E+02	2.29E+01	2.13E+03	8.55E+01
Co-60	5.74E-01	2.29E-02	5.77E-01	2.31E-02	1.31E+00	5.25E-02
Cs-137	2.30E+00	9.21E-02	2.47E+00	9.88E-02	5.55E+00	2.22E-01
Ir-192	6.29E+00	2.51E-01	6.29E+00	2.51E-01	1.42E+01	5.70E-01
Po-210	2.04E+01	8.14E-01	1.68E+02	6.73E+00	7.84E+02	3.14E+01
Pu-238	1.56E+02	6.22E+00	2.95E+02	1.18E+01	1.10E+03	4.40E+01
Pu-239	1.42E+02	5.66E+00	2.69E+02	1.07E+01	1.00E+03	4.00E+01
Ra-226	9.88E-02	3.96E-03	1.01E-01	4.03E-03	1.73E+00	6.92E-02
Sr-90	9.32E+00	3.74E-01	1.74E+02	6.96E+00	4.07E+02	1.62E+01

TABLE 11.20 Worksheet Results Obtained by Dividing the General Soil Guidelines (pCi/g) for Group F in the Traditional Unit by 27.027 (pCi/Bq)

Am-241	9.21E+01	3.69E+00	1.17E+02	4.70E+00	3.10E+02	1.24E+01
Cf-252	3.19E+00	1.27E-01	3.20E+00	1.28E-01	7.22E+00	2.89E-01
Cm-244	3.01E+02	1.20E+01	5.74E+02	2.29E+01	2.13E+03	8.55E+01
Co-60	5.74E-01	2.29E-02	5.77E-01	2.31E-02	1.31E+00	5.25E-02
Cs-137	2.30E+00	9.21E-02	2.47E+00	9.88E-02	5.55E+00	2.22E-01
Ir-192	6.29E+00	2.51E-01	6.29E+00	2.51E-01	1.42E+01	5.70E-01
Po-210	2.04E+01	8.14E-01	1.68E+02	6.73E+00	7.84E+02	3.14E+01
Pu-238	1.56E+02	6.22E+00	2.95E+02	1.18E+01	1.10E+03	4.40E+01
Pu-239	1.42E+02	5.66E+00	2.69E+02	1.07E+01	1.00E+03	4.00E+01
Ra-226	9.88E-02	3.96E-03	1.01E-01	4.03E-03	1.73E+00	6.92E-02
Sr-90	9.32E+00	3.74E-01	1.74E+02	6.96E+00	4.07E+02	1.62E+01

11.7 COMPARISON OF GROUP G RESULTS

Table 11.21 was obtained with input dataset nine and shows the general operational guidelines in the SI unit (Bq/m^2) for subgroup G2; the operational guidelines in the traditional unit (pCi/m^2) are presented in Table 10.2. To verify that unit conversion is correctly performed, the results in Table 10.2 were transferred to a worksheet, divided by 27.027 (pCi/Bq), and then compared with those in Table 11.21. Table 11.22 shows the division results, which are almost the same as those in Table 11.21.

TABLE 11.21 General Operational Guidelines for Subgroup G2 (surface soil operational guidelines for the early phase of response after an RDD event) in the SI Unit

Radionuclide	Operational Guidelines for Individual Food Category (Bq/m ²)		
	Vegetable	Milk	Final Operational Guidelines
Am-241	1.20E+01	5.61E+04	1.20E+01
Cf-252	8.99E+00	3.15E+04	8.99E+00
Cm-244	1.70E+01	5.96E+04	1.70E+01
Co-60	1.85E+03	6.48E+03	1.85E+03
Cs-137	3.50E+03	3.10E+03	3.10E+03
Ir-192	6.99E+03	2.45E+07	6.99E+03
Po-210	3.75E+00	7.71E+01	3.75E+00
Pu-238	1.47E+01	9.36E+04	1.47E+01
Pu-239	1.35E+01	8.59E+04	1.35E+01
Ra-226	5.00E+00	2.69E+01	5.00E+00
Sr-90	2.75E+02	6.87E+02	2.75E+02

TABLE 11.22 Worksheet Results Obtained by Dividing the Results Shown in Table 10.2 by 27.027 (pCi/Bq)

Am-241	1.20E+01	5.62E+04	1.20E+01
Cf-252	8.99E+00	3.15E+04	8.99E+00
Cm-244	1.70E+01	5.96E+04	1.70E+01
Co-60	1.85E+03	6.48E+03	1.85E+03
Cs-137	3.50E+03	3.10E+03	3.10E+03
Ir-192	6.99E+03	2.45E+07	6.99E+03
Po-210	3.74E+00	7.70E+01	3.74E+00
Pu-238	1.47E+01	9.36E+04	1.47E+01
Pu-239	1.35E+01	8.58E+04	1.35E+01
Ra-226	5.00E+00	2.69E+01	5.00E+00
Sr-90	2.75E+02	6.88E+02	2.75E+02

Table 11.23 was obtained with input dataset twelve and shows the estimated concentrations in different types of plant food and livestock products based on measurement data (7.5E+7 pCi/m² for Pu-239 and 1.0E+7 pCi/m² for Po-210). The concentrations are expressed in the SI units (Bq/kg or Bq/L). The estimated concentrations expressed in the traditional units (pCi/kg or pCi/L) are presented in Table 10.12. To verify that unit conversion is correctly performed, the results in Table 10.12 were transferred to a worksheet, divided by 27.027 (pCi/Bq), and then compared with those in Table 11.23. Table 11.24 shows the division results, which are almost the same as those in Table 11.23.

TABLE 11.23 Group G Measurement-Based Results for Radionuclide Concentrations in Food Types in the SI Unit

Radionuclide	PVs for Food (pCi/kg)	Estimated Concentrations in Plant Food and Livestock Product									
		FRMAC Methodology*		OGT Methodology*				OGT Methodology*			
		Vegetable (Bq/kg)	Milk (Bq/L)	Non-Leafy Vegetable (Bq/kg)**	Leafy Vegetable (Bq/kg)**	Meat (Bq/kg)**	Milk (Bq/L)**	Non-Leafy Vegetable (Bq/kg)***	Leafy Vegetable (Bq/kg)***	Meat (Bq/kg)***	Milk (Bq/L)***
Po-210	4.05E+01	7.40E+04	3.14E+03	7.93E+03	5.83E+03	1.94E+03	1.18E+02	1.56E+03	1.60E+03	2.06E+02	1.24E+01
Pu-239	1.46E+02	5.55E+05	7.63E+01	6.52E+04	4.88E+04	3.33E+02	2.69E+00	1.46E+04	1.50E+04	4.12E+01	3.33E-01

TABLE 11.24 Worksheet Results Obtained by Dividing the Results Shown in Table 10.12 by 27.027 (pCi/Bq)

Po-210	4.05E+01	7.40E+04	3.15E+03	7.92E+03	5.85E+03	1.94E+03	1.18E+02	1.56E+03	1.60E+03	2.06E+02	1.24E+01
Pu-239	1.46E+02	5.55E+05	7.62E+01	6.51E+04	4.88E+04	3.33E+02	2.69E+00	1.46E+04	1.50E+04	4.11E+01	3.33E-01

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12 CONCLUSIONS

Although RESRAD-RDD version 1.7 and version 2.01 have different programming designs, they implement the same equations to derive operational guidelines and estimate total radiation doses for different operational guideline groups. Therefore, the comparison of their calculation results serves as a means of verifying the correct implementation of equations in the two versions. According to the comparisons presented in Chapters 4–10, the results (in traditional units) generated by the two versions were essentially the same when the same input dataset was used. On the basis of that observation, it is concluded that both versions implement the equations correctly and produce correct calculation results.

In Chapter 11, the calculation results expressed in the SI units as produced by version 2.01 were verified. The verification was performed by comparing the results in the SI units with the results in the traditional units, which are presented in previous chapters, to determine whether they are correlated by a factor of 27.027 (pCi/Bq) or 100 (rem/Sv). The comparison demonstrates that unit conversion is correctly performed in version 2.01 and that the results in the SI units are also accurate.

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