

Upgrading RESRAD-RDD and Planning for Improvised Nuclear Device Incidents – The RESRAD-RDD&IND

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RESRAD-RDD Background

- Computer model that runs on the .NET framework (4.0)
- First released in 2004
- Calculates operational guidelines for a radiological dispersal device (RDD)
- Helps decision-makers make risk-informed decisions in an RDD scenario
- Examples of calculations include:
 - Access control to contaminated zone
 - Procedures for protection (evacuation/sheltering)
 - Relocation and critical infrastructure utilization
 - Temporary access to contaminated zone for essential services
 - Transportation and access routes
 - Release of real property from controlled areas
 - Food safety
- Employed in real-world training exercises (e.g. Liberty RadEx)



RESRAD-RDD&IND Basics

Eleven radionuclides are currently considered in RESRAD-RDD:

Radionuclide	Half-Life	Primary Decay Mode	Purpose
Am-241	4.33E+2 y	α	Smoke detectors
Cf-252	2.64E+0 y	α, S.F.	Neutron source
Cm-244	1.81E+1 y	α	Medical procedures
Co-60	5.27E+0 y	γ	Medical procedures
Cs-137	3.02E+1 y	γ	Medical procedures
Ir-192	2.02E-1 y	γ	Welding
Po-210	3.79E-1 y	α	Electrostatic brush
Pu-238	8.77E+1 y	α	Thermoelectric batteries
Pu-239	2.41E+4 y	α	Thermoelectric batteries
Ra-226	1.60E+3 y	γ	Oil-drilling byproduct
Sr-90	2.88E+1 y	β	Thermoelectric batteries

44 – 60 additional radionuclides will be added for RESRAD-RDD&IND

RESRAD-RDD Conversion (Interface)

Released	Under Development
RESRAD-RDD Version 1.6.1 Beta File Help Select Dose Conversion Factors (DCFs) ICRP-30 Based ICRP-30 Based ICRP-60 Based View DCFs Protective Action Guides (PAGs) Edit PAG Values Select a group Group A Access Control During Emergency Response Operations	RESRAD-RDD File View Help Global Jettings Group: A Access Control During Emergency Response Operations Correction / Resuspension / Conversion Factors Result Type © General Guidelines Measurement-Based Guidelines Result Type Result Type Result Type Result Type Result Type Begin Guidelines Result Type Result Type Result Type
Group B Early Phase Protective Action (Evacuation or Sheltering)	Resuspension Factor (1 / m): 1E-06
Group C Relocation and Critical Infrastructure Utilization Group D Temporary Access to Relocation Areas for Essential Services	General Darameters
Group E Transportation and Access Routes	DCF Library Parameters Specific Parameters
Group F-4 Release of Real Property from Radiologically Controlled Areas Group G Food Consumption	SI Units in Results Calculate >>
Exit RESRAD-RDD	Les Age

Interface uses a combo-box for group selection and tab controls for parameters

RESRAD-RDD Conversion (Interface)



SI units will be available for concentration (Bq) and dose (Sv)

RESRAD-RDD Conversion (Interface)

- More units available:
 - More units now supported for concentrations (Ci, Bq, d.p.m., d.p.s.)
 - SI units (Sv) will be supported for doses
 - Concentrations may be entered in magnitudes from pico- to giga-
- Calculations about nine times faster with the same inputs
- Fewer clicks required for the same calculations
- Reports can be written to PDFs instead of HTML

RESRAD-RDD Conversion (Database)

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	Results-GroupA1.xls	8/23/2013 9:59 AM	Microsoft Excel 97	55 KB
	Results-GroupA1continuous1.xls	3/3/2010 4:06 PM	Microsoft Excel 97	19 KB
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	Results-GroupB.xls	8/23/2013 10:50 AM	Microsoft Excel 97	38 KB
	Results-GroupB-measurement.xls	8/23/2013 10:24 AM	Microsoft Excel 97	27 KB
	Results-GroupC1.xls	10/7/2010 9:32 AM	Microsoft Excel 97	25 KB
	Results-GroupC1-measurement.xls	8/23/2013 1:12 PM	Microsoft Excel 97	28 KB
	Results-GroupC2.xls	3/4/2010 11:17 AM	Microsoft Excel 97	23 KB
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RESRAD-RDD Conversion (Database)

- QC/QA procedures much easier to implement
- Debugging errors is faster process with fewer side-effects
- Database scalable for more radionuclides
- No special spreadsheet software required
- Validating user input simpler with a database-driven code
- The program and database communicate faster than a spreadsheet



Future Goals

- Scale up the database by incorporating more radionuclides (such as IND [Improvised Nuclear Device] or nuclear bomb)
- Allow users to run calculations with multiple radionuclides
- Provide callback support in the case of an RDD or IND event



RESRAD-RDD&IND Conversion (Interface)

- More units available:
 - More units now supported for concentrations (Ci, Bq, d.p.m., d.p.s.)
 - SI units (Sv) available for dose results
 - Concentrations may be entered in magnitudes from femto- to giga-
- Calculations ten times faster with the same inputs
- Fewer clicks required for the same calculations
- Reports can be written to PDFs instead of HTML

RESRAD-RDD&IND Conversion (Calculations)

- Calculation times for all Group A general guidelines, all inputs left at default values
- Version 1.7 results: 32.8 seconds:

A	ir Concentratio		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	3.26E+03								
10	0.37	22.2	3.26E+02	1.63E+03	3.26E+03	6.51E+03					
100	3.7	222	3.26E+01	1.63E+02	3.26E+02	6.51E+02	1.63E+03	3.26E+03	8.14E+03		
1,000	37	2,220	3.26E+00	1.63E+01	3.26E+01	6.51E+01	1.63E+02	3.26E+02	8.14E+02	3.26E+03	
10,000	370	22,200	3.26E-01	1.63E+00	3.26E+00	6.51E+00	1.63E+01	3.26E+01	8.14E+01	3.26E+02	
100,000	3,700	222,000	3.26E-02	1.63E-01	3.26E-01	6.51E-01	1.63E+00	3.26E+00	8.14E+00	3.26E+01	

TABLE 3 Stay Times^a With Full Face Air Purifying Respirators based on Air Concentration Measurement

• Version 2.0 result the state of the tradionuclide of the tradionucl

Group A - Results - With Full-Face Air-Purifying Respirators Table 3 - Stay Times¹ With Full-Face Air-Purifying Respirators Based on Air Concentration Measurement

Air	Concentra	tion	Stay Time ¹ for Given Dose, h									
pCI/cm ^a	Bq/cm ^a	dpm/100 cm*	0.1 rem	0.5 rem	1 rem	2 rem	5 rem	10 rem	25 rem	100 rem		
0.1	0.0037	0.222					1000			1202		
1	0.037	2.22	3.26E+3			1222						
10	0.37	22.2	3.26E+2	1.63E+3	3.26E+3	6.51E+3						
100	3.7	222	3.26E+1	1.63E+2	3.26E+2	6.51E+2	1.63E+3	3.26E+3				
1,000	37	2,220	3.26E+0	1.63E+1	3.26E+1	6.51E+1	1.63E+2	3.26E+2	8.14E+2	3.26E+		
10,000	370	22,200	3.26E-1	1.63E+0	3.26E+0	6.51E+0	1.63E+1	3.26E+1	8.14E+1	3.26E+		
100,000	3,700	222,000	3.26E-2	1.63E-1	3.26E-1	6.51E-1	1.63E+0	3.26E+0	8.14E+0	3.26E+		

¹ Stay times were calculated based on a reference radionuclide. If the contaminant is known, stay times listed in this table can be adjusted by multiplication with a correction factor. The correction factor was calculated as the ratio of the DSR of the reference radionuclide to the DSR of the radionuclide of concern. The correction factors for different radionuclides are different. They are listed in Table 5. When the calculated stay time is greater than 8,760 h (i.e., 1 yr), '---' is displayed.

RESRAD-RDD&IND Conversion (Calculations)

- Calculation times for all Group D general guidelines, all inputs left at default values
- Version 1.7 results: 64.2 seconds:

	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	3.00E+02	6.92E+03	1.99E+03	3.74E+03	> 8760	> 8760	1.05E+03	1.98E+02	1.55E+02	1.94E+03	> 8760
1.00E+04	1.00E+08	3.70E+02	2.22E+06	8.68E+00	4.57E+01	1.46E+01	2.72E+02	1.09E+03	1.42E+03	6.89E+01	7.57E+00	6.94E+00	7.82E+01	2.71E+03
1.00E+05	1.00E+09	3.70E+03	2.22E+07	8.68E-01	3.94E+00	1.46E+00	2.63E+01	9.60E+01	9.86E+01	6.21E+00	7.57E-01	6.94E-01	6.03E+00	1.90E+02
1.00E+06	1.00E+10	3.70E+04	2.22E+08	8.68E-02	3.94E-01	1.46E-01	2.63E+00	9.36E+00	9.61E+00	6.21E-01	7.57E-02	6.94E-02	6.03E-01	1.53E+01
1.00E+07	1.00E+11	3.70E+05	2.22E+09	8.68E-03	3.94E-02	1.46E-02	2.63E-01	9.36E-01	9.61E-01	6.21E-02	7.57E-03	6.94E-03	6.03E-02	1.53E+00

Table 1 Stay Times for Group D1-1 Scenario: Worker Access to Business (Outdoor Exposure)

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Group D - Results - Stay Time Tables for Group D

Table 1 - Stay Times for Worker Access to Businesses (Outdoor Exposure)

Radionuclide Concentration							(Stay Time	e (h) for \sharp	500 mren	n			
pCi/cm ²	pCi/m²	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+1	1.00E+5	3.70E-1	2.22E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3
1.00E+2	1.00E+6	3.70E+0	2.22E+4	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3
1.00E+3	1.00E+7	3.70E+1	2.22E+5	3.00E+2	6.92E+3	1.99E+3	3.74E+3	>8.76E+3	>8.76E+3	1.05E+3	1.98E+2	1.55E+2	1.94E+3	>8.76E+3
1.00E+4	1.00E+8	3.70E+2	2.22E+6	8.68E+0	4.57E+1	1.46E+1	2.72E+2	1.09E+3	1.42E+3	6.89E+1	7.57E+0	6.94E+0	7.82E+1	2.71E+3
1.00E+5	1.00E+9	3.70E+3	2.22E+7	8.68E-1	3.94E+0	1.46E+0	2.63E+1	9.60E+1	9.86E+1	6.21E+0	7.57E-1	6.94E-1	6.03E+0	1.90E+2
1.00E+6	1.00E+10	3.70E+4	2.22E+8	8.68E-2	3.94E-1	1.46E-1	2.63E+0	9.36E+0	9.61E+0	6.21E-1	7.57E-2	6.94E-2	6.03E-1	1.53E+1
1.00E+7	1.00E+11	3.70E+5	2.22E+9	8.68E-3	3.94E-2	1.46E-2	2.63E-1	9.36E-1	9.61E-1	6.21E-2	7.57E-3	6.94E-3	6.03E-2	1.53E+0

RESRAD-RDD&IND Conversion (Calculations)

- Time saved by:
 - Keeping constant values within .exe file
 - Parallelizing code as appropriate
 - Preserving data that will be reusable
 - Writing tables by nuclide instead of by concentration:

Group D - Results - Stay Time Tables for Group D

Table 1 - Stay Times for Worker Access to Businesses (Outdoor Exposure)

Radionuclide Concentration				Stay Time (h) for 500 mrem										
pCi/cm ²	pCi/m²	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+1	1.00E+5	3.70E-1	2.22E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8.76E+3	>8 76E+3
1.00E+2	1.00E+6	3.70E+0	2.22E+4	>8.76E+3	>87.jE+3	>87 iE+3	>8.76E+3	>8.76E+3	>8.7 SE+3	>%.76E+3	>8./ 6E+3	>8. 6E+3	>₹. 6E+3	>3.16E+3
1.00E+3	1.00E+7	3.70E+1	2.22E+5	3.00 E+2	6.92E+3	1.99E+3	3.74E+3	>8.76E+3	>8.75E+3	1.05E+3	1.98E+2	1.55E+2	1.94E+3	>8.16E+3
1.00E+4	1.00E+8	3.70E+2	2.22E+6	8.68 E+0	4.57 E+1	1.46E+1	2.72E+2	1.09E+3	1.42E+3	6.89E+1	7.5 'E+0	6.9 IE+0	7.82E+1	2.71E+3
1.00E+5	1.00E+9	3.70E+3	2.22E+7	8.68E-1	3.94 E+0	1.46E+0	2.63E+1	9.60E+1	9.86E+1	6.2 E+0	7.57E-1	6.94E-1	6.03E+0	1.9)E+2
1.00E+6	1.00E+10	3.70E+4	2.22E+8	8.68E-2	3.94 E- 1	1.46E-1	2.63F+0	9.36F+0	9.61F.+0	6.21E-1	7.57E-2	6.94E-2	6.03/2-1	1.5?E+1
1.00E+7	1.00E+11	3.70E+5	2.22E+9	8.682-3	3.94 <i>E</i> -2	1.46E-2	2.63E-1	9.36E-1	9.61E-1	6.2, E-2	7.5/E-3	6.94E-3	6.63E-2	1.53E+0

- This order saves time since radionuclide-specific data is not reset in every cell

Improvement of RESRAD-RDD

- Converting RESRAD-RDD from Excel Spread Sheets to a "code"
- Adopting the new Resuspension Factor formula used by TurboFRMAC
- Updating the DOE/HS-0001 (Prelim. Report on Operational Guidelines)
- Incorporating the "Additional Scenarios" to the code
- Adding Improvised Nuclear Device (IND) and reactor accident radionuclides and scenarios

Future Plan

- Develop new risk models for Improvised Nuclear Device (IND) incidents
- Collect new data to support database and modeling parameters
- Conduct model-model comparison and model-data validation exercises

Thank you!



The next RESRAD training Course: Sept. 15-26, 2014 at Argonne National Lab

More Info at RESRAD Web Site:

http://www.evs.anl.gov/resrad

Email: resrad@anl.gov