SOFTWARE RELEASE NOTICE

| | |
|---|---|
| 1. SRN Number: **PA-SRN-226** | |
| 2. Project Title: **PCSA Tool Development** | Project No. **20.01402.671** |
| 3. SRN Title: **RSAC Version 5.2** | |
| 4. Originator/Requestor: **Bruce Mabrito** | Date: **9/20/2000** |

5. Summary of Actions

- ■ Release of new software
- ☐ Release of modified software:
  - ☐ Enhancements made
  - ☐ Corrections made
- ☐ Change of access software
- ☐ Software Retirement

6. Persons Authorized Access

| Name | Read Only/Read-Write | Addition/Change/Delete |
|---|---|---|
| **Roland Benke** | **RO** | **New** |
| **James Weldy** | **RO** | |
| **Mike Smith** | **RO** | |
| **Patrick LaPlante** | **RO** | |
| **Gordon Wittmeyer** | **RO** | |
| **Biswajit Dasgupta** | **RO** | |
| **Darius Daruwalla** | **RO** | |
| **Asad Chowdhury** | **RO** | |

7. Element Manager Approval: Date: 9-21-2000

8. Remarks:

SOFTWARE SUMMARY FORM

| | | |
|---|---|---|
| 01. Summary Date: **9/12/2000** | 02. Summary prepared by (Name and phone) **Roland Benke (210) 522-5250** | 03. Summary Action: **NEW** |
| 04. Software Date: **2/22/1994** | 05. Short Title: **RSAC-V.5.2** | |
| 06. Software Title: **Radiological Safety Analysis Computer Program, Version 5.2** | | 07. Internal Software ID: **None** |

| 08. Software Type: | 09. Processing Mode: | 10. Application Area |
|---|---|---|
| ☐ Automated Data System<br>■ Computer Program<br>☐ Subroutine/Module | ■ Interactive<br>☐ Batch<br>☐ Combination | a. General:<br>■ Scientific/Engineering ☐ Auxiliary Analyses<br>☐ Total System PA<br>☐ Subsystem PA ☐ Other<br>b. Specific: |

| 11. Submitting Organization and Address: | 12. Technical Contact(s) and Phone: |
|---|---|
| **Radiation Safety Information Computational Center**<br>**Oak Ridge National Laboratory**<br>**P.O. Box 2008**<br>**Oak Ridge, TN 37381-6362** | Roland Benke (CNWRA) **(210) 522-5250**<br>James Wedly (CNWRA) **(210) 522-6800** |

13. Software Application: **RSAC-5.2 calculates consequences for atmosphere releases of radionuclides. Radiation doses can be calculated from the inhalation, ingestion, ground surface, and submersion pathways.** RB 9/21/00

| 14. Computer Platform | 15. Computer Operating System: | 16. Programming Language(s): | 17. Number of Source Program Statements: |
|---|---|---|---|
| **PC** | **DOS based** | **None (executable)** | **N/A** |
| 18. Computer Memory Requirements: **450 KB** | 19. Tape Drives: **N/A** | 20. Disk Units: **2.6 MB** | 21. Graphics: **N/A** |

22. Other Operational Requirements: **3.5 inch disk drive**

| 23. Software Availability: | 24. Documentation Availability: |
|---|---|
| ■ Available ☐ Limited ☐ In-House ONLY | ■ Available ☐ Preliminary ☐ In-House ONLY |

25. Developed by others, NOT AT CNWRA

Software Developer: _____ Date: 9/20/2000

CNWRA Form TOP-4-1 (05/98)

Roland R. Benke 9/21/00

# CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES
## DESIGN VERIFICATION REPORT FOR CNWRA SOFTWARE

## ACQUIRED CODE - NOT TO BE MODIFIED[1]

**Software Title/Name:** RSAC - Radiological Safety Analysis Computer Program

**Version:** 5.2

**Demonstration workstation:** IBM personal computer or compatible

**Operating System:** OS/2

**Developer:** Westinghouse Idaho Nuclear Company, Inc.

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**1. Output: TOP-018, Section 5.5.4**

**Software designed so that individual runs are uniquely identified by Date, Time, Name of software and version?**

Yes: ☒ No: ☐ N/A: ☐

Date and time of run: included in header of output file

Name and version: included in header of output file

Notes: Acquired code that is not to be modified is accepted as is.

**2. Medium and Header Documentation: TOP-018, Section 5.5.6**

The physical labeling of software medium (tapes, disks, etc.) contain required information?

B Sen 9/15/2000

Yes: ☒ No: ☐ N/A: ☒

Program Name: Radiological Safety Analysis Computer Program

Module/Name/Title: RSAC

Module Revision: 5.2

File Type (ASCII, OBJ, EXE): not explicitly stated on printed label

Recording Date: software date is listed

Operating System of Supporting Hardware: not explicitly stated on printed label

Notes: Acquired code that is not to be modified may not have all above elements.

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[1] See TOP-018, Table 1 for criteria.

**3. User's Manual: TOP-018, Section 5.5.5**

a) Is there a Users' Manual for the software?

Yes: ☒ No: ☐ N/A: ☐

User's Manual Version and Date: The Radiological Safety Analysis Computer Program (RSAC-5) User's Manual, Revision 1. WINCO-1123 Westinghouse Idaho Nuclear Company, Inc. February 1994.

Notes:

b) Are there basic instructions for the use of the software?

Yes: ☒ No: ☐ N/A: ☐

Location of Instruction: see user's manual / User's Manual for RSAC-5 will be restored by R. Benke.

Notes:

**4. Acceptance Testing: TOP-018, Section 5.6**

a) Has installation testing been conducted for each intended computer platform and operating system?

Yes: ☒ **No:** ☐ N/A: ☐

Platform(s): IBM personal computer or compatible (on "Phoenix.28" in Bldg 189, Rm. A204)

Operating System(s): DOS installation within Windows NT

Location of Test Results: see attached diskette and attached printouts of output files

Notes:

**5. Configuration Control: TOP-018, Section 5.7**

a) Is the Software Summary Form completed and signed?

Yes: ☒ No: ☐ N/A: ☐

Software Summary Form Approval Date: 9/21/2000

Notes:

b) Is a software technical description prepared, documenting the essential mathematical and numerical basis?

Yes: ☒ No: ☐ N/A: ☐

Location Technical Description: refer to user's manual

Notes:

c) Is the source code available (or, is the executable code available in the case of (acquired/commercial codes)?

Yes: ☒ No: ☐ N/A: ☐

Location of Source Code: see attached diskette

Notes:

**6. Configuration Control, continued: TOP-018, Section 5.7**

Have all the script/make files and executable files been submitted to the Software Custodian?

Yes: ☒ No: ☐ N/A: ☐

Location of Script/Make Files: see attached diskette

Notes: all contained within a single diskette for installation

**7. Software Release: TOP-018, Section 5.9**

Upon acceptance of the software as verified above, has a Software release Notice, Form TOP-6 been issued?

Yes: ☒ No: ☐ N/A: ☐

Version number on software ~~(1.0 for 1st issue):~~ BEm 9/15/2000 RSAC - 5.2

Version number on SRN: RSAC-5.2

Notes:

**8. Software Validation: TOP-018, Section 5.10**

a) Has a Software Validation Test Plan (SVTP) been prepared for the range of application of the software?

Yes: ☒ No: ☐ N/A: ☐

Version/Date of SVTP: RSAC-5 SVVP Revision 1, 9/10/91

Date reviewed and approved via QAP-002: NOT Applicable BEm 9/15/2000

Notes: refer to the Software Verification and Validation Plan (SVVP) in the latter half of the attached Software Verification and Validation Report (SVVR), Vol. 1 by Shonka Research Associates, Inc.

b) Has a Software Validation Test Report (SVTR) been prepared that documents the results of the validation cases, interpretation of the results, and determination if the software has been validated?

Yes: ☒ No: ☐ N/A: ☐

Version/Date of SVTR: RSAC-5 SVVR, September 1993

Date reviewed and approved via QAP-002:

Notes: see attached SVVR Volume 1

Additional Remarks:

developed by others
**CNWRA Software Developer/Date**

[signature] 11/2/2000
**CNWRA Software Custodian/Date**

Roland R. Bass 11/02/00

```
 EXAMPLE2     RSAC-5 INPUT     07/14/00     15:20
0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789

* Calculation of inhalation dose
# Requesting direct input of only Sr-90 and Y-90
2000,0
SR 90,0.15
Y 90,0.15
2999
# Meteorological data input
5000
5001,4.5,0,1000.,1.099E3,0,0
5002,0.001,0.01,0,0.001,0.001
5101,1.E2,1.5E2
5201,0.001111,0
5301,10.,20.,30.
5400,1,60.,10.6,1.
5401,15.,8.,20.,11.
5999
# Calculation of inhalation dose
7000,0,2,1,1,2
7001,3.33E-4,0,0,0
7002,1,4,5,18
7081,38,39
7999
10000

0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789
```

EXAMPLE2: Calculation of inhalation dose

***DIRECT RADIONUCLIDE INPUT

ANY PREVIOUS INVENTORY HAS BEEN ZEROED

| NUCLIDE | | HALF LIFE | | CURIES |
|---|---|---|---|---|
| 380900 | Sr 90 | 2.912E+01 | yr | 1.500E-01 |
| 390900 | Y 90 | 6.410E+01 | h | 1.500E-01 |

***METEOROLOGICAL DATA

MEAN WIND SPEED = 4.500E+00 (m/s) STACK HEIGHT = 0.000E+00 (m)
MIXING LAYER HEIGHT = 1.000E+03 (m) AIR DENSITY = 1.099E+03 (g/cu m)
WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

NO CORRECTION IS BEING MADE FOR CLOUD DEPLETION BY DRY DEPOSITION

DEPOSITION VELOCITIES (m/s)
SOLIDS = 1.000E-03 HALOGENS = 1.000E-02 NOBLE GASES = 0.000E+00
CESIUM = 1.000E-03 RUTHENIUM = 1.000E-03

THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
1.111E-03 0.000E+00

CROSSWIND DISTANCES -- METERS

1.000E+01 2.000E+01 3.000E+01

BUILDING WIDTH = 6.000E+01 (m) BUILDING HEIGHT = 1.060E+01 (m)
BUILDING WAKE COEFFICIENT = 1.000E+00

| DOWNWIND DISTANCE | EFFECTIVE STACK HEIGHT (m) | SIGY (m) | SIGZ (m) | CHI/Q (s/cu m) |
|---|---|---|---|---|
| 1.000E+02 | 0.000E+00 | 1.500E+01 | 8.000E+00 | 2.096E-04 |
| 1.500E+02 | 0.000E+00 | 2.000E+01 | 1.100E+01 | 1.602E-04 |

*** INHALATION DOSE EQUIVALENT CALCULATION

BREATHING RATE = 3.330E-04 (cu m/s)
RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION = 9.001E+02 (s)
INTERNAL EXPOSURE TIME PERIOD = 5.000E+01 (yr)

PARTICLE SIZE = 1.0 MICRONS AMAD
LUNG DEPOSITION FRACTIONS: N-P = 0.300 T-B = 0.080 P = 0.250

LUNG CLEARANCE CLASSES USED IN CALCULATIONS

| ELEMENT | | CLASS |
|---|---|---|
| 38 | Sr | D |
| 39 | Y | Y |

EXAMPLE2: Calculation of inhalation dose

DOWNWIND DISTANCE = 1.000E+02 (m) PLUME TRAVEL TIME = 2.222E+01 (s)
CHI/Q = 2.096E-04 (s/cu m)

| LUNGS | INHALATION | ISOTOPE | NUCLIDE | CDE(rem) | WCDE (rem) |
|---|---|---|---|---|---|
| | | Y - 90 | 390900 | 3.56E-04 | 4.27E-05 |
| | | TOTAL Y (ATOMIC NO 39) | | 3.56E-04 | 4.27E-05 |
| | | TOTAL LUNGS INHALATION = | | 3.56E-04 | 4.27E-05 |

| CROSSWIND DISTANCE | DOSE |
|---|---|
| 1.000E+01 | 3.17E-04 |
| 2.000E+01 | 2.23E-04 |
| 3.000E+01 | 1.24E-04 |

| ULI WALL | INHALATION | ISOTOPE | NUCLIDE | CDE(rem) | WCDE (rem) |
|---|---|---|---|---|---|
| | | Y - 90 | 390900 | 2.09E-04 | 1.26E-05 |
| | | TOTAL Y (ATOMIC NO 39) | | 2.09E-04 | 1.26E-05 |
| | | TOTAL ULI WALL INHALATION = | | 2.09E-04 | 1.26E-05 |

| CROSSWIND DISTANCE | DOSE |
|---|---|
| 1.000E+01 | 1.86E-04 |
| 2.000E+01 | 1.31E-04 |
| 3.000E+01 | 7.31E-05 |

| LLI WALL | INHALATION | ISOTOPE | NUCLIDE | CDE(rem) | WCDE (rem) |
|---|---|---|---|---|---|
| | | Y - 90 | 390900 | 5.03E-04 | 3.02E-05 |
| | | TOTAL Y (ATOMIC NO 39) | | 5.03E-04 | 3.02E-05 |
| | | TOTAL LLI WALL INHALATION = | | 5.03E-04 | 3.02E-05 |

| CROSSWIND DISTANCE | DOSE |
|---|---|
| 1.000E+01 | 4.47E-04 |
| 2.000E+01 | 3.15E-04 |
| 3.000E+01 | 1.75E-04 |

| CEDE | INHALATION | ISOTOPE | NUCLIDE | CEDE(rem) |
|---|---|---|---|---|
| | | Sr - 90 | 380900 | 2.41E-03 |
| | | TOTAL Sr (ATOMIC NO 38) | | 2.41E-03 |
| | | Y - 90 | 390900 | 8.59E-05 |

DOWNWIND DISTANCE = 1.000E+02 CEDE INHALATION DOSE EQUIVALENT

| CEDE | INHALATION | ISOTOPE | NUCLIDE | CEDE(rem) |
|---|---|---|---|---|
| | | TOTAL Y (ATOMIC NO 39) | | 8.59E-05 |
| | TOTAL CEDE | INHALATION = | | 2.49E-03 |

| CROSSWIND DISTANCE | DOSE |
|---|---|
| 1.000E+01 | 2.22E-03 |
| 2.000E+01 | 1.56E-03 |
| 3.000E+01 | 8.70E-04 |

DOWNWIND DISTANCE = 1.500E+02 (m) PLUME TRAVEL TIME = 3.333E+01 (s)
CHI/Q = 1.602E-04 (s/cu m)

| LUNGS | INHALATION | ISOTOPE | NUCLIDE | CDE(rem) | WCDE (rem) |
|---|---|---|---|---|---|
| | | Y - 90 | 390900 | 2.72E-04 | 3.27E-05 |
| | | TOTAL Y (ATOMIC NO 39) | | 2.72E-04 | 3.27E-05 |
| | TOTAL LUNGS | INHALATION = | | 2.72E-04 | 3.27E-05 |

| CROSSWIND DISTANCE | DOSE |
|---|---|
| 1.000E+01 | 2.50E-04 |
| 2.000E+01 | 1.95E-04 |
| 3.000E+01 | 1.29E-04 |

| ULI WALL | INHALATION | ISOTOPE | NUCLIDE | CDE(rem) | WCDE (rem) |
|---|---|---|---|---|---|
| | | Y - 90 | 390900 | 1.60E-04 | 9.60E-06 |
| | | TOTAL Y (ATOMIC NO 39) | | 1.60E-04 | 9.60E-06 |
| | TOTAL ULI WALL | INHALATION = | | 1.60E-04 | 9.60E-06 |

| CROSSWIND DISTANCE | DOSE |
|---|---|
| 1.000E+01 | 1.47E-04 |
| 2.000E+01 | 1.15E-04 |
| 3.000E+01 | 7.58E-05 |

DOWNWIND DISTANCE = 1.500E+02 LLI WALL INHALATION DOSE EQUIVALENT

| LLI WALL INHALATION | ISOTOPE | NUCLIDE | CDE(rem) | WCDE (rem) |
|---|---|---|---|---|
| | Y - 90 | 390900 | 3.84E-04 | 2.31E-05 |
| | TOTAL Y (ATOMIC NO 39) | | 3.84E-04 | 2.31E-05 |
| | TOTAL LLI WALL INHALATION = | | 3.84E-04 | 2.31E-05 |

| CROSSWIND DISTANCE | DOSE |
|---|---|
| 1.000E+01 | 3.54E-04 |
| 2.000E+01 | 2.76E-04 |
| 3.000E+01 | 1.82E-04 |

| CEDE INHALATION | ISOTOPE | NUCLIDE | CEDE(rem) |
|---|---|---|---|
| | Sr - 90 | 380900 | 1.84E-03 |
| | TOTAL Sr (ATOMIC NO 38) | | 1.84E-03 |
| | Y - 90 | 390900 | 6.56E-05 |
| | TOTAL Y (ATOMIC NO 39) | | 6.56E-05 |
| | TOTAL CEDE INHALATION = | | 1.91E-03 |

| CROSSWIND DISTANCE | DOSE |
|---|---|
| 1.000E+01 | 1.75E-03 |
| 2.000E+01 | 1.37E-03 |
| 3.000E+01 | 9.03E-04 |

&& INHALATION COMMITTED DOSE EQUIVALENTS ORDERED BY ORGAN (rem)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+02 | 1.50E+02 |
|---|---|---|---|
| LUNGS | 1 | 3.56E-04 | 2.72E-04 |
| ULI WALL | 4 | 2.09E-04 | 1.60E-04 |
| LLI WALL | 5 | 5.03E-04 | 3.84E-04 |

&& INHALATION COMMITTED DOSE EQUIVALENCES ORDERED BY DOSE (rem)

| | | DOWNWIND DISTANCES (m) | |
|---|---|---|---|
| ORGAN | NO. | 1.00E+02 | 1.50E+02 |
| LUNGS | 1 | 3.56E-04 | 2.72E-04 |
| ULI WALL | 4 | 2.09E-04 | 1.60E-04 |
| LLI WALL | 5 | 5.03E-04 | 3.84E-04 |

&& INHALATION WEIGHTED COMMITTED DOSE EQUIVALENTS (rem)

| | | DOWNWIND DISTANCES (m) | |
|---|---|---|---|
| ORGAN | NO. | 1.00E+02 | 1.50E+02 |
| LUNGS | 1 | 4.27E-05 | 3.27E-05 |
| ULI WALL | 4 | 1.26E-05 | 9.60E-06 |
| LLI WALL | 5 | 3.02E-05 | 2.31E-05 |
| CEDE | 18 | 2.49E-03 | 1.91E-03 |

EXECUTION TIME = 2.20E-01 SECONDS

```
 EXAMPLE3     RSAC-5 INPUT     07/14/00     15:33
0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789

* Ingestion dose calculation from an acute release
# Direct input of Pu and Am
2000,0
PU238,0.72
PU239,0.18
AM241,0.045
2999
# Meteorological data
5000
5001,4.,0,2000.,1.099E3,0,0
5002,0.001,0.01,0,0.001,0.001
5101,1.E4,5.E4
5201,1.,0
5400,3,0,0,0
5421,2.1E-6,3.2E-7
5999
# Ingestion dose calculation
7000,3,-2,2,1,1
7001,3.33E-4,0,0,0
7004,1,2,1.,7.
7051,520.,64.,110.,310.,0.5,0.75
7052,0.57,0.2,1.,0.0021,60.,30.,1.
7053,225.,60.,1.,16.,2.,20.
7054,0.4,0.43,90.,2.,0.28,4.9
7055,.5,.33,0.5,.33
7081,94,95
7999
10000

0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789
```

EXAMPLE3: Ingestion dose calculation from an acute release

***DIRECT RADIONUCLIDE INPUT

ANY PREVIOUS INVENTORY HAS BEEN ZEROED

| NUCLIDE | | HALF LIFE | | CURIES |
|---|---|---|---|---|
| 942380 | Pu238 | 8.775E+01 | yr | 7.200E-01 |
| 942390 | Pu239 | 2.413E+04 | yr | 1.800E-01 |
| 952410 | Am241 | 4.322E+02 | yr | 4.500E-02 |

***METEOROLOGICAL DATA

MEAN WIND SPEED = 4.000E+00 (m/s) STACK HEIGHT = 0.000E+00 (m)
MIXING LAYER HEIGHT = 2.000E+03 (m) AIR DENSITY = 1.099E+03 (g/cu m)
WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

NO CORRECTION IS BEING MADE FOR CLOUD DEPLETION BY DRY DEPOSITION

DEPOSITION VELOCITIES (m/s)
SOLIDS = 1.000E-03 HALOGENS = 1.000E-02 NOBLE GASES = 0.000E+00
CESIUM = 1.000E-03 RUTHENIUM = 1.000E-03

THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
1.000E+00 0.000E+00

CHI/Q VALUES INPUT DIRECTLY

| DOWNWIND DISTANCE | CHI/Q |
|---|---|
| 1.000E+04 | 2.100E-06 |
| 5.000E+04 | 3.200E-07 |

*** INGESTION DOSE EQUIVALENT CALCULATION

RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION = 1.000E+00 (s)
INTERNAL EXPOSURE TIME PERIOD = 5.000E+01 (yr)

INGESTION CALCULATIONS MADE USING USER SUPPLIED CONSTANTS

INGESTION CONSTANTS:

| | |
|---|---|
| 5.20E+02 | STORED VEGETABLE USAGE FACTOR (Kg/yr) |
| 6.40E+01 | FRESH VEGETABLE USAGE FACTOR (Kg/yr) |
| 1.10E+02 | MEAT USAGE FACTOR (Kg/yr) |
| 3.10E+02 | MILK USAGE FACTOR (L/yr) |
| 5.00E-01 | FRACTION OF STORED VEGETABLES FROM GARDEN |
| 7.50E-01 | FRACTION OF FRESH VEGETABLES FROM GARDEN |
| 5.70E-01 | RETENTION FACTOR FOR ACTIVITY ON FORAGE |
| 2.00E-01 | RETENTION FACTOR FOR ACTIVITY ON VEGETABLES |
| 1.00E+00 | RETENTION FACTOR FOR IODINES |
| 2.10E-03 | REMOVAL RATE CONSTANT FOR CROPS (1/h) |
| 6.00E+01 | VEGETABLE EXPOSURE TIME TO PLUME FOR CHRONIC RELEASE (d) |
| 3.00E+01 | FORAGE EXPOSURE TIME TO PLUME FOR CHRONIC RELEASE (d) |
| 1.00E+00 | HTO REMOVAL HALF TIME (d) |

EXAMPLE3: Ingestion dose calculation from an acute release

| | |
|---|---|
| 2.25E+02 | EFFECTIVE SURFACE SOIL DENSITY (Kg/sq m) |
| 6.00E+01 | STORED VEGETABLE HOLDUP TIME AFTER HARVEST (d) |
| 1.00E+00 | FRESH VEGETABLE HOLDUP TIME AFTER HARVEST (d) |
| 1.60E+01 | ANIMALS DAILY FORAGE FEED (Kg/d) |
| 2.00E+00 | FEED-MILK-RECEPTOR TRANSFER TIME (d) |
| 2.00E+01 | SLAUGHTER TO CONSUMPTION TIME (d) |
| 4.00E-01 | FRACTION OF YEAR ON PASTURE |
| 4.30E-01 | PASTURE FEED FRACTION |
| 9.00E+01 | STORED FEED STORAGE TIME |
| 2.00E+00 | VEGETABLE VEGETATION YIELD (Kg/sq m) |
| 2.80E-01 | FORAGE VEGETATION YIELD (Kg/sq m) |
| 4.90E+00 | ABSOLUTE HUMIDITY (g/cu m) |

ACUTE RELEASE OVER 1.000E+00 (d)
HARVEST DURATION TIME OF 7.000E+00 (d) AFTER ACUTE RELEASE
CONSUMPTION OF CROPS GROWN ON CONTAMINATED SOIL FOR 1.500E+01 (Y)

FRACTIONS OF ANNUAL VEGETABLES AND FORAGE CONTAMINATED BY ACUTE RELEASE

| | |
|---|---|
| 5.0E-01 | STORED VEGETABLES |
| 3.3E-01 | FRESH VEGETABLES |
| 5.0E-01 | STORED FEED |
| 3.3E-01 | PASTURE FEED |

INGESTION TRANSFER CONSTANTS

| ELEMENT | BV1 FORAGE/ SOIL (dry) | BV2 VEG/SOIL (wet) | FM MILK (d/L) | FF MEAT (d/kg) | TRANS- LOCATION |
|---|---|---|---|---|---|
| H 1 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.0E+00 |
| He 2 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.0E+00 |
| Li 3 | 2.5E-02 | 1.7E-03 | 2.0E-02 | 1.0E-02 | 1.0E+00 |
| Be 4 | 1.0E-02 | 6.4E-04 | 9.0E-07 | 1.0E-03 | 1.0E+00 |
| B 5 | 4.0E+00 | 8.6E-01 | 1.5E-03 | 8.0E-04 | 1.0E+00 |
| C 6 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.0E+00 |
| N 7 | 3.0E+01 | 1.3E+01 | 2.5E-02 | 7.5E-02 | 1.0E+00 |
| O 8 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.0E+00 |
| F 9 | 6.0E-02 | 2.6E-03 | 1.0E-03 | 1.5E-01 | 1.0E+00 |
| Ne 10 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.0E+00 |
| Na 11 | 7.5E-02 | 2.4E-02 | 3.5E-02 | 5.5E-02 | 1.0E+00 |
| Mg 12 | 1.0E+00 | 2.4E-01 | 4.0E-03 | 5.0E-03 | 1.0E+00 |
| Al 13 | 4.0E-03 | 2.8E-04 | 2.0E-04 | 1.5E-03 | 1.0E+00 |
| Si 14 | 3.5E-01 | 3.0E-02 | 2.0E-05 | 4.0E-05 | 1.0E+00 |
| P 15 | 3.5E+00 | 1.5E+00 | 1.5E-02 | 5.5E-02 | 1.0E+00 |
| S 16 | 1.5E+00 | 6.4E-01 | 1.5E-02 | 1.0E-01 | 1.0E+00 |
| Cl 17 | 7.0E+01 | 3.0E+01 | 1.5E-02 | 8.0E-02 | 1.0E+00 |
| Ar 18 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.0E+00 |
| K 19 | 1.0E+00 | 2.4E-01 | 7.0E-03 | 2.0E-02 | 1.0E+00 |
| Ca 20 | 3.5E+00 | 1.5E-01 | 1.0E-02 | 7.0E-04 | 1.0E+00 |
| Sc 21 | 6.0E-03 | 4.3E-04 | 5.0E-06 | 1.5E-02 | 1.0E+00 |
| Ti 22 | 5.5E-03 | 1.3E-03 | 1.0E-02 | 3.0E-02 | 1.0E+00 |
| V 23 | 5.5E-03 | 1.3E-03 | 2.0E-05 | 2.5E-03 | 1.0E+00 |
| Cr 24 | 7.5E-03 | 1.9E-03 | 1.5E-03 | 5.5E-03 | 1.0E+00 |
| Mn 25 | 2.5E-01 | 2.1E-02 | 3.5E-04 | 4.0E-04 | 1.0E+00 |

| | | | | | |
|---|---|---|---|---|---|
| Fe 26 | 4.0E-03 | 4.3E-04 | 2.5E-04 | 2.0E-02 | 1.0E+00 |
| Co 27 | 2.0E-02 | 3.0E-03 | 2.0E-03 | 2.0E-02 | 1.0E+00 |

EXAMPLE3: Ingestion dose calculation from an acute release

| ELEMENT | BV1 FORAGE/ SOIL (dry) | BV2 VEG/SOIL (wet) | FM MILK (d/L) | FF MEAT (d/kg) | TRANS- LOCATION |
|---|---|---|---|---|---|
| Ni 28 | 6.0E-02 | 2.6E-02 | 1.0E-03 | 6.0E-03 | 1.0E+00 |
| Cu 29 | 4.0E-01 | 1.1E-01 | 1.5E-03 | 1.0E-02 | 1.0E+00 |
| Zn 30 | 1.5E+00 | 3.9E-01 | 1.0E-02 | 1.0E-01 | 1.0E+00 |
| Ga 31 | 4.0E-03 | 1.7E-04 | 5.0E-05 | 5.0E-04 | 1.0E+00 |
| Ge 32 | 4.0E-01 | 3.4E-02 | 7.0E-02 | 7.0E-01 | 1.0E+00 |
| As 33 | 4.0E-02 | 2.6E-03 | 6.0E-05 | 2.0E-03 | 1.0E+00 |
| Se 34 | 2.5E-02 | 1.1E-02 | 4.0E-03 | 1.5E-02 | 1.0E+00 |
| Br 35 | 1.5E+00 | 6.4E-01 | 2.0E-02 | 2.5E-02 | 1.0E+00 |
| Kr 36 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.0E+00 |
| Rb 37 | 1.5E-01 | 3.0E-02 | 1.0E-02 | 1.5E-02 | 1.0E+00 |
| Sr 38 | 2.5E+00 | 1.1E-01 | 1.5E-03 | 3.0E-04 | 1.5E-01 |
| Y 39 | 1.5E-02 | 2.6E-03 | 2.0E-05 | 3.0E-04 | 1.0E+00 |
| Zr 40 | 2.0E-03 | 2.1E-04 | 3.0E-05 | 5.5E-03 | 1.0E+00 |
| Nb 41 | 2.0E-02 | 2.1E-03 | 2.0E-02 | 2.5E-01 | 1.0E+00 |
| Mo 42 | 2.5E-01 | 2.6E-02 | 1.5E-03 | 6.0E-03 | 1.0E+00 |
| Tc 43 | 9.5E+00 | 6.4E-01 | 1.0E-02 | 8.5E-03 | 1.0E+00 |
| Ru 44 | 7.5E-02 | 8.6E-03 | 6.0E-07 | 2.0E-03 | 5.0E-02 |
| Rh 45 | 1.5E-01 | 1.7E-02 | 1.0E-02 | 2.0E-03 | 1.0E+00 |
| Pd 46 | 1.5E-01 | 1.7E-02 | 1.0E-02 | 4.0E-03 | 1.0E+00 |
| Ag 47 | 4.0E-01 | 4.3E-02 | 2.0E-02 | 3.0E-03 | 1.0E+00 |
| Cd 48 | 5.5E-01 | 6.4E-02 | 1.0E-03 | 5.5E-04 | 1.0E+00 |
| In 49 | 4.0E-03 | 1.7E-04 | 1.0E-04 | 8.0E-03 | 1.0E+00 |
| Sn 50 | 3.0E-02 | 2.6E-03 | 1.0E-03 | 8.0E-02 | 1.0E+00 |
| Sb 51 | 2.0E-01 | 1.3E-02 | 1.0E-04 | 1.0E-03 | 1.0E+00 |
| Te 52 | 2.5E-02 | 1.7E-03 | 2.0E-04 | 1.5E-02 | 1.0E+00 |
| I 53 | 1.5E-01 | 2.1E-02 | 1.0E-02 | 7.0E-03 | 1.0E-01 |
| Xe 54 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.0E+00 |
| Cs 55 | 8.0E-02 | 1.3E-02 | 7.0E-03 | 2.0E-02 | 5.0E-01 |
| Ba 56 | 1.5E-01 | 6.4E-03 | 3.5E-04 | 1.5E-04 | 1.0E+00 |
| La 57 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 3.0E-04 | 1.0E+00 |
| Ce 58 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 7.5E-04 | 3.0E-01 |
| Pr 59 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 3.0E-04 | 1.0E+00 |
| Nd 60 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 3.0E-04 | 1.0E+00 |
| Pm 61 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 5.0E-03 | 1.0E+00 |
| Sm 62 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 5.0E-03 | 1.0E+00 |
| Eu 63 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 5.0E-03 | 1.0E+00 |
| Gd 64 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 3.5E-03 | 1.0E+00 |
| Tb 65 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 4.5E-03 | 1.0E+00 |
| Dy 66 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 5.5E-03 | 1.0E+00 |
| Ho 67 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 4.5E-03 | 1.0E+00 |
| Er 68 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 4.0E-03 | 1.0E+00 |
| Tm 69 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 4.5E-03 | 1.0E+00 |
| Yb 70 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 4.0E-03 | 1.0E+00 |
| Lu 71 | 1.0E-02 | 1.7E-03 | 2.0E-05 | 4.5E-03 | 1.0E+00 |
| Hf 72 | 3.5E-03 | 3.6E-04 | 5.0E-06 | 1.0E-03 | 1.0E+00 |
| Ta 73 | 1.0E-02 | 1.1E-03 | 3.0E-06 | 6.0E-04 | 1.0E+00 |
| W 74 | 4.5E-02 | 4.3E-03 | 3.0E-04 | 4.5E-02 | 1.0E+00 |
| Re 75 | 1.5E+00 | 1.5E-01 | 1.5E-03 | 8.0E-03 | 1.0E+00 |

EXAMPLE3: Ingestion dose calculation from an acute release

| ELEMENT | BV1 FORAGE/ SOIL (dry) | BV2 VEG/SOIL (wet) | FM MILK (d/L) | FF MEAT (d/kg) | TRANS-LOCATION |
|---|---|---|---|---|---|
| Os 76 | 1.5E-02 | 1.5E-03 | 5.0E-03 | 4.0E-01 | 1.0E+00 |
| Ir 77 | 5.5E-02 | 6.4E-03 | 2.0E-06 | 1.5E-03 | 1.0E+00 |
| Pt 78 | 9.5E-02 | 1.1E-02 | 5.0E-03 | 4.0E-03 | 1.0E+00 |
| Au 79 | 4.0E-01 | 4.3E-02 | 5.5E-06 | 8.0E-03 | 1.0E+00 |
| Hg 80 | 9.0E-01 | 8.6E-02 | 4.5E-04 | 2.5E-01 | 1.0E+00 |
| Tl 81 | 4.0E-03 | 1.7E-04 | 2.0E-03 | 4.0E-02 | 1.0E+00 |
| Pb 82 | 4.5E-02 | 3.9E-03 | 2.5E-04 | 3.0E-04 | 1.0E+00 |
| Bi 83 | 3.5E-02 | 2.1E-03 | 5.0E-04 | 4.0E-04 | 1.0E+00 |
| Po 84 | 2.5E-03 | 1.7E-04 | 3.5E-04 | 9.5E-05 | 1.0E+00 |
| At 85 | 1.0E+00 | 6.4E-02 | 1.0E-02 | 1.0E-02 | 1.0E+00 |
| Rn 86 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.0E+00 |
| Fr 87 | 3.0E-02 | 3.4E-03 | 2.0E-02 | 2.5E-03 | 1.0E+00 |
| Ra 88 | 1.5E-02 | 6.4E-04 | 4.5E-04 | 2.5E-04 | 1.0E+00 |
| Ac 89 | 3.5E-03 | 1.5E-04 | 2.0E-05 | 2.5E-05 | 1.0E+00 |
| Th 90 | 8.5E-04 | 3.6E-05 | 5.0E-06 | 6.0E-06 | 1.0E+00 |
| Pa 91 | 2.5E-03 | 1.1E-04 | 5.0E-06 | 1.0E-05 | 1.0E+00 |
| U 92 | 8.5E-03 | 1.7E-03 | 6.0E-04 | 2.0E-04 | 1.0E+00 |
| Np 93 | 1.0E-01 | 4.3E-03 | 5.0E-06 | 5.5E-05 | 1.0E+00 |
| Pu 94 | 4.5E-04 | 1.9E-05 | 1.0E-07 | 5.0E-07 | 1.0E-02 |
| Am 95 | 5.5E-03 | 1.1E-04 | 4.0E-07 | 3.5E-06 | 3.0E-01 |
| Cm 96 | 8.5E-04 | 6.4E-06 | 2.0E-05 | 3.5E-06 | 3.0E-01 |

DOWNWIND DISTANCE = 1.000E+04 (m) PLUME TRAVEL TIME = 2.500E+03 (s)
CHI/Q = 2.100E-06 (s/cu m)

DOWNWIND DISTANCE = 5.000E+04 (m) PLUME TRAVEL TIME = 1.250E+04 (s)
CHI/Q = 3.200E-07 (s/cu m)

&& INGESTION COMMITTED DOSE EQUIVALENTS ORDERED BY ORGAN (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 | 5.00E+04 |
|---|---|---|---|
| GONADS | 6 | 2.81E-05 | 4.29E-06 |
| BONE SUR | 8 | 2.24E-03 | 3.41E-04 |
| R MARROW | 9 | 1.82E-04 | 2.77E-05 |
| LIVER | 12 | 4.88E-04 | 7.44E-05 |

---
ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

EXAMPLE3: Ingestion dose calculation from an acute release

&& INGESTION COMMITTED DOSE EQUIVALENCES ORDERED BY DOSE (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 | 5.00E+04 |
|---|---|---|---|
| BONE SUR | 8 | 2.24E-03 | 3.41E-04 |
| LIVER | 12 | 4.88E-04 | 7.44E-05 |
| R MARROW | 9 | 1.82E-04 | 2.77E-05 |
| GONADS | 6 | 2.81E-05 | 4.29E-06 |

---
ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

&& INGESTION WEIGHTED COMMITTED DOSE EQUIVALENTS (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 | 5.00E+04 |
|---|---|---|---|
| GONADS | 6 | 7.03E-06 | 1.07E-06 |
| BONE SUR | 8 | 6.72E-05 | 1.02E-05 |
| R MARROW | 9 | 2.18E-05 | 3.32E-06 |
| LIVER | 12 | 2.93E-05 | 4.47E-06 |
| CEDE | 18 | 1.26E-04 | 1.92E-05 |

---
ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

EXECUTION TIME = 1.10E-01 SECONDS

```
 EXAMPLE4     RSAC-5 INPUT     07/14/00     15:25
0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789

* Ground surface dose calculation
# Direct input of Co-60
2000,0
CO 60,75.
2999
# fractionate to correct for 40/168 hour occupancy
1000
1001,1,0,0
1004,0,0.2381
1999
# Meterological data input with user sigma's
5000
5001,6.,0,2000.,1.24E3,0,0
5002,0.001,0.01,0,0.001,0.001
5101,3.5E3
5201,1.,0
5400,2,0,0,0
5410,1,3,0
5999
# Ground surface dose calculation
7000,4,-2,1,1,1
7001,3.33E-4,0,1.,1.
7081,27
7999
10000

0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789
```

EXAMPLE4: Ground surface dose calculation

***DIRECT RADIONUCLIDE INPUT

ANY PREVIOUS INVENTORY HAS BEEN ZEROED

| NUCLIDE | | HALF LIFE | | CURIES |
|---|---|---|---|---|
| 270600 | Co 60 | 5.271E+00 | yr | 7.500E+01 |

***FISSION PRODUCT CALCULATION

FRACTION OF RADIONUCLIDE INVENTORY RELEASED = 2.381E-01

TOTAL RADIONUCLIDE RELEASE = 6.607E+11 D/s OR 1.786E+01 Ci

***METEOROLOGICAL DATA

MEAN WIND SPEED = 6.000E+00 (m/s) STACK HEIGHT = 0.000E+00 (m)
MIXING LAYER HEIGHT = 2.000E+03 (m) AIR DENSITY = 1.240E+03 (g/cu m)
WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

NO CORRECTION IS BEING MADE FOR CLOUD DEPLETION BY DRY DEPOSITION

DEPOSITION VELOCITIES (m/s)
SOLIDS = 1.000E-03 HALOGENS = 1.000E-02 NOBLE GASES = 0.000E+00
CESIUM = 1.000E-03 RUTHENIUM = 1.000E-03

THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
1.000E+00 0.000E+00

PASQUILL CLASS C METEOROLOGY, H-G SIGMA VALUES

NO BUILDING WAKE CORRECTION MADE

| DOWNWIND DISTANCE | EFFECTIVE STACK HEIGHT (m) | SIGY (m) | SIGZ (m) | CHI/Q (s/cu m) |
|---|---|---|---|---|
| 3.500E+03 | 0.000E+00 | 3.546E+02 | 1.979E+02 | 7.560E-07 |

*** GROUND SURFACE DEPOSITION DOSE EQUIVALENT CALCULATION

TIME RECEPTOR IS EXPOSED TO CONTAMINATED SOIL = 1.000E+00 (yr)
BUILDING SHIELDING FACTOR = 1.000E+00
RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION = 1.000E+00 SECONDS

DOWNWIND DISTANCE = 3.500E+03 (m) PLUME TRAVEL TIME = 5.833E+02 (s)
CHI/Q = 7.560E-07 (s/cu m)

EXAMPLE4: Ground surface dose calculation

&& GROUND SURFACE DOSE EQUIVALENTS ORDERED BY ORGAN (rem)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 3.50E+03 |
|---|---|---|
| LUNGS | 1 | 2.45E-03 |
| STOMACH | 2 | 2.26E-03 |
| S INT | 3 | 2.11E-03 |
| UL INT | 4 | 2.44E-03 |
| LL INT | 5 | 2.24E-03 |
| TESTES | 6 | 3.21E-03 |
| BREAST | 7 | 2.89E-03 |
| SKELETON | 8 | 2.62E-03 |
| RED MARR | 9 | 2.47E-03 |
| THYROID | 10 | 3.06E-03 |
| KIDNEYS | 11 | 2.44E-03 |
| LIVER | 12 | 2.32E-03 |
| SPLEEN | 13 | 2.23E-03 |
| ADRENALS | 14 | 2.33E-03 |
| PANCREAS | 15 | 2.00E-03 |
| SKIN | 16 | 3.70E-03 |
| BRAIN | 17 | 2.62E-03 |
| THYMUS | 18 | 2.57E-03 |
| BLADDER | 19 | 2.32E-03 |
| MARROW | 20 | 2.57E-03 |
| HEART | 21 | 2.29E-03 |
| OVARIES | 22 | 2.21E-03 |
| UTERUS | 23 | 2.05E-03 |

EXAMPLE4: Ground surface dose calculation

&& GROUND SURFACE DOSE EQUIVALENCES ORDERED BY DOSE (rem)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 3.50E+03 |
|---|---|---|
| SKIN | 16 | 3.70E-03 |
| TESTES | 6 | 3.21E-03 |
| THYROID | 10 | 3.06E-03 |
| BREAST | 7 | 2.89E-03 |
| SKELETON | 8 | 2.62E-03 |
| BRAIN | 17 | 2.62E-03 |
| THYMUS | 18 | 2.57E-03 |
| MARROW | 20 | 2.57E-03 |
| RED MARR | 9 | 2.47E-03 |
| LUNGS | 1 | 2.45E-03 |
| UL INT | 4 | 2.44E-03 |
| KIDNEYS | 11 | 2.44E-03 |
| ADRENALS | 14 | 2.33E-03 |
| LIVER | 12 | 2.32E-03 |
| BLADDER | 19 | 2.32E-03 |
| HEART | 21 | 2.29E-03 |
| STOMACH | 2 | 2.26E-03 |
| LL INT | 5 | 2.24E-03 |
| SPLEEN | 13 | 2.23E-03 |
| OVARIES | 22 | 2.21E-03 |
| S INT | 3 | 2.11E-03 |
| UTERUS | 23 | 2.05E-03 |
| PANCREAS | 15 | 2.00E-03 |

EXAMPLE4: Ground surface dose calculation

&& GROUND SURFACE WEIGHTED DOSE EQUIVALENTS (rem)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 3.50E+03 |
|---|---|---|
| LUNGS | 1 | 2.94E-04 |
| STOMACH | 2 | 1.35E-04 |
| S INT | 3 | 1.27E-04 |
| UL INT | 4 | 1.46E-04 |
| LL INT | 5 | 1.35E-04 |
| TESTES | 6 | 8.04E-04 |
| BREAST | 7 | 4.33E-04 |
| SKELETON | 8 | 7.86E-05 |
| RED MARR | 9 | 2.97E-04 |
| THYROID | 10 | 9.17E-05 |
| KIDNEYS | 11 | 1.46E-04 |
| LIVER | 12 | 1.39E-04 |
| SPLEEN | 13 | 1.34E-04 |
| ADRENALS | 14 | 1.40E-04 |
| PANCREAS | 15 | 1.20E-04 |
| SKIN | 16 | 3.70E-05 |
| BRAIN | 17 | 1.57E-04 |
| THYMUS | 18 | 1.54E-04 |
| BLADDER | 19 | 1.39E-04 |
| MARROW | 20 | 1.54E-04 |
| HEART | 21 | 1.38E-04 |
| OVARIES | 22 | 5.52E-04 |
| UTERUS | 23 | 1.23E-04 |
| EXT EDE | 24 | 2.74E-03 |

EXECUTION TIME = 1.10E-01 SECONDS

```
 EXAMPLE7     RSAC-5 INPUT     07/14/00     15:27
0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789

* Comparison of cloud gamma dose models
# Direct input of Cs-137 and Ba-137m
2000,0
CS137,100.
BA137M,94.6
2999
# Meteorological data input
5000
5001,0.5,0,400.,1.099E3,0,0
5101,1.E2,1.E3,1.E4,1.E5
5201,1.,0
5400,2,0,0,0
5410,1,6,0
5999
# Demo correct doses by using the finite plume model
9000,0,0,2
# Demo problems with semi-inf model & small plume
9000,1,0,2
# Demo problems with air immersion & small plume
7000,5,-2,1,1,2
7001,3.33E-4,0,0,0
7002,24
7081,55,56
7999
10000

0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789
```

EXAMPLE7: Comparison of cloud gamma dose models

***DIRECT RADIONUCLIDE INPUT

ANY PREVIOUS INVENTORY HAS BEEN ZEROED

| NUCLIDE | | HALF LIFE | | CURIES |
|---|---|---|---|---|
| 551370 | Cs137 | 3.000E+01 | yr | 1.000E+02 |
| 561371 | Ba137M | 2.552E+00 | m | 9.460E+01 |

***METEOROLOGICAL DATA

MEAN WIND SPEED = 5.000E-01 (m/s) STACK HEIGHT = 0.000E+00 (m)
MIXING LAYER HEIGHT = 4.000E+02 (m) AIR DENSITY = 1.099E+03 (g/cu m)
WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

NO CORRECTION IS BEING MADE FOR CLOUD DEPLETION BY DRY DEPOSITION

DEPOSITION VELOCITIES (m/s)
SOLIDS = 0.000E+00 HALOGENS = 0.000E+00 NOBLE GASES = 0.000E+00
CESIUM = 0.000E+00 RUTHENIUM = 0.000E+00

THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
1.000E+00 0.000E+00

PASQUILL CLASS F METEOROLOGY, H-G SIGMA VALUES

NO BUILDING WAKE CORRECTION MADE

| DOWNWIND DISTANCE | EFFECTIVE STACK HEIGHT (m) | SIGY (m) | SIGZ (m) | CHI/Q (s/cu m) |
|---|---|---|---|---|
| 1.000E+02 | 0.000E+00 | 4.011E+00 | 2.372E+00 | 6.691E-02 |
| 1.000E+03 | 0.000E+00 | 3.531E+01 | 1.290E+01 | 1.398E-03 |
| 1.000E+04 | 0.000E+00 | 2.876E+02 | 4.818E+01 | 4.594E-05 |
| 1.000E+05 | 0.000E+00 | 1.952E+03 | 9.108E+01 | 3.581E-06 |

***GAMMA DOSE CALCULATION WITH EXPOSURE TIME = 1.0000E+00 (s)
CALCULATIONS MADE USING THE FINITE MODEL

EXTERNAL EDE

DOWNWIND DISTANCE = 1.000E+02 (m) DOSE = 1.39E-02 (rem)

DOWNWIND DISTANCE = 1.000E+03 (m) DOSE = 1.57E-03 (rem)

DOWNWIND DISTANCE = 1.000E+04 (m) DOSE = 1.95E-04 (rem)

DOWNWIND DISTANCE = 1.000E+05 (m) DOSE = 2.30E-05 (rem)

***GAMMA DOSE CALCULATION WITH EXPOSURE TIME = 1.0000E+00 (s)
CALCULATIONS MADE USING THE SEMI-INFINITE MODEL

EXTERNAL EDE

EXAMPLE7: Comparison of cloud gamma dose models

DOWNWIND DISTANCE = 1.000E+02 (m) DOSE = 6.26E-01 (rem)

DOWNWIND DISTANCE = 1.000E+03 (m) DOSE = 1.31E-02 (rem)

DOWNWIND DISTANCE = 1.000E+04 (m) DOSE = 4.30E-04 (rem)

DOWNWIND DISTANCE = 1.000E+05 (m) DOSE = 3.35E-05 (rem)

*** AIR IMMERSION DOSE EQUIVALENT CALCULATION

RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION = 1.000E+00 SECONDS

DOWNWIND DISTANCE = 1.000E+02 (m) PLUME TRAVEL TIME = 2.000E+02 (s)
CHI/Q = 6.691E-02 (s/cu m)

DOWNWIND DISTANCE = 1.000E+03 (m) PLUME TRAVEL TIME = 2.000E+03 (s)
CHI/Q = 1.398E-03 (s/cu m)

DOWNWIND DISTANCE = 1.000E+04 (m) PLUME TRAVEL TIME = 2.000E+04 (s)
CHI/Q = 4.594E-05 (s/cu m)

DOWNWIND DISTANCE = 1.000E+05 (m) PLUME TRAVEL TIME = 2.000E+05 (s)
CHI/Q = 3.581E-06 (s/cu m)

&& AIR IMMERSION DOSE EQUIVALENTS ORDERED BY ORGAN (rem)

| | | DOWNWIND DISTANCES (m) | | | |
|---|---|---|---|---|---|
| ORGAN | NO. | 1.00E+02 | 1.00E+03 | 1.00E+04 | 1.00E+05 |
| --- | --- | --- | --- | --- | --- |

NO DOSE CALCULATED (NO DOE DRCF FOR REQUESTED RADIONUCLIDES)

&& AIR IMMERSION DOSE EQUIVALENCES ORDERED BY DOSE (rem)

| | | DOWNWIND DISTANCES (m) | | | |
|---|---|---|---|---|---|
| ORGAN | NO. | 1.00E+02 | 1.00E+03 | 1.00E+04 | 1.00E+05 |
| --- | --- | --- | --- | --- | --- |

NO DOSE CALCULATED (NO DOE DRCF FOR REQUESTED RADIONUCLIDES)

EXAMPLE7: Comparison of cloud gamma dose models

&& AIR IMMERSION WEIGHTED DOSE EQUIVALENTS (rem)

| | | DOWNWIND DISTANCES (m) | | | |
|---|---|---|---|---|---|
| ORGAN | NO. | 1.00E+02 | 1.00E+03 | 1.00E+04 | 1.00E+05 |
| EXT EDE | 24 | 6.62E-01 | 1.38E-02 | 4.54E-04 | 3.54E-05 |

EXECUTION TIME = 1.10E-01 SECONDS

# MEMORANDUM

To: Bruce Mabrito

From: Roland Benke

Subject: Documentation of Installation Testing for the RSAC-5.2 Code

Date: September 12, 2000

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The Radiological Safety Analysis Computer Program, Version 5.2 (RSAC) calculates the radiological consequences from a radioactive release. The RSAC code provided a more efficient means for calculating the doses from radionuclide releases compared to hand calculations. RSAC can be obtained under the CCC-125 code package designation from the Radiation Safety Information Computational Center (Radiation Safety Information Computational Center, Oak Ridge National Laboratory, PO Box 2008, Oak Ridge, TN 37381-6362). Shonka Research Associates, Inc. (Shonka Research Associates, 1993) verified and validated the use RSAC for safety related dose calculations in accordance with ANSI/ANS-10.4, "American National Standard Guidelines for the Verification and Validation of Scientific and Engineering Programs for the Nuclear Industry" (American National Standards Institute, Inc./American Nuclear Society, 1987).

RSAC was installed on an IBM-compatible personal computer from the RSAC source diskette by executing the installation routine, install.exe. Testing of RSAC was performed on the installed version 5.2 to verify that several example input files produced results that matched the values in the RSAC User's Manual (Wenzel, 1994). Example input file numbers 2, 3, 4, and 7 were chosen because they calculated dose from the same anticipated pathways used in the consequence analysis (inhalation, ingestion, ground surface, and gamma cloud submersion, respectively). The dose results in the output files generated by running the installed version of RSAC matched those contained in the example output files in the RSAC User's Manual. The output files are named Example2.out, Example3.out, Example4.out, and Example7.out and are contained in the attached diskette. Printouts of the output files are also attached to this memorandum.

**References**

American National Standards Institute, Inc./American Nuclear Society (ANSI/ANS). 1987. American National Standard Guidelines for the Verification and Validation of Scientific and Engineering Programs for the Nuclear Industry, ANSI/ANS -10.4.

Shonka Research Associates, Inc. 1993. Software Verification and Validation Report for WINCO RSAC-5 Code. Marietta, Georgia.

Wenzel, D. R. 1994. The radiological Safety Analysis Computer Program (RSAC-5) User's Manual, WINCO-1123, Revision 1. Westinghouse Idaho Nuclear Company, Inc. Idaho National Engineering Laboratory: Idaho Falls, Idaho.

# SOFTWARE VALIDATION REPORT FOR RSAC VERSION 5.2

**January 2003**

Center for Nuclear Waste Regulatory Analyses
Southwest Research Institute
San Antonio, Texas

**Author**

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Roland Benke

01/23/2003

Date

**Element Manager**

Asadul Chowdhury

1/23/03

Date

## 1.0 Scope of the Validation

This software validation report was derived from the software validation test plan for the RSAC Version 5.2 code (Revision 1, November 2001).

RSAC Version 5.2 is an acquired software not to be modified and is under configuration control at the Center for Nuclear Waste Regulatory Analyses, software release number 226. RSAC Version 5.2 (Wenzel, 1994) was developed by Westinghouse Idaho Nuclear Company, Inc. at the Idaho National Engineering Laboratory in Idaho Falls, Idaho. RSAC Version 5.2 can be obtained under the CCC-125 code package designation from the Radiation Safety Information Computational Center (Radiation Safety Information Computational Center, Oak Ridge National Laboratory, PO Box 2008, Oak Ridge, TN 37381-6362).

The validation tests the RSAC dose calculation for the pathways of inhalation, ingestion, ground surface exposure, and submersion. This validation test exercises the following modules (called series in the RSAC documentation): fission product inventory calculation, radionuclide inventory input, meteorological data input, internal/external dose calculation; and cloud gamma dose calculation. This validation test does not exercise the following RSAC modules: dose summary; definition of radionuclide data constants; post-release radioactive decay; and fifty-mile radius dose calculation.

Shonka Research Associates, Inc. (Shonka Research Associates, 1993) verified and validated the use of RSAC for safety related dose calculations in accordance with ANSI/ANS-10.4, "American National Standard Guidelines for the Verification and Validation of Scientific and Engineering Programs for the Nuclear Industry" (American National Standards Institute, Inc./American Nuclear Society, 1987). The Shonka Research Associates Executive Summary Report (Shonka Research Associates, 1993) is part of the QA software control packet for RSAC Version 5.2 at the Center for Nuclear Waste Regulatory Analyses. Shonka Research Associates denied requests for more detailed documentation of their verification and validation for RSAC Version 5.2. For this reason, no previous work is relied on for the validation of RSAC Version 5.2.

RSAC Version 5.2 calculates the radiological consequences from the atmospheric release of radioactive material. Internal doses were calculated for the pathways of inhalation and ingestion, and the external doses were computed for the pathways of ground surface exposure and submersion. The RSAC code is currently being used, and expected to be used in the future, to calculate radiological doses from these four pathways.

Testing of RSAC was performed on the installed version 5.2 for an example scenario to verify the resulting doses produced were in agreement with simplified hand calculations. The following simplified hand calculations of dose will be performed in a spreadsheet for the four pathways: inhalation, ground surface, submersion, and ingestion. In many cases, the RSAC code includes added complexity, and for that reason, these simplified hand calculations are not expected to reproduce the RSAC results exactly.

## 2.0 References

Shonka Research Associates, Inc. Software Verification and Validation Report for WINCO RSAC-5 Code. Marietta, Georgia. 1993.

Wenzel, D. R. The Radiological Safety Analysis Computer Program (RSAC-5) User's Manual, WINCO-1123, Revision 1. Westinghouse Idaho Nuclear Company, Inc. Idaho National Engineering Laboratory: Idaho Falls, Idaho. 1994.

## 3.0 Environment

3.1 Software

RSAC Version 5.2 is DOS-based. The validation test will be conducted under a Windows NT Version 4.0 operating system. The following list of files are required for the test.

| | | |
|---|---|---|
| Rp.exe | Fones | Nuclide.k01 |
| Rsac5.exe | Modint | Nuclide.k02 |
| Dfh.dat | Popcq | Nuclide.k03 |
| Input.dat | Read1 | Nuclide.k04 |
| Nuclide.dat | Stdext | Rs.bat |
| Clarion.dmp | Stdint | Rsrp.bat |
| Read1.dtt | Stdnuc | Read1.out |
| Popcq.dxt | Trancon | Valrsac5 |
| F77l.eer | Ex_3x2.k01 | Valrsac5.dtt |
| F77l3.eer | Input.k01 | Valrsac5.out |
| Ex9src | Read1.k01 | |

3.2 Hardware

The hardware required is an IBM-compatible computer with a hard drive named C:.

## 4.0 Prerequisites

The files, listed in section 3.1, must be located in a directory, named Rsac5. The directory Rsac5 must be located in the root directory of the C: drive.

## 5.0 Assumptions and Constraints

None. Assumptions of the hand calculation are presented in section 6.1.1.

## 6.0 Test Case

6.1 Pathway Test

RSAC Version 5.2 has been incorporated into the PCSA Tool, a code developed at the Center for Nuclear Waste and Regulatory Analyses. However, not all modules of the RSAC code have been incorporated into the PCSA Tool. This test simulates an instantaneous radionuclide release into the atmosphere and downwind transport of the radioactive plume and calculates the doses to a receptor via four pathways: inhalation, ground surface, submersion, and ingestion. The objective of this test is to validate the modules of the RSAC code that are utilized by the PCSA Tool. This validation test exercises the following modlues (called series in the RSAC documentation): fission product inventory calculation, radionuclide inventory input, meteorological data input, internal/external dose calculation; and cloud gamma dose calculation. This validation test does not exercise the following RSAC modules: dose summary; definition of radionuclide data constants; post-release radioactive decay; and fifty-mile radius dose calculation.

6.1.1 Test Input

The files required for the test are listed in section 3.1 Software, and the setup of the test input is described in section 4.0 Prerequisites. Specifically, the test input for the RSAC Version 5.2 code can be viewed in the file named Valrsac5.

6.1.2 Test Procedure

6.1.2.1 Running the RSAC code

The seven steps for running RSAC are listed below.

(1) Execute the batch file *RP.exe* and enter *Valrsac5* after the input file prompt
(2) Select the 'A)' option to edit the file
(3) Press Enter twice to avoid editing the title
(4) Select the 'Run RSAC-5 with file currently in memory' from the menu options
(5) Press Enter when prompted after the calculation
(6) Select the 'Browse RSAC-5 output file' option
(7) Compare the dose results for each radionuclide to those doses from the hand calculation.

6.1.2.2 Simplified Hand Calculations for Validation

The nine steps for the simplified hand calculations are presented next. Following the nine steps yields doses for the pathways of inhalation, ground surface, submersion, and ingestion (these four doses are referred to as the "pathway doses"). Some of the nine steps calculate intermediate quantities, which are used in the calculation of the pathway doses. Validation comparisons are performed on the four pathway doses (inhalation, ground surface, submersion, and ingestion).

**(1) Calculate Airborne Concentration**

Neglecting dry plume depletion and reflection from the mixing layer height, calculate airborne concentration downwind:

$$\chi = \frac{Q}{\pi u \sigma_y(x)\sigma_z(x)} \exp\left(-\frac{h^2}{2\sigma_z^2}\right)$$

where
$\chi$ represents the airborne concentration (Ci/m$^3$) at a downwind distance $x$ (m),
$Q$ represents the released activity release rate (Ci/s)
$u$ represents the average wind speed (m/s),
$\sigma_y(x)$ represents the standard deviation of horizontal dispersion (m) at a downwind distance $x$,
$\sigma_z(x)$ represents the standard deviation of vertical dispersion (m) at a downwind distance $x$, and
$h$ represents the stack height (m).

**(2) Calculate Inhalation Dose**

The inhalation committed effective dose equivalent (CEDE) is calculated in Sv from the following expression:

$$\text{Inhalation CEDE} = \left(\frac{3.7 \times 10^{10}\,\text{Bq}}{1\text{Ci}}\right)\left(\text{DCF}_{\text{inh}} \times \chi \times \text{BR} \times t_r\right)$$

where
$\text{DCF}_{\text{inh}}$ represents the dose conversion factor for inhalation of the radionuclide of interest (Sv/Bq),
BR represents the breathing rate (m$^3$/s), and
$t_r$ represents the release duration (s).

Note, this calculation assumes the same duration for release and exposure.

**(3) Calculate Ground Surface Dose**

The effective dose equivalent (EDE) from ground surface exposure is calculated from the following relationship:

$$\text{Ground Surface EDE} = \text{DRCF}_{gs} \times \frac{\chi}{Q} \times V_d \times f_{shield} \times \frac{A_0}{\lambda}\left[1 - e^{-\lambda t_e}\right]$$

where
$\text{DRCF}_{gs}$ represents the dose rate conversion factor due to ground surface exposure from the radionuclide of interest (Sv $m^2$/Bq s),
$V_d$ represents the deposition velocity (m/s),
$f_{shield}$ represents the building shielding factor (unitless),
$A_0$ represents the undecayed activity released (Bq),
$\lambda$ represents the radioactive decay constant for the radionuclide of interest (1/s), and
$t_e$ represents the ground surface exposure time (s).

**(4) Calculate Air Submersion Dose**

Assuming negligible radioactive decay during plume transport, the effective dose equivalent (EDE) from air submersion is calculated from the following relationship:

$$\text{Submersion EDE} = \text{DRCF}_{sub} \times \frac{\chi}{Q} \times A_0$$

where
$\text{DRCF}_{sub}$ represents the dose rate conversion factor due to air submersion from the radionuclide of interest (Sv $m^3$/Bq s).

**(5) Calculate Ground Concentration**

Assuming negligible radioactive decay during plume transport, the ground concentration, $G$ (Bq/$m^2$), is calculated:

$$G = \left(\frac{3.7 \times 10^{10}\ \text{Bq}}{1\ \text{Ci}}\right)\left(\chi \times v_d \times t_r\right)$$

where
$v_d$ represents the deposition velocity (m/s).

**(6) Calculate Ingestion Dose from Leafy Vegetables**

The ingestion dose from leafy vegetables, $D_{leafyveg}$ (Sv), is calculated from the following relationship, which includes contributions from deposited activity on foliage and root uptake:

$$D_{leafyveg} = \text{DCF}_{ing}\,\text{U}_{leafyveg}\left(\frac{f_{contam} \times f_{trans,leafveg} \times f_{int,veg}}{Y_{veg}} + \frac{B_{produce}}{\phi}\right)G$$

where
$\text{DCF}_{ing}$ represents the dose conversion factor for ingestion (Sv/Bq),
$\text{U}_{leafyveg}$ represents the leafy vegetable consumption rate (kg/yr),
$f_{contam}$ represents the fraction of crops contaminated (unitless),

$f_{trans,leafveg}$ represents the translocation fraction of the deposited activity for leafy vegetables (unitless),
$f_{int,veg}$ represents the interception fraction for radionuclide deposition on vegetable foliage (unitless),
$Y_{veg}$ represents the crop yield for vegetables (kg/m$^2$),
$B_{produce}$ represents the conversion factor for root uptake from contaminated soil to edible portion of crop for produce (Bq/kg crop per Bq/kg soil), and
$\phi$ represents the effective surface soil density (kg/m$^2$ soil).

**(7) Calculate Ingestion Dose from Nonleafy Vegetables**

The ingestion dose from nonleafy vegetables, $D_{nonleafyveg}$ (Sv), is calculated from the following relationship for root uptake:

$$D_{nonleafyveg} = \mathrm{DCF_{ing}U_{nonleafyveg}}\left(\frac{f_{contam} \times f_{trans,nonleaf} \times f_{\mathrm{int,veg}}}{Y_{veg}} + \frac{B_{produce}}{\phi}\right)G$$

where
$\mathrm{U_{nonleafyveg}}$ represents the nonleafy vegetable consumption rate (kg/yr), and
$f_{trans,nonleaf}$ represents the fraction of the deposited activity translocated to the edible portion of the nonleafy vegetable (unitless),

**(8) Calculate Ingestion Dose from Milk**

Assuming livestock feeds entirely on forage, the ingestion dose from milk, $D_{milk}$ (Sv), is calculated from the following relationship:

$$D_{milk} = \mathrm{DCF_{ing}U_{milk}F_{milk}U_{feed}}\left(\frac{f_{contam} \times f_{trans,forage} \times f_{\mathrm{int,forage}}}{Y_{forage}} + \frac{B_{forage}}{\phi}\right)G$$

where
$\mathrm{U_{milk}}$ represents the milk consumption rate (L/yr),
$\mathrm{F_{milk}}$ represents the bioconversion factor for animal's intake of radioactivity to radioactivity in milk (Bq/L milk per Bq/day intake = day/L),
$\mathrm{U_{feed}}$ represents the animal's consumption rate of feed (kg/day), and
$f_{int,forage}$ represents the interception fraction for radionuclide deposition on forage (unitless), and
$Y_{forage}$ represents the crop yield for forage (kg/m$^2$), and
$B_{forage}$ represents the conversion factor for root uptake from contaminated soil to edible portion of crop for forage (Bq/kg crop per Bq/kg soil).

**(9) Calculate Ingestion Dose from Meat**

Assuming livestock feeds entirely on forage, the ingestion dose from meat, $D_{meat}$ (Sv), is calculated from the following relationship:

$$D_{meat} = \mathrm{DCF_{ing}U_{meat}F_{meat}U_{feed}}\left(\frac{f_{contam} \times f_{trans,forage} \times f_{\mathrm{int,forage}}}{Y_{forage}} + \frac{B_{forage}}{\phi}\right)G$$

where
$\mathrm{U_{meat}}$ represents the meat consumption rate (kg/yr),
$\mathrm{F_{meat}}$ represents the bioconversion factor for animal's intake of radioactivity to radioactivity in meat (Bq/kg meat per Bq/day intake = day/kg ), and
$\mathrm{U_{feed}}$ represents the animal's consumption rate of feed (kg/day).

The total ingestion dose is calculated as the sum of ingestion doses from leafy vegetables, nonleafy vegetables, milk, and meat.

If the dose outputs for a selected number of individual radionuclides from the RSAC Version 5.2 code are in reasonable agreement (i.e., within a factor of 2) with the results from the simplified hand calculations, the validation test is passed.

### 6.1.3 Test Results

Three radionuclides (I-129, H-3, and Co-60) were selected for the validation test based on their significance to the radiological pathway doses during preclosure spent nuclear fuel handling and operations. The nine steps from the previous section were followed, and the results for the four pathway doses are presented in Tables 1–4. The pathway doses were within a factor of 2 for each radionuclide, and therefore, the validation test was passed.

**Table 1.** Results for Inhalation Dose.

| Radionuclide | Inhalation Committed Effective Dose Equivalent (Sv) | | Ratio (Validation Calculation to RSAC Version 5.2) |
|---|---|---|---|
| | Validation Calculation | RSAC Version 5.2 | |
| I-129 | $8.90\times10^{-6}$ | $9.66\times10^{-6}$ | 0.92 |
| H-3 | $3.28\times10^{-9}$ | $5.12\times10^{-9}$ | 0.64 |
| Co-60 | $1.12\times10^{-5}$ | $8.05\times10^{-6}$ | 1.4 |

**Table 2.** Results for Ground Surface Dose.

| Radionuclide | Ground Surface Effective Dose Equivalent (Sv) | | Ratio (Validation Calculation to RSAC Version 5.2) |
|---|---|---|---|
| | Validation Calculation | RSAC Version 5.2 | |
| I-129 | $3.25\times10^{-6}$ | $2.65\times10^{-6}$ | 1.2 |
| H-3 | $0.00\times10^{+0}$ | $0.00\times10^{+0}$ | (same value) |
| Co-60 | $2.77\times10^{-5}$ | $2.59\times10^{-5}$ | 1.1 |

**Table 3.** Results for Submersion Dose.

| Radionuclide | Submersion Effective Dose Equivalent (Sv) | | Ratio (Validation Calculation to RSAC Version 5.2) |
|---|---|---|---|
| | Validation Calculation | RSAC Version 5.2 | |
| I-129 | $2.17\times10^{-10}$ | $2.27\times10^{-10}$ | 0.95 |
| H-3 | $1.89\times10^{-13}$ | none | not applicable* |
| Co-60 | $7.18\times10^{-8}$ | $7.13\times10^{-8}$ | 1.0 |

*RSAC Version 5.2 does not calculate a submersion dose for H-3. The submersion dose rate conversion factor and resulting effective dose equivalent for H-3 are orders of magnitude smaller than those for the other radionuclides.

**Table 4.** Results for Ingestion Dose.

| Radionuclide | Ingestion Committed Effective Dose Equivalent (Sv) | | Ratio (Validation Calculation to RSAC Version 5.2) |
|---|---|---|---|
| | Validation Calculation | RSAC Version 5.2 | |
| I-129 | $9.90\times10^{-2}$ | $1.26\times10^{-1}$ | 0.79 |
| H-3 | $6.31\times10^{-7}$ | $7.49\times10^{-7}$ | 0.84 |
| Co-60 | $2.37\times10^{-4}$ | $2.41\times10^{-4}$ | 1.0 |

## 7.0 Notes

Doses are not calculated for chronic releases. Therefore, a specialized dose calculation for tritium (H-3), to account for tritiated water reaching equilibrium with the water in plants, was not performed.

There are three attachments to this validation report.

Attachments:
1. Printout of the RSAC Version 5.2 output file, Valrsac5.out (27 pages)
2. Printout of the Validation Test Spreadsheet, RSAC52-validation.xls (2 pages)
3. Diskette containing the following files:
   \RSAC 5.2 Validation\RSAC Files\Valrsac5
   \RSAC 5.2 Validation\RSAC Files\Valrsac5.dtt
   \RSAC 5.2 Validation\RSAC Files\Valrsac5.out
   \RSAC 5.2 Validation\Validation Report\RSAC52-Validation.wpd
   \RSAC 5.2 Validation\Validation Spreadsheet\RSAC52-validation.xls

**INHALATION, see (1) and (2) in Section 6.1.2.2 of the software validation report**

| | | | |
|---|---|---|---|
| $t_r$ | 900 | s | max duration for Hilsmeier-Gifford, see p. 4-18 of RSAC-6 manual |
| x | 10,000 | m | assumption |
| Q | 0.001111111 | Ci/s | assumed 1 Ci released over time duration, $t_r$ |
| u | 1 | m/s | assumption |
| $\sigma_y$ | 300 | m | from p. C-2 of RSAC-6 manual, Hilsmeier-Gifford |
| $\sigma_z$ | 50 | m | from p. C-3 of RSAC-6 manual, Hilsmeier-Gifford |
| h | 40 | m | assumption |
| BR | 3.33E-04 | $m^3/s$ | |
| Chi | 1.71E-08 | $Ci/m^3$ | |
| Chi/Q | 1.54E-05 | $s/m^3$ | |

| | I-129 | H-3 | Co-60 | |
|---|---|---|---|---|
| $DCF_{inh}$ (FGR-11) | 4.69E-08 | 1.73E-11 | 5.91E-08 | Sv/Bq |

Inhalation CEDE (Sv) Results

| | I-129 | H-3 | Co-60 |
|---|---|---|---|
| Validation calculation | 8.90E-06 | 3.28E-09 | 1.12E-05 |
| RSAC5 result | 9.66E-06 | 5.12E-09 | 8.05E-06 |
| Validation-to-RSAC5 Ratio | 0.92 | 0.64 | 1.4 |

**GROUND SURFACE (for 1 yr following the release), see (1) and (3) in Section 6.1.2.2 of the software validation report**

| | | | |
|---|---|---|---|
| $t_e$ | 31557600 | s | assumed one-year exposure |
| $f_{shield}$ | 0.7 | unitless | assumption |
| $A_0$ | 3.70E+10 | Bq | assumed 1 Ci released |

| | I-129 | H-3 | Co-60 | |
|---|---|---|---|---|
| $DRCF_{gs}$ (FGR-12) | 2.58E-17 | 0.00E+00 | 2.35E-15 | Sv $m^2$ / Bq s |
| $V_d$ | 0.01 | 0.01 | 0.001 | m/s |
| $\lambda$ (RHH, 1970) | 2.20E-15 | 1.79E-09 | 4.17E-09 | 1/s |

Ground Surface EDE (Sv) Results

| | I-129 | H-3 | Co-60 |
|---|---|---|---|
| Validation calculation | 3.25E-06 | 0.00E+00 | 2.77E-05 |
| RSAC5 result | 2.65E-06 | 0.00E+00 | 2.59E-05 |
| Validation-to-RSAC5 Ratio | 1.2 | n/a | 1.1 |

**SUBMERSION, see (1) and (4) in Section 6.1.2.2 of the software validation report**

| | I-129 | H-3 | Co-60 | |
|---|---|---|---|---|
| $DRCF_{sub}$ (FGR-12) | 3.80E-16 | 3.31E-19 | 1.26E-13 | Sv $m^3$ / Bq s |

Submersion EDE (Sv) Results

| | I-129 | H-3 | Co-60 |
|---|---|---|---|
| Validation calculation | 2.17E-10 | 1.89E-13 | 7.18E-08 |
| RSAC5 result | 2.27E-10 | none | 7.13E-08 |
| Validation-to-RSAC5 Ratio | 0.95 | n/a* | 1.0 |

** RSAC5 does not calculate a submerison dose for H-3.*
*It should be noted that the submersion DRCF and resulting EDE are orders of magnitude smaller than the other radionuclides.*

## INGESTION (for 1 yr following the release), see (1) and (5)-(9) in Sec. 6.1.2.2 of the software validation report

| | | | | | |
|---|---|---|---|---|---|
| $f_{contam}$ | 1 | unitless | $U_{leafveg}$ | 64 | kg/yr |
| $Y_{veg}$ | 2 | $kg/m^2$ | $U_{nonleafveg}$ | 520 | kg/yr |
| $Y_{forage}$ | 0.28 | $kg/m^2$ | $U_{milk}$ | 310 | L/yr |
| $\phi$ | 225 | $kg/m^2$ | $U_{meat}$ | 110 | kg/yr |
| | | | $U_{feed}$ | 16 | kg/day |

| | I-129 | H-3 | Co-60 | |
|---|---|---|---|---|
| $DCF_{ing}$ (FGR-11) | 7.46E-08 | 1.73E-11 | 2.77E-09 | Sv/Bq |
| $f_{int,forage}$ | 1.00 | 0.57 | 0.57 | unitless |
| $f_{int,veg}$ | 0.20 | 0.20 | 0.20 | unitless |
| $f_{trans,leafveg}$ | 1.00 | 1.00 | 1.00 | unitless |
| $f_{trans,nonleaf}$ | 0.10 | 1.00 | 1.00 | unitless |
| $f_{trans,forage}$ | 1.00 | 1.00 | 1.00 | unitless |
| $B_{produce}$ | 2.10E-02 | 0.00 | 3.00E-03 | Bq/kg crop per Bq/kg soil |
| $B_{forage}$ | 1.50E-02 | 0.00 | 2.00E-02 | Bq/kg crop per Bq/kg soil |
| $F_{milk}$ | 1.00E-02 | 0.00 | 2.00E-03 | Bq/L milk per Bq/day feed |
| $F_{meat}$ | 7.00E-03 | 0.00 | 2.00E-02 | Bq/kg meat per Bq/day feed |
| $D_{leafveg}$ | 2.72E-03 | 6.31E-07 | 1.01E-05 | Sv for 1 year following the release |
| $D_{nonleafveg}$ | 2.23E-03 | 0.00E+00 | 8.21E-05 | Sv for 1 year following the release |
| $D_{milk}$ | 7.53E-02 | 0.00E+00 | 3.19E-05 | Sv for 1 year following the release |
| $D_{meat}$ | 1.87E-02 | 0.00E+00 | 1.13E-04 | Sv for 1 year following the release |

Ingestion CEDE (Sv) Results

| | I-129 | H-3 | Co-60 |
|---|---|---|---|
| Validation calculation | 9.90E-02 | 6.31E-07 | 2.37E-04 |
| RSAC5 result | 1.26E-01 | 7.49E-07 | 2.41E-04 |
| Validation-to-RSAC5 Ratio | 0.79 | 0.84 | 1.0 |

## REFERENCES

FGR-11 EPA. Federal Guidance Report No. 11, EPA 520/1–88–020, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion." Washington, DC: EPA. Office of Radiation Programs. 1988.

FGR-12 EPA. Federal Guidance Report No. 12, EPA 402–R–93–081, "External Exposure to Radionuclides in Air, Water, and Soil." Washington, DC: EPA. 1993.

RHH, 1970 U.S. Department of Health, Education, and Welfare. "Radiological Health Handbook." Rockville, Maryland: U.S. Department of Health, Education, and Welfare. Public Health Service. Bureau of Radiological Health. 1970

RSAC-6 manual Wenzel, D.R., Schrader, B.J. "The Radiological Safety Analysis Computer Program (RSAC–6) User's Manual." INEEL/EXT-01-00540. Idaho Falls, Idaho: Idaho National Engineering and Environmental Laboratory. 2001.

```
 VALRSAC5      RSAC-5 INPUT      11/21/02      07:02
0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789

* Validation Run with 1 Ci release of I-129, H-3, and Co-60
# Radionuclide Releases (Ci)
2000,0
H  3,1.
CO 60,1.
I129,1.
2999
# Meteorological Inputs
5000
5001,1.,40.,1420.,1.099E3,0,1
5002,.001,.01,0.,.001,.001
5101,10000.
5201,1.,0
5400,2,0,0,0
5410,1,6,0
5999
# Inhalation Calculation
7000,0,1,2,0,1
7001,3.33E-4,0,0,0
7999
# Ground Surface Calculation
7000,4,1,2,0,1
7001,0,0,1.,0.7
7999
# Submersion Calculation
7000,5,1,2,0,1
7001,0,0,0,0
7999
# Ingestion Calculation
7000,3,1,2,0,1
7001,0,0,1.,0
7004,0,2,7.,7.
7051,520.,64.,110.,310.,1.,1.
7052,0.57,0.2,1.,0,60.,30.,100.
7053,225.,0,1.,16.,0,0
7054,0,0,0,2.,0.28,4.9
7055,1.,1.,1.,1.
7999
10000

0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789
                RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL 1129  DATE  11/21/02  TIME 07:02  PAGE   1
VALRSAC5:  Validation Run with 1 Ci release of I-129, H-3, and Co-60

***DIRECT RADIONUCLIDE INPUT

        ANY PREVIOUS INVENTORY HAS BEEN ZEROED

    NUCLIDE          HALF LIFE       CURIES

  10030   H  3    1.228E+01  yr    1.000E+00
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 270600  Co 60    5.271E+00  yr    1.000E+00
 531290   I129    1.570E+07  yr    1.000E+00

***METEOROLOGICAL DATA

        MEAN WIND SPEED = 1.000E+00 (m/s)   STACK HEIGHT = 4.000E+01 (m)
    MIXING LAYER HEIGHT = 1.420E+03 (m)      AIR DENSITY = 1.099E+03 (g/cu m)
    WET DEPOSITION SCAVENGING COEFFICIENT = 0.000E+00 (1/S)

    CLOUD DEPLETION BY FALLOUT IS INCLUDED

    DEPOSITION VELOCITIES (m/s)
         SOLIDS = 1.000E-03    HALOGENS = 1.000E-02   NOBLE GASES = 0.000E+00
         CESIUM = 1.000E-03   RUTHENIUM = 1.000E-03

    THERE IS 1 SET OF LEAKAGE CONSTANTS (K1,K2)
          1.000E+00       0.000E+00

    PASQUILL CLASS F METEOROLOGY,  H-G   SIGMA VALUES

    DOWNWIND DISTANCE  EFFECTIVE STACK   SIGY        SIGZ        CHI/Q
                          HEIGHT (m)     (m)         (m)        (s/cu m)
         1.000E+04         4.000E+01   2.876E+02   4.818E+01   1.627E-05

  *** INHALATION DOSE EQUIVALENT CALCULATION

                        BREATHING RATE =  3.330E-04 (cu m/s)
                 RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION =  1.000E+00 (s)
        INTERNAL EXPOSURE TIME PERIOD  =  5.000E+01 (yr)

    PARTICLE SIZE =  1.0 MICRONS AMAD
    LUNG DEPOSITION FRACTIONS: N-P = 0.300  T-B = 0.080  P = 0.250

  LUNG CLEARANCE CLASSES USED IN CALCULATIONS
      ELEMENT     CLASS

       1    H      HTO
       4   Be       Y
       6    C      ORG
      11   Na       D
      14   Si       W
      15    P       D
      16    S       D
      17   Cl       D
      19    K       D
```



```
  LUNG CLEARANCE CLASSES USED IN CALCULATIONS
      ELEMENT     CLASS

      20   Ca       W
      21   Sc       Y
      24   Cr       Y
      25   Mn       W
      26   Fe       W
```

| | | |
|---|---|---|
| 27 | Co | Y |
| 28 | Ni | W |
| 29 | Cu | Y |
| 30 | Zn | Y |
| 32 | Ge | W |
| 34 | Se | W |
| 35 | Br | D |
| 37 | Rb | D |
| 38 | Sr | D |
| 39 | Y | Y |
| 40 | Zr | W |
| 41 | Nb | Y |
| 42 | Mo | Y |
| 43 | Tc | W |
| 44 | Ru | Y |
| 45 | Rh | Y |
| 46 | Pd | Y |
| 47 | Ag | Y |
| 48 | Cd | Y |
| 49 | In | W |
| 50 | Sn | W |
| 51 | Sb | D |
| 52 | Te | W |
| 53 | I | D |
| 55 | Cs | D |
| 56 | Ba | D |
| 57 | La | W |
| 58 | Ce | Y |
| 59 | Pr | Y |
| 60 | Nd | Y |
| 61 | Pm | Y |
| 62 | Sm | W |
| 63 | Eu | W |
| 64 | Gd | W |
| 73 | Ta | Y |
| 77 | Ir | Y |
| 81 | Tl | D |
| 82 | Pb | D |
| 83 | Bi | W |
| 84 | Po | W |
| 85 | At | D |
| 88 | Ra | W |
| 89 | Ac | Y |
| 90 | Th | Y |



LUNG CLEARANCE CLASSES USED IN CALCULATIONS

| ELEMENT | | CLASS |
|---|---|---|
| 91 | Pa | Y |
| 92 | U | Y |
| 93 | Np | W |
| 94 | Pu | Y |
| 95 | Am | W |
| 96 | Cm | W |

DOWNWIND DISTANCE = 1.000E+04 (m) PLUME TRAVEL TIME = 1.000E+04 (s)
CHI/Q = 1.627E-05 (s/cu m)

| | | | | | |
|---|---|---|---|---|---|
| LUNGS | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | Co - 60 | 270600 | 6.98E-05 | 8.38E-06 |
| | | TOTAL Co (ATOMIC NO 27) | | 6.98E-05 | 8.38E-06 |
| | | TOTAL LUNGS INHALATION = | | 6.98E-05 | 8.38E-06 |
| S WALL | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| SI WALL | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| ULI WALL | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| LLI WALL | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| GONADS | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| BREASTS | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| BONE SUR | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |



DOWNWIND DISTANCE = 1.000E+04 R MARROW INHALATION DOSE EQUIVALENT

| | | | | | |
|---|---|---|---|---|---|
| R MARROW | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| THYROID | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | I - 129 | 531290 | 3.17E-04 | 9.50E-06 |
| | | TOTAL I (ATOMIC NO 53) | | 3.17E-04 | 9.50E-06 |
| | | TOTAL THYROID INHALATION = | | 3.17E-04 | 9.50E-06 |

| | | | | | |
|---|---|---|---|---|---|
| KIDNEYS | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| LIVER | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| SPLEEN | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| PANCREAS | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| S TISSUE | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | H - 3 | 10030 | 5.12E-09 | 5.12E-09 |
| | | TOTAL H (ATOMIC NO 1) | | 5.12E-09 | 5.12E-09 |
| | | TOTAL S TISSUE INHALATION = | | 5.12E-09 | 5.12E-09 |
| OTHER | INHALATION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| CEDE | INHALATION | ISOTOPE | NUCLIDE | CEDE (Sv) | |
| | | H - 3 | 10030 | 5.12E-09 | |
| | | TOTAL H (ATOMIC NO 1) | | 5.12E-09 | |
| | | Co - 60 | 270600 | 8.05E-06 | |

RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL 1129 DATE 11/21/02 TIME 07:02 PAGE 5
VALRSAC5: Validation Run with 1 Ci release of I-129, H-3, and Co-60

DOWNWIND DISTANCE = 1.000E+04 CEDE INHALATION DOSE EQUIVALENT

| | | | | |
|---|---|---|---|---|
| CEDE | INHALATION | ISOTOPE | NUCLIDE | CEDE (Sv) |
| | | TOTAL Co (ATOMIC NO 27) | | 8.05E-06 |
| | | I - 129 | 531290 | 9.66E-06 |
| | | TOTAL I (ATOMIC NO 53) | | 9.66E-06 |
| | | TOTAL CEDE INHALATION = | | 1.77E-05 |

&& INHALATION COMMITTED DOSE EQUIVALENTS ORDERED BY ORGAN (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 |
|---|---|---|
| --- | --- | --- |

```
LUNGS       1   6.98E-05
THYROID    10   3.17E-04
S TISSUE   15   5.12E-09

----------
ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

&&      INHALATION COMMITTED DOSE EQUIVALENCES ORDERED BY DOSE  (Sv)

                DOWNWIND DISTANCES (m)
  ORGAN    NO.  1.00E+04
--------   ---  --------
THYROID    10   3.17E-04
LUNGS       1   6.98E-05
S TISSUE   15   5.12E-09

----------
ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE
              RADIOLOGICAL SAFETY ANALYSIS COMPUTER PROGRAM (RSAC-5)
(RSAC-5E,REV 5.2,02/22/94) SERIAL 1129  DATE  11/21/02  TIME 07:02  PAGE   6
VALRSAC5:  Validation Run with 1 Ci release of I-129, H-3, and Co-60

&&      INHALATION WEIGHTED COMMITTED DOSE EQUIVALENTS  (Sv)

                DOWNWIND DISTANCES (m)
  ORGAN    NO.  1.00E+04
--------   ---  --------
LUNGS       1   8.38E-06
THYROID    10   9.50E-06
S TISSUE   15   5.12E-09
CEDE       18   1.77E-05

----------
ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

*** GROUND SURFACE DEPOSITION DOSE EQUIVALENT CALCULATION

  TIME RECEPTOR IS EXPOSED TO CONTAMINATED SOIL =  1.000E+00 (yr)
  BUILDING SHIELDING FACTOR =  7.000E-01
  RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION =  1.000E+00 SECONDS

  DOWNWIND DISTANCE =  1.000E+04 (m)     PLUME TRAVEL TIME =  1.000E+04 (s)
                                         CHI/Q =  1.627E-05 (s/cu m)

                                          D.E.    WEIGHTED  INITIAL   INITIAL
 LUNGS    GROUND SUR  ISOTOPE  NUCLIDE    (Sv)      (Sv)     (Sv/h )  micro-Ci
                                                            (W/0 BSF)  PER sq m

                     Co -  60  270600  2.31E-05  2.77E-06  4.02E-09  1.61E-02

            TOTAL Co (ATOMIC NO 27)    2.31E-05  2.77E-06

                      I - 129  531290  1.31E-06  1.57E-07  2.13E-10  1.61E-01

            TOTAL  I (ATOMIC NO 53)    1.31E-06  1.57E-07

       TOTAL LUNGS    GROUND SURFACE =  2.44E-05  2.93E-06
```

| STOMACH GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 2.13E-05 | 1.28E-06 | 3.70E-09 | 1.61E-02 |
| TOTAL Co (ATOMIC NO 27) | | | 2.13E-05 | 1.28E-06 | | |
| | I - 129 | 531290 | 9.51E-07 | 5.71E-08 | 1.55E-10 | 1.61E-01 |
| TOTAL I (ATOMIC NO 53) | | | 9.51E-07 | 5.71E-08 | | |

TOTAL STOMACH GROUND SURFACE = 2.22E-05 1.33E-06



DOWNWIND DISTANCE = 1.000E+04 S INT GROUND SURFACE DOSE EQUIVALENT

| S INT GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 1.99E-05 | 1.19E-06 | 3.46E-09 | 1.61E-02 |
| TOTAL Co (ATOMIC NO 27) | | | 1.99E-05 | 1.19E-06 | | |
| | I - 129 | 531290 | 6.85E-07 | 4.11E-08 | 1.12E-10 | 1.61E-01 |
| TOTAL I (ATOMIC NO 53) | | | 6.85E-07 | 4.11E-08 | | |

TOTAL S INT GROUND SURFACE = 2.06E-05 1.24E-06

| UL INT GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 2.30E-05 | 1.38E-06 | 4.00E-09 | 1.61E-02 |
| TOTAL Co (ATOMIC NO 27) | | | 2.30E-05 | 1.38E-06 | | |
| | I - 129 | 531290 | 1.12E-06 | 6.70E-08 | 1.82E-10 | 1.61E-01 |
| TOTAL I (ATOMIC NO 53) | | | 1.12E-06 | 6.70E-08 | | |

TOTAL UL INT GROUND SURFACE = 2.41E-05 1.45E-06

| LL INT GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 2.12E-05 | 1.27E-06 | 3.68E-09 | 1.61E-02 |
| TOTAL Co (ATOMIC NO 27) | | | 2.12E-05 | 1.27E-06 | | |
| | I - 129 | 531290 | 8.17E-07 | 4.90E-08 | 1.33E-10 | 1.61E-01 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | TOTAL I (ATOMIC NO 53) | | | 8.17E-07 | 4.90E-08 | | |
| TOTAL LL INT GROUND SURFACE = | | | | 2.20E-05 | 1.32E-06 | | |
| TESTES | GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
| | | Co - 60 | 270600 | 3.03E-05 | 7.58E-06 | 5.27E-09 | 1.61E-02 |
| | TOTAL Co (ATOMIC NO 27) | | | 3.03E-05 | 7.58E-06 | | |
| | | I - 129 | 531290 | 3.77E-06 | 9.43E-07 | 6.15E-10 | 1.61E-01 |



DOWNWIND DISTANCE = 1.000E+04 TESTES GROUND SURFACE DOSE EQUIVALENT

| | | | | | |
|---|---|---|---|---|---|
| TESTES | GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) |
| | TOTAL I (ATOMIC NO 53) | | | 3.77E-06 | 9.43E-07 |
| TOTAL TESTES GROUND SURFACE = | | | | 3.41E-05 | 8.52E-06 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BREAST | GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
| | | Co - 60 | 270600 | 2.72E-05 | 4.08E-06 | 4.74E-09 | 1.61E-02 |
| | TOTAL Co (ATOMIC NO 27) | | | 2.72E-05 | 4.08E-06 | | |
| | | I - 129 | 531290 | 5.79E-06 | 8.68E-07 | 9.43E-10 | 1.61E-01 |
| | TOTAL I (ATOMIC NO 53) | | | 5.79E-06 | 8.68E-07 | | |
| TOTAL BREAST GROUND SURFACE = | | | | 3.30E-05 | 4.95E-06 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SKELETON | GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
| | | Co - 60 | 270600 | 2.47E-05 | 7.41E-07 | 4.30E-09 | 1.61E-02 |
| | TOTAL Co (ATOMIC NO 27) | | | 2.47E-05 | 7.41E-07 | | |
| | | I - 129 | 531290 | 2.28E-06 | 6.85E-08 | 3.72E-10 | 1.61E-01 |
| | TOTAL I (ATOMIC NO 53) | | | 2.28E-06 | 6.85E-08 | | |
| TOTAL SKELETON GROUND SURFACE = | | | | 2.70E-05 | 8.10E-07 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | D.E. | WEIGHTED | INITIAL | INITIAL |

| RED MARR GROUND SUR | ISOTOPE | NUCLIDE | (Sv) | (Sv) | (Sv/h ) (W/0 BSF) | micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 2.33E-05 | 2.80E-06 | 4.06E-09 | 1.61E-02 |
| TOTAL Co (ATOMIC NO 27) | | | 2.33E-05 | 2.80E-06 | | |
| | I - 129 | 531290 | 4.91E-07 | 5.89E-08 | 8.00E-11 | 1.61E-01 |
| TOTAL I (ATOMIC NO 53) | | | 4.91E-07 | 5.89E-08 | | |



DOWNWIND DISTANCE = 1.000E+04 RED MARR GROUND SURFACE DOSE EQUIVALENT

TOTAL RED MARR GROUND SURFACE = 2.38E-05 2.86E-06

| THYROID GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 2.88E-05 | 8.65E-07 | 5.01E-09 | 1.61E-02 |
| TOTAL Co (ATOMIC NO 27) | | | 2.88E-05 | 8.65E-07 | | |
| | I - 129 | 531290 | 2.65E-06 | 7.95E-08 | 4.32E-10 | 1.61E-01 |
| TOTAL I (ATOMIC NO 53) | | | 2.65E-06 | 7.95E-08 | | |

TOTAL THYROID GROUND SURFACE = 3.15E-05 9.44E-07

| KIDNEYS GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 2.30E-05 | 1.38E-06 | 4.00E-09 | 1.61E-02 |
| TOTAL Co (ATOMIC NO 27) | | | 2.30E-05 | 1.38E-06 | | |
| | I - 129 | 531290 | 2.16E-06 | 1.30E-07 | 3.52E-10 | 1.61E-01 |
| TOTAL I (ATOMIC NO 53) | | | 2.16E-06 | 1.30E-07 | | |

TOTAL KIDNEYS GROUND SURFACE = 2.52E-05 1.51E-06

| LIVER GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 2.19E-05 | 1.31E-06 | 3.80E-09 | 1.61E-02 |
| TOTAL Co (ATOMIC NO 27) | | | 2.19E-05 | 1.31E-06 | | |
| | I - 129 | 531290 | 1.03E-06 | 6.18E-08 | 1.68E-10 | 1.61E-01 |

TOTAL I (ATOMIC NO 53) 1.03E-06 6.18E-08

TOTAL LIVER GROUND SURFACE = 2.29E-05 1.37E-06



DOWNWIND DISTANCE = 1.000E+04 SPLEEN GROUND SURFACE DOSE EQUIVALENT

| SPLEEN GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 2.11E-05 | 1.26E-06 | 3.66E-09 | 1.61E-02 |
| TOTAL Co (ATOMIC NO 27) | | | 2.11E-05 | 1.26E-06 | | |
| | I - 129 | 531290 | 8.44E-07 | 5.06E-08 | 1.38E-10 | 1.61E-01 |
| TOTAL I (ATOMIC NO 53) | | | 8.44E-07 | 5.06E-08 | | |
| TOTAL SPLEEN GROUND SURFACE = | | | 2.19E-05 | 1.31E-06 | | |

| ADRENALS GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 2.20E-05 | 1.32E-06 | 3.82E-09 | 1.61E-02 |
| TOTAL Co (ATOMIC NO 27) | | | 2.20E-05 | 1.32E-06 | | |
| | I - 129 | 531290 | 9.91E-07 | 5.95E-08 | 1.62E-10 | 1.61E-01 |
| TOTAL I (ATOMIC NO 53) | | | 9.91E-07 | 5.95E-08 | | |
| TOTAL ADRENALS GROUND SURFACE = | | | 2.30E-05 | 1.38E-06 | | |

| PANCREAS GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 1.89E-05 | 1.13E-06 | 3.28E-09 | 1.61E-02 |
| TOTAL Co (ATOMIC NO 27) | | | 1.89E-05 | 1.13E-06 | | |
| | I - 129 | 531290 | 6.18E-07 | 3.71E-08 | 1.01E-10 | 1.61E-01 |
| TOTAL I (ATOMIC NO 53) | | | 6.18E-07 | 3.71E-08 | | |
| TOTAL PANCREAS GROUND SURFACE = | | | 1.95E-05 | 1.17E-06 | | |

| SKIN GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 3.49E-05 | 3.49E-07 | 6.07E-09 | 1.61E-02 |

TOTAL Co (ATOMIC NO 27) 3.49E-05 3.49E-07

I - 129 531290 6.45E-06 6.45E-08 1.05E-09 1.61E-01



DOWNWIND DISTANCE = 1.000E+04 SKIN GROUND SURFACE DOSE EQUIVALENT

| SKIN GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) |
|---|---|---|---|---|
| TOTAL I | (ATOMIC NO 53) | | 6.45E-06 | 6.45E-08 |
| TOTAL SKIN | GROUND SURFACE = | | 4.13E-05 | 4.13E-07 |

| BRAIN GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 2.47E-05 | 1.48E-06 | 4.30E-09 | 1.61E-02 |
| TOTAL Co | (ATOMIC NO 27) | | 2.47E-05 | 1.48E-06 | | |
| | I - 129 | 531290 | 6.19E-07 | 3.71E-08 | 1.01E-10 | 1.61E-01 |
| TOTAL I | (ATOMIC NO 53) | | 6.19E-07 | 3.71E-08 | | |
| TOTAL BRAIN | GROUND SURFACE = | | 2.53E-05 | 1.52E-06 | | |

| THYMUS GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 2.43E-05 | 1.46E-06 | 4.22E-09 | 1.61E-02 |
| TOTAL Co | (ATOMIC NO 27) | | 2.43E-05 | 1.46E-06 | | |
| | I - 129 | 531290 | 1.62E-06 | 9.74E-08 | 2.65E-10 | 1.61E-01 |
| TOTAL I | (ATOMIC NO 53) | | 1.62E-06 | 9.74E-08 | | |
| TOTAL THYMUS | GROUND SURFACE = | | 2.59E-05 | 1.55E-06 | | |

| BLADDER GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|
| | Co - 60 | 270600 | 2.19E-05 | 1.31E-06 | 3.80E-09 | 1.61E-02 |
| TOTAL Co | (ATOMIC NO 27) | | 2.19E-05 | 1.31E-06 | | |
| | I - 129 | 531290 | 1.37E-06 | 8.21E-08 | 2.23E-10 | 1.61E-01 |
| TOTAL I | (ATOMIC NO 53) | | 1.37E-06 | 8.21E-08 | | |

DOWNWIND DISTANCE = 1.000E+04 BLADDER GROUND SURFACE DOSE EQUIVALENT

TOTAL BLADDER GROUND SURFACE = 2.32E-05 1.39E-06

| MARROW | GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|---|
| | | Co - 60 | 270600 | 2.43E-05 | 1.46E-06 | 4.22E-09 | 1.61E-02 |
| | TOTAL Co (ATOMIC NO 27) | | | 2.43E-05 | 1.46E-06 | | |
| | | I - 129 | 531290 | 2.21E-06 | 1.33E-07 | 3.60E-10 | 1.61E-01 |
| | TOTAL I (ATOMIC NO 53) | | | 2.21E-06 | 1.33E-07 | | |
| TOTAL MARROW | GROUND SURFACE = | | | 2.65E-05 | 1.59E-06 | | |

| HEART | GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|---|
| | | Co - 60 | 270600 | 2.16E-05 | 1.30E-06 | 3.76E-09 | 1.61E-02 |
| | TOTAL Co (ATOMIC NO 27) | | | 2.16E-05 | 1.30E-06 | | |
| | | I - 129 | 531290 | 6.07E-07 | 3.64E-08 | 9.89E-11 | 1.61E-01 |
| | TOTAL I (ATOMIC NO 53) | | | 6.07E-07 | 3.64E-08 | | |
| TOTAL HEART | GROUND SURFACE = | | | 2.22E-05 | 1.33E-06 | | |

| OVARIES | GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) (W/0 BSF) | INITIAL micro-Ci PER sq m |
|---|---|---|---|---|---|---|---|
| | | Co - 60 | 270600 | 2.08E-05 | 5.21E-06 | 3.62E-09 | 1.61E-02 |
| | TOTAL Co (ATOMIC NO 27) | | | 2.08E-05 | 5.21E-06 | | |
| | | I - 129 | 531290 | 9.38E-07 | 2.34E-07 | 1.53E-10 | 1.61E-01 |
| | TOTAL I (ATOMIC NO 53) | | | 9.38E-07 | 2.34E-07 | | |
| TOTAL OVARIES | GROUND SURFACE = | | | 2.18E-05 | 5.44E-06 | | |



DOWNWIND DISTANCE = 1.000E+04 UTERUS GROUND SURFACE DOSE EQUIVALENT

| UTERUS | GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) | INITIAL (Sv/h ) | INITIAL micro-Ci |
|---|---|---|---|---|---|---|---|

| | | | | | (W/0 BSF) | PER sq m |
|---|---|---|---|---|---|---|
| Co - 60 | 270600 | 1.93E-05 | 1.16E-06 | 3.36E-09 | 1.61E-02 |
| TOTAL Co (ATOMIC NO 27) | | 1.93E-05 | 1.16E-06 | | |
| I - 129 | 531290 | 4.95E-07 | 2.97E-08 | 8.06E-11 | 1.61E-01 |
| TOTAL I (ATOMIC NO 53) | | 4.95E-07 | 2.97E-08 | | |
| TOTAL UTERUS GROUND SURFACE = | | 1.98E-05 | 1.19E-06 | | |

| EXT EDE GROUND SUR | ISOTOPE | NUCLIDE | D.E. (Sv) | WEIGHTED (Sv) |
|---|---|---|---|---|
| Co - 60 | 270600 | 2.59E-05 | | |
| TOTAL Co (ATOMIC NO 27) | | 2.59E-05 | | |
| I - 129 | 531290 | 2.65E-06 | | |
| TOTAL I (ATOMIC NO 53) | | 2.65E-06 | | |
| TOTAL EXT EDE GROUND SURFACE = | | 2.85E-05 | | |



&& GROUND SURFACE DOSE EQUIVALENTS ORDERED BY ORGAN (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 |
|---|---|---|
| LUNGS | 1 | 2.44E-05 |
| STOMACH | 2 | 2.22E-05 |
| S INT | 3 | 2.06E-05 |
| UL INT | 4 | 2.41E-05 |
| LL INT | 5 | 2.20E-05 |
| TESTES | 6 | 3.41E-05 |
| BREAST | 7 | 3.30E-05 |
| SKELETON | 8 | 2.70E-05 |
| RED MARR | 9 | 2.38E-05 |
| THYROID | 10 | 3.15E-05 |
| KIDNEYS | 11 | 2.52E-05 |
| LIVER | 12 | 2.29E-05 |
| SPLEEN | 13 | 2.19E-05 |
| ADRENALS | 14 | 2.30E-05 |
| PANCREAS | 15 | 1.95E-05 |
| SKIN | 16 | 4.13E-05 |
| BRAIN | 17 | 2.53E-05 |
| THYMUS | 18 | 2.59E-05 |
| BLADDER | 19 | 2.32E-05 |
| MARROW | 20 | 2.65E-05 |
| HEART | 21 | 2.22E-05 |
| OVARIES | 22 | 2.18E-05 |
| UTERUS | 23 | 1.98E-05 |

&& GROUND SURFACE DOSE EQUIVALENCES ORDERED BY DOSE (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 |
|---|---|---|
| SKIN | 16 | 4.13E-05 |
| TESTES | 6 | 3.41E-05 |
| BREAST | 7 | 3.30E-05 |
| THYROID | 10 | 3.15E-05 |
| SKELETON | 8 | 2.70E-05 |
| MARROW | 20 | 2.65E-05 |
| THYMUS | 18 | 2.59E-05 |
| BRAIN | 17 | 2.53E-05 |
| KIDNEYS | 11 | 2.52E-05 |
| LUNGS | 1 | 2.44E-05 |
| UL INT | 4 | 2.41E-05 |
| RED MARR | 9 | 2.38E-05 |
| BLADDER | 19 | 2.32E-05 |
| ADRENALS | 14 | 2.30E-05 |
| LIVER | 12 | 2.29E-05 |
| STOMACH | 2 | 2.22E-05 |
| HEART | 21 | 2.22E-05 |
| LL INT | 5 | 2.20E-05 |
| SPLEEN | 13 | 2.19E-05 |
| OVARIES | 22 | 2.18E-05 |
| S INT | 3 | 2.06E-05 |
| UTERUS | 23 | 1.98E-05 |
| PANCREAS | 15 | 1.95E-05 |



&& GROUND SURFACE WEIGHTED DOSE EQUIVALENTS (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 |
|---|---|---|
| LUNGS | 1 | 2.93E-06 |
| STOMACH | 2 | 1.33E-06 |
| S INT | 3 | 1.24E-06 |
| UL INT | 4 | 1.45E-06 |
| LL INT | 5 | 1.32E-06 |
| TESTES | 6 | 8.52E-06 |
| BREAST | 7 | 4.95E-06 |
| SKELETON | 8 | 8.10E-07 |
| RED MARR | 9 | 2.86E-06 |
| THYROID | 10 | 9.44E-07 |
| KIDNEYS | 11 | 1.51E-06 |
| LIVER | 12 | 1.37E-06 |
| SPLEEN | 13 | 1.31E-06 |
| ADRENALS | 14 | 1.38E-06 |
| PANCREAS | 15 | 1.17E-06 |
| SKIN | 16 | 4.13E-07 |
| BRAIN | 17 | 1.52E-06 |

| | | |
|---|---|---|
| THYMUS | 18 | 1.55E-06 |
| BLADDER | 19 | 1.39E-06 |
| MARROW | 20 | 1.59E-06 |
| HEART | 21 | 1.33E-06 |
| OVARIES | 22 | 5.44E-06 |
| UTERUS | 23 | 1.19E-06 |
| EXT EDE | 24 | 2.85E-05 |

*** AIR IMMERSION DOSE EQUIVALENT CALCULATION

RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION = 1.000E+00 SECONDS

DOWNWIND DISTANCE = 1.000E+04 (m) PLUME TRAVEL TIME = 1.000E+04 (s)
CHI/Q = 1.627E-05 (s/cu m)

| LUNGS AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|---|
| | Co - 60 | 270600 | 6.36E-08 | 7.63E-09 |
| | TOTAL Co (ATOMIC NO 27) | | 6.36E-08 | 7.63E-09 |
| | I - 129 | 531290 | 1.14E-10 | 1.37E-11 |
| | TOTAL I (ATOMIC NO 53) | | 1.14E-10 | 1.37E-11 |
| TOTAL LUNGS AIR IMMERSION = | | | 6.37E-08 | 7.64E-09 |



DOWNWIND DISTANCE = 1.000E+04 STOMACH AIR IMMERSION DOSE EQUIVALENT

| STOMACH AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|---|
| | Co - 60 | 270600 | 5.86E-08 | 3.52E-09 |
| | TOTAL Co (ATOMIC NO 27) | | 5.86E-08 | 3.52E-09 |
| | I - 129 | 531290 | 8.35E-11 | 5.01E-12 |
| | TOTAL I (ATOMIC NO 53) | | 8.35E-11 | 5.01E-12 |
| TOTAL STOMACH AIR IMMERSION = | | | 5.87E-08 | 3.52E-09 |

| S INT AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|---|
| | Co - 60 | 270600 | 5.49E-08 | 3.30E-09 |
| | TOTAL Co (ATOMIC NO 27) | | 5.49E-08 | 3.30E-09 |
| | I - 129 | 531290 | 6.08E-11 | 3.65E-12 |
| | TOTAL I (ATOMIC NO 53) | | 6.08E-11 | 3.65E-12 |
| TOTAL S INT AIR IMMERSION = | | | 5.50E-08 | 3.30E-09 |

| UL INT AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|---|

| | | | |
|---|---|---|---|
| Co - 60 | 270600 | 6.36E-08 | 3.81E-09 |
| TOTAL Co (ATOMIC NO 27) | | 6.36E-08 | 3.81E-09 |
| I - 129 | 531290 | 9.78E-11 | 5.87E-12 |
| TOTAL I (ATOMIC NO 53) | | 9.78E-11 | 5.87E-12 |
| TOTAL UL INT AIR IMMERSION = | | 6.37E-08 | 3.82E-09 |

LL INT AIR IMMERSION

| ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|
| Co - 60 | 270600 | 5.86E-08 | 3.52E-09 |
| TOTAL Co (ATOMIC NO 27) | | 5.86E-08 | 3.52E-09 |
| I - 129 | 531290 | 7.13E-11 | 4.28E-12 |
| TOTAL I (ATOMIC NO 53) | | 7.13E-11 | 4.28E-12 |



DOWNWIND DISTANCE = 1.000E+04 LL INT AIR IMMERSION DOSE EQUIVALENT

| | | | |
|---|---|---|---|
| TOTAL LL INT AIR IMMERSION = | | 5.87E-08 | 3.52E-09 |

TESTES AIR IMMERSION

| ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|
| Co - 60 | 270600 | 8.35E-08 | 2.09E-08 |
| TOTAL Co (ATOMIC NO 27) | | 8.35E-08 | 2.09E-08 |
| I - 129 | 531290 | 3.23E-10 | 8.08E-11 |
| TOTAL I (ATOMIC NO 53) | | 3.23E-10 | 8.08E-11 |
| TOTAL TESTES AIR IMMERSION = | | 8.38E-08 | 2.09E-08 |

BREAST AIR IMMERSION

| ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|
| Co - 60 | 270600 | 7.52E-08 | 1.13E-08 |
| TOTAL Co (ATOMIC NO 27) | | 7.52E-08 | 1.13E-08 |
| I - 129 | 531290 | 4.90E-10 | 7.35E-11 |
| TOTAL I (ATOMIC NO 53) | | 4.90E-10 | 7.35E-11 |
| TOTAL BREAST AIR IMMERSION = | | 7.57E-08 | 1.13E-08 |

SKELETON AIR IMMERSION

| ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|
| Co - 60 | 270600 | 6.80E-08 | 2.04E-09 |

| | | | |
|---|---|---|---|
| TOTAL Co (ATOMIC NO 27) | | 6.80E-08 | 2.04E-09 |
| I - 129 | 531290 | 2.00E-10 | 6.00E-12 |
| TOTAL I (ATOMIC NO 53) | | 2.00E-10 | 6.00E-12 |
| TOTAL SKELETON AIR IMMERSION = | | 6.82E-08 | 2.05E-09 |



DOWNWIND DISTANCE = 1.000E+04 RED MARR AIR IMMERSION DOSE EQUIVALENT

| RED MARR AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|---|
| | Co - 60 | 270600 | 6.41E-08 | 7.69E-09 |
| TOTAL Co (ATOMIC NO 27) | | | 6.41E-08 | 7.69E-09 |
| | I - 129 | 531290 | 4.32E-11 | 5.19E-12 |
| TOTAL I (ATOMIC NO 53) | | | 4.32E-11 | 5.19E-12 |
| TOTAL RED MARR AIR IMMERSION = | | | 6.42E-08 | 7.70E-09 |

| THYROID AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|---|
| | Co - 60 | 270600 | 7.96E-08 | 2.39E-09 |
| TOTAL Co (ATOMIC NO 27) | | | 7.96E-08 | 2.39E-09 |
| | I - 129 | 531290 | 2.29E-10 | 6.88E-12 |
| TOTAL I (ATOMIC NO 53) | | | 2.29E-10 | 6.88E-12 |
| TOTAL THYROID AIR IMMERSION = | | | 7.98E-08 | 2.39E-09 |

| KIDNEYS AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|---|
| | Co - 60 | 270600 | 6.36E-08 | 3.81E-09 |
| TOTAL Co (ATOMIC NO 27) | | | 6.36E-08 | 3.81E-09 |
| | I - 129 | 531290 | 1.87E-10 | 1.12E-11 |
| TOTAL I (ATOMIC NO 53) | | | 1.87E-10 | 1.12E-11 |
| TOTAL KIDNEYS AIR IMMERSION = | | | 6.38E-08 | 3.83E-09 |

| LIVER AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|---|
| | Co - 60 | 270600 | 6.02E-08 | 3.61E-09 |
| TOTAL Co (ATOMIC NO 27) | | | 6.02E-08 | 3.61E-09 |
| | I - 129 | 531290 | 9.12E-11 | 5.47E-12 |

TOTAL I (ATOMIC NO 53) 9.12E-11 5.47E-12



DOWNWIND DISTANCE = 1.000E+04 LIVER AIR IMMERSION DOSE EQUIVALENT

TOTAL LIVER AIR IMMERSION = 6.03E-08 3.62E-09

| SPLEEN AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|---|
| | Co - 60 | 270600 | 5.80E-08 | 3.48E-09 |
| | TOTAL Co (ATOMIC NO 27) | | 5.80E-08 | 3.48E-09 |
| | I - 129 | 531290 | 7.41E-11 | 4.44E-12 |
| | TOTAL I (ATOMIC NO 53) | | 7.41E-11 | 4.44E-12 |

TOTAL SPLEEN AIR IMMERSION = 5.81E-08 3.49E-09

| ADRENALS AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|---|
| | Co - 60 | 270600 | 6.08E-08 | 3.65E-09 |
| | TOTAL Co (ATOMIC NO 27) | | 6.08E-08 | 3.65E-09 |
| | I - 129 | 531290 | 8.62E-11 | 5.17E-12 |
| | TOTAL I (ATOMIC NO 53) | | 8.62E-11 | 5.17E-12 |

TOTAL ADRENALS AIR IMMERSION = 6.09E-08 3.65E-09

| PANCREAS AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|---|
| | Co - 60 | 270600 | 5.21E-08 | 3.12E-09 |
| | TOTAL Co (ATOMIC NO 27) | | 5.21E-08 | 3.12E-09 |
| | I - 129 | 531290 | 5.40E-11 | 3.24E-12 |
| | TOTAL I (ATOMIC NO 53) | | 5.40E-11 | 3.24E-12 |

TOTAL PANCREAS AIR IMMERSION = 5.21E-08 3.13E-09



DOWNWIND DISTANCE = 1.000E+04 SKIN AIR IMMERSION DOSE EQUIVALENT

| SKIN AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
|---|---|---|---|---|
| | Co - 60 | 270600 | 9.78E-08 | 9.78E-10 |
| | TOTAL Co (ATOMIC NO 27) | | 9.78E-08 | 9.78E-10 |

| | | | | |
|---|---|---|---|---|
| | | I - 129 | 531290 | 6.41E-10 | 6.41E-12 |
| | | TOTAL I (ATOMIC NO 53) | | 6.41E-10 | 6.41E-12 |
| | TOTAL SKIN | AIR IMMERSION = | | 9.85E-08 | 9.85E-10 |
| BRAIN | AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
| | | Co - 60 | 270600 | 6.80E-08 | 4.08E-09 |
| | | TOTAL Co (ATOMIC NO 27) | | 6.80E-08 | 4.08E-09 |
| | | I - 129 | 531290 | 5.53E-11 | 3.32E-12 |
| | | TOTAL I (ATOMIC NO 53) | | 5.53E-11 | 3.32E-12 |
| | TOTAL BRAIN | AIR IMMERSION = | | 6.80E-08 | 4.08E-09 |
| THYMUS | AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
| | | Co - 60 | 270600 | 6.69E-08 | 4.01E-09 |
| | | TOTAL Co (ATOMIC NO 27) | | 6.69E-08 | 4.01E-09 |
| | | I - 129 | 531290 | 1.44E-10 | 8.66E-12 |
| | | TOTAL I (ATOMIC NO 53) | | 1.44E-10 | 8.66E-12 |
| | TOTAL THYMUS | AIR IMMERSION = | | 6.70E-08 | 4.02E-09 |
| BLADDER | AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
| | | Co - 60 | 270600 | 6.02E-08 | 3.61E-09 |
| | | TOTAL Co (ATOMIC NO 27) | | 6.02E-08 | 3.61E-09 |
| | | I - 129 | 531290 | 1.20E-10 | 7.23E-12 |
| | | TOTAL I (ATOMIC NO 53) | | 1.20E-10 | 7.23E-12 |



DOWNWIND DISTANCE = 1.000E+04 BLADDER AIR IMMERSION DOSE EQUIVALENT

| | | | | | |
|---|---|---|---|---|---|
| | TOTAL BLADDER | AIR IMMERSION = | | 6.04E-08 | 3.62E-09 |
| MARROW | AIR IMMERSION | ISOTOPE | NUCLIDE | DE (Sv) | WDE (Sv) |
| | | Co - 60 | 270600 | 6.69E-08 | 4.01E-09 |
| | | TOTAL Co (ATOMIC NO 27) | | 6.69E-08 | 4.01E-09 |
| | | I - 129 | 531290 | 1.94E-10 | 1.16E-11 |
| | | TOTAL I (ATOMIC NO 53) | | 1.94E-10 | 1.16E-11 |

TOTAL MARROW AIR IMMERSION = 6.71E-08 4.02E-09

HEART AIR IMMERSION ISOTOPE NUCLIDE DE (Sv) WDE (Sv)

Co - 60 270600 5.97E-08 3.58E-09

TOTAL Co (ATOMIC NO 27) 5.97E-08 3.58E-09

I - 129 531290 5.40E-11 3.24E-12

TOTAL I (ATOMIC NO 53) 5.40E-11 3.24E-12

TOTAL HEART AIR IMMERSION = 5.97E-08 3.58E-09

OVARIES AIR IMMERSION ISOTOPE NUCLIDE DE (Sv) WDE (Sv)

Co - 60 270600 5.75E-08 1.44E-08

TOTAL Co (ATOMIC NO 27) 5.75E-08 1.44E-08

I - 129 531290 8.18E-11 2.05E-11

TOTAL I (ATOMIC NO 53) 8.18E-11 2.05E-11

TOTAL OVARIES AIR IMMERSION = 5.76E-08 1.44E-08



DOWNWIND DISTANCE = 1.000E+04 UTERUS AIR IMMERSION DOSE EQUIVALENT

UTERUS AIR IMMERSION ISOTOPE NUCLIDE DE (Sv) WDE (Sv)

Co - 60 270600 5.32E-08 3.19E-09

TOTAL Co (ATOMIC NO 27) 5.32E-08 3.19E-09

I - 129 531290 4.51E-11 2.71E-12

TOTAL I (ATOMIC NO 53) 4.51E-11 2.71E-12

TOTAL UTERUS AIR IMMERSION = 5.33E-08 3.20E-09

EXT EDE AIR IMMERSION ISOTOPE NUCLIDE DE (Sv)

Co - 60 270600 7.13E-08

TOTAL Co (ATOMIC NO 27) 7.13E-08

I - 129 531290 2.27E-10

TOTAL I (ATOMIC NO 53) 2.27E-10

TOTAL EXT EDE AIR IMMERSION = 7.15E-08

VALRSAC5: Validation Run with 1 Ci release of I-129, H-3, and Co-60

&& AIR IMMERSION DOSE EQUIVALENTS ORDERED BY ORGAN (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 |
|---|---|---|
| LUNGS | 1 | 6.37E-08 |
| STOMACH | 2 | 5.87E-08 |
| S INT | 3 | 5.50E-08 |
| UL INT | 4 | 6.37E-08 |
| LL INT | 5 | 5.87E-08 |
| TESTES | 6 | 8.38E-08 |
| BREAST | 7 | 7.57E-08 |
| SKELETON | 8 | 6.82E-08 |
| RED MARR | 9 | 6.42E-08 |
| THYROID | 10 | 7.98E-08 |
| KIDNEYS | 11 | 6.38E-08 |
| LIVER | 12 | 6.03E-08 |
| SPLEEN | 13 | 5.81E-08 |
| ADRENALS | 14 | 6.09E-08 |
| PANCREAS | 15 | 5.21E-08 |
| SKIN | 16 | 9.85E-08 |
| BRAIN | 17 | 6.80E-08 |
| THYMUS | 18 | 6.70E-08 |
| BLADDER | 19 | 6.04E-08 |
| MARROW | 20 | 6.71E-08 |
| HEART | 21 | 5.97E-08 |
| OVARIES | 22 | 5.76E-08 |
| UTERUS | 23 | 5.33E-08 |


VALRSAC5: Validation Run with 1 Ci release of I-129, H-3, and Co-60

&& AIR IMMERSION DOSE EQUIVALENCES ORDERED BY DOSE (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 |
|---|---|---|
| SKIN | 16 | 9.85E-08 |
| TESTES | 6 | 8.38E-08 |
| THYROID | 10 | 7.98E-08 |
| BREAST | 7 | 7.57E-08 |
| SKELETON | 8 | 6.82E-08 |
| BRAIN | 17 | 6.80E-08 |
| MARROW | 20 | 6.71E-08 |
| THYMUS | 18 | 6.70E-08 |
| RED MARR | 9 | 6.42E-08 |
| KIDNEYS | 11 | 6.38E-08 |
| LUNGS | 1 | 6.37E-08 |
| UL INT | 4 | 6.37E-08 |
| ADRENALS | 14 | 6.09E-08 |
| BLADDER | 19 | 6.04E-08 |
| LIVER | 12 | 6.03E-08 |
| HEART | 21 | 5.97E-08 |
| STOMACH | 2 | 5.87E-08 |
| LL INT | 5 | 5.87E-08 |

| | | |
|---|---|---|
| SPLEEN | 13 | 5.81E-08 |
| OVARIES | 22 | 5.76E-08 |
| S INT | 3 | 5.50E-08 |
| UTERUS | 23 | 5.33E-08 |
| PANCREAS | 15 | 5.21E-08 |



&& AIR IMMERSION WEIGHTED DOSE EQUIVALENTS (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 |
|---|---|---|
| LUNGS | 1 | 7.64E-09 |
| STOMACH | 2 | 3.52E-09 |
| S INT | 3 | 3.30E-09 |
| UL INT | 4 | 3.82E-09 |
| LL INT | 5 | 3.52E-09 |
| TESTES | 6 | 2.09E-08 |
| BREAST | 7 | 1.13E-08 |
| SKELETON | 8 | 2.05E-09 |
| RED MARR | 9 | 7.70E-09 |
| THYROID | 10 | 2.39E-09 |
| KIDNEYS | 11 | 3.83E-09 |
| LIVER | 12 | 3.62E-09 |
| SPLEEN | 13 | 3.49E-09 |
| ADRENALS | 14 | 3.65E-09 |
| PANCREAS | 15 | 3.13E-09 |
| SKIN | 16 | 9.85E-10 |
| BRAIN | 17 | 4.08E-09 |
| THYMUS | 18 | 4.02E-09 |
| BLADDER | 19 | 3.62E-09 |
| MARROW | 20 | 4.02E-09 |
| HEART | 21 | 3.58E-09 |
| OVARIES | 22 | 1.44E-08 |
| UTERUS | 23 | 3.20E-09 |
| EXT EDE | 24 | 7.15E-08 |

*** INGESTION DOSE EQUIVALENT CALCULATION

RELEASE TIME FOR EXPONENTIAL DECAY FUNCTION = 1.000E+00 (s)
INTERNAL EXPOSURE TIME PERIOD = 5.000E+01 (yr)

INGESTION CALCULATIONS MADE USING USER SUPPLIED CONSTANTS

INGESTION CONSTANTS:

| | |
|---|---|
| 5.20E+02 | STORED VEGETABLE USAGE FACTOR (Kg/yr) |
| 6.40E+01 | FRESH VEGETABLE USAGE FACTOR (Kg/yr) |
| 1.10E+02 | MEAT USAGE FACTOR (Kg/yr) |
| 3.10E+02 | MILK USAGE FACTOR (L/yr) |
| 1.00E+00 | FRACTION OF STORED VEGETABLES FROM GARDEN |
| 1.00E+00 | FRACTION OF FRESH VEGETABLES FROM GARDEN |



5.70E-01 RETENTION FACTOR FOR ACTIVITY ON FORAGE

```
2.00E-01  RETENTION FACTOR FOR ACTIVITY ON VEGETABLES
1.00E+00  RETENTION FACTOR FOR IODINES
0.00E+00  REMOVAL RATE CONSTANT FOR CROPS (1/h)
6.00E+01  VEGETABLE EXPOSURE TIME TO PLUME FOR CHRONIC RELEASE (d)
3.00E+01  FORAGE EXPOSURE TIME TO PLUME FOR CHRONIC RELEASE (d)
1.00E+02  HTO REMOVAL HALF TIME (d)
2.25E+02  EFFECTIVE SURFACE SOIL DENSITY (Kg/sq m)
0.00E+00  STORED VEGETABLE HOLDUP TIME AFTER HARVEST (d)
1.00E+00  FRESH VEGETABLE HOLDUP TIME AFTER HARVEST (d)
1.60E+01  ANIMALS DAILY FORAGE FEED (Kg/d)
0.00E+00  FEED-MILK-RECEPTOR TRANSFER TIME (d)
0.00E+00  SLAUGHTER TO CONSUMPTION TIME (d)
0.00E+00  FRACTION OF YEAR ON PASTURE
0.00E+00  PASTURE FEED FRACTION
0.00E+00  STORED FEED STORAGE TIME
2.00E+00  VEGETABLE VEGETATION YIELD (Kg/sq m)
2.80E-01  FORAGE VEGETATION YIELD (Kg/sq m)
4.90E+00  ABSOLUTE HUMIDITY (g/cu m)

ACUTE RELEASE OVER   7.000E+00 (d)
HARVEST DURATION TIME OF   7.000E+00 (d) AFTER ACUTE RELEASE
CONSUMPTION OF CROPS GROWN ON CONTAMINATED SOIL FOR   1.000E+00 (Y)

   FRACTIONS OF ANNUAL VEGETABLES AND FORAGE CONTAMINATED BY ACUTE RELEASE
                 1.0E+00  STORED VEGETABLES
                 1.0E+00  FRESH VEGETABLES
                 1.0E+00  STORED FEED
                 1.0E+00  PASTURE FEED

DOWNWIND DISTANCE =  1.000E+04 (m)     PLUME TRAVEL TIME =  1.000E+04 (s)
                                       CHI/Q =  1.627E-05 (s/cu m)

   LUNGS     INGESTION    ISOTOPE    NUCLIDE    CDE (Sv)   WCDE  (Sv)

                          Co -  60    270600    7.73E-05     9.27E-06

                     TOTAL Co (ATOMIC NO 27)    7.73E-05     9.27E-06

                TOTAL LUNGS     INGESTION =     7.73E-05     9.27E-06

   S WALL    INGESTION    ISOTOPE    NUCLIDE    CDE (Sv)   WCDE  (Sv)

                                               0.           0.

   SI WALL   INGESTION    ISOTOPE    NUCLIDE    CDE (Sv)   WCDE  (Sv)

                          Co -  60    270600    3.14E-04     1.88E-05

                     TOTAL Co (ATOMIC NO 27)    3.14E-04     1.88E-05

                TOTAL SI WALL   INGESTION =     3.14E-04     1.88E-05
```



```
DOWNWIND DISTANCE =  1.000E+04    ULI WALL  INGESTION DOSE EQUIVALENT
```

| | | | | | |
|---|---|---|---|---|---|
| ULI WALL | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | Co - 60 | 270600 | 5.07E-04 | 3.04E-05 |
| | | TOTAL Co (ATOMIC NO 27) | | 5.07E-04 | 3.04E-05 |
| | | TOTAL ULI WALL INGESTION = | | 5.07E-04 | 3.04E-05 |
| LLI WALL | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | Co - 60 | 270600 | 9.90E-04 | 5.94E-05 |
| | | TOTAL Co (ATOMIC NO 27) | | 9.90E-04 | 5.94E-05 |
| | | TOTAL LLI WALL INGESTION = | | 9.90E-04 | 5.94E-05 |
| GONADS | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | Co - 60 | 270600 | 2.90E-04 | 7.24E-05 |
| | | TOTAL Co (ATOMIC NO 27) | | 2.90E-04 | 7.24E-05 |
| | | TOTAL GONADS INGESTION = | | 2.90E-04 | 7.24E-05 |
| BREASTS | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | Co - 60 | 270600 | 9.90E-05 | 1.48E-05 |
| | | TOTAL Co (ATOMIC NO 27) | | 9.90E-05 | 1.48E-05 |
| | | TOTAL BREASTS INGESTION = | | 9.90E-05 | 1.48E-05 |
| BONE SUR | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| R MARROW | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | Co - 60 | 270600 | 1.16E-04 | 1.39E-05 |
| | | TOTAL Co (ATOMIC NO 27) | | 1.16E-04 | 1.39E-05 |
| | | TOTAL R MARROW INGESTION = | | 1.16E-04 | 1.39E-05 |



DOWNWIND DISTANCE = 1.000E+04 THYROID INGESTION DOSE EQUIVALENT

| | | | | | |
|---|---|---|---|---|---|
| THYROID | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | I - 129 | 531290 | 4.19E+00 | 1.26E-01 |
| | | TOTAL I (ATOMIC NO 53) | | 4.19E+00 | 1.26E-01 |
| | | TOTAL THYROID INGESTION = | | 4.19E+00 | 1.26E-01 |

| | | | | | |
|---|---|---|---|---|---|
| KIDNEYS | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| LIVER | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | Co - 60 | 270600 | 2.05E-04 | 1.23E-05 |
| | | TOTAL Co (ATOMIC NO 27) | | 2.05E-04 | 1.23E-05 |
| | | TOTAL LIVER INGESTION = | | 2.05E-04 | 1.23E-05 |
| SPLEEN | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| PANCREAS | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | | | 0. | 0. |
| S TISSUE | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | H - 3 | 10030 | 7.49E-07 | 7.49E-07 |
| | | TOTAL H (ATOMIC NO 1) | | 7.49E-07 | 7.49E-07 |
| | | TOTAL S TISSUE INGESTION = | | 7.49E-07 | 7.49E-07 |
| OTHER | INGESTION | ISOTOPE | NUCLIDE | CDE (Sv) | WCDE (Sv) |
| | | Co - 60 | 270600 | 1.88E-04 | 1.13E-05 |
| | | TOTAL Co (ATOMIC NO 27) | | 1.88E-04 | 1.13E-05 |
| | | TOTAL OTHER INGESTION = | | 1.88E-04 | 1.13E-05 |



DOWNWIND DISTANCE = 1.000E+04 CEDE INGESTION DOSE EQUIVALENT

| | | | | |
|---|---|---|---|---|
| CEDE | INGESTION | ISOTOPE | NUCLIDE | CEDE (Sv) |
| | | H - 3 | 10030 | 7.49E-07 |
| | | TOTAL H (ATOMIC NO 1) | | 7.49E-07 |
| | | Co - 60 | 270600 | 2.41E-04 |
| | | TOTAL Co (ATOMIC NO 27) | | 2.41E-04 |
| | | I - 129 | 531290 | 1.26E-01 |
| | | TOTAL I (ATOMIC NO 53) | | 1.26E-01 |
| | | TOTAL CEDE INGESTION = | | 1.26E-01 |

&&  INGESTION COMMITTED DOSE EQUIVALENTS ORDERED BY ORGAN  (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 |
|---|---|---|
| LUNGS | 1 | 7.73E-05 |
| SI WALL | 3 | 3.14E-04 |
| ULI WALL | 4 | 5.07E-04 |
| LLI WALL | 5 | 9.90E-04 |
| GONADS | 6 | 2.90E-04 |
| BREASTS | 7 | 9.90E-05 |
| R MARROW | 9 | 1.16E-04 |
| THYROID | 10 | 4.19E+00 |
| LIVER | 12 | 2.05E-04 |
| S TISSUE | 15 | 7.49E-07 |
| OTHER | 17 | 1.88E-04 |

---

ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE



&&  INGESTION COMMITTED DOSE EQUIVALENCES ORDERED BY DOSE  (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 |
|---|---|---|
| THYROID | 10 | 4.19E+00 |
| LLI WALL | 5 | 9.90E-04 |
| ULI WALL | 4 | 5.07E-04 |
| SI WALL | 3 | 3.14E-04 |
| GONADS | 6 | 2.90E-04 |
| LIVER | 12 | 2.05E-04 |
| OTHER | 17 | 1.88E-04 |
| R MARROW | 9 | 1.16E-04 |
| BREASTS | 7 | 9.90E-05 |
| LUNGS | 1 | 7.73E-05 |
| S TISSUE | 15 | 7.49E-07 |

---

ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

&&  INGESTION WEIGHTED COMMITTED DOSE EQUIVALENTS  (Sv)

| ORGAN | NO. | DOWNWIND DISTANCES (m) 1.00E+04 |
|---|---|---|
| LUNGS | 1 | 9.27E-06 |
| SI WALL | 3 | 1.88E-05 |
| ULI WALL | 4 | 3.04E-05 |
| LLI WALL | 5 | 5.94E-05 |
| GONADS | 6 | 7.24E-05 |
| BREASTS | 7 | 1.48E-05 |
| R MARROW | 9 | 1.39E-05 |
| THYROID | 10 | 1.26E-01 |
| LIVER | 12 | 1.23E-05 |

```
S TISSUE  15   7.49E-07
OTHER     17   1.13E-05
CEDE      18   1.26E-01

----------
ORGANS WITH NO CALCULATED DOSE HAVE BEEN SUPPRESSED FROM TABLE

  EXECUTION TIME =  1.16E+00 SECONDS
```

# SOFTWARE VALIDATION TEST PLAN FOR RSAC VERSION 5.2

**December 2001**

Center for Nuclear Waste Regulatory Analyses
Southwest Research Institute
San Antonio, Texas

**Author**

Roland R. Benke

Roland Benke

12/05/2001

Date

**Element Manager**

Asadul Chowdhury

12-05-2001

Date

## 1.0 Scope of the Validation

RSAC Version 5.2 is an acquired software not to be modified and is under configuration control at the Center for Nuclear Waste Regulatory Analyses, software release number 226. RSAC Version 5.2 (Wenzel, 1994) was developed by Westinghouse Idaho Nuclear Company, Inc. at the Idaho National Engineering Laboratory in Idaho Falls, Idaho. RSAC Version 5.2 can be obtained under the CCC-125 code package designation from the Radiation Safety Information Computational Center (Radiation Safety Information Computational Center, Oak Ridge National Laboratory, PO Box 2008, Oak Ridge, TN 37381-6362).

RSAC Version 5.2 calculates the radiological consequences from the atmospheric release of radioactive material. Internal doses were calculated for the pathways of inhalation and ingestion, and the external doses were computed for the pathways of ground surface exposure and submersion.

The validation plan tests the RSAC Version 5.2 dose calculation for the pathways of inhalation, ingestion, ground surface exposure, and submersion. Testing of RSAC Version 5.2 was performed to verify execution of the four example input files produced results that matched the values in the RSAC Version 5.2 User's Manual (Wenzel, 1994). This validation test exercises the following modules (called series in the RSAC Version 5.2 documentation): fission product inventory calculation, radionuclide inventory input, meteorological data input, internal/external dose calculation, and cloud gamma dose calculation. This validation test does not exercise the following RSAC Version 5.2 modules: dose summary, definition of radionuclide data constants, post-release radioactive decay, and fifty-mile radius dose calculation.

In addition, Shonka Research Associates, Inc. (Shonka Research Associates, 1993) verified and validated the use of RSAC Version 5.2 for safety related dose calculations in accordance with ANSI/ANS-10.4, "American National Standard Guidelines for the Verification and Validation of Scientific and Engineering Programs for the Nuclear Industry" (American National Standards Institute, 1987). The Shonka Research Associates Executive Summary Report (Shonka Research Associates, 1993) is part of the QA software control packet for RSAC Version 5.2 at the Center for Nuclear Waste Regulatory Analyses.

## 2.0 References

American National Standards Institute, "Guidelines for the Verification and Validation of Scientific and Engineering Programs for the Nuclear Industry," ANSI/ANS–10.4–1987, Washington, DC.

Shonka Research Associates, Inc. Software Verification and Validation Report for WINCO RSAC-5 Code. Marietta, Georgia. 1993.

Wenzel, D. R. The Radiological Safety Analysis Computer Program (RSAC-5) User's

Manual, WINCO-1123, Revision 1. Westinghouse Idaho Nuclear Company, Inc. Idaho National Engineering Laboratory: Idaho Falls, Idaho. 1994.

## 3.0 Environment

### 3.1 Software

RSAC Version 5.2 is DOS-based. The validation test will be conducted under a Windows NT Version 4.0 operating system. The following list of files is required for the test.

| | | |
|---|---|---|
| Rp.exe | Example2 | Example4.k01 |
| Rsac5.exe | Example3 | Example7.k01 |
| Dfh.dat | Example4 | Input.k01 |
| Input.dat | Example7 | Nuclide.k01 |
| Nuclide.dat | Fones | Read1.k01 |
| Clarion.dmp | Modint | Nuclide.k02 |
| Example2.dtt | Popcq | Nuclide.k03 |
| Example3.dtt | Read1 | Nuclide.k04 |
| Example4.dtt | Stdext | Rs.bat |
| Example7.dtt | Stdint | Rsrp.bat |
| Read1.dtt | Stdnuc | Example2.out |
| Popcq.dxt | Trancon | Example3.out |
| F77l.eer | Ex_3x2.k01 | Example4.out |
| F77l3.eer | Example2.k01 | Example7.out |
| Ex9src | Example3.k01 | Read1.out |

### 3.2 Hardware

The hardware required is an IBM-compatible personal computer with a hard drive named C:.

## 4.0 Prerequisites

The files, listed in section 3.1, must be located in a directory named Rsac5. The directory Rsac5 must be located in the root directory of the C: drive.

## 5.0 Assumptions and Constraints

None.

## 6.0 Test Case

### 6.1 Pathway Tests

RSAC Version 5.2 has been incorporated into the PCSA Tool, a code developed at the Center for Nuclear Waste and Regulatory Analyses. However, not all modules of the RSAC code have been incorporated into the PCSA Tool. The objective of this test is to validate the modules of the RSAC code that are utilized by the PCSA Tool. This validation test exercises the following modules (called series in the RSAC Version 5.2 documentation): fission product inventory calculation, radionuclide inventory input, meteorological data input, internal/external dose calculation; and cloud gamma dose calculation. This validation test does not exercise the following RSAC Version 5.2 modules: dose summary, definition of radionuclide data constants, post-release radioactive decay, and fifty-mile radius dose calculation.

This test involves executing four sample input files and comparing the output with known solutions, prepared by the code developers and documented in the RSAC Version 5.2 User's Guide (Wenzel, 1994). Four test input files, *Example2*, *Example3*, *Example4*, and *Example7,* were chosen because they calculate the dose from the same pathways used in the consequence analysis of the PCSA Tool.

#### 6.1.1 Test Input

The files required for the test are listed in section 3.1 Software, and the setup of the test input is described in section 4.0 Prerequisites.

#### 6.1.2 Test Procedure

The steps of the test procedure are listed below for the test file, *Example2*.

(1) Execute the batch file *RP.exe* and enter *Example2* after the input file prompt
(2) Select the 'A)' option to edit the file
(3) Press Enter twice to avoid editing the title
(4) Select the 'Run RSAC-5 with file currently in memory' from the menu options
(5) Press Enter when prompted after the calculation

(6) Select the 'Browse RSAC-5 output file' option
(7) Compare the test results to the published results in the User's Manual (Wenzel, 1994)

Repeat steps (1)-(7) for the test file, *Example3.*
Repeat steps (1)-(7) for the test file, *Example4.*
Repeat steps (1)-(7) for the test file, *Example7.*

6.1.3 Expected Test Results

The test procedure creates output results, in files named *Example2.out, Example3.out, Example4.out, and Example7.out*, that are to be compared with the published solutions in the User's Manual (Wenzel, 1994). If the output results are identical for each of the four test files, the validation test is passed.

## 7.0 Notes

None.