RADTRAD Change Log: Version 5.2.0

Released December 2025

- Updates:

- With the changes to the X/Q implementation in Rev. 1 of RG 1.183, users expressed interest in adding a X/Q option that used the worst two-hour dose times for the EAB to base the X/Q values on rather than each individual dose locations worst two-hour dose time. This option was added to the X/Q tables as REV1_EAB.

- During the process of adding in the new X/Q option, it was noticed that compartments that weren't set as dose locations and thus would not have a X/Q table associated with the compartment were being printed out to the X/Q section of the log file. This information was removed and only dose locations that had their X/Q tables adjusted are included in the log file.

- The Rev. 1 FHA model was adding elemental iodine that was re-evolved from the pool to the environment's atmosphere correctly, but any compartment that had a flow path from the environment to the compartment did not see an increase of iodine in the compartment's atmosphere. Logic was added to correctly add the elemental iodine passing from the environment to the compartment(s) accounting for atmospheric conditions and pathway conditions like deposition and filtration.

- A typo was introduced in version 5.1.1 that caused any model that used the Rev. 1 PWR default release timings and fractions to cause an error and was fixed in this update.

- A bug was found that the analytical code (AC) was not using the same release durations for the Rev. 1 and Rev. 0 PWR and BWR default release timings as shown in SNAP. The durations shown in SNAP were correct and the AC was changed to use the same values.

- The NRC suggested that the name of the output file <TestName>NRC.out is adding misguided importance to the file. The <TestName>NRC.out file provides extra information that should be used alongside the <TestName>.out file and has been renamed to <TestName>ExtInfo.out. The contents of the file remain unchanged.

- A bug was found that caused models to fail when the show event flag was set to false. When the worst two-hour dose calculations were modified in a previous update, the calculations used the time of the last output assuming that the last output would be the end of the simulation. However, when the show event flag was set to false, the last output was not guaranteed to be at the end of the simulation causing the worst two-hour dose logic to break. The output will now always include the end of the simulation results (unless an error occurs during the simulation) and the worst two-hour dose calculations now use the user input to know when the simulation ends.

- Users can now set their own chemical groups and assign elements to each of the user-defined chemical groups. However, the Noble Gases and Halogen groups will remain as the first two

chemical groups and the user cannot change the elements in these groups or use these elements in another group. This is due to the significant differences in how these elements are handled in the AC.

RADTRAD Change Log: Version 5.1.1

Released August 2025

- Updates:

  - A bug with how the DF calculated in phase one of the Regulatory Guide 1.183 Rev. 1 FHA model was implemented was found. The DF was still being used as an overall DF instead of only applying to elemental iodine. The DF was corrected and now only applies to the fraction of iodine that is elemental. The DF for aerosol iodine (CsI) is infinite (meaning all CsI is dissolved into the pool), and the DF for organic iodine is set to 1 (meaning no organic iodine is dissolved into the pool).

  - The amount of ingrowth of a daughter nuclide from the decay of the parent nuclide during a set period of time now includes the decay of the daughter during that time. Previously, everything that decayed from the parent nuclide was added to the inventory of the daughter(s).

  - A limit on the size of the dose used in the L infinite error check was added. The default is set to a 1E-6 rem dose but can be changed with the command line option –minL.

  - The regression testing for the RADTRAD AC now includes a comparison of the worst two-hour doses printed in the output rather than strictly relying on the plot files to provide comparisons between the two codes.

  - Fixed an issue were dose summaries were unintentionally removed for the NRC output file.

  - Changed the value that limits the output of nuclide activity from 1E-4 to 0.0. Now, only the nuclides that are not changing the doses are excluded from the output.

RADTRAD Change Log: Version 5.1.0

Released April 2025

- Updates:

  - A new model parameter was added to the input files to specify if the inputs should follow the regulatory guide revision 0 or revision 1 guidelines. The –REV command line option was also added to specify the model parameter. The default option when none is specified is REV1. To select a particular revision, include –REV # (note the space between REV and the #) where # is 0 or 1.

  - The chemical groups specified in Regulatory Guide 1.183 Revision 1 were changed slightly when compared to revision 0. These changes include a new chemical group, Molybdenum, which includes the elements Mo, Tc, and Nb. These elements were removed from their previous groups. The element Zr was also moved to the Cerium group. These changes are only applied when the REV1 model parameter is set.

  - When REV1 is turned on, the REA-CRDA accident types now include an option to turn on the calculation of additional fission gas release due to pellet fragmentation. This option requires input for

the change in enthalpy in the fuel rod in units of cal/g and the burnup of the fuel in terms of MWd/MTU.

- The regulatory guide introduced a new implementation of the X/Q tables. The tables were no longer based on a problem time and the worst two-hour dose time should have the worst or highest X/Q value associated with that time. The revision one implementation of the X/Q tables now includes a duration that the X/Q value will be used and RADTRAD determines when the worst two-hour dose occurs to apply the values. This implementation can be turned on or off by setting the X/Q revision flag to REV0 or REV1 (this is different than the model parameter REV0 or REV1 flag). The X/Q revision flag is set to REV1 by default when the model parameter REV1 flag is specified.

- A new pathway was included in RADTRAD 5.1.0. This new pathway calculates the releases in a BWR MSL as described in Appendix A of Regulatory Guide 1.183 Revision 1. This pathway is only available when REV1 is specified in the model parameters.

- A new model for the FHA accident type was added to calculate the re-evolution of iodine from the spent fuel pool. This model is based off of Regulatory Guide 1.183 Revision 1 Appendix B. The accident type is only available when the model parameter REV1 is defined.

- Some unintended changes happened while fixing the worst two-hour dose specified in the change log below for 5.0.4. These changes caused some bugs when calculating the worst two-hour doses at certain simulation times. These bugs were fixed by basing the worst two-hour doses on the plot points rather than time steps and interpolation between two points was added when a specific time is set. The plot points are generated more frequently and therefore provide a more accurate calculation of the worst two-hour dose.

RADTRAD Change Log: Version 5.0.4

Released March 2024

- **Updates:**

  - A bug was discovered that made it so that the activity of daughter products was not being counted when the nuclides in the initial inventory decayed. The decay process in RADTRAD would still remove and add activity from parent and daughter nuclides, but only if they were in the initial inventory. The fix allows RADTRAD to automatically add daughters to the inventory. To prevent the inventories and output files from becoming excessively large, only the first daughter in each decay chain is automatically added to the inventory. Nuclides can be added to the inventory with an initial activity of 0 if the user is interested in seeing the contribution of adding in a specific daughter.

  - The ability to limit the minimum time step size was included when using the default time step (this capability was already in place for the adaptive time stepping option). The default timestep size is reduced based on the smallest half-life in the inventory. If a nuclide with a short half-life is included, then the timestep size will be very small. Allowing the user to set a minimum time step size prevents it from getting smaller than wanted or expected. The ability to set the minimum timestep has also been included in the SNAP plugin.

- A bug was discovered that showed that the max 2-hour dose was not being correctly captured when the max 2-hour dose occurred later than 24 hours into the run. The bug was caused by an error with the timestep and corrected.

- The gamma energy and frequency can now be added to the .nix file for every nuclide in the following form:<gammaDecay name=”gamma 1” energy=”1.51E-1” frequency=”7.55E-1”>. This addition is meant as a steppingstone to build off to output gamma spectra for users.

- A change was made to the output to include the mass of each nuclide for every reported timestep.

- The error information will not be included in the plot file by default when using adaptive time stepping and the –rgtest argument. This change in default allows the plot files between the tests using adaptive time stepping and the tests using the external time step file from the adaptive time step tests to be identical and confirms that state is being preserved correctly. The error information can still be reported in the plot file of a regression test if the –c or –calculate_error commands are used along with the –rgtest command.

- The compiler for RADTRAD was updated to Java 8 rather than the previous Java 6. The new compiler allowed for newer code features that helped with the changes above. Java 8 is now recommended by Java and Java 6 is becoming more outdated. The change in compiler did not affect the regression results.

RADTRAD Change Log: Version 5.0.3

Released June 2022

- **Updates:**

  - Modified the plots in the output plot file. There are now three options for generating output plot data. The plots are selected using the command line options identified below:

    - --addTransPlots – Gives the transport group atom count per compartment and compartment location (atmosphere, surface, sump, or filtered).

    - --addNucliPlots – Gives the set of nuclide plots per compartment and compartment location.

    - --addActivityPlots – Compartment decay activity in Curies or MBeq per compartment.

RADTRAD Change Log: Version 5.0.2

Released February 2021

- **Updates:**

  - A bug was discovered that causes RADTRAD to fail when run with SNAP version 3.1.2 if the "Adaptive" or "Default with Error Calculation" options are selected for the "Time Step Algorithm" parameter. This bug is resolved in Version 5.0.2. Note that versions of RADTRAD older than 5.0.2 may fail if run with newer versions of SNAP (3.1.2 and later) if these time stepping options are enabled.

RADTRAD Change Log: Version 5.0.1

Released June 2020

- **Updates:**

  - An error in the implementation of the L∞ (local) error norm was fixed, making this a suitable error norm to use in addition to the L2 (global) norm. The L∞ norm determines the nuclide with the largest error and minimizes this error. This minimizes error, even for nuclides that have negligible impact. The L2 norm calculates a root mean square error for dose which is then minimized. The practical result is that the L2 norm minimizes the error of those nuclides which contribute the most to dose.

  - A source term initialization error that occurs when adaptive time stepping is used was fixed. This bug was introduced with adaptive time stepping in RADTRAD 4.5.0. Impacts vary among test cases, with test results showing many cases with negligible impact, and other cases showing error as large as 20% in the cumulative dose. Cloudshine dose appears to be more heavily impacted than TDED and Thyroid dose.

RADTRAD Change Log: Version 5.0.0

Released February 2020

- **Updates:**

  - RADTRAD 4.x was converted from Fortran to java. While java is a modern language, many of the paradigms of Fortran were maintained in the code. RADTRAD 5.0.0 involved significant changes to modernize the structure of the code, remove limitations, and make the code more maintainable.

  - There is no longer a limit on the number of components allowed or size of tables in a RADTRAD model.

  - The code has been optimized to make the adaptive time stepping algorithm much faster.

  - In previous versions, the adaptive time stepping algorithm calculated error only at the dose locations. Because of this, there was often a time delay between the event that caused the error (e.g., a gap release to containment) and the algorithm's measurement of that error (e.g., in a dose location

many compartments downstream of containment). In such a scenario, the algorithm would attempt to decrease time steps to correct for a mechanism that had already passed, as it occurred many time steps before the error was measured. In order to address this, RADTRAD 5.0.0 calculates phantom doses in each compartment (doses that are not used or output in the formal calculation) and estimates error using these doses. This allows for error to be measured closer to the point of occurrence, improving the algorithms ability to adapt the time step accordingly.

- In addition to the L2 (global) error norm, and L∞ (local) error norm was added. The L2 norm minimizes error in nuclides that contribute the most to dose. The L∞ seeks to minimize error in all nuclides whether they contribute significantly to dose or not. The L∞ error norm is expected to cause more timesteps to occur in general. However, in the RADTRAD 5.0.0 release, there is an implementation error in the L∞ algorithm, and the L2 norm is recommended. This is fixed in RADTRAD 5.0.1.

- The command line option '-M' or '--useMAXerror' was added, which causes the calculated error to be based on the maximum error over all dose values rather than using an averaged error that is weighted toward nuclides with larger dose concentrations.

- The 'r' or '--rgtest' (regression testing) command line option causes the plot and output file to remove markers that might differ in different versions of the code to simplify comparison. In RADTRAD 4.5.x, this option did not cause the cpu time plot variable to be removed from the plot file, so the command line option '-T' or '--cpu_time_off' had to be used as well for regression tests. In RADTRAD 5.0.0, the cpu time variable is removed when the '--rgtest' command line option is used.

- Legacy code to process RADTRAD 3.x input files was removed.

- The command line option '--addNucliPlots' was added. This causes the nuclide quantity in each compartment to be included in the plot file.

- The command line option '--addTransPlots' was added. This causes the quantity in each compartment of each transport group to be included in the plot file.

- **Code Fixes:**

  - SNAP allowed RADTRAD component numbers to be specified manually. However, RADTRAD would fail or get incorrect results if the components were not ordered sequentially. This was corrected so that the user can customize the component numbering and get correct results.

  - The adaptive time step algorithm would sometimes get into cycles where the timestep is doubled and then cut in half repeatedly, suggesting that the error calculation was not stable. Code was added that causes RADTRAD to wait 10 time steps after the time step size has been cut to increase the time step in order to improve stability.

RADTRAD Change Log: Version 4.5.8

Released June 2018

- **Code Fixes:**

  - Added a command line option '--aerosol_24_hr_limit' that causes aerosol natural deposition filter to cease removing nuclide after 24 hours if no deposition rates are included in the table after 24 hours.

  - A command line option '—2hr_limitB4_24hrs' was added that causes the time step size from 12.5 hours to 24 hours to be limited to a maximum of 2 hours in the default time step algorithm. After 24 hours, the time step size can grow to a maximum of 4 hours.

  - A divide by zero error was fixed that occurred when a compartment with spray removal contained no nuclide to remove.

  - The NRC output file had some mislabeled columns in the DOSE CONVERSION FACTORS AND DECAY CONSTANTS table. The column labels were corrected.

  - The filter table in the output file now displays time to 1/100th of a second.

RADTRAD Change Log: Version 4.5.7

Release May 2018

- **Code Changes:**

  - Removed extra space from output file header

RADTRAD Change Log: Version 4.5.6

Released May 2017

- **Code Fixes:**

  - RADTRAD fails with an 'array out of bounds' exception if the filter table contains more than 12 entries. This limit has been increased to 50 entries.

RADTRAD Change Log: Version 4.5.5

Released April 2017

- **Code Fixes:**

  - The copyright notice was being printed at the start of each logical page in the output and NRC output files. The copyright is now just printed at the start and end of the output files.

  - The plot variable type 'body' was changed to 'cloudshine'.

  - The plot variable type 'cloudshine' was mislabeled in earlier versions of RADTRAD. The correct label of 'inhalation' is now used.

  - The 'skin' dose is printed at all dose locations.

  - When the 'level doses' diagnostic flag is set to 3 or higher, extra dose information is printed that specifies the organ type the dose is applied to. In previous version, the organ type string was not set, so the organ was listed as 'null'. The organ name is now printed.

RADTRAD Change Log: Version 4.5.4

Released June 2016

- **Code Fixes:**

  - The maximum number of sources allowed in a model is 10. However an error would occur if more than 5 sources were included in a model because a maximum of 5 release fraction and timing tables was allowed. The maximum number of release fraction timing table was increased to be equal to the number of sources allowed.

RADTRAD Change Log: Version 4.5.3

Released April 2016

- **Code Fixes:**

  - The nuclide file information table now prints "Specific Inventory" for each nuclide in units of Ci/MWt and MBq/MWt (in separate columns).

  - "Iodine Units" was renamed to "Release Units". The options "Curies and REM based" or "SI Units" are supported. Units in the output and NRC output files are printed in the associated units.

  - The plot file now includes both British units of REM as well as SI units of mSv. The units can be selected by the user in AptPlot.

RADTRAD Change Log: Version 4.5.2

Released October 2015

- **Code Fixes:**

  - The interim "skin dose" value that was printed to the NRC output file was the deposition skin dose. The deposition velocity used in the code is zero and thus the interim skin dose was zero. However in the final "skin dose" result, cloudshine skin dose was printed. This value is nonzero. For consistency, the interim value that is printed is now cloudshine skin dose.

  - When printing interim accumulated dose data, which is recorded per dose location, info was printed based on the number of compartments, not based on the number of dose locations. This was causing the code to fail on index errors in a few cases. This has now been corrected.

RADTRAD Change Log: Version 4.5.1

Released August 2015

- **Updates:**

  - Added copyright information to the RADTRAD output files.

RADTRAD Change Log: Version 4.5.0

Released May 2015

- **Updates:**

  - Added the option for user to select an adaptive time step algorithm which dynamically adjusts time step size in order to keep the estimated solution error within a user specified limit. Estimated solution error is included as a plot variable.

  - Added the option for user to select the default time step option with error calculation. This option does not use adaptive time stepping, but does calculate error, and includes the estimated error plot variable to determine whether an adaptive time step solution is advisable.

  - Added a reactor coolant system (RCS) activity calculator to the SNAP model editor to permit the calculation of radionuclide concentration in the reactor coolant based on the ANS 18.1 Standard and the GALE-BWR and GALE-PWR computer codes. Pre-incident and co-incident iodine spiking is included in the model. The ability to consider dose equivalent I-131 and Xe-133 is also included.

  - Added the ability for the user to model alternative source term (AST) non-LOCA DBAs described in Regulatory Guide 1.183 (RG 1.183). Accident scenarios include the fuel handling accident and a rod ejection (PWR) or control rod drop (BWR) accident. The design basis accident models based on the TID-14844 and the alternate source term in RG 1.183 is retained. The ability to consider a gap release from either RG 1.25 or RG 1.183 is also available.

- **Code Fixes:**

  - Update the dose conversion factors (DCFs) to those provided in the Radiological Toolbox which are based on the DCFs compiled in FGR-11 and FGR-12. A total of 748 dose conversion factors is available.

  - Updated and added larger radionuclide database from ICRP-38 (838 available nuclides). Note that FGR11 and 12 DCFs are not available for all nuclides. A warning is provided in the SNAP model editor if the user selects a nuclide for which no DCF is available. Users can input DCF data as needed.

  - Plot variables were previously named based on the dose location number (e.g., dose1.body). They are now named based on the dose location name with spaces removed (e.g. ExclusionAreaBoundary.body).

  - Changes to the output files:

    - Previously the model description was printed to the output and NRC output file in the header to sections or at page divisions. Now the description is only printed at the start of the output file and the model 'title' is printed in the header to sections or at page divisions.

    - Worst two hour dose is printed as a time range rather than a single time value.

    - Worst two hour dose was removed from final doses since this information is already provided in the section just above final doses.