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**Savannah River Site
High-Level Waste Tank Farm Closure
Radionuclide Screening Process (First-Level)
Development and Application**

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Radionuclide Screening Process (First-Level)
Development and Application**


Approval Page



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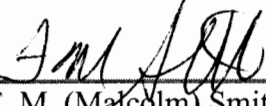
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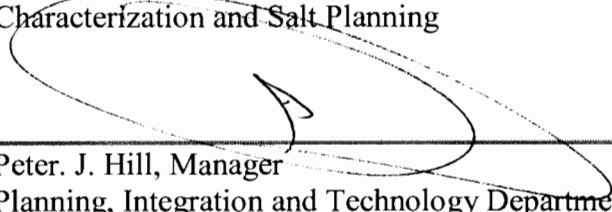
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INTRODUCTION AND SUMMARY

Savannah River Site (SRS) high-level waste tank closure decisions require a thorough understanding of the fate and transport of residual radioactive material in the tanks. The transport analysis requires the application of detailed models to support decision making and is most effective when the list of radionuclides studied is focused on the most important isotopes. Screening methods can be effectively used to narrow a long list of potential radionuclides to those that require detailed modeling.

The purpose of this report is to develop and apply a screening process that can be applied to evaluate radionuclides in SRS high-level waste sludge. The final result of the evaluation is a list of nuclides which are carried forward for further analysis.

The screening process developed in this report uses information about the physical properties of each radioisotope such as half-life and decay mechanism. Information about the source and handling of the waste is used in the decisions based on creation mechanisms and time since the isotope was created. In addition, screening factors which convert a quantity of each radionuclide to a dose that were developed for ground disposal of radionuclides are used.

The screening factors used in this report were developed by the National Council on Radiation Protection and Measurements (NCRP). The NCRP was formed in 1964 and chartered by the U. S. Congress to provide technical analysis, education and guidance on matters involving radioactive materials. They have addressed the issue of environmental transport screening models and developed an approach that can be used to estimate the doses resulting from the disposal of the waste. Details about the NCRP methodology can be found in their report (NCRP 1996) and will not be repeated here.

A comprehensive list of 849 radioactive isotopes was evaluated for either inclusion or exclusion from the list of radionuclides in SRS high-level waste requiring further analysis. Of these, 159 require further evaluation and 690 can be safely excluded from further consideration.

The body of this report is divided into three parts in order to make it easier to follow. Part 1 contains a description of the screening process development, Part 2 contains background information needed to perform the screening and Part 3 contains details of the application of the screening process.

PART 1. FIRST-LEVEL RADIONUCLIDE SCREENING PROCESS DEVELOPMENT AND DESCRIPTION

The reason that a screening process is developed, in the broadest sense, is so that it can be used to sort out which things are more important and which things are less important. In order to accomplish this, the screening steps have to be aggressive enough to remove the least important items from further detailed analysis and at the same time be conservative enough so that decision makers will still have all of the baseline information needed to clearly understand the details and intricacies of the problem they are addressing.

Developing a process which accomplishes both objectives is not something that is prescribed by detailed analysis in textbooks. Instead, it is a process which is developed based on input from people who are interested in and have an appreciation for the complicated real world problem under consideration.

A successful screening process is therefore one that would win agreement from the experts working in the field as being consistent with their intuitive understanding of the relative importance of various factors while at the same time providing a written, logical and understandable process that can be used to explain the reasoning to everyone else.

The screening process developed in the following paragraphs is a step-by-step application of a logical process for why it would be important to either retain certain isotopes or why it would be safe to exclude others. Note that this is a first-level screening process because it starts from a comprehensive list of possible high-level waste radionuclides and uses fairly general information to focus (shorten) the list for nuclides of a later, more detailed analysis.

The starting list is prepared by compiling radionuclides of interest identified from any of five different reference documents. Note that many of the nuclides will be common to all of the lists. The radionuclides were compiled from the following:

1. National Council on Radiation Protection and Measurements, "Screening Models for Releases of Radionuclides to Atmosphere, Surface Water and Ground", NCRP Report No.123, Volumes I and II, (NCRP 1996) which identifies 826 nuclides of interest in determining radiation exposure due to releases to the air, water and ground.
2. United States EPA, Risk Assessment Web Site (EPA, 2005), which provides conversion factors for 824 nuclides which are of interest in determining human health cancer risk from radionuclides in the air, soil and water.
3. Nucleonic - Reference Data Manual, "Fission-Product Yields from Neutron-Induced Fission", which details 148 radionuclides produced from thermal neutron induced fission of U-235 (Katcoff 1960).

4. United States Department of Energy, “Integrated Data Base Report: US Spent Nuclear Fuel and Radioactive Waste Projections, and Characteristics”, (DOE 1997), which identified 168 nuclides of issue in making material disposition decisions.
5. Atomic Energy of Canada Limited, “Derivation of Initial Radionuclide Inventories for the Safety Assessment of the Disposal of Used CANDU Fuel”, (AECL-9881), which lists 211 nuclides of interest in making decisions about disposal of spent fuel from heavy water reactors (note that the five reactors operated at SRS were also heavy water reactors).

In addition to including all of the nuclides identified in any of these documents, any decay product of these nuclides is also identified and included. In a few cases, isotopes that were at one time thought to be stable have recently been identified as being radioactive, but with extremely long half-lives. These are also included on the list, for completeness.

The result of this massive compilation is a list of 849 radionuclides which will be used at the start of the radionuclide screening process. Since this screening process begins with such a comprehensive list, it is unlikely that it will have to be revised to include additional nuclides, except in the rare case of a change in estimated half-life due to advances in the state of the art with respect to radioisotope property measurements.

The screening is performed in careful, precise steps to ensure that each isotope is thoroughly evaluated and that no isotope is screened out by an overly aggressive screen.

Because of the extensive information already available about SRS high-level waste sludge, the first part of the process is to identify those nuclides which are already under consideration. Two (inclusion) criteria have been identified. The first is used to identify those isotopes which are members of any of the four decay series (Ac, Np, Th, and U) because we already know that the first member of each of these is present in high level waste sludge. The second takes advantage of the accumulated knowledge of five decades of safe high-level waste storage and identifies any isotope which is tracked in the current waste characterization process (Hamm 2005). The isotopes in the characterization process were not selected because they will be of concern in a long-term disposal analysis. Some are short-lived and are mainly important because of interim storage of the waste. The screening steps are:

- Step 1. Identify isotopes that are part of any of the four decay series (Ac, Np, Th, U) and retain for further analysis because the waste is known to contain the first member of each of the series.
- Step 2. Identify isotopes for which there is high-level waste sludge characterization information and retain for further analysis since these have been determined to be likely to be present in the waste and of importance to some aspect of the

program. Note that this step may identify isotopes for inclusion that could have been screened out at some later step if they had not been so designated.

Next, the remaining list of nuclides can be examined to eliminate those isotopes which are generally considered to be not worthy of detailed analysis. In the following steps, those that are not of interest due to their very long half-lives (and correspondingly low activity) and those that have been screened out using the most up-to-date method developed by the NCRP (NCRP 1996) are identified for exclusion.

Step 3. Identify isotopes for which there is no dose conversion information (typically very long lived and essentially stable isotopes). The two most comprehensive sources of information are the NCRP (NCRP 1996) and U.S. EPA Risk Assessment Web Site and both of these were consulted. Dose conversion factors do not exist for these isotopes because they are not considered to merit the development of factors.

Step 4. Identify isotopes that have been screened out by the NCRP using the screening methodology for ground disposal (NCRP 1996).

The next part of the screening process employs some general information about the inventory of radioisotopes in high level waste sludge.

Step 5. Assuming a conservatively large activity level (1 million curies) of any isotope remaining in the residual material and using the screening factors from NCRP (NCRP 1996); identify those that would result in a hypothetical exposure to a member of the public of 4 mrem per year or less. Note that this analysis includes the exposure due to all daughter nuclides and is conservative.

Step 6. Assuming a conservatively large mass (1000 lbs) of any isotope remaining in the residual material and using the screening factors from NCRP (NCRP 1996) identify those that would result in a hypothetical exposure to a member of the public of 4 mrem or less. Note that this analysis includes the exposure due to all daughter nuclides and is conservative.

Step 7. Identify isotopes that would not be in the waste due to their physical properties (e.g., present as a gas and released in the reactor or during processing).

Next, more specific information about the waste at the SRS is used to identify those nuclides which can be excluded due to the combination of the knowledge of the history of the site waste.

Step 8. Employ information about the age of the waste (minimum of 15 years) to identify those nuclides that would not be expected to be in the waste at the time of closure due to their short half-lives. Restrict this analysis to those

isotopes that have no on-going source and decay directly to stable products so that no isotopes with significant daughters are prematurely eliminated.

- Step 9. Employ information about the age of the waste (minimum of 15 years) to identify those nuclides that would not be expected to be in the waste at the time of closure due to their short half-lives. Apply this analysis to those isotopes that have no on-going source and decay to short-lived daughters (less than 1 year) and then to stable products so that no isotopes with significant daughters are prematurely eliminated.

Next, some basic information about the duration of institutional control combined with specific isotope characteristics can be used to distinguish nuclides that are not going to be of interest to 'long-term' closure.

- Step 10. Employ detailed decay scheme information to identify short-lived isotopes with no ongoing sources that will decay to stable isotopes in multiple short steps. This step requires the careful review of each decay scheme individually. Although there is not a general rule of thumb, it is obvious from inspection of the decay chain that both the parent and the daughters are effectively extinct.
- Step 11. Employ detailed decay scheme information to identify those short-lived isotopes with no ongoing sources that will decay to a longer lived isotope that is separately tracked. Once this decay has happened, the parent isotope is no longer of interest.
- Step 12. Employ detailed decay scheme information and an assumed period of institutional control (100 years) to identify those isotopes with no ongoing sources that will decay to a stable isotope during the period of institutional control.
- Step 13. Employ detailed decay scheme information and an assumed period of institutional control (100 years) to identify those isotopes with no ongoing sources that will decay to a longer lived isotope that is separately tracked during the period of institutional control. Once this decay has happened, the parent isotope is no longer of interest.

The isotopes remaining on the list which have not been identified for either inclusion or exclusion can now be examined. However, examination of the isotopes which fall in this category shows that many of these were not created in the SRS reactors. Note that the initial, comprehensive list of 849 radionuclides was pulled from a variety of sources and includes isotopes of interest for many different reasons so this is expected. Further investigation of the remaining isotopes must be performed before they can be addressed.

Step 14. The remaining isotopes are now identified as those isotopes which require more understanding and analysis before they can be screened for either inclusion or exclusion.

The first-level screening process will address all of the original 849 nuclides and screen them either in for further evaluation or out and requiring no further evaluation. The first-level screening process development is complete at this point and can be applied to the radioisotopes of interest.

PART 2. BACKGROUND AND REFERENCE INFORMATION NEEDED FOR SCREENING PROCESS APPLICATION

Background

The primary mission of the Savannah River Site (SRS) was the production of nuclear materials, mainly plutonium and tritium. In performing this mission, SRS generated large amounts of high-level radioactive waste (HLW) from processing of reactor fuel and target assemblies. The radioactive sludge waste material resulting from approximately 5 decades of processing has been stored in large underground tanks at the site and is now being removed and processed for permanent disposition.

The waste is present in three forms: sludge, salt, and supernate. Although some materials from offsite sources have been processed, the majority of assemblies were from one of the five reactors operating at the site. In 1955, the SRS had 5 operating nuclear reactors, however, over the years the reactors were gradually taken offline and out of service. One reactor operated briefly in 1992, but the rest were not used after 1989 (over 15 years ago).

The site is currently going through the process of removing the waste from the tanks and processing it for permanent disposal. The removal of the waste from the tanks will necessarily leave behind a small volume of residual material. There are many issues associated with the residual material that must be resolved prior to final tank closure. In order to support the discussion and resolution of the issues involving specific radionuclides in the waste, it is useful to have an understanding of the processes leading to the creation of the isotopes, the processes of isotope decay, and an understanding of which isotopes cause the greatest risk to health.

Fortunately, the waste in the tanks at the SRS and other DOE sites has been extensively studied during the past 50 years. The processes involved in isotope generation and decay are well understood and well characterized. Screening models developed to sort out radionuclides with health risk have been developed and widely applied in support of the disposal of radioactive materials. The results of these decades of work can be used to help determine which radionuclides will be of particular interest to decision makers at the time of tank closure.

Radioisotope Properties, Creation Mechanisms, and Decay Modes

In order to evaluate the list of isotopes, it is necessary to understand the mechanisms leading to the creation of each one. For our purposes, there are essentially three ways that radioactive isotopes can be formed – fission, activation, and decay. Fission is a nuclear reaction in which an atomic nucleus splits into fragments. Neutron activation, called simply activation in this report, involves the capture of a neutron by the nucleus of

an atom. Radioactive decay is the spontaneous disintegration of a radionuclide accompanied by the emission of ionizing radiation in the form of alpha or beta particles or gamma rays. The radioactive processes are discussed in much greater detail in any of a number of textbooks.

The isotopes of interest in the high-level waste were formed by fission, activation or decay while in a nuclear reactor. The fission and activation processes can be considered to be essentially a one-time event. That is, once the fission has occurred or the isotope has been activated, and the material has been removed from the reactor, there is no further formation of the isotope through that mechanism. The isotopes formed by a decay process will continue to be formed until the parent isotope has become extinct.

Table A1 in Appendix A is a list of property data for each of the 849 isotopes addressed in this report. It includes the atomic number, element name, half-life, decay constant, and specific activity. Isotopes which continue to be formed as of the present time (year 2005) (as decay products) are designated. The generation category of the isotope as to whether it is a fission product, activation product or a decay product is provided. Isotopes which are naturally occurring are also noted.

Table A2 in Appendix A shows the creation mechanism of each of the 849 isotopes addressed in this report. If the isotope could still be formed as of the present time (year 2005) it is noted. If the isotope only forms through fission or activation it is noted as one for which formation in 2005 is not occurring. Isotopes that are formed through a decay process for which the parents are extinct are noted as no ongoing formation. The time frame for this assessment is 15 years and is based on the fact that the reactors were shutdown by 1989 (about 15 years ago).

If the radioisotope was created through a chain of decays, that is also shown on the table along with the details of the ancestor decay to the progeny.

Table A3 in Appendix A shows the decay mechanism for each of the 849 isotopes. The complete decay mechanism from the isotope down to a stable isotope is given. If the isotope is a member of one of the four decay series, this fact is also shown. The table shows the mode of decay using the following symbols:

<i>Symbol</i>	<i>Decay Mode</i>
α	Alpha decay
β^-	Beta decay
EC	Electron Conversion (either β^+ decay or electron capture)
IT	Internal conversion (decay from a higher to a lower state of stability)

These three tables (A1 through A3) contain all of the radionuclide characteristic information needed to apply the first-level screening process.

Radioactive Decay Characterized by Isotope Half-life

Radioactive decay is a very well understood process. The half-life of an isotope is, by definition, the amount of time that it takes for one half of the initial activity of that isotope to decay. In equation form, this is expressed as follows:

$$\text{Activity} = \text{Initial Activity} * (0.5)^{(\text{Time elapsed}/\text{Half-life})}$$

The percent of the initial amount left as a function of the number of half-lives elapsed is shown below. After seven half-lives, less than 1 percent of the initial activity is still present. This property can be used to distinguish radionuclides that are mainly a concern when the reactor assemblies are first removed from the reactor from those that are of concern on an intermediate timescale such as the period of institutional control, and those that are of long-term concern. Note that it is important to understand whether or not an isotope has an on-going source before screening due to half-life.

The amount of a radionuclide that is left after seven half-lives is less than 1% of the starting amount. This fact will be used in the screening process.

Number of Half-lives	Fraction Remaining	Percent Remaining (%)
1	½	50
2	¼	25
3	1/8	12.5
4	1/16	6.25
5	1/32	3.125
6	1/64	1.56
7	1/128	0.78

Significant Daughters of Radioisotopes

Some isotopes have daughter products that are long-lived and that pose a significant health risk. In NCRP Publication No. 123, Volume II there is a table that identifies nuclides that reportedly have significant long lived daughters. The process used to determine which nuclides have significant daughters is not explained and it is apparent that some of the isotopes on the table are errors.

The approach taken in this analysis is to look at each of the 849 nuclides individually. No daughters are excluded based on the characteristic of the parents alone.

NCRP Screening Model

The process detailed in the NCRP manual (NCRP 1996) is intended to be applied to landfills that accept radioactive material for disposal. NCRP applied their process to a list of 826 radionuclides which could be released due to a variety of causes such as disposal of medical and research waste, accident cleanup, and defense waste disposal.

The ground disposal scenario is for waste that is put into landfills. The landfills are subject to much higher infiltration rates than those waste forms that include stabilization with grout (such as the waste tanks). Even so, the process used does provide a quick method for evaluation and will be used as part of the screening analysis performed for this report. The analysis determines the dose to an individual through the groundwater pathway using conservative (pessimistic) assumptions. The reader interested in detailed discussion of the process should refer to the manual.

The screening factors developed using the NCRP process provide a conversion factor in units of dose/activity for a given disposal scenario. The screening factors used in this report are found in Table 3.2 of the manual (NCRP 1996).

PART 3. RADONUCLIDE SCREENING PROCESS (FIRST-LEVEL) APPLICATION

The screening process developed in this report consists of the application of 14 screening steps (using both inclusion and exclusion criteria). The analysis assumes that the waste tanks have been filled with inert material and closed and that any exposure from the waste will be through the groundwater pathway.

Two inclusion criteria are applied first and used to identify those nuclides that will be included in the final list without any additional technical reasoning. The exclusion criteria are then applied in the order that they are presented and used to identify those nuclides that will not require further consideration. Note that an isotope that has been identified for inclusion will not be screened out even if it later meets one of the exclusion criteria. There are several radionuclides that are tracked in the high-level waste program that are not of concern with respect to long-term closure. They are kept on the list simply to be consistent with the current tank farm inventory process.

The results of the application of each step are discussed in the following sections. The screening process produces the final list of radionuclides recommended for further consideration.

Summary tables of the results are presented in the body of the document. Table A4 through A8 (in Appendix A) provide the details of the screening process for each of the 14.

The process starts with the list of 849 radionuclides discussed earlier in this report.

Step 1. Member of Thorium, Uranium, Actinium, or Neptunium Decay Series (Inclusion)

HLW sludge is known to contain the first member of each of four decay series (Hamm 2005). Therefore, all of the descendants are automatically retained. All of these nuclides will be addressed in any detailed fate and transport modeling performed for tank farm closure. The progression of each series is shown below. There are 54 isotopes (not including the final, stable end product of each series) in this category as shown in Table 1.

Decay Series for Actinium, Neptunium, Thorium, and Uranium

Actinium Series

U-235 (7E8y) → Th-231 (26h) → Pa-231 (3.3E4y) → Ac-227 (21.8y) → Th-227 (19d) and Fr-223 (22m) → Ra-223 (11d) → Rn-219 (4s) → Po-215 (<1s) → Pb-211 (36m) → Bi-211 (2m) → Tl-207 (5m) → Po-211 (0.5s) → Pb-207 (stable)

Neptunium Series

Pu-241 (14.3y) → Am-241 (4.3E2y) → Np-237 (2.1E6y) → Pa-233 (27d) → U-233 (1.6E5y) → Th-229 (7.3E3y) → Ra-225 (15d) → Ac-225 (10d) → Fr-221 (5m) → At-217 (<1s) → Bi-213 (46m) → Po-213 (<1s) and Tl-209 (2.2m) → Pb-209 (3.3h) → Bi-209 (stable)

Thorium Series

Th-232 (1.4E10y) → Ra-228 (5.7y) → Ac-228 (6h) → Th-228 (1.9y) → Ra-224 (4d) → Rn-220 (56s) → Po-206 (<1s) → Pb-212 (11h) → Bi-212 (61m) → Po-212 (<1s) and Tl-208 (3m) → Pb-208 (stable)

Uranium Series

U-238 (4.5E9y) → Th-234 (24d) → Pa-234 (6.7h) → U-234 (2.5E5y) → Th-230 (7.5E4y) → Ra-226 (1.6E3y) → Rn-222 (4d) → Po-218 (3m) → Pb-214 (27m) and At-208 (1.5s) → Bi-214 (20m) → Po-214 (<1s) and Tl-210 (1.3m) → Pb-210 (22y) → Bi-210 (5d) → Po-210 (13.8d) → Pb-206 (stable)

Table 1. Radionuclides Included As Members of Decay Series (54 Isotopes)

U-235 (Actinium Series)	Pu-241 (Neptunium Series)	Th-232 (Thorium Series)	U-238 (Uranium Series)
Th-231	Am-241	Ra-228	Th-234
Pa-231	Np-237	Ac-228	Pa-234
Ac-227	Pa-233	Th-228	U-234
Th-227	U-233	Ra-224	Th-230
Fr-223	Th-229	Rn-220	Ra-226
Ra-223	Ra-225	Po-216	Rn-222
Rn-219	Ac-225	Pb-212	Po-218
Po-215	Fr-221	Bi-212	Pb-214
Pb-211	At-217	Po-212	At-218
Bi-211	Bi-213	Tl-208	Bi-214
Po-211	Po-213		Po-214
Tl-207	Tl-209		Tl-210
	Pb-209		Pb-210
			Bi-210
			Po-210

At the end of this step 54 radionuclides have been screened (all for inclusion) and 795 remain.

Step 2. Radionuclide Characterized in Residual Sludge Material Estimate (Inclusion)

HLW sludge has been well characterized and estimates of the inventory of 64 radionuclides are currently available (Hamm 2005) as shown in Table 2. Fourteen of these have already been identified for inclusion based on criterion 1 and are indicated in bold. The remaining radionuclides will be automatically retained.

Table 2. Radionuclides Included Because They Are Characterized in High-Level Waste (64 Isotopes)

Ac-227	Cf-252	Eu-152	Pm-147	Ru-106	Th-230
Al-26	Cm-242	Eu-154	Pr-144	Sb-125	Th-232
Am-241	Cm-243	Eu-155	Pu-238	Sb-126	U-232
Am-242m	Cm-244	H-3	Pu-239	Sb-126m	U-233
Am-243	Cm-245	I-129	Pu-240	Se-79	U-234
Ba-137m	Cm-247	Na-22	Pu-241	Sm-151	U-235
Bk-249	Cm-248	Nb-94	Pu-242	Sn-126	U-236
C-14	Co-60	Ni-59	Pu-244	Sr-90	U-238
Ce-144	Cs-134	Ni-63	Ra-226	Tc-99	Y-90
Cf-249	Cs-135	Np-237	Ra-228	Te-125m	
Cf-251	Cs-137	Pa-231	Rh-106	Th-229	

At the end of this step 104 radionuclides have been screened (all for inclusion) and 745 remain.

Step 3. Radionuclides without Dose Conversion Factors (Exclusion)

There are 23 isotopes that are not included in the NCRP screening model (NCRP 1996). One of these is a short-lived member of one of the decay chains (in bold) and has already been screened. The remaining 22 are excluded because they do not have screening factors. The radionuclides that are excluded are shown in Table 3.

Table 3. Radionuclides without Dose Conversion Factors (23 isotopes)

<i>Retained from earlier step:</i>			
Tl-210			
<i>Screened out at this step:</i>			
Ar-42	Fe-52m	Pb-204	Sm-149
As-79	Ga-74	Po-209	Te-118
Bi-208	Gd-150	Po-212m	V-50
Ce-142	Nb-92	Rh-105m	Yb-165
Es-255	Nd-144	Se-79m	
Cf-247	Os-186	Sm-148	

At the end of this step 126 radionuclides have been screened (104 for inclusion and 22 for exclusion) and 723 remain.

Step 4. Radionuclides Screened by NCRP as Not Significant for Ground Disposal (Exclusion)

The NCRP screening process identified 388 radionuclides that are screened from further evaluation in the groundwater pathway because they are insignificant contributors to dose. The list of isotopes that meet this criterion is shown in Table 4. Of these, there are 24 (in bold) that have already been retained in either step 1 or 2. The remaining 364 will be excluded based on this criterion.

Table 4. Radioisotopes Screened by NCRP in Table 3.2 (388 Isotopes)

<i>Retained from earlier step:</i>						
At-217	Pb-212	Ra-224	Pr-144			
Bi-211	Po-211	Rn-219	Rh-106			
Bi-212	Po-212	Rn-220	Y-90			
Bi-213	Po-213	Tl-207				
Fr-221	Po-214	Tl-208				
Pb-209	Po-215	Tl-209				
Pb-211	Po-216	Ba-137m				
<i>Screened out at this step:</i>						
Ac-223	Cd-115	Hf-183	La-132	Pb-203	Sb-128m	Te-129
Ac-224	Ce-134	Hf-184	La-134	Pm-148	Sb-130	Te-132
Ag-102	Ce-135	Hg-197	La-135	Pm-149	Sc-43	Te-133
Ag-104	Cl-38	Hg-197m	La-140	Pm-150	Sc-44	Te-133m
Ag-104m	Cl-39	Hg-199m	La-142	Po-203	Sc-44m	Te-134
Ag-106	Co-61	Ho-155	Lu-170	Pr-136	Sc-47	Ti-45
Ag-108	Co-62m	Ho-161	Lu-172	Pr-138	Sc-48	Tl-197
Ag-109m	Cs-126	Ho-162	Lu-176m	Pr-138m	Sc-49	Tl-198
Ag-110	Cs-128	Ho-162m	Lu-177	Pr-142	Se-70	Tl-198m
Ag-112	Cs-129	Ho-164	Lu-178	Pr-142m	Se-77m	Tl-199
Al-28	Cs-130	Ho-164m	Lu-178m	Pr-144m	Se-81	Tl-200
Ar-37	Cs-132	Ho-166	Lu-179	Pr-145	Se-81m	Tl-201
Ar-39	Cs-135m	Ho-167	Md-257	Pt-186	Se-83	Tl-206
Ar-41	Cs-138	I-120	Mg-28	Pt-191	Si-31	Tm-162
As-69	Cu-60	I-120m	Mn-52	Pt-195m	Sm-141	Tm-166
As-70	Cu-61	I-122	Mn-52m	Pt-197	Sm-141m	Tm-172
As-72	Cu-62	I-124	Mn-56	Pt-197m	Sm-142	Tm-173
As-76	Cu-64	I-128	Mo-101	Pt-199	Sm-153	Tm-175
As-77	Cu-66	I-130	Mo-90	Pt-200	Sn-110	V-47
As-78	Cu-67	I-132	N-13	Rb-79	Sn-111	W-176
At-215	Dy-155	I-132m	Na-24	Rb-80	Sn-121	W-177
At-216	Dy-165	I-133	Nb-89a	Rb-81m	Sn-123m	W-187
Au-194	Dy-166	I-134	Nb-89b	Rb-82	Sn-128	Xe-120
Au-198	Er-161	I-135	Nb-90	Rb-82m	Sr-80	Xe-122
Au-198m	Er-165	In-110	Nb-96	Rb-88	Sr-81	Xe-129m
Au-199	Er-172	In-110m	Nb-97	Re-177	Sr-87m	Xe-131m

Table 4. Continued

Au-200	Eu-146	In-111	Nb-97m	Re-180	Sr-92	Xe-133
Au-200m	Eu-150m	In-112	Nb-98	Re-182	Ta-174	Xe-133m
Au-201	Eu-152m	In-113m	Nd-136	Re-182m	Ta-176	Xe-135m
Ba-126	Eu-157	In-114	Nd-138	Re-186	Ta-177	Xe-138
Ba-128	Eu-158	In-115m	Nd-141	Re-188	Ta-178	Y-86
Ba-135m	F-18	In-116m	Nd-141m	Re-188m	Ta-178m	Y-86m
Ba-139	Fe-52	Ir-182	Nd-149	Re-189	Ta-180	Y-87
Ba-142	Fr-219	Ir-184	Ne-19	Rh-100	Ta-183	Y-90m
Bi-200	Fr-220	Ir-186	Ni-65	Rh-103m	Ta-184	Y-92
Bi-201	Ga-66	Ir-186m	Ni-66	Rh-105	Ta-186	Y-94
Bi-203	Ga-67	Ir-187	O-15	Rh-106m	Tb-150	Yb-162
Bi-206	Ga-68	Ir-188	Os-180	Rh-107	Tb-154	Yb-166
Br-74	Ga-70	Ir-191m	Os-182	Rh-99m	Tb-155	Yb-175
Br-74m	Ga-72	Ir-194	Os-189m	Rn-218	Tb-156	Yb-177
Br-76	Ga-73	Ir-195	Os-190m	Ru-105	Tb-156m	Yb-178
Br-77	Gd-159	Ir-195m	Os-193	Ru-94	Tb-156n	Zn-62
Br-80	Ge-66	K-38	P-30	Sb-115	Tb-161	Zn-63
Br-80m	Ge-67	K-42	Pa-234m	Sb-116	Tc-101	Zn-69
Br-82	Ge-69	K-43	Pb-198	Sb-116m	Tc-104	Zn-69m
Br-83	Ge-75	K-44	Pb-199	Sb-117	Tc-95	Zn-71m
Br-84	Ge-77	Kr-74	Pb-200	Sb-118m	Tc-96	Zn-72
C-11	Ge-78	Kr-76	Pb-201	Sb-120	Tc-96m	Zr-86
Ca-47	Hf-170	Kr-77	Pd-100	Sb-120m	Te-116	Zr-89
Ca-49	Hf-174	Kr-83m	Pd-109	Sb-122	Te-127	Zr-97
Cd-104	Hf-177m	Kr-87	Pm-141	Sb-128	Tc-94	
Cd-107	Hf-180m	Kr-88	Pm-142	Sb-119	Tc-94m	

At the end of this step 490 radionuclides have been screened (104 for inclusion and 386 for exclusion) and 359 remain.

Step 5. Radionuclides That Do Not Exceed 4 Millirem at 1 Million Curies of Activity (Exclusion)

The major contributors to waste activity are well known and documented (Tran 2005). It is extremely unlikely that any previously unidentified nuclide would be present in a substantial quantity. The highly conservative assumption that 1 million curies of each isotope is present in the residual material in the tanks is used for this criterion.

The value of 1 million curies is approximately 4 times the activity level of the largest estimated value of any nuclide in either tank farm in the present (year 2005) (Tran 2005).

This assumption and the NCRP screening factors for the groundwater pathway are used to identify those isotopes for which the resulting dose would be less than 4 mrem per year. Note that this evaluation includes the effect of exposure to all of the daughters in each decay chain. This criterion identifies 89 isotopes which are shown in Table 5.

Seven of these are on the included list (in bold) and the remaining 82 are screened out at this step.

Table

Table 5. Radionuclides Which Do Not Exceed 4 Millirem/year at 1 Million Curies of Inventory (89 Isotopes)

<i>Retained from earlier step:</i>				
Ac-225				
Fr-223				
Ra-223				
Ra-225				
Th-227				
Sb-126				
Sb-126m				
<i>Screened out at this step:</i>				
Ag-103	Cr-51	Ir-189	Pd-103	Tb-147
Ag-106m	Cs-127	Ir-190	Po-205	Te-121
Ag-111	Cs-131	Ir-190m	Pr-137	Te-131
Ag-115	Cs-136	Ir-190n	Pr-143	Te-131m
Am-237	Er-169	La-131	Pt-188	Tl-202
As-71	Eu-147	La-141	Pt-189	Tm-167
As-74	Eu-156	La-143	Rb-81	V-48
Ba-131	Gd-147	Lu-171	Rb-86	W-178
Ba-131m	Ge-71	Mn-51	Rb-89	Xe-121
Ba-140	Hf-179m	Nb-95	Re-178	Xe-127
Ba-141	I-121	Nb-95m	Rh-99	Y-91m
Bi-205	I-126	Nd-151	Sb-129	Y-93
Cd-117	I-131	Os-191	Sb-131	Y-95
Cd-117m	In-117	Os-191m	Se-73m	Yb-167
Ce-141	In-117m	P-32	Sm-156	
Ce-143	In-119	P-33	Sn-117m	
Cr-48	In-119m	Pa-227	Sr-82	

At the end of this step, 572 radionuclides have been screened (104 for inclusion and 468 for exclusion) and 277 remain.

Step 6. Radionuclides That Do Not Exceed 4 Millirem/year at 1,000 Pounds of Mass (Exclusion)

Radionuclides with extremely long half-lives have corresponding low specific activities. Due to this fact, a very large quantity of these isotopes is required to create a significant amount of activity. It is extremely unlikely that any previously unidentified nuclide would be present in HLW sludge in a substantial quantity. In order to identify any minor isotopes that should be included, the highly conservative assumption that 1000 lbs of the residual material is present in the residual material in the tanks is used.

The 1000 lbs value is based on the very rough estimate that the total mass of material left in 50 tanks estimated at 100 gallons each is 5000 gallons. Based on a characteristic concentration of settled sludge at 2 lbs/gal there would be roughly 10,000 pounds of mass. Because the radioactive isotopes make up a small fraction on a mass basis of the total inventory in a tank, it is extremely unlikely that any individual isotope would exceed 10% of the total mass. Ten percent of the 10,000 lb rough estimate gives a very conservative value of 1000 lbs for screening purposes.

The NCRP screening factors for the groundwater pathway and the assumption that there is 1000 lbs of the isotope present are used to identify 67 isotopes which are shown in Table 6. Of these, 7 have already been identified for inclusion on the list and 54 have already been identified for exclusion based on earlier criteria (shown in bold). Six additional nuclides are screened out due to this criterion.

Table 6. Radionuclides Which Do Not Exceed 4 Millirem/year at 1000 lbs of Inventory (67 isotopes)

<i>Retained from earlier step:</i>			
Ac-225			
Fr-223			
Ra-223			
Ra-225			
Th-227			
Sb-126			
Sb-126m			
<hr/>			
<i>Screened out at this step:</i>			
Ag-103	Er-169	Os-191	Te-131
Ag-106m	Eu-156	Os-191m	Te-131m
Ag-111	Ge-71	P-32	Tl-202
As-71	I-121	Pa-227	Tm-167
As-74	I-126	Pd-103	V-48
Ba-131	I-131	Po-205	W-178
Ba-131m	In-117	Pr-143	Xe-121
Ba-140	In-117m	Pt-188	Xe-127
Cd-117	Ir-189	Pt-189	Yb-167
Cd-117m	Ir-190	Rb-86	Cd-113
Ce-143	Ir-190m	Rh-99	Gd-152
Cr-48	Ir-190n	Sb-131	In-115
Cs-127	La-131	Sm-156	Re-187
Cs-131	La-143	Sn-117m	Ta-180m
Cs-136	Lu-171	Te-121	Te-123

At the end of this step, 578 radionuclides have been screened (104 for inclusion and 474 for exclusion) and 271 remain.

Step 7. Radionuclides Which Are Not in Waste Due to Physical Properties (Exclusion)

Some elements exist only as gases. Argon, krypton, neon, radon and xenon are in this category and have 30 isotopes as shown in Table 7. Only radionuclides with no on-going source are considered in this step. Twenty-four isotopes have already been excluded based on earlier criteria. Examination of the remaining 6 isotopes shows that they can be excluded based on the fact that they are formed in the reactor or during the assembly cooling period. Any gas that was not released during reactor operation or assembly cooling can be expected to be released during processing. Therefore, they will not be present in the high level waste sludge. The six isotopes are excluded based on this criterion.

Table 7. Gas Phase Radionuclides (30 Isotopes)

<i>Screened out in a prior step:</i>		
Ar-42	Kr-81m	Xe-129m
Ar-37	Kr-83m	Xe-131m
Ar-39	Kr-87	Xe-133
Ar-41	Kr-88	Xe-133m
Kr-74	Ne-19	Xe-135m
Kr-76	Rn-218	Xe-138
Kr-77	Xe-120	Xe-121
Kr-79	Xe-122	Xe-127
<i>Screened out at this step:</i>		
Kr-81		
Kr-85		
Kr-85m		
Xe-123		
Xe-125		
Xe-135		

At the end of this step, 584 radionuclides have been screened (104 for inclusion and 480 for exclusion) and 265 remain.

Step 8. Short-lived Radionuclides Which Decay Directly to Stable Products (Exclusion)

There are 288 isotopes that are not created from decay series (they have no ongoing source of formation) and have undergone 7 or more half lives in the last 15 years and decay directly to stable isotopes. The 15 year time period is based on the time elapsed from the present to the last time the reactors were operated in 1989. There are 47 radionuclides excluded based on this criterion, while the rest were excluded in earlier steps (shown in bold).

Table 8. Radionuclides Decayed Directly to Stable Products (288 isotopes)

Screened out at this step:

Ar-37	Cs-130	Ir-187	Re-180	Tc-96	V-48
Kr-79	Cs-132	Ir-188	Re-182	Te-127	Ag-105
Kr-83m	Cs-138	Ir-191m	Re-182m	Ti-45	As-73
Ne-19	Cu-60	Ir-195	Re-188	Tl-198	Au-195
Xe-129m	Cu-61	K-38	Re-189	Tl-199	Au-195m
Xe-131m	Cu-62	K-42	Rh-100	Tl-200	Be-7
Xe-133	Cu-64	K-43	Rh-103m	Tl-201	Ca-45
Xe-127	Cu-66	K-44	Rh-105	Tm-162	Cd-109
Cs-134	Cu-67	La-132	Rh-106m	Tm-166	Ce-139
Rh-106	Dy-165	La-134	Sb-115	Tm-172	Co-56
Ga-74	Er-165	La-135	Sb-116	Tm-173	Co-57
Po-212m	Eu-152m	La-140	Sb-116m	V-47	Co-58
Ag-102	Eu-157	Lu-170	Sb-117	Y-86	Dy-159
Ag-104	Eu-158	Lu-176m	Sb-118m	Y-87	Eu-149
Ag-104m	F-18	Lu-177	Sb-119	Y-92	Fe-59
Ag-106	Ga-66	Lu-178	Sb-120	Y-94	Gd-151
Ag-109m	Ga-67	Lu-178m	Sb-120m	Yb-175	Gd-153
Ag-110	Ga-68	Lu-179	Sb-122	Zn-63	Hf-175
Ag-112	Ga-70	Mn-52	Sb-128	Zn-69	Hf-181
Al-28	Ga-72	Mn-56	Sb-130	Zn-71m	Hg-203
As-70	Ga-73	N-13	Sc-43	Zr-89	I-125
As-72	Gd-159	Na-24	Sc-47	Ag-106m	Ir-194m
As-76	Ge-69	Nb-90	Sc-48	Ag-111	Lu-173
As-77	Ge-75	Nb-96	Sc-49	As-74	Mn-54
As-78	Hf-177m	Nb-97	Se-77m	Ce-141	Os-185
Au-198	Hg-197	Nb-98	Se-81	Cr-51	Pm-143
Au-199	Hg-199m	Nd-141	Si-31	Cs-131	Rb-84
Au-200	Ho-161	Ni-65	Sm-153	Cs-136	Re-184
Au-201	Ho-162	O-15	Sn-123m	Er-169	S-35
Ba-135m	Ho-164	Os-189m	Ta-174	Eu-156	Sb-124
Ba-139	Ho-166	Os-190m	Ta-176	Ge-71	Sc-46
Bi-206	Ho-167	Os-193	Ta-177	Hf-179m	Se-75
Br-74	I-120	P-30	Ta-178	I-126	Sn-113
Br-74m	I-120m	Pb-203	Ta-178m	I-131	Sn-119m
Br-76	I-122	Pm-142	Ta-180	In-117	Sn-123
Br-77	I-124	Pm-150	Ta-183	In-119	Sr-85
Br-80	I-128	Pr-136	Ta-184	Ir-189	Sr-89
Br-82	I-130	Pr-138	Ta-186	Ir-190	Ta-179
Br-83	I-132	Pr-138m	Tb-154	Lu-171	Tb-160
Br-84	I-134	Pr-142	Tb-155	Nb-95	Tm-170
C-11	In-110	Pr-145	Tb-156	Os-191	Tm-171
Cd-107	In-110m	Pt-191	Tb-156n	P-33	V-49
Cl-38	In-111	Pt-195m	Tb-161	Pr-143	W-181
Co-61	In-112	Pt-197	Tc-101	Rb-86	W-185

Table 8. Continued

Co-62m	In-113m	Rb-80	Tc-104	Rh-99	Y-88
Cs-126	In-114	Rb-82	Tc-94	Sn-117m	Y-91
Cs-128	In-116m	Rb-82m	Tc-94m	Te-121	Yb-169
Cs-129	Ir-184	Rb-88	Tc-95	Tm-167	Zn-65

At the end of this step, 631 radionuclides have been screened (104 for inclusion and 527 for exclusion) and 218 remain.

Step 9. Short-lived Radionuclides Which Decay to a Short-lived Daughter and Then to a Stable Product (Exclusion)

There are 169 isotopes that have no on-going source of formation and have decayed to a short-lived daughter (with less than a 1 year half-life) and then to a stable product. These isotopes are shown in Table 9. Of the 169, there are 130 that have already been screened (shown in bold). The remaining 39 isotopes are excluded based on this criterion.

Table 9. Radionuclides Decayed to Stable Product in Two Steps (169 Isotopes)

Screened out at this step:

Kr-74	Fe-52	Pb-199	Tl-198m	Mn-51	Ni-56
Kr-76	Ge-66	Pb-200	Tm-175	Nb-95m	Ni-57
Kr-77	Ge-67	Pb-201	W-176	Nd-151	Pr-139
Kr-88	Ge-77	Pd-100	W-177	Os-191m	Rb-83
Xe-120	Ge-78	Pd-109	Y-86m	Pd-103	Re-181
Xe-122	Hf-170	Pm-141	Y-90m	Pt-188	Re-184m
Xe-133m	Hf-183	Pr-142m	Yb-162	Pt-189	Ru-103
Xe-138	Hf-184	Pt-197m	Yb-166	Rb-89	Sb-124m
Xe-125	Hg-197m	Pt-199	Yb-177	Sm-156	Sb-124n
Ru-106	Ho-162m	Pt-200	Yb-178	Sr-82	Se-73
Rh-105m	Ho-164m	Rb-79	Zn-62	Te-131	Sr-83
Te-118	I-132m	Re-188m	Zn-69m	W-178	Sr-85m
As-69	I-133	Rh-99m	Zn-72	Y-91m	Sr-91
Au-198m	Ir-195m	Ru-94	Zr-86	Yb-167	Ta-175
Au-200m	Mg-28	Sb-128m	Ag-103	Ag-110m	Ta-182m
Ba-126	Mn-52m	Sc-44m	As-71	Br-75	Ta-185
Ba-128	Mo-101	Se-70	Ba-131	Co-58m	Tb-151
Ba-142	Mo-90	Se-81m	Ba-140	Cr-49	Tb-153
Bi-203	Nb-89a	Sm-142	Cd-117	Ga-65	Tc-95m
Br-80m	Nb-89b	Sn-110	Cd-117m	Gd-149	Te-121m
Ca-47	Nb-97m	Sn-111	Ce-143	Ge-68	Te-127m
Ca-49	Nd-136	Sr-80	Cr-48	Hf-172	W-188
Cd-104	Nd-138	Sr-92	Cs-127	Hg-195	Zr-88
Ce-134	Nd-141m	Tb-156m	I-121	Ho-159	Zr-95

Table 9. Continued

Ce-135	Nd-149	Tc-96m	In-117m	In-114m
Dy-155	Ni-66	Te-116	In-119m	Ir-185
Dy-166	Os-180	Te-132	Ir-190m	K-45
Er-161	Os-182	Te-134	Ir-190n	Lu-169
Er-172	Pb-198	Tl-197	La-141	Lu-177m

At the end of this step, 670 radionuclides have been screened (104 for inclusion and 566 for exclusion) and 179 remain.

Step 10. Short-lived Radionuclides Which Decay to Stable Isotope in Multiple Steps (Exclusion)

The remaining radionuclides are examined and it can be seen by inspection that there are 13 isotopes that are short-lived, have no on-going source of formation, decay to two or more short-lived isotopes and then to a final stable isotope. These are determined based on inspection of the decay scheme and no specific criteria have been developed for them.

All 13 of these isotopes are excluded.

An example is Os-181, which is a short-lived activation product with no on-going source of formation. Os-181 rapidly decays to Re-181 which in turn decays to W-181. In a short time, all of the Os-181 and its daughters have decayed to Ta-181, a stable isotope.

Os-181 (105m) → Re-181 (20h) → W-181 (121d) → Ta-181 (stable)

All 13 of these isotopes are excluded.

Table 10. Radionuclides Decayed to Stable Isotope in Multiple Steps (13 Isotopes)

<i>Screened out at this step</i>	
Cs-125	Pa-228
Hf-173	Pb-195m
Hg-195m	Sb-127
Nb-88	Sn-127
Nd-139	Tb-149
Nd-139m	Tl-195
Os-181	

At the end of this step, 683 radionuclides have been screened (104 for inclusion and 579 for exclusion) and 166 remain.

Step 11. Radionuclides Which Decay to Longer Lived Radionuclides (Exclusion)

There are 101 isotopes that have no on-going source of formation, are short-lived and then decay to a longer lived daughter that will be addressed separately. There is no reason to keep further track of the now extinct parent. These isotopes are shown in Table 11. All 101 of these isotopes are excluded based on this criterion.

Table 11. Radionuclides Which Decay to Longer-Lived Radionuclides (101 Isotopes)

Screened out at this step:

Ac-226	Ce-137m	Es-254	In-109	Pm-144	Ta-172
Am-238	Cf-244	Es-254m	Lu-174m	Pm-148m	Ta-173
Am-239	Cf-246	Eu-145	Md-258	Pm-151	Tc-93
Am-240	Cf-248	Eu-148	Mo-93m	Po-207	Tc-93m
Am-244	Cf-253	Fm-252	Mo-99	Pr-147	Tc-97m
Am-244m	Cf-254	Fm-253	Nd-147	Pt-193m	Tc-99m
Am-245	Cm-238	Fm-254	Np-232	Pu-234	Te-123m
Am-246m	Cm-240	Fm-255	Np-233	Pu-235	Te-129m
At-207	Cm-241	Fm-257	Np-234	Pu-237	Th-226
At-211	Cm-249	Fr-222	Np-235	Pu-245	Tl-194
Au-193	Co-55	Gd-145	Np-236m	Ra-222	Tl-194m
Ba-133m	Cs-134m	Gd-146	Np-238	Ra-227	U-230
Bi-202	Dy-157	Hf-182m	Np-240m	Rh-101m	U-231
Bk-245	Er-171	Hg-193	Pa-230	Ru-97	U-237
Bk-246	Es-250m	Hg-193m	Pa-232	Sm-145	U-239
Cd-115m	Es-251	Ho-157	Pb-202m	Sm-155	W-179
Ce-137	Es-253	I-123	Pd-101	Sn-125	

At the end of this step, 784 radionuclides have been screened (104 for inclusion and 680 for exclusion) and 65 remain.

Step 12. Radionuclides Which Will Decay to Stable Isotope during Period of Institutional Control (Exclusion)

Some radionuclides will persist in the waste for a time after tank closure. This criterion identifies those nuclides that have no ongoing source of formation and that are decaying away quickly enough that 99% will have decayed away at the end of a 115 year time period. The 115 year time is based on 15 years from the last time the reactors were operated added to a future 100 year period of institutional control. Note that this step can only be applied to isotopes with no ongoing generation source. Eight radionuclides are excluded based on this criterion.

Table 12. Isotopes that Decay to Stable Isotopes during Institutional Control Period (8 Isotopes)

Screened out at this step:

Ba-133
Fe-55
Lu-174
Os-194
Rh-101
Rh-102
Rh-102m
Tl-204

At the end of this step, 792 radionuclides have been screened (104 for inclusion and 688 for exclusion) and 57 remain.

Step 13. Radionuclides Which Decay to Longer-Lived Isotope during Institutional Control Period.

Two radionuclides with no on-going source of formation will persist in the waste for some time after tank closure while decaying to a longer lived isotope which is already being addressed. Therefore, there is no need to track the parent isotope. They are listed in Table 13 and are both excluded based on this criterion.

Table 13. Radionuclides Which Decay to Longer Lived Radionuclides during Institutional Control (2 Isotopes)

Screened out at this step:

Cd-113m
Pm-146

At the end of this step, 794 radionuclides have been screened (104 for inclusion and 690 for exclusion) and 55 remain.

Step 14. Isotopes Requiring Analysis Before They Can Be Screened

The remaining 55 isotopes require more analysis to determine if they should be retained for further consideration or screened out. Some of these are created using methods which are not likely to have taken place in the production process in the reactors and can be eliminated after it is confirmed that they would not be in the waste. The remaining isotopes will require an estimate of the amount that could be present in the waste and should be added to the high-level waste characterization database. Until that time, these 55 will be retained for further evaluation.

Table 14. Isotopes Requiring Additional Analysis (55 isotopes)

Retained at this step:

Ag-108m	Eu-150	Mo-93	Re-186m
Am-242	Fe-60	Nb-93m	Si-32
Am-246	Gd-148	Np-236	Sm-146
Be-10	Hf-178m	Np-239	Sm-147
Bi-207	Hf-182	Np-240	Sn-121m
Bi-210m	Hg-194	Pb-202	Ta-182
Bk-247	Ho-166m	Pb-205	Tb-157
Bk-250	Ir-192	Pd-107	Tb-158
Ca-41	Ir-192m	Pm-145	Tc-97
Cf-250	K-40	Pt-193	Tc-98

Table 14. Continued

Cl-36	La-137	Pu-236	Ti-44
Cm-246	La-138	Pu-243	U-240
Cm-250	Lu-176	Pu-246	Zr-93
Co-60m	Mn-53	Rb-87	

At the end of this step, all 849 radionuclides have been screened (159 for inclusion and 690 for exclusion).

RESULTS AND CONCLUSION

A first-level screening process for application to SRS high-level waste radionuclides has been developed and applied. A comprehensive list of 849 radioactive isotopes was evaluated for either inclusion or exclusion from the list of radionuclides requiring further evaluation. The result of the application of the first-level screening is the identification of 159 isotopes that should be carried forward for further evaluation and 690 radioisotopes that can safely be excluded from further consideration. The 159 radionuclides which should be carried forward are identified in Table 15, below:

Table 15. Radionuclides Retained for Further Evaluation (159 Isotopes)

H-3	Mo-93	Pm-145	Tl-208	Po-216	Th-234	Pu-246
Be-10	Tc-97	Pm-147	Tl-209	Po-218	Pa-231	Am-241
C-14	Tc-98	Sm-146	Tl-210	At-217	Pa-233	Am-242
Na-22	Tc-99	Sm-147	Pb-202	At-218	Pa-234	Am-242m
Al-26	Ru-106	Sm-151	Pb-205	Rn-219	U-232	Am-243
Si-32	Rh-106	Eu-150	Pb-209	Rn-220	U-233	Am-246
Cl-36	Pd-107	Eu-152	Pb-210	Rn-222	U-234	Cm-242
K-40	Ag-108m	Eu-154	Pb-211	Fr-221	U-235	Cm-243
Ca-41	Sn-121m	Eu-155	Pb-212	Fr-223	U-236	Cm-244
Ti-44	Sn-126	Gd-148	Pb-214	Ra-223	U-238	Cm-245
Mn-53	Sb-125	Tb-157	Bi-207	Ra-224	U-240	Cm-246
Fe-60	Sb-126	Tb-158	Bi-210	Ra-225	Np-236	Cm-247
Co-60	Sb-126m	Ho-166m	Bi-210m	Ra-226	Np-237	Cm-248
Co-60m	Te-125m	Lu-176	Bi-211	Ra-228	Np-239	Cm-250
Ni-59	I-129	Hf-178m	Bi-212	Ac-225	Np-240	Bk-247
Ni-63	Cs-134	Hf-182	Bi-213	Ac-227	Pu-236	Bk-249
Se-79	Cs-135	Ta-182	Bi-214	Ac-228	Pu-238	Bk-250
Rb-87	Cs-137	Re-186m	Po-210	Th-227	Pu-239	Cf-249
Sr-90	Ba-137m	Ir-192	Po-211	Th-228	Pu-240	Cf-250
Y-90	La-137	Ir-192m	Po-212	Th-229	Pu-241	Cf-251
Zr-93	La-138	Pt-193	Po-213	Th-230	Pu-242	Cf-252
Nb-93m	Ce-144	Hg-194	Po-214	Th-231	Pu-243	
Nb-94	Pr-144	Tl-207	Po-215	Th-232	Pu-244	

The purpose of this report was to provide readers with an easy to use compilation of radionuclide properties, including creation and decay mechanisms, as well as a logical process for thinking about why certain radionuclides are important for long term closure discussion.

The screening process developed in this report relies heavily on decades of work performed to understand general radionuclide properties and processes, SRS specific radionuclide concerns and on screening methods for focusing considerations important to decisions about radionuclide disposal.

The screening process ultimately developed for this report consisted of the application of 14 steps (two for inclusion of nuclides and 12 for exclusion of nuclides). The final list of isotopes identifies 159 that should be retained and further evaluated and 690 that could safely be excluded from further detailed consideration.

At some future time, a second level of screening could be applied using information about the quantity of material to be left in the tanks developed for planning purposes and the standard NCRP screening factors. This would be a 'second-level' screening process and would further reduce the list of nuclides requiring detailed fate and transport analysis. This is outside of the scope of this report.

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Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Ac-223	89	Actinium	2.10	minutes	3.99E-06	1.74E+05	4.02E+08	No		-	X	X	
Ac-224	89	Actinium	2.78	hours	3.17E-04	2.19E+03	5.04E+06	No		-	X	X	
Ac-225	89	Actinium	10.0	days	2.74E-02	2.53E+01	5.81E+04	Yes		X	X	X	
Ac-226	89	Actinium	29.37	hours	3.35E-03	2.07E+02	4.73E+05	No		X		X	
Ac-227	89	Actinium	21.772	years	2.18E+01	3.18E-02	7.24E+01	Yes		X	X	X	
Ac-228	89	Actinium	6.15	hours	7.02E-04	9.88E+02	2.24E+06	Yes			X	X	
Ag-102	47	Silver	12.9	minutes	2.45E-05	2.83E+04	1.43E+08	No		X			
Ag-103	47	Silver	65.7	minutes	1.25E-04	5.55E+03	2.78E+07	No		X			
Ag-104	47	Silver	69.2	minutes	1.32E-04	5.27E+03	2.61E+07	No		X	X		
Ag-104m	47	Silver	33.5	minutes	6.37E-05	1.09E+04	5.40E+07	No		X			
Ag-105	47	Silver	41.29	days	1.13E-01	6.13E+00	3.01E+04	No		X			
Ag-106	47	Silver	23.96	minutes	4.56E-05	1.52E+04	7.41E+07	No		X			
Ag-106m	47	Silver	8.28	days	2.27E-02	3.06E+01	1.49E+05	No		X			
Ag-108	47	Silver	2.37	minutes	4.51E-06	1.54E+05	7.35E+08	Yes		X	X		
Ag-108m	47	Silver	438	years	4.38E+02	1.58E-03	7.56E+00	No		X			
Ag-109m	47	Silver	38.0	seconds	1.20E-06	5.76E+05	2.73E+09	No	X		X		
Ag-110	47	Silver	24.6	seconds	7.80E-07	8.89E+05	4.17E+09	No		X	X		
Ag-110m	47	Silver	249.76	days	6.84E-01	1.01E+00	4.76E+03	No		X			
Ag-111	47	Silver	7.45	days	2.04E-02	3.40E+01	1.58E+05	No	X	X			
Ag-112	47	Silver	3.130	hours	3.57E-04	1.94E+03	8.95E+06	No	X	X			
Ag-115	47	Silver	20.0	minutes	3.80E-05	1.82E+04	8.18E+07	No	X	X			
Al-26	13	Aluminum	7.17E+05	years	7.17E+05	9.67E-07	1.92E-02	No		X			
Al-28	13	Aluminum	2.2414	minutes	4.26E-06	1.63E+05	3.00E+09	No		X	X		
Am-237	95	Americium	73.0	minutes	1.39E-04	4.99E+03	1.09E+07	No		X		X	
Am-238	95	Americium	98	minutes	1.86E-04	3.72E+03	8.07E+06	No		X	X	X	
Am-239	95	Americium	11.9	hours	1.36E-03	5.10E+02	1.10E+06	No		X		X	
Am-240	95	Americium	50.8	hours	5.80E-03	1.20E+02	2.57E+05	No		X		X	
Am-241	95	Americium	432.2	years	4.32E+02	1.60E-03	3.44E+00	Yes			X	X	
Am-242	95	Americium	16.02	hours	1.83E-03	3.79E+02	8.09E+05	Yes		X	X	X	
Am-242m	95	Americium	141	years	1.41E+02	4.91E-03	1.05E+01	No		X		X	
Am-243	95	Americium	7,370	years	7.37E+03	9.40E-05	2.00E-01	Yes		X	X	X	
Am-244	95	Americium	10.1	hours	1.15E-03	6.01E+02	1.27E+06	No		X		X	
Am-244m	95	Americium	26	minutes	4.94E-05	1.40E+04	2.97E+07	No		X		X	

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Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Am-245	95	Americium	2.05	hours	2.34E-04	2.96E+03	6.24E+06	No			X	X	
Am-246	95	Americium	39	minutes	7.42E-05	9.35E+03	1.96E+07	Yes			X	X	
Am-246m	95	Americium	25.0	minutes	4.75E-05	1.46E+04	3.06E+07	No		X		X	
Ar-37	18	Argon	34.95	days	9.57E-02	7.24E+00	1.01E+05	No		X			
Ar-39	18	Argon	269	years	2.69E+02	2.58E-03	3.41E+01	No		X	X		
Ar-41	18	Argon	109.61	years	1.10E+02	6.32E-03	7.96E+01	No		X			
Ar-42	18	Argon	32.9	years	3.29E+01	2.11E-02	2.59E+02	No		X			
As-69	33	Arsenic	15.2	minutes	2.89E-05	2.40E+04	1.79E+08	No		X			
As-70	33	Arsenic	52.6	minutes	1.00E-04	6.93E+03	5.11E+07	No		X	X		
As-71	33	Arsenic	65.28	hours	7.45E-03	9.31E+01	6.77E+05	No		X			
As-72	33	Arsenic	26.0	hours	2.97E-03	2.34E+02	1.68E+06	No		X	X		
As-73	33	Arsenic	80.30	days	2.20E-01	3.15E+00	2.23E+04	No		X	X		
As-74	33	Arsenic	17.77	days	4.87E-02	1.42E+01	9.94E+04	No		X			
As-76	33	Arsenic	1.0942	days	3.00E-03	2.31E+02	1.57E+06	No		X			
As-77	33	Arsenic	38.83	hours	4.43E-03	1.56E+02	1.05E+06	No	X	X	X		
As-78	33	Arsenic	90.7	minutes	1.72E-04	4.02E+03	2.66E+07	No	X	X	X		
As-79	33	Arsenic	9.01	minutes	1.71E-05	4.05E+04	2.64E+08	No	X	X			
At-207	85	Astatine	1.80	hours	2.05E-04	3.37E+03	8.42E+06	No		X			
At-211	85	Astatine	7.214	hours	8.23E-04	8.42E+02	2.06E+06	No		X			
At-215	85	Astatine	1.00E-04	seconds	3.17E-12	2.19E+11	5.25E+14	No			X		
At-216	85	Astatine	3.00E-04	seconds	9.51E-12	7.29E+10	1.74E+14	No			X		
At-217	85	Astatine	0.0323	seconds	1.02E-09	6.77E+08	1.61E+12	Yes			X		
At-218	85	Astatine	1.5	seconds	4.75E-08	1.46E+07	3.45E+10	Yes			X		
Au-193	79	Gold	17.65	hours	2.01E-03	3.44E+02	9.21E+05	No		X	X		
Au-194	79	Gold	38.02	hours	4.34E-03	1.60E+02	4.25E+05	Yes		X	X		
Au-195	79	Gold	186.098	days	5.10E-01	1.36E+00	3.60E+03	No		X	X		
Au-195m	79	Gold	30.5	seconds	9.66E-07	7.17E+05	1.90E+09	No		X			
Au-198	79	Gold	2.6956	days	7.38E-03	9.39E+01	2.45E+05	No		X	X		
Au-198m	79	Gold	2.27	days	6.21E-03	1.12E+02	2.91E+05	No		X			
Au-199	79	Gold	3.139	days	8.59E-03	8.06E+01	2.09E+05	No		X	X		
Au-200	79	Gold	48.4	minutes	9.20E-05	7.53E+03	1.94E+07	No		X	X		
Au-200m	79	Gold	18.7	hours	2.13E-03	3.25E+02	8.39E+05	No		X			
Au-201	79	Gold	26	minutes	4.94E-05	1.40E+04	3.60E+07	No		X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Ba-126	56	Barium	100	minutes	1.90E-04	3.64E+03	1.49E+07	No		X			
Ba-128	56	Barium	2.43	days	6.65E-03	1.04E+02	4.20E+05	No		X			
Ba-131	56	Barium	11.50	days	3.15E-02	2.20E+01	8.67E+04	No		X	X		
Ba-131m	56	Barium	14.6	minutes	2.78E-05	2.50E+04	9.84E+07	No		X			
Ba-133	56	Barium	3,841	days	1.05E+01	6.59E-02	2.56E+02	No		X	X		
Ba-133m	56	Barium	38.9	hours	4.44E-03	1.56E+02	6.06E+05	No		X			
Ba-135m	56	Barium	28.7	hours	3.27E-03	2.12E+02	8.10E+05	No		X			
Ba-137m	56	Barium	2.552	minutes	4.85E-06	1.43E+05	5.38E+08	Yes	X		X		
Ba-139	56	Barium	83.06	minutes	1.58E-04	4.39E+03	1.63E+07	No	X	X			
Ba-140	56	Barium	12.752	days	3.49E-02	1.98E+01	7.32E+04	No	X				
Ba-141	56	Barium	18.27	minutes	3.47E-05	2.00E+04	7.31E+07	No	X				
Ba-142	56	Barium	10.6	minutes	2.02E-05	3.44E+04	1.25E+08	No	X				
Be-10	4	Beryllium	1.51E+06	years	1.51E+06	4.59E-07	2.37E-02	No		X			
Be-7	4	Beryllium	53.22	days	1.46E-01	4.76E+00	3.51E+05	No		X			
Bi-200	83	Bismuth	36.4	minutes	6.92E-05	1.00E+04	2.59E+07	No		X			
Bi-201	83	Bismuth	108	minutes	2.05E-04	3.37E+03	8.67E+06	No		X			
Bi-202	83	Bismuth	1.72	hours	1.96E-04	3.53E+03	9.03E+06	No			X		
Bi-203	83	Bismuth	11.76	hours	1.34E-03	5.17E+02	1.31E+06	No		X	X		
Bi-205	83	Bismuth	15.31	days	4.19E-02	1.65E+01	4.16E+04	No		X	X		
Bi-206	83	Bismuth	6.243	days	1.71E-02	4.05E+01	1.02E+05	No		X			
Bi-207	83	Bismuth	32.9	years	3.29E+01	2.11E-02	5.25E+01	No		X	X		
Bi-208	83	Bismuth	3.68E+05	years	3.68E+05	1.88E-06	4.67E-03	No		X			
Bi-210	83	Bismuth	5.012	days	1.37E-02	5.05E+01	1.24E+05	Yes		X	X		
Bi-210m	83	Bismuth	3.04E+06	years	3.04E+06	2.28E-07	5.60E-04	No		X			
Bi-211	83	Bismuth	2.14	minutes	4.07E-06	1.70E+05	4.17E+08	Yes			X		
Bi-212	83	Bismuth	60.55	minutes	1.15E-04	6.02E+03	1.47E+07	Yes			X		
Bi-213	83	Bismuth	45.59	minutes	8.67E-05	7.99E+03	1.94E+07	Yes			X		
Bi-214	83	Bismuth	19.9	minutes	3.78E-05	1.83E+04	4.42E+07	Yes			X		
Bk-245	97	Berkelium	4.94	days	1.35E-02	5.12E+01	1.08E+05	No		X		X	
Bk-246	97	Berkelium	1.80	days	4.93E-03	1.41E+02	2.95E+05	No		X	X	X	
Bk-247	97	Berkelium	1,380	years	1.38E+03	5.02E-04	1.05E+00	No		X	X	X	
Bk-249	97	Berkelium	330	days	9.03E-01	7.67E-01	1.59E+03	No		X	X	X	
Bk-250	97	Berkelium	3.212	hours	3.66E-04	1.89E+03	3.91E+06	Yes		X	X	X	

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Br-74	35	Bromine	25.4	minutes	4.83E-05	1.44E+04	1.00E+08	No		X	X		
Br-74m	35	Bromine	46	minutes	8.75E-05	7.92E+03	5.53E+07	No		X			
Br-75	35	Bromine	96.7	minutes	1.84E-04	3.77E+03	2.59E+07	No		X			
Br-76	35	Bromine	16.2	hours	1.85E-03	3.75E+02	2.55E+06	No		X	X		
Br-77	35	Bromine	57.036	hours	6.51E-03	1.07E+02	7.14E+05	No		X	X		
Br-80	35	Bromine	17.68	minutes	3.36E-05	2.06E+04	1.33E+08	No		X	X		
Br-80m	35	Bromine	4.4205	hours	5.04E-04	1.37E+03	8.87E+06	No		X			
Br-82	35	Bromine	35.282	hours	4.02E-03	1.72E+02	1.08E+06	No		X			
Br-83	35	Bromine	2.40	hours	2.74E-04	2.53E+03	1.57E+07	No	X	X	X		
Br-84	35	Bromine	31.80	minutes	6.05E-05	1.15E+04	7.05E+07	No	X	X			
C-11	6	Carbon	20.334	minutes	3.87E-05	1.79E+04	8.41E+08	No		X			
C-14	6	Carbon	5700	years	5.70E+03	1.22E-04	4.48E+00	No		X			
Ca-41	20	Calcium	1.02E+05	years	1.02E+05	6.79E-06	8.56E-02	No		X			
Ca-45	20	Calcium	162.61	days	4.45E-01	1.56E+00	1.79E+04	No		X	X		
Ca-47	20	Calcium	4.536	days	1.24E-02	5.58E+01	6.13E+05	No		X			
Ca-49	20	Calcium	8.718	minutes	1.66E-05	4.18E+04	4.41E+08	No		X			
Cd-104	48	Cadmium	57.7	minutes	1.10E-04	6.32E+03	3.14E+07	No		X			
Cd-107	48	Cadmium	6.50	hours	7.42E-04	9.35E+02	4.51E+06	No		X			
Cd-109	48	Cadmium	461.4	days	1.26E+00	5.49E-01	2.60E+03	No		X	X		
Cd-113	48	Cadmium	7.7E+15	years	7.70E+15	9.00E-17	4.11E-13	Yes	X		X		
Cd-113m	48	Cadmium	14.1	years	1.41E+01	4.91E-02	2.25E+02	No		X			
Cd-115	48	Cadmium	53.46	hours	6.10E-03	1.14E+02	5.10E+05	No	X	X	X		
Cd-115m	48	Cadmium	44.56	days	1.22E-01	5.68E+00	2.55E+04	No	X	X	X		
Cd-117	48	Cadmium	2.49	hours	2.84E-04	2.44E+03	1.08E+07	No	X	X			
Cd-117m	48	Cadmium	3.36	hours	3.83E-04	1.81E+03	7.98E+06	No	X	X			
Ce-134	58	Cerium	3.16	days	8.65E-03	8.01E+01	3.09E+05	No		X			
Ce-135	58	Cerium	17.7	hours	2.02E-03	3.43E+02	1.31E+06	No		X			
Ce-137	58	Cerium	9.0	hours	1.03E-03	6.75E+02	2.54E+06	No		X	X		
Ce-137m	58	Cerium	34.4	hours	3.92E-03	1.77E+02	6.66E+05	No		X			
Ce-139	58	Cerium	137.641	days	3.77E-01	1.84E+00	6.83E+03	No		X	X		
Ce-141	58	Cerium	32.508	days	8.90E-02	7.79E+00	2.85E+04	No	X	X	X		
Ce-142	58	Cerium	2.6E+17	years	2.60E+17	2.67E-18	9.69E-15	No	X		X		
Ce-143	58	Cerium	33.039	hours	3.77E-03	1.84E+02	6.64E+05	No	X	X	X		

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Ce-144	58	Cerium	284.91	days	7.80E-01	8.88E-01	3.19E+03	No	X				
Cf-244	98	Californium	19.4	minutes	3.69E-05	1.88E+04	3.98E+07	No		X		X	
Cf-246	98	Californium	35.7	hours	4.07E-03	1.70E+02	3.57E+05	No		X		X	
Cf-247	98	Californium	3.11	hour	3.55E-04	1.95E+03	4.08E+06	No		X		X	
Cf-248	98	Californium	333.5	days	9.13E-01	7.59E-01	1.58E+03	No		X	X	X	
Cf-249	98	Californium	351	years	3.51E+02	1.97E-03	4.09E+00	No		X	X	X	
Cf-250	98	Californium	13.08	years	1.31E+01	5.30E-02	1.09E+02	Yes		X	X	X	
Cf-251	98	Californium	898	years	8.98E+02	7.72E-04	1.59E+00	No		X	X	X	
Cf-252	98	Californium	3	years	2.65E+00	2.62E-01	5.37E+02	No		X		X	
Cf-253	98	Californium	17.81	days	4.88E-02	1.42E+01	2.90E+04	No		X	X	X	
Cf-254	98	Californium	60.5	days	1.66E-01	4.18E+00	8.50E+03	No		X		X	
Cl-36	17	Chlorine	3.01E+05	years	3.01E+05	2.30E-06	3.30E-02	No		X			
Cl-38	17	Chlorine	37.24	minutes	7.08E-05	9.79E+03	1.33E+08	No		X			
Cl-39	17	Chlorine	55.6	minutes	1.06E-04	6.56E+03	8.68E+07	No		X			
Cm-238	96	Curium	2.4	hours	2.74E-04	2.53E+03	5.49E+06	No		X		X	
Cm-240	96	Curium	27	days	7.39E-02	9.37E+00	2.02E+04	No		X	X	X	
Cm-241	96	Curium	32.8	days	8.98E-02	7.72E+00	1.65E+04	No		X		X	
Cm-242	96	Curium	162.8	days	4.46E-01	1.55E+00	3.32E+03	Yes		X	X	X	
Cm-243	96	Curium	29.1	years	2.91E+01	2.38E-02	5.06E+01	No		X		X	
Cm-244	96	Curium	18.1	years	1.81E+01	3.83E-02	8.10E+01	No		X	X	X	
Cm-245	96	Curium	8,500	years	8.50E+03	8.15E-05	1.72E-01	Yes		X	X	X	
Cm-246	96	Curium	4,760	years	4.76E+03	1.46E-04	3.06E-01	Yes		X	X	X	
Cm-247	96	Curium	1.56E+07	years	1.56E+07	4.44E-08	9.29E-05	Yes		X	X	X	
Cm-248	96	Curium	3.48E+05	years	3.48E+05	1.99E-06	4.15E-03	Yes		X	X	X	
Cm-249	96	Curium	64.15	minutes	1.22E-04	5.68E+03	1.18E+07	No		X		X	
Cm-250	96	Curium	8.3E+03	years	8.30E+03	8.35E-05	1.72E-01	No		X		X	
Co-55	27	Cobalt	17.53	hours	2.00E-03	3.47E+02	3.14E+06	No		X			
Co-56	27	Cobalt	77.233	days	2.11E-01	3.28E+00	2.97E+04	No		X	X		
Co-57	27	Cobalt	271.74	days	7.44E-01	9.31E-01	8.44E+03	No		X	X		
Co-58	27	Cobalt	70.86	days	1.94E-01	3.57E+00	3.18E+04	No		X	X		
Co-58m	27	Cobalt	9.04	hours	1.03E-03	6.72E+02	5.98E+06	No		X			
Co-60	27	Cobalt	1925.28	days	5.27E+00	1.31E-01	1.13E+03	Yes		X	X		
Co-60m	27	Cobalt	10.467	minutes	1.99E-05	3.48E+04	3.00E+08	Yes		X	X		

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Co-61	27	Cobalt	1.650	hours	1.88E-04	3.68E+03	3.12E+07	No		X			
Co-62m	27	Cobalt	13.91	minutes	2.64E-05	2.62E+04	2.18E+08	No		X			
Cr-48	24	Chromium	21.56	hours	2.46E-03	2.82E+02	3.03E+06	No		X			
Cr-49	24	Chromium	42.3	minutes	8.04E-05	8.62E+03	9.08E+07	No		X			
Cr-51	24	Chromium	27.7025	days	7.58E-02	9.14E+00	9.25E+04	No		X	X		
Cs-125	55	Cesium	46.7	minutes	8.88E-05	7.80E+03	3.22E+07	No		X			
Cs-126	55	Cesium	1.64	minutes	3.12E-06	2.22E+05	9.11E+08	No			X		
Cs-127	55	Cesium	6.25	hours	7.13E-04	9.72E+02	3.95E+06	No		X			
Cs-128	55	Cesium	3.66	minutes	6.96E-06	9.96E+04	4.02E+08	No			X		
Cs-129	55	Cesium	32.06	hours	3.66E-03	1.89E+02	7.58E+05	No		X			
Cs-130	55	Cesium	29.21	minutes	5.55E-05	1.25E+04	4.96E+07	No		X			
Cs-131	55	Cesium	9.689	days	2.65E-02	2.61E+01	1.03E+05	No		X	X		
Cs-132	55	Cesium	6.480	days	1.77E-02	3.91E+01	1.53E+05	No		X			
Cs-134	55	Cesium	2.0652	years	2.07E+00	3.36E-01	1.29E+03	No		X	X		
Cs-134m	55	Cesium	2.912	hours	3.32E-04	2.09E+03	8.04E+06	No		X			
Cs-135	55	Cesium	2.3E+06	years	2.30E+06	3.01E-07	1.15E-03	No	X		X		
Cs-135m	55	Cesium	53	minutes	1.01E-04	6.88E+03	2.63E+07	No		X			
Cs-136	55	Cesium	13.04	days	3.57E-02	1.94E+01	7.37E+04	No		X			
Cs-137	55	Cesium	30.03	years	3.00E+01	2.31E-02	8.70E+01	No	X				
Cs-138	55	Cesium	33.41	minutes	6.35E-05	1.09E+04	4.08E+07	No	X	X	X		
Cu-60	29	Copper	23.7	minutes	4.51E-05	1.54E+04	1.32E+08	No		X			
Cu-61	29	Copper	3.333	hours	3.80E-04	1.82E+03	1.54E+07	No		X			
Cu-62	29	Copper	9.67	minutes	1.84E-05	3.77E+04	3.14E+08	No		X	X		
Cu-64	29	Copper	12.700	hours	1.45E-03	4.78E+02	3.86E+06	No		X			
Cu-66	29	Copper	5.120	minutes	9.73E-06	7.12E+04	5.57E+08	No		X	X		
Cu-67	29	Copper	61.83	hours	7.05E-03	9.83E+01	7.57E+05	No		X			
Dy-155	66	Dysprosium	9.9	hours	1.13E-03	6.14E+02	2.04E+06	No		X	X		
Dy-157	66	Dysprosium	8.14	hours	9.29E-04	7.46E+02	2.45E+06	No		X	X		
Dy-159	66	Dysprosium	144.4	days	3.95E-01	1.75E+00	5.69E+03	No		X	X		
Dy-165	66	Dysprosium	2.334	hours	2.66E-04	2.60E+03	8.14E+06	No		X			
Dy-166	66	Dysprosium	81.6	hours	9.31E-03	7.44E+01	2.32E+05	No	X	X			
Er-161	68	Erbium	3.21	hours	3.66E-04	1.89E+03	6.07E+06	No		X			
Er-165	68	Erbium	10.36	hours	1.18E-03	5.86E+02	1.83E+06	No		X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Er-169	68	Erbium	9.392	days	2.57E-02	2.70E+01	8.23E+04	No		X			
Er-171	68	Erbium	7.516	hours	8.57E-04	8.08E+02	2.44E+06	No		X			
Er-172	68	Erbium	49.3	hours	5.62E-03	1.23E+02	3.70E+05	No		X			
Es-250m	99	Einsteinium	2	hours	2.53E-04	2.74E+03	5.65E+06	No		X		X	
Es-251	99	Einsteinium	33	hours	3.76E-03	1.84E+02	3.79E+05	No		X		X	
Es-253	99	Einsteinium	20.47	days	5.60E-02	1.24E+01	2.52E+04	No			X	X	
Es-254	99	Einsteinium	275.7	days	7.55E-01	9.18E-01	1.87E+03	No		X	X	X	
Es-254m	99	Einsteinium	39.3	hours	4.48E-03	1.55E+02	3.14E+05	No		X		X	
Es-255	99	Einsteinium	39.8	days	1.09E-01	6.36E+00	1.29E+04	No		X		X	
Eu-145	63	Europium	5.93	days	1.62E-02	4.27E+01	1.52E+05	No		X	X		
Eu-146	63	Europium	4.61	days	1.26E-02	5.49E+01	1.94E+05	No		X	X		
Eu-147	63	Europium	24.1	days	6.60E-02	1.05E+01	3.69E+04	No		X	X		
Eu-148	63	Europium	54.5	days	1.49E-01	4.64E+00	1.62E+04	No		X			
Eu-149	63	Europium	93.1	days	2.55E-01	2.72E+00	9.42E+03	No		X	X		
Eu-150	63	Europium	36.9	years	3.69E+01	1.88E-02	6.46E+01	No		X			
Eu-150m	63	Europium	12.8	hours	1.46E-03	4.75E+02	1.63E+06	No		X			
Eu-152	63	Europium	13.506	years	1.35E+01	5.13E-02	1.74E+02	No		X			
Eu-152m	63	Europium	9.3116	hours	1.06E-03	6.52E+02	2.22E+06	No		X			
Eu-154	63	Europium	8.590	years	8.59E+00	8.07E-02	2.70E+02	No		X			
Eu-155	63	Europium	4.753	years	4.75E+00	1.46E-01	4.86E+02	No	X	X	X		
Eu-156	63	Europium	15.19	days	4.16E-02	1.67E+01	5.52E+04	No	X	X	X		
Eu-157	63	Europium	15.18	hours	1.73E-03	4.00E+02	1.32E+06	No	X	X			
Eu-158	63	Europium	45.9	minutes	8.73E-05	7.94E+03	2.59E+07	No	X	X			
F-18	9	Fluorine	1.8291	hours	2.09E-04	3.32E+03	9.53E+07	No		X			
Fe-52	26	Iron	8.275	hours	9.44E-04	7.34E+02	7.29E+06	No		X	X		
Fe-52m	26	Iron	46	seconds	1.46E-06	4.75E+05	4.72E+09	No		X			
Fe-55	26	Iron	2.737	years	2.74E+00	2.53E-01	2.38E+03	No		X	X		
Fe-59	26	Iron	44.495	days	1.22E-01	5.69E+00	4.98E+04	No		X			
Fe-60	26	Iron	1.50E+06	years	1.50E+06	4.62E-07	4.04E-03	No		X			
Fm-252	100	Fermium	25.39	hours	2.90E-03	2.39E+02	4.90E+05	No		X		X	
Fm-253	100	Fermium	3.00	days	8.21E-03	8.44E+01	1.72E+05	No		X		X	
Fm-254	100	Fermium	3.240	hours	3.70E-04	1.87E+03	3.81E+06	No			X	X	
Fm-255	100	Fermium	20.07	hours	2.29E-03	3.03E+02	6.13E+05	No			X	X	

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Fm-257	100	Fermium	100.5	days	2.75E-01	2.52E+00	5.06E+03	No		X	X	X	
Fr-219	87	Francium	0.02	seconds	6.34E-10	1.09E+09	2.58E+12	No			X		
Fr-220	87	Francium	27.4	seconds	8.68E-07	7.98E+05	1.87E+09	No			X		
Fr-221	87	Francium	4.9	minutes	9.32E-06	7.44E+04	1.74E+08	Yes			X		
Fr-222	87	Francium	14.2	minutes	2.70E-05	2.57E+04	5.97E+07	No		X			
Fr-223	87	Francium	22.00	minutes	4.18E-05	1.66E+04	3.84E+07	Yes			X		
Ga-65	31	Gallium	15.2	minutes	2.89E-05	2.40E+04	1.90E+08	No		X			
Ga-66	31	Gallium	9.49	hours	1.08E-03	6.40E+02	5.01E+06	No		X	X		
Ga-67	31	Gallium	3.2623	days	8.93E-03	7.76E+01	5.98E+05	No		X	X		
Ga-68	31	Gallium	67.71	minutes	1.29E-04	5.38E+03	4.09E+07	No		X	X		
Ga-70	31	Gallium	21.14	minutes	4.02E-05	1.72E+04	1.27E+08	No		X			
Ga-72	31	Gallium	14.095	hours	1.61E-03	4.31E+02	3.09E+06	No	X	X	X		
Ga-73	31	Gallium	4.86	hours	5.54E-04	1.25E+03	8.84E+06	No	X	X			
Ga-74	31	Gallium	8.2	minutes	1.56E-05	4.45E+04	3.10E+08	No	X	X			
Gd-145	64	Gadolinium	23.0	minutes	4.37E-05	1.58E+04	5.64E+07	No		X			
Gd-146	64	Gadolinium	48.27	days	1.32E-01	5.24E+00	1.85E+04	No		X			
Gd-147	64	Gadolinium	38.06	hours	4.34E-03	1.60E+02	5.61E+05	No		X	X		
Gd-148	64	Gadolinium	70.9	years	7.09E+01	9.77E-03	3.41E+01	No		X			
Gd-149	64	Gadolinium	9.28	days	2.54E-02	2.73E+01	9.45E+04	No		X	X		
Gd-150	64	Gadolinium	1.80E+06	years	1.80E+06	3.85E-07	1.33E-03	No		X	X		
Gd-151	64	Gadolinium	124	days	3.39E-01	2.04E+00	6.98E+03	No		X	X		
Gd-152	64	Gadolinium	1.08E+14	years	1.08E+14	6.42E-15	2.18E-11	No					X
Gd-153	64	Gadolinium	240.4	days	6.58E-01	1.05E+00	3.55E+03	No			X		
Gd-159	64	Gadolinium	18.479	hours	2.11E-03	3.29E+02	1.07E+06	No	X	X			
Ge-66	32	Germanium	2.26	hours	2.58E-04	2.69E+03	2.10E+07	No		X			
Ge-67	32	Germanium	18.9	minutes	3.59E-05	1.93E+04	1.49E+08	No		X			
Ge-68	32	Germanium	270.95	days	7.42E-01	9.34E-01	7.09E+03	No		X			
Ge-69	32	Germanium	39.05	hours	4.45E-03	1.56E+02	1.16E+06	No		X	X		
Ge-71	32	Germanium	11.43	days	3.13E-02	2.21E+01	1.61E+05	No		X	X		
Ge-75	32	Germanium	82.78	minutes	1.57E-04	4.40E+03	3.03E+07	No		X			
Ge-77	32	Germanium	11.30	hours	1.29E-03	5.38E+02	3.60E+06	No	X	X			
Ge-78	32	Germanium	88.0	minutes	1.67E-04	4.14E+03	2.74E+07	No	X	X			
H-3	1	Hydrogen	12.32	years	1.23E+01	5.63E-02	9.68E+03	No	X	X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Hf-170	72	Hafnium	16.01	hours	1.83E-03	3.79E+02	1.15E+06	No		X			
Hf-172	72	Hafnium	1.87	years	1.87E+00	3.71E-01	1.11E+03	No		X	X		
Hf-173	72	Hafnium	23.6	hours	2.69E-03	2.57E+02	7.68E+05	No		X	X		
Hf-174	72	Hafnium	2.0E+15	years	2.00E+15	3.47E-16	1.03E-12	No					X
Hf-175	72	Hafnium	70	days	1.92E-01	3.62E+00	1.07E+04	No		X	X		
Hf-177m	72	Hafnium	51.4	minutes	9.77E-05	7.09E+03	2.07E+07	No		X			
Hf-178m	72	Hafnium	31	years	3.10E+01	2.24E-02	6.48E+01	No		X			
Hf-179m	72	Hafnium	25.05	days	6.86E-02	1.01E+01	2.91E+04	No		X			
Hf-180m	72	Hafnium	5.47	hours	6.24E-04	1.11E+03	3.19E+06	No		X			
Hf-181	72	Hafnium	42.39	days	1.16E-01	5.97E+00	1.70E+04	No		X			
Hf-182	72	Hafnium	8.9E+06	years	8.90E+06	7.79E-08	2.21E-04	No		X	X		
Hf-182m	72	Hafnium	61.5	minutes	1.17E-04	5.93E+03	1.68E+07	No		X			
Hf-183	72	Hafnium	1.067	hours	1.22E-04	5.69E+03	1.61E+07	No		X			
Hf-184	72	Hafnium	4.12	hours	4.70E-04	1.47E+03	4.14E+06	No		X			
Hg-193	80	Mercury	3.80	hours	4.33E-04	1.60E+03	4.28E+06	No		X	X		
Hg-193m	80	Mercury	11.8	hours	1.35E-03	5.15E+02	1.38E+06	No		X			
Hg-194	80	Mercury	444	years	4.44E+02	1.56E-03	4.15E+00	No		X	X		
Hg-195	80	Mercury	10.53	hours	1.20E-03	5.77E+02	1.53E+06	No		X	X		
Hg-195m	80	Mercury	41.6	hours	4.75E-03	1.46E+02	3.87E+05	No		X			
Hg-197	80	Mercury	64.14	hours	7.32E-03	9.47E+01	2.48E+05	No		X	X		
Hg-197m	80	Mercury	23.8	hours	2.72E-03	2.55E+02	6.69E+05	No		X			
Hg-199m	80	Mercury	42.67	minutes	8.11E-05	8.54E+03	2.22E+07	No		X			
Hg-203	80	Mercury	46.595	days	1.28E-01	5.43E+00	1.38E+04	No		X			
Ho-155	67	Holmium	48	minutes	9.13E-05	7.59E+03	2.53E+07	No		X			
Ho-157	67	Holmium	12.6	minutes	2.40E-05	2.89E+04	9.51E+07	No		X			
Ho-159	67	Holmium	33.05	minutes	6.28E-05	1.10E+04	3.58E+07	No		X			
Ho-161	67	Holmium	2.48	hours	2.83E-04	2.45E+03	7.86E+06	No			X		
Ho-162	67	Holmium	15.0	minutes	2.85E-05	2.43E+04	7.74E+07	No			X		
Ho-162m	67	Holmium	67.0	minutes	1.27E-04	5.44E+03	1.73E+07	No		X			
Ho-164	67	Holmium	29	minutes	5.51E-05	1.26E+04	3.96E+07	No		X	X		
Ho-164m	67	Holmium	37.5	minutes	7.13E-05	9.72E+03	3.06E+07	No		X			
Ho-166	67	Holmium	26.83	hours	3.06E-03	2.26E+02	7.04E+05	No	X	X	X		
Ho-166m	67	Holmium	1.20E+03	years	1.20E+03	5.78E-04	1.80E+00	No		X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Ho-167	67	Holmium	3.003	hours	3.43E-04	2.02E+03	6.25E+06	No		X			
I-120	53	Iodine	81.6	minutes	1.55E-04	4.47E+03	1.92E+07	No		X	X		
I-120m	53	Iodine	53	minutes	1.01E-04	6.88E+03	2.96E+07	No		X			
I-121	53	Iodine	2.12	hours	2.42E-04	2.87E+03	1.22E+07	No		X	X		
I-122	53	Iodine	3.63	minutes	6.90E-06	1.00E+05	4.25E+08	No		X	X		
I-123	53	Iodine	13.232	hours	1.51E-03	4.59E+02	1.93E+06	No		X	X		
I-124	53	Iodine	4.1760	days	1.14E-02	6.06E+01	2.52E+05	No		X			
I-125	53	Iodine	59.400	days	1.63E-01	4.26E+00	1.76E+04	No		X	X		
I-126	53	Iodine	12.93	days	3.54E-02	1.96E+01	8.02E+04	No		X			
I-128	53	Iodine	24.99	minutes	4.75E-05	1.46E+04	5.88E+07	No		X			
I-129	53	Iodine	1.57E+07	years	1.57E+07	4.41E-08	1.77E-04	No	X		X		
I-130	53	Iodine	12.36	hours	1.41E-03	4.91E+02	1.95E+06	No		X			
I-131	53	Iodine	8.02070	days	2.20E-02	3.16E+01	1.24E+05	No	X		X		
I-132	53	Iodine	2.295	hours	2.62E-04	2.65E+03	1.04E+07	No	X		X		
I-132m	53	Iodine	1.387	hours	1.58E-04	4.38E+03	1.71E+07	No		X			
I-133	53	Iodine	20.8	hours	2.37E-03	2.92E+02	1.13E+06	No	X		X		
I-134	53	Iodine	52.5	minutes	9.98E-05	6.94E+03	2.68E+07	No	X		X		
I-135	53	Iodine	6.57	hours	7.49E-04	9.25E+02	3.54E+06	No	X				
In-109	49	Indium	4.2	hours	4.79E-04	1.45E+03	6.85E+06	No		X			
In-110	49	Indium	4.9	hours	5.59E-04	1.24E+03	5.82E+06	No		X	X		
In-110m	49	Indium	69.1	minutes	1.31E-04	5.27E+03	2.48E+07	No		X			
In-111	49	Indium	2.8047	days	7.68E-03	9.02E+01	4.20E+05	No		X	X		
In-112	49	Indium	14.97	minutes	2.85E-05	2.43E+04	1.12E+08	No		X			
In-113m	49	Indium	99.476	minutes	1.89E-04	3.66E+03	1.67E+07	No		X			
In-114	49	Indium	71.9	seconds	2.28E-06	3.04E+05	1.38E+09	No		X	X		
In-114m	49	Indium	49.51	days	1.36E-01	5.11E+00	2.32E+04	No		X			
In-115	49	Indium	4.41E+14	years	4.41E+14	1.57E-15	7.06E-12	No	X		X		
In-115m	49	Indium	4.486	hours	5.12E-04	1.35E+03	6.08E+06	No		X			
In-116m	49	Indium	54.29	minutes	1.03E-04	6.71E+03	2.99E+07	No		X			
In-117	49	Indium	43.2	minutes	8.21E-05	8.44E+03	3.72E+07	No	X	X	X		
In-117m	49	Indium	116.2	minutes	2.21E-04	3.14E+03	1.38E+07	No	X	X	X		
In-119	49	Indium	2.4	minutes	4.56E-06	1.52E+05	6.59E+08	No	X	X	X		
In-119m	49	Indium	18.0	minutes	3.42E-05	2.02E+04	8.79E+07	No		X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Ir-182	77	Iridium	15	minutes	2.85E-05	2.43E+04	6.89E+07	No		X			
Ir-184	77	Iridium	3.09	hours	3.52E-04	1.97E+03	5.52E+06	No		X			
Ir-185	77	Iridium	14.4	hours	1.64E-03	4.22E+02	1.18E+06	No		X			
Ir-186	77	Iridium	16.64	hours	1.90E-03	3.65E+02	1.01E+06	No		X	X		
Ir-186m	77	Iridium	1.90	hours	2.17E-04	3.20E+03	8.88E+06	No		X			
Ir-187	77	Iridium	10.5	hours	1.20E-03	5.79E+02	1.60E+06	No		X			
Ir-188	77	Iridium	41.5	hours	4.73E-03	1.46E+02	4.02E+05	No		X	X		
Ir-189	77	Iridium	13.2	days	3.61E-02	1.92E+01	5.24E+04	No		X	X		
Ir-190	77	Iridium	11.78	days	3.23E-02	2.15E+01	5.84E+04	No		X	X		
Ir-190m	77	Iridium	1.120	hours	1.28E-04	5.42E+03	1.47E+07	No		X			
Ir-190n	77	Iridium	3.087	hours	3.52E-04	1.97E+03	5.35E+06	No		X			
Ir-191m	77	Iridium	4.94	seconds	1.57E-07	4.43E+06	1.20E+10	No		X			
Ir-192	77	Iridium	73.827	days	2.02E-01	3.43E+00	9.22E+03	Yes		X	X		
Ir-192m	77	Iridium	241	years	2.41E+02	2.88E-03	7.73E+00	No		X			
Ir-194	77	Iridium	19.28	hours	2.20E-03	3.15E+02	8.39E+05	Yes		X	X		
Ir-194m	77	Iridium	171	days	4.68E-01	1.48E+00	3.94E+03	No		X			
Ir-195	77	Iridium	2.5	hours	2.85E-04	2.43E+03	6.43E+06	No		X	X		
Ir-195m	77	Iridium	3.8	hours	4.33E-04	1.60E+03	4.23E+06	No		X			
K-38	19	Potassium	7.636	minutes	1.45E-05	4.77E+04	6.49E+08	No		X			
K-40	19	Potassium	1.248E+09	years	1.25E+09	5.55E-10	7.17E-06	No					X
K-42	19	Potassium	12	hours	1.41E-03	4.93E+02	6.06E+06	No		X	X		
K-43	19	Potassium	22.3	hours	2.54E-03	2.72E+02	3.27E+06	No		X			
K-44	19	Potassium	22.13	minutes	4.21E-05	1.65E+04	1.93E+08	No		X			
K-45	19	Potassium	17.3	minutes	3.29E-05	2.11E+04	2.42E+08	No		X			
Kr-74	36	Krypton	11.50	minutes	2.19E-05	3.17E+04	2.21E+08	No		X			
Kr-76	36	Krypton	14.8	hours	1.69E-03	4.10E+02	2.79E+06	No		X			
Kr-77	36	Krypton	74.4	minutes	1.41E-04	4.90E+03	3.28E+07	No		X			
Kr-79	36	Krypton	35.04	hours	4.00E-03	1.73E+02	1.13E+06	No		X	X		
Kr-81	36	Krypton	2.29E+05	years	2.29E+05	3.03E-06	1.93E-02	No		X	X		
Kr-81m	36	Krypton	13.10	seconds	4.15E-07	1.67E+06	1.06E+10	No		X			
Kr-83m	36	Krypton	1.83	hours	2.09E-04	3.32E+03	2.06E+07	No	X		X		
Kr-85	36	Krypton	3916.8	days	1.07E+01	6.46E-02	3.93E+02	No	X	X	X		
Kr-85m	36	Krypton	4.480	hours	5.11E-04	1.36E+03	8.24E+06	No	X	X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Kr-87	36	Krypton	76.3	minutes	1.45E-04	4.78E+03	2.83E+07	No	X	X			
Kr-88	36	Krypton	2.84	hours	3.24E-04	2.14E+03	1.25E+07	No	X				
La-131	57	Lanthanum	59	minutes	1.12E-04	6.18E+03	2.43E+07	No		X			
La-132	57	Lanthanum	4.8	hours	5.48E-04	1.27E+03	4.95E+06	No		X			
La-134	57	Lanthanum	6.45	minutes	1.23E-05	5.65E+04	2.18E+08	No		X	X		
La-135	57	Lanthanum	19.5	hours	2.22E-03	3.12E+02	1.19E+06	No		X	X		
La-137	57	Lanthanum	6E+04	years	6.00E+04	1.16E-05	4.35E-02	No		X	X		
La-138	57	Lanthanum	1.02E+11	years	1.02E+11	6.79E-12	2.54E-08	No					X
La-140	57	Lanthanum	1.6781	days	4.59E-03	1.51E+02	5.56E+05	No	X	X	X		
La-141	57	Lanthanum	3.92	hours	4.47E-04	1.55E+03	5.67E+06	No	X		X		
La-142	57	Lanthanum	91.1	minutes	1.73E-04	4.00E+03	1.45E+07	No	X		X		
La-143	57	Lanthanum	14.2	minutes	2.70E-05	2.57E+04	9.27E+07	No	X				
Lu-169	71	Lutetium	34.06	hours	3.89E-03	1.78E+02	5.45E+05	No		X			
Lu-170	71	Lutetium	2.012	days	5.51E-03	1.26E+02	3.82E+05	No		X	X		
Lu-171	71	Lutetium	8.24	days	2.26E-02	3.07E+01	9.27E+04	No		X			
Lu-172	71	Lutetium	6.70	days	1.83E-02	3.78E+01	1.13E+05	Yes		X	X		
Lu-173	71	Lutetium	1.37	years	1.37E+00	5.06E-01	1.51E+03	No		X	X		
Lu-174	71	Lutetium	3.31	years	3.31E+00	2.09E-01	6.21E+02	No		X	X		
Lu-174m	71	Lutetium	142	days	3.89E-01	1.78E+00	5.29E+03	No		X			
Lu-176	71	Lutetium	3.76E+10	years	3.76E+10	1.84E-11	5.41E-08	No					X
Lu-176m	71	Lutetium	3.664	hours	4.18E-04	1.66E+03	4.86E+06	No		X			
Lu-177	71	Lutetium	6.6475	days	1.82E-02	3.81E+01	1.11E+05	No		X	X		
Lu-177m	71	Lutetium	160.44	days	4.39E-01	1.58E+00	4.60E+03	No		X			
Lu-178	71	Lutetium	28.4	minutes	5.40E-05	1.28E+04	3.72E+07	No		X	X		
Lu-178m	71	Lutetium	23.1	minutes	4.39E-05	1.58E+04	4.58E+07	No		X			
Lu-179	71	Lutetium	4.59	hours	5.24E-04	1.32E+03	3.82E+06	No		X			
Md-257	101	Mendelevium	5.52	hours	6.30E-04	1.10E+03	2.21E+06	No		X		X	
Md-258	101	Mendelevium	51.5	days	1.41E-01	4.91E+00	9.84E+03	No		X		X	
Mg-28	12	Magnesium	20.915	hours	2.39E-03	2.90E+02	5.36E+06	No		X			
Mn-51	25	Manganese	46.2	minutes	8.78E-05	7.89E+03	7.99E+07	No		X			
Mn-52	25	Manganese	5.591	days	1.53E-02	4.53E+01	4.50E+05	No		X	X		
Mn-52m	25	Manganese	21.1	minutes	4.01E-05	1.73E+04	1.72E+08	No		X			
Mn-53	25	Manganese	3.74E+06	years	3.74E+06	1.85E-07	1.81E-03	No		X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Mn-54	25	Manganese	312.12	days	8.55E-01	8.11E-01	7.75E+03	No		X			
Mn-56	25	Manganese	2.5789	hours	2.94E-04	2.36E+03	2.17E+07	No		X			
Mo-101	42	Molybdenum	14.61	minutes	2.78E-05	2.49E+04	1.28E+08	No	X	X			
Mo-90	42	Molybdenum	5.56	hours	6.34E-04	1.09E+03	6.27E+06	No		X			
Mo-93	42	Molybdenum	4.0E+03	years	4.00E+03	1.73E-04	9.62E-01	No		X	X		
Mo-93m	42	Molybdenum	6.85	hours	7.81E-04	8.87E+02	4.92E+06	No		X			
Mo-99	42	Molybdenum	2.7489	days	7.53E-03	9.21E+01	4.80E+05	No	X	X			
N-13	7	Nitrogen	9.965	minutes	1.89E-05	3.66E+04	1.45E+09	No		X			
Na-22	11	Sodium	2.6027	years	2.60E+00	2.66E-01	6.25E+03	No		X			
Na-24	11	Sodium	14.951	hours	1.71E-03	4.06E+02	8.74E+06	No		X			
Nb-88	41	Niobium	14.55	minutes	2.77E-05	2.51E+04	1.47E+08	No		X			
Nb-89a	41	Niobium	66	minutes	1.25E-04	5.52E+03	3.20E+07	No		X			
Nb-89b	41	Niobium	2.03	hours	2.32E-04	2.99E+03	1.74E+07	No		X			
Nb-90	41	Niobium	14.60	hours	1.67E-03	4.16E+02	2.39E+06	No		X	X		
Nb-92	41	Niobium	3.47E+07	years	3.47E+07	2.00E-08	1.12E-04	No		X			
Nb-93m	41	Niobium	16.13	years	1.61E+01	4.30E-02	2.39E+02	Yes	X	X	X		
Nb-94	41	Niobium	2.03E+04	years	2.03E+04	3.41E-05	1.88E-01	No		X			
Nb-95	41	Niobium	34.991	days	9.58E-02	7.23E+00	3.93E+04	No	X		X		
Nb-95m	41	Niobium	3.61	days	9.88E-03	7.01E+01	3.81E+05	No		X			
Nb-96	41	Niobium	23.35	hours	2.66E-03	2.60E+02	1.40E+06	No		X			
Nb-97	41	Niobium	72.1	minutes	1.37E-04	5.06E+03	2.69E+07	No	X		X		
Nb-97m	41	Niobium	58.7	seconds	1.86E-06	3.73E+05	1.98E+09	No	X		X		
Nb-98	41	Niobium	51.3	minutes	9.75E-05	7.11E+03	3.74E+07	No	X				
Nd-136	60	Neodymium	50.65	minutes	9.63E-05	7.20E+03	2.73E+07	No		X			
Nd-138	60	Neodymium	5.04	hours	5.75E-04	1.21E+03	4.51E+06	No		X			
Nd-139	60	Neodymium	29.7	minutes	5.65E-05	1.23E+04	4.56E+07	No			X		
Nd-139m	60	Neodymium	5.50	hours	6.27E-04	1.10E+03	4.10E+06	No		X			
Nd-141	60	Neodymium	2.49	hours	2.84E-04	2.44E+03	8.93E+06	No		X	X		
Nd-141m	60	Neodymium	62.0	seconds	1.96E-06	3.53E+05	1.29E+09	No		X			
Nd-144	60	Neodymium	2.29E+15	years	2.29E+15	3.03E-16	1.09E-12	Yes	X		X		
Nd-147	60	Neodymium	10.98	days	3.01E-02	2.31E+01	8.10E+04	No	X	X	X		
Nd-149	60	Neodymium	1.728	hours	1.97E-04	3.52E+03	1.22E+07	No		X			
Nd-151	60	Neodymium	12.44	minutes	2.37E-05	2.93E+04	1.00E+08	No		X			

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Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Ne-19	10	Neon	17.22	seconds	5.46E-07	1.27E+06	3.45E+10	No		X			
Ni-56	28	Nickel	6.075	days	1.66E-02	4.17E+01	3.84E+05	No		X			
Ni-57	28	Nickel	35.60	hours	4.06E-03	1.71E+02	1.55E+06	No		X			
Ni-59	28	Nickel	7.6E+04	years	7.60E+04	9.12E-06	7.98E-02	No		X			
Ni-63	28	Nickel	100.1	years	1.00E+02	6.92E-03	5.67E+01	No		X			
Ni-65	28	Nickel	2.5172	hours	2.87E-04	2.41E+03	1.92E+07	No		X			
Ni-66	28	Nickel	54.6	hours	6.23E-03	1.11E+02	8.70E+05	No		X			
Np-232	93	Neptunium	14.7	minutes	2.79E-05	2.48E+04	5.52E+07	No		X		X	
Np-233	93	Neptunium	36.2	minutes	6.88E-05	1.01E+04	2.23E+07	No		X		X	
Np-234	93	Neptunium	4.4	days	1.20E-02	5.75E+01	1.27E+05	No		X	X	X	
Np-235	93	Neptunium	396.1	days	1.08E+00	6.39E-01	1.40E+03	No		X	X	X	
Np-236	93	Neptunium	1.54E+05	years	1.54E+05	4.50E-06	9.84E-03	No		X		X	
Np-236m	93	Neptunium	22.5	hours	2.57E-03	2.70E+02	5.91E+05	No		X		X	
Np-237	93	Neptunium	2.144E+06	years	2.14E+06	3.23E-07	7.04E-04	Yes		X	X	X	
Np-238	93	Neptunium	2.117	days	5.80E-03	1.20E+02	2.59E+05	No		X		X	
Np-239	93	Neptunium	2.356	days	6.45E-03	1.07E+02	2.32E+05	Yes		X	X	X	
Np-240	93	Neptunium	61.9	minutes	1.18E-04	5.89E+03	1.27E+07	Yes		X	X	X	
Np-240m	93	Neptunium	7.22	minutes	1.37E-05	5.05E+04	1.09E+08	No		X		X	
O-15	8	Oxygen	122.24	seconds	3.87E-06	1.79E+05	6.16E+09	No		X			
Os-180	76	Osmium	21.5	minutes	4.09E-05	1.70E+04	4.86E+07	No		X			
Os-181	76	Osmium	105	minutes	2.00E-04	3.47E+03	9.90E+06	No		X			
Os-182	76	Osmium	22.10	hours	2.52E-03	2.75E+02	7.80E+05	No		X	X		
Os-185	76	Osmium	93.6	days	2.56E-01	2.70E+00	7.55E+03	No		X	X		
Os-186	76	Osmium	2E+15	years	2.00E+15	3.47E-16	9.62E-13	Yes			X		X
Os-189m	76	Osmium	5.81	hours	6.63E-04	1.05E+03	2.86E+06	No		X			
Os-190m	76	Osmium	9.9	minutes	1.88E-05	3.68E+04	1.00E+08	No		X			
Os-191	76	Osmium	15.4	days	4.22E-02	1.64E+01	4.44E+04	No			X		
Os-191m	76	Osmium	13.10	hours	1.49E-03	4.64E+02	1.25E+06	No		X			
Os-193	76	Osmium	30.11	hours	3.43E-03	2.02E+02	5.40E+05	No		X			
Os-194	76	Osmium	6.0	years	6.00E+00	1.16E-01	3.07E+02	No		X			
P-30	15	Phosphorus	2.498	minutes	4.75E-06	1.46E+05	2.51E+09	No		X			
P-32	15	Phosphorus	14.262	days	3.90E-02	1.77E+01	2.86E+05	Yes		X	X		
P-33	15	Phosphorus	25.34	days	6.94E-02	9.99E+00	1.56E+05	No		X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Pa-227	91	Protactinium	38.3	minutes	7.28E-05	9.52E+03	2.16E+07	No		X		X	
Pa-228	91	Protactinium	22	hours	2.51E-03	2.76E+02	6.25E+05	No		X		X	
Pa-230	91	Protactinium	17.4	days	4.76E-02	1.45E+01	3.27E+04	No		X		X	
Pa-231	91	Protactinium	3.276E+04	years	3.28E+04	2.12E-05	4.73E-02	Yes			X	X	
Pa-232	91	Protactinium	1.31	days	3.59E-03	1.93E+02	4.30E+05	No		X		X	
Pa-233	91	Protactinium	26.975	days	7.39E-02	9.38E+00	2.08E+04	Yes		X	X	X	
Pa-234	91	Protactinium	6.70	hours	7.64E-04	9.07E+02	2.00E+06	Yes			X	X	
Pa-234m	91	Protactinium	1.17	minutes	2.22E-06	3.12E+05	6.87E+08	No		X		X	
Pb-195m	82	Lead	15.0	minutes	2.85E-05	2.43E+04	6.43E+07	No		X			
Pb-198	82	Lead	2.40	hours	2.74E-04	2.53E+03	6.60E+06	No		X			
Pb-199	82	Lead	90	minutes	1.71E-04	4.05E+03	1.05E+07	No		X			
Pb-200	82	Lead	21.5	hours	2.45E-03	2.83E+02	7.29E+05	No		X	X		
Pb-201	82	Lead	9.33	hours	1.06E-03	6.51E+02	1.67E+06	No		X	X		
Pb-202	82	Lead	5.25E+04	years	5.25E+04	1.32E-05	3.37E-02	No		X	X		
Pb-202m	82	Lead	3.53	hours	4.03E-04	1.72E+03	4.40E+06	No		X			
Pb-203	82	Lead	51.920	hours	5.92E-03	1.17E+02	2.98E+05	No		X	X		
Pb-204	82	Lead	1.4E+17	years	1.40E+17	4.95E-18	1.25E-14	No					X
Pb-205	82	Lead	1.73E+07	years	1.73E+07	4.01E-08	1.01E-04	Yes		X	X		
Pb-209	82	Lead	3.253	hours	3.71E-04	1.87E+03	4.61E+06	Yes		X	X		
Pb-210	82	Lead	22.20	years	2.22E+01	3.12E-02	7.67E+01	Yes			X		
Pb-211	82	Lead	36.1	minutes	6.86E-05	1.01E+04	2.47E+07	Yes			X		
Pb-212	82	Lead	10.64	hours	1.21E-03	5.71E+02	1.39E+06	Yes			X		
Pb-214	82	Lead	26.8	minutes	5.10E-05	1.36E+04	3.28E+07	Yes			X		
Pd-100	46	Palladium	3.63	days	9.94E-03	6.97E+01	3.60E+05	No		X			
Pd-101	46	Palladium	8.47	hours	9.66E-04	7.17E+02	3.67E+06	No		X			
Pd-103	46	Palladium	16.991	days	4.65E-02	1.49E+01	7.47E+04	No		X	X		
Pd-107	46	Palladium	6.5E+06	years	6.50E+06	1.07E-07	5.14E-04	No	X		X		
Pd-109	46	Palladium	13.7012	hours	1.56E-03	4.43E+02	2.10E+06	No	X	X			
Pm-141	61	Promethium	20.90	minutes	3.97E-05	1.74E+04	6.39E+07	No		X	X		
Pm-142	61	Promethium	40.5	seconds	1.28E-06	5.40E+05	1.96E+09	No			X		
Pm-143	61	Promethium	265	days	7.26E-01	9.55E-01	3.45E+03	No		X			
Pm-144	61	Promethium	363	days	9.94E-01	6.97E-01	2.50E+03	No		X			
Pm-145	61	Promethium	17.7	years	1.77E+01	3.92E-02	1.39E+02	No		X	X		

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Pm-146	61	Promethium	5.53	years	5.53E+00	1.25E-01	4.43E+02	No		X			
Pm-147	61	Promethium	2.6234	years	2.62E+00	2.64E-01	9.28E+02	No	X	X	X		
Pm-148	61	Promethium	5.368	days	1.47E-02	4.72E+01	1.64E+05	No		X	X		
Pm-148m	61	Promethium	41.29	days	1.13E-01	6.13E+00	2.14E+04	No		X			
Pm-149	61	Promethium	53.08	hours	6.06E-03	1.14E+02	3.97E+05	No	X	X	X		
Pm-150	61	Promethium	2.68	hours	3.06E-04	2.27E+03	7.80E+06	No		X			
Pm-151	61	Promethium	28.40	hours	3.24E-03	2.14E+02	7.31E+05	No	X	X	X		
Po-203	84	Polonium	36.7	minutes	6.98E-05	9.93E+03	2.53E+07	No		X			
Po-205	84	Polonium	1.74	hours	1.98E-04	3.49E+03	8.79E+06	No		X			
Po-207	84	Polonium	5.80	hours	6.62E-04	1.05E+03	2.61E+06	No		X	X		
Po-209	84	Polonium	102.00	years	1.02E+02	6.79E-03	1.68E+01	No		X			
Po-210	84	Polonium	138.376	days	3.79E-01	1.83E+00	4.50E+03	Yes		X	X		
Po-211	84	Polonium	0.516	seconds	1.64E-08	4.24E+07	1.04E+11	Yes			X		
Po-212	84	Polonium	3.00E-07	seconds	9.51E-15	7.29E+13	1.78E+17	Yes			X		
Po-212m	84	Polonium	2.98E-07	seconds	9.44E-15	7.34E+13	1.79E+17	No		X			
Po-213	84	Polonium	3.65E-06	seconds	1.16E-13	5.99E+12	1.45E+16	Yes			X		
Po-214	84	Polonium	1.643E-04	seconds	5.21E-12	1.33E+11	3.21E+14	Yes			X		
Po-215	84	Polonium	1.781E-03	seconds	5.64E-11	1.23E+10	2.95E+13	Yes		X	X		
Po-216	84	Polonium	0.145	seconds	4.59E-09	1.51E+08	3.61E+11	Yes			X		
Po-218	84	Polonium	3.10	minutes	5.89E-06	1.18E+05	2.78E+08	Yes			X		
Pr-136	59	Praseodymium	13.1	minutes	2.49E-05	2.78E+04	1.06E+08	No		X	X		
Pr-137	59	Praseodymium	1.28	hours	1.46E-04	4.75E+03	1.79E+07	No		X			
Pr-138	59	Praseodymium	1.45	minutes	2.76E-06	2.51E+05	9.40E+08	No			X		
Pr-138m	59	Praseodymium	2.12	hours	2.42E-04	2.87E+03	1.07E+07	No		X			
Pr-139	59	Praseodymium	4.41	hours	5.03E-04	1.38E+03	5.12E+06	No		X	X		
Pr-142	59	Praseodymium	19.12	hours	2.18E-03	3.18E+02	1.16E+06	No		X	X		
Pr-142m	59	Praseodymium	14.6	minutes	2.78E-05	2.50E+04	9.08E+07	No		X			
Pr-143	59	Praseodymium	13.57	days	3.72E-02	1.87E+01	6.73E+04	No	X	X	X		
Pr-144	59	Praseodymium	17.28	minutes	3.29E-05	2.11E+04	7.56E+07	No	X		X		
Pr-144m	59	Praseodymium	7.2	minutes	1.37E-05	5.06E+04	1.82E+08	No	X		X		
Pr-145	59	Praseodymium	5.984	hours	6.83E-04	1.02E+03	3.61E+06	No	X				
Pr-147	59	Praseodymium	13.4	minutes	2.55E-05	2.72E+04	9.55E+07	No	X	X			
Pt-186	78	Platinum	2.08	hours	2.37E-04	2.92E+03	8.11E+06	No		X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Pt-188	78	Platinum	10.2	days	2.79E-02	2.48E+01	6.82E+04	No		X			
Pt-189	78	Platinum	10.87	hours	1.24E-03	5.59E+02	1.53E+06	No		X			
Pt-191	78	Platinum	2.862	days	7.84E-03	8.84E+01	2.39E+05	No		X			
Pt-193	78	Platinum	50	years	5.00E+01	1.39E-02	3.71E+01	No		X	X		
Pt-193m	78	Platinum	4.33	days	1.19E-02	5.85E+01	1.56E+05	No		X			
Pt-195m	78	Platinum	4.010	days	1.10E-02	6.31E+01	1.67E+05	No		X			
Pt-197	78	Platinum	19.8915	hours	2.27E-03	3.05E+02	8.00E+05	No		X	X		
Pt-197m	78	Platinum	95.41	minutes	1.81E-04	3.82E+03	1.00E+07	No		X			
Pt-199	78	Platinum	30.80	minutes	5.86E-05	1.18E+04	3.07E+07	No		X			
Pt-200	78	Platinum	12.5	hours	1.43E-03	4.86E+02	1.25E+06	No		X			
Pu-234	94	Plutonium	8.8	hours	1.00E-03	6.90E+02	1.52E+06	No		X	X	X	
Pu-235	94	Plutonium	25.3	minutes	4.81E-05	1.44E+04	3.17E+07	No		X		X	
Pu-236	94	Plutonium	2.858	years	2.86E+00	2.42E-01	5.30E+02	Yes		X	X	X	
Pu-237	94	Plutonium	45.2	days	1.24E-01	5.60E+00	1.22E+04	No		X	X	X	
Pu-238	94	Plutonium	87.7	years	8.77E+01	7.90E-03	1.71E+01	No			X	X	
Pu-239	94	Plutonium	24,110	years	2.41E+04	2.87E-05	6.21E-02	No		X	X	X	
Pu-240	94	Plutonium	6,561	years	6.56E+03	1.06E-04	2.27E-01	Yes		X	X	X	
Pu-241 (Neptunium Series)	94	Plutonium	14.290	years	1.43E+01	4.85E-02	1.04E+02	Yes		X	X	X	
Pu-242	94	Plutonium	3.75E+05	years	3.75E+05	1.85E-06	3.94E-03	Yes		X	X	X	
Pu-243	94	Plutonium	4.956	hours	5.65E-04	1.23E+03	2.60E+06	Yes		X	X	X	
Pu-244	94	Plutonium	8.00E+07	years	8.00E+07	8.66E-09	1.83E-05	Yes		X	X	X	
Pu-245	94	Plutonium	10.5	hours	1.20E-03	5.79E+02	1.22E+06	No		X		X	
Pu-246	94	Plutonium	10.84	days	2.97E-02	2.34E+01	4.90E+04	Yes		X	X	X	
Ra-222	88	Radium	38.0	seconds	1.20E-06	5.76E+05	1.34E+09	No			X		
Ra-223	88	Radium	11.430	days	3.13E-02	2.21E+01	5.13E+04	Yes			X		
Ra-224	88	Radium	3.63	days	9.94E-03	6.97E+01	1.61E+05	Yes			X		
Ra-225	88	Radium	14.9	days	4.08E-02	1.70E+01	3.90E+04	Yes			X		
Ra-226	88	Radium	1,600	years	1.60E+03	4.33E-04	9.89E-01	Yes			X		
Ra-227	88	Radium	42.2	minutes	8.02E-05	8.64E+03	1.96E+07	No		X			
Ra-228	88	Radium	5.75	years	5.75E+00	1.21E-01	2.73E+02	Yes			X		
Rb-79	37	Rubidium	22.9	minutes	4.35E-05	1.59E+04	1.04E+08	No		X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Rb-80	37	Rubidium	33.4	seconds	1.06E-06	6.55E+05	4.23E+09	No			X		
Rb-81	37	Rubidium	4.570	hours	5.21E-04	1.33E+03	8.47E+06	No			X		
Rb-81m	37	Rubidium	30.5	minutes	5.80E-05	1.20E+04	7.62E+07	No		X			
Rb-82	37	Rubidium	1.273	minutes	2.42E-06	2.86E+05	1.80E+09	No			X		
Rb-82m	37	Rubidium	6.472	hours	7.38E-04	9.39E+02	5.91E+06	No		X			
Rb-83	37	Rubidium	86.2	days	2.36E-01	2.94E+00	1.83E+04	No		X	X		
Rb-84	37	Rubidium	33.1	days	9.06E-02	7.65E+00	4.70E+04	No		X			
Rb-86	37	Rubidium	18.642	days	5.10E-02	1.36E+01	8.15E+04	No		X			
Rb-87	37	Rubidium	4.97E+10	years	4.97E+10	1.39E-11	8.27E-08	No	X		X		
Rb-88	37	Rubidium	17.773	minutes	3.38E-05	2.05E+04	1.20E+08	No	X	X	X		
Rb-89	37	Rubidium	15.15	minutes	2.88E-05	2.41E+04	1.40E+08	No	X				
Re-177	75	Rhenium	14	minutes	2.66E-05	2.60E+04	7.59E+07	No		X			
Re-178	75	Rhenium	13.2	minutes	2.51E-05	2.76E+04	8.01E+07	No		X			
Re-180	75	Rhenium	2.44	minutes	4.64E-06	1.49E+05	4.28E+08	No		X	X		
Re-181	75	Rhenium	19.9	hours	2.27E-03	3.05E+02	8.71E+05	No		X	X		
Re-182	75	Rhenium	64.0	hours	7.30E-03	9.49E+01	2.69E+05	No		X	X		
Re-182m	75	Rhenium	12.7	hours	1.45E-03	4.78E+02	1.36E+06	No		X			
Re-184	75	Rhenium	38.0	days	1.04E-01	6.66E+00	1.87E+04	No		X	X		
Re-184m	75	Rhenium	169	days	4.63E-01	1.50E+00	4.20E+03	No		X			
Re-186	75	Rhenium	3.7186	days	1.02E-02	6.81E+01	1.89E+05	Yes		X	X		
Re-186m	75	Rhenium	2.0E+05	years	2.00E+05	3.47E-06	9.62E-03	No		X			
Re-187	75	Rhenium	4.12E+10	years	4.12E+10	1.68E-11	4.64E-08	No			X		X
Re-188	75	Rhenium	17.003	hours	1.94E-03	3.57E+02	9.81E+05	No		X	X		
Re-188m	75	Rhenium	18.59	minutes	3.53E-05	1.96E+04	5.38E+07	No		X			
Re-189	75	Rhenium	24.3	hours	2.77E-03	2.50E+02	6.83E+05	No		X			
Rh-100	45	Rhodium	20.8	hours	2.37E-03	2.92E+02	1.51E+06	No		X	X		
Rh-101	45	Rhodium	3.3	years	3.30E+00	2.10E-01	1.07E+03	No		X	X		
Rh-101m	45	Rhodium	4.34	days	1.19E-02	5.83E+01	2.98E+05	No		X			
Rh-102	45	Rhodium	208	days	5.69E-01	1.22E+00	6.16E+03	Yes		X	X		
Rh-102m	45	Rhodium	2.9	years	2.90E+00	2.39E-01	1.21E+03	No		X			
Rh-103m	45	Rhodium	56.114	minutes	1.07E-04	6.50E+03	3.26E+07	No	X		X		
Rh-105	45	Rhodium	35.36	hours	4.03E-03	1.72E+02	8.45E+05	No	X	X	X		
Rh-105m	45	Rhodium	56.00	minutes	1.06E-04	6.51E+03	3.20E+07	No	X		X		

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Rh-106	45	Rhodium	29.80	seconds	9.44E-07	7.34E+05	3.57E+09	No	X		X		
Rh-106m	45	Rhodium	131	minutes	2.49E-04	2.78E+03	1.36E+07	No		X			
Rh-107	45	Rhodium	21.7	minutes	4.13E-05	1.68E+04	8.10E+07	No	X	X			
Rh-99	45	Rhodium	16.1	days	4.41E-02	1.57E+01	8.20E+04	No		X			
Rh-99m	45	Rhodium	4.7	hours	5.36E-04	1.29E+03	6.74E+06	No		X			
Rn-218	86	Radon	0.035	seconds	1.11E-09	6.25E+08	1.48E+12	No			X		
Rn-219	86	Radon	3.96	seconds	1.25E-07	5.52E+06	1.30E+10	Yes			X		
Rn-220	86	Radon	55.6	seconds	1.76E-06	3.93E+05	9.23E+08	Yes			X		
Rn-222	86	Radon	3.8235	days	1.05E-02	6.62E+01	1.54E+05	Yes			X		
Ru-103	44	Ruthenium	39.26	days	1.07E-01	6.45E+00	3.23E+04	No	X	X			
Ru-105	44	Ruthenium	4.44	hours	5.07E-04	1.37E+03	6.73E+06	No	X	X			
Ru-106	44	Ruthenium	373.59	days	1.02E+00	6.78E-01	3.30E+03	No	X				
Ru-94	44	Ruthenium	51.8	minutes	9.85E-05	7.04E+03	3.86E+07	No		X			
Ru-97	44	Ruthenium	2.791	days	7.64E-03	9.07E+01	4.83E+05	No		X			
S-35	16	Sulphur	87.51	days	2.40E-01	2.89E+00	4.27E+04	No		X			
Sb-115	51	Antimony	32.1	minutes	6.10E-05	1.14E+04	5.10E+07	No		X			
Sb-116	51	Antimony	15.8	minutes	3.00E-05	2.31E+04	1.03E+08	No		X	X		
Sb-116m	51	Antimony	60.3	minutes	1.15E-04	6.04E+03	2.69E+07	No		X			
Sb-117	51	Antimony	2.80	hours	3.19E-04	2.17E+03	9.57E+06	No		X			
Sb-118m	51	Antimony	5.00	hours	5.70E-04	1.21E+03	5.32E+06	No		X			
Sb-119	51	Antimony	38.19	hours	4.36E-03	1.59E+02	6.90E+05	No		X			
Sb-120	51	Antimony	15.89	minutes	3.02E-05	2.29E+04	9.87E+07	No		X			
Sb-120m	51	Antimony	5.76	days	1.58E-02	4.39E+01	1.89E+05	No		X			
Sb-122	51	Antimony	2.7238	days	7.46E-03	9.29E+01	3.93E+05	No		X			
Sb-124	51	Antimony	60.11	days	1.65E-01	4.21E+00	1.75E+04	No		X	X		
Sb-124m	51	Antimony	93	seconds	2.95E-06	2.35E+05	9.79E+08	No		X			
Sb-124n	51	Antimony	20.2	minutes	3.84E-05	1.80E+04	7.51E+07	No		X			
Sb-125	51	Antimony	2.75856	years	2.76E+00	2.51E-01	1.04E+03	No	X	X	X		
Sb-126	51	Antimony	12.35	days	3.38E-02	2.05E+01	8.40E+04	Yes	X		X		
Sb-126m	51	Antimony	19.15	minutes	3.64E-05	1.90E+04	7.80E+07	Yes	X	X	X		
Sb-127	51	Antimony	3.85	days	1.05E-02	6.57E+01	2.67E+05	No	X		X		
Sb-128	51	Antimony	9.01	hours	1.03E-03	6.74E+02	2.72E+06	No		X	X		
Sb-128m	51	Antimony	10.4	minutes	1.98E-05	3.50E+04	1.41E+08	No	X	X	X		

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Sb-129	51	Antimony	4.40	hours	5.02E-04	1.38E+03	5.53E+06	No	X				
Sb-130	51	Antimony	39.5	minutes	7.51E-05	9.23E+03	3.66E+07	No	X	X			
Sb-131	51	Antimony	23.03	minutes	4.38E-05	1.58E+04	6.24E+07	No	X				
Sc-43	21	Scandium	3.891	hours	4.44E-04	1.56E+03	1.87E+07	No		X			
Sc-44	21	Scandium	3.97	hours	4.53E-04	1.53E+03	1.80E+07	Yes		X	X		
Sc-44m	21	Scandium	58.61	hours	6.69E-03	1.04E+02	1.22E+06	No		X			
Sc-46	21	Scandium	83.79	days	2.29E-01	3.02E+00	3.39E+04	No		X			
Sc-47	21	Scandium	3.3492	days	9.17E-03	7.56E+01	8.30E+05	No			X		
Sc-48	21	Scandium	43.67	hours	4.98E-03	1.39E+02	1.50E+06	No		X			
Sc-49	21	Scandium	57.2	minutes	1.09E-04	6.37E+03	6.71E+07	No		X	X		
Se-70	34	Selenium	41.1	minutes	7.81E-05	8.87E+03	6.54E+07	No		X			
Se-73	34	Selenium	7.15	hours	8.16E-04	8.50E+02	6.01E+06	No		X	X		
Se-73m	34	Selenium	39.8	minutes	7.57E-05	9.16E+03	6.48E+07	No		X			
Se-75	34	Selenium	119.779	days	3.28E-01	2.11E+00	1.45E+04	No		X	X		
Se-77m	34	Selenium	17.36	seconds	5.50E-07	1.26E+06	8.45E+09	No		X			
Se-79	34	Selenium	2.95E+05	years	2.95E+05	2.35E-06	1.54E-02	No	X		X		
Se-79m	34	Selenium	3.9	minutes	7.42E-06	9.35E+04	6.11E+08	No	X	X	X		
Se-81	34	Selenium	18.45	minutes	3.51E-05	1.98E+04	1.26E+08	No	X	X	X		
Se-81m	34	Selenium	57.28	minutes	1.09E-04	6.36E+03	4.06E+07	No	X	X			
Se-83	34	Selenium	22.3	minutes	4.24E-05	1.63E+04	1.02E+08	No	X	X			
Si-31	14	Silicon	157.3	minutes	2.99E-04	2.32E+03	3.86E+07	No		X			
Si-32	14	Silicon	132	years	1.32E+02	5.25E-03	8.47E+01	No		X			
Sm-141	62	Samarium	10.2	minutes	1.94E-05	3.57E+04	1.31E+08	No		X			
Sm-141m	62	Samarium	22.6	minutes	4.30E-05	1.61E+04	5.91E+07	No		X			
Sm-142	62	Samarium	72.49	minutes	1.38E-04	5.03E+03	1.83E+07	No		X			
Sm-145	62	Samarium	340	days	9.31E-01	7.44E-01	2.65E+03	No		X	X		
Sm-146	62	Samarium	1.03E+08	years	1.03E+08	6.73E-09	2.38E-05	Yes		X	X		
Sm-147	62	Samarium	1.06E+11	years	1.06E+11	6.54E-12	2.30E-08	Yes	X		X		
Sm-148	62	Samarium	7E+15	years	7.00E+15	9.90E-17	3.45E-13	Yes			X		X
Sm-149	62	Samarium	2E+15	years	2.00E+15	3.47E-16	1.20E-12	No	X		X		
Sm-151	62	Samarium	90	years	9.00E+01	7.70E-03	2.63E+01	No	X		X		
Sm-153	62	Samarium	46.284	hours	5.28E-03	1.31E+02	4.43E+05	No	X	X			
Sm-155	62	Samarium	22.3	minutes	4.24E-05	1.63E+04	5.44E+07	No	X	X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Sm-156	62	Samarium	9.4	hours	1.07E-03	6.46E+02	2.14E+06	No	X				
Sn-110	50	Tin	4.11	hours	4.69E-04	1.48E+03	6.94E+06	No		X			
Sn-111	50	Tin	35.3	minutes	6.71E-05	1.03E+04	4.80E+07	No		X			
Sn-113	50	Tin	115.09	days	3.15E-01	2.20E+00	1.00E+04	No		X			
Sn-117m	50	Tin	13.76	days	3.77E-02	1.84E+01	8.12E+04	No		X			
Sn-119m	50	Tin	293.1	days	8.02E-01	8.64E-01	3.75E+03	No		X			
Sn-121	50	Tin	27.03	hours	3.08E-03	2.25E+02	9.59E+05	Yes	X	X	X		
Sn-121m	50	Tin	43.9	years	4.39E+01	1.58E-02	6.74E+01	No	X	X			
Sn-123	50	Tin	129.2	days	3.54E-01	1.96E+00	8.22E+03	No	X	X			
Sn-123m	50	Tin	40.06	minutes	7.62E-05	9.10E+03	3.82E+07	No	X	X			
Sn-125	50	Tin	9.64	days	2.64E-02	2.63E+01	1.08E+05	No	X	X			
Sn-126	50	Tin	2.3E+05	years	2.30E+05	3.01E-06	1.23E-02	No	X				
Sn-127	50	Tin	2.10	hours	2.40E-04	2.89E+03	1.18E+07	No	X	X			
Sn-128	50	Tin	59.07	minutes	1.12E-04	6.17E+03	2.49E+07	No	X				
Sr-80	38	Strontium	106.3	minutes	2.02E-04	3.43E+03	2.21E+07	No		X			
Sr-81	38	Strontium	22.3	minutes	4.24E-05	1.63E+04	1.04E+08	No		X			
Sr-82	38	Strontium	25.55	days	7.00E-02	9.91E+00	6.24E+04	No		X			
Sr-83	38	Strontium	32.41	hours	3.70E-03	1.87E+02	1.17E+06	No		X			
Sr-85	38	Strontium	64.84	days	1.78E-01	3.90E+00	2.37E+04	No		X	X		
Sr-85m	38	Strontium	67.63	minutes	1.29E-04	5.39E+03	3.27E+07	No		X			
Sr-87m	38	Strontium	2.815	hours	3.21E-04	2.16E+03	1.28E+07	No		X			
Sr-89	38	Strontium	50.57	days	1.38E-01	5.01E+00	2.90E+04	No	X	X	X		
Sr-90	38	Strontium	28.90	years	2.89E+01	2.40E-02	1.38E+02	No	X				
Sr-91	38	Strontium	9.63	hours	1.10E-03	6.31E+02	3.58E+06	No	X	X			
Sr-92	38	Strontium	2.66	hours	3.03E-04	2.28E+03	1.28E+07	No	X				
Ta-172	73	Tantalum	36.8	minutes	7.00E-05	9.90E+03	2.97E+07	No		X			
Ta-173	73	Tantalum	3.14	hours	3.58E-04	1.93E+03	5.77E+06	No		X			
Ta-174	73	Tantalum	1.14	hours	1.30E-04	5.33E+03	1.58E+07	No		X			
Ta-175	73	Tantalum	10.5	hours	1.20E-03	5.79E+02	1.71E+06	No		X			
Ta-176	73	Tantalum	8.09	hours	9.23E-04	7.51E+02	2.20E+06	No		X	X		
Ta-177	73	Tantalum	56.56	hours	6.45E-03	1.07E+02	3.13E+05	No		X	X		
Ta-178	73	Tantalum	9.31	minutes	1.77E-05	3.92E+04	1.14E+08	No			X		
Ta-178m	73	Tantalum	2.36	hours	2.69E-04	2.57E+03	7.47E+06	No		X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Ta-179	73	Tantalum	1.82	years	1.82E+00	3.81E-01	1.10E+03	No		X	X		
Ta-180	73	Tantalum	8.154	hours	9.30E-04	7.45E+02	2.14E+06	No		X			
Ta-180m	73	Tantalum	1.2E+15	years	1.20E+15	5.78E-16	1.66E-12	No					X
Ta-182	73	Tantalum	114.43	days	3.13E-01	2.21E+00	6.28E+03	Yes		X	X		
Ta-182m	73	Tantalum	15.84	minutes	3.01E-05	2.30E+04	6.53E+07	No		X			
Ta-183	73	Tantalum	5.1	days	1.40E-02	4.96E+01	1.40E+05	No		X	X		
Ta-184	73	Tantalum	8.7	hours	9.92E-04	6.98E+02	1.96E+06	No		X	X		
Ta-185	73	Tantalum	49.4	minutes	9.39E-05	7.38E+03	2.06E+07	No		X			
Ta-186	73	Tantalum	10.5	minutes	2.00E-05	3.47E+04	9.64E+07	No		X			
Tb-147	65	Terbium	1.7	hours	1.94E-04	3.57E+03	1.26E+07	No		X			
Tb-149	65	Terbium	4.118	hours	4.70E-04	1.48E+03	5.11E+06	No		X			
Tb-150	65	Terbium	3.48	hours	3.97E-04	1.75E+03	6.01E+06	No		X			
Tb-151	65	Terbium	17.609	hours	2.01E-03	3.45E+02	1.18E+06	No		X			
Tb-153	65	Terbium	2.34	days	6.41E-03	1.08E+02	3.65E+05	No		X			
Tb-154	65	Terbium	21.5	hours	2.45E-03	2.83E+02	9.47E+05	No		X			
Tb-155	65	Terbium	5.32	days	1.46E-02	4.76E+01	1.58E+05	No		X	X		
Tb-156	65	Terbium	5.35	days	1.46E-02	4.73E+01	1.57E+05	No		X	X		
Tb-156m	65	Terbium	24.4	hours	2.78E-03	2.49E+02	8.24E+05	No		X			
Tb-156n	65	Terbium	5.3	hours	6.05E-04	1.15E+03	3.79E+06	No		X			
Tb-157	65	Terbium	71	years	7.10E+01	9.76E-03	3.21E+01	No		X	X		
Tb-158	65	Terbium	180	years	1.80E+02	3.85E-03	1.26E+01	No		X			
Tb-160	65	Terbium	72.3	days	1.98E-01	3.50E+00	1.13E+04	No		X			
Tb-161	65	Terbium	6.906	days	1.89E-02	3.67E+01	1.18E+05	No	X	X			
Tc-101	43	Technetium	14.22	minutes	2.70E-05	2.56E+04	1.31E+08	No	X	X	X		
Tc-104	43	Technetium	18.3	minutes	3.48E-05	1.99E+04	9.89E+07	No	X	X			
Tc-93	43	Technetium	2.75	hours	3.14E-04	2.21E+03	1.23E+07	No		X	X		
Tc-93m	43	Technetium	43.5	minutes	8.27E-05	8.38E+03	4.65E+07	No		X			
Tc-94	43	Technetium	293	minutes	5.57E-04	1.24E+03	6.83E+06	No		X	X		
Tc-94m	43	Technetium	52.0	minutes	9.89E-05	7.01E+03	3.85E+07	No		X			
Tc-95	43	Technetium	20.0	hours	2.28E-03	3.04E+02	1.65E+06	No		X	X		
Tc-95m	43	Technetium	61	days	1.67E-01	4.15E+00	2.26E+04	No		X			
Tc-96	43	Technetium	4.28	days	1.17E-02	5.91E+01	3.18E+05	No		X	X		
Tc-96m	43	Technetium	51.5	minutes	9.79E-05	7.08E+03	3.81E+07	No		X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Tc-97	43	Technetium	4.21E+06	years	4.21E+06	1.65E-07	8.76E-04	No		X	X		
Tc-97m	43	Technetium	91.4	days	2.50E-01	2.77E+00	1.47E+04	No		X			
Tc-98	43	Technetium	4.2E+06	years	4.20E+06	1.65E-07	8.69E-04	No		X			
Tc-99	43	Technetium	2.111E+05	years	2.11E+05	3.28E-06	1.71E-02	No	X	X	X		
Tc-99m	43	Technetium	6.0058	hours	6.85E-04	1.01E+03	5.28E+06	No	X		X		
Te-116	52	Tellurium	2.49	hours	2.84E-04	2.44E+03	1.09E+07	No		X			
Te-118	52	Tellurium	6.00	days	1.64E-02	4.22E+01	1.85E+05	No		X			
Te-121	52	Tellurium	19.16	days	5.25E-02	1.32E+01	5.64E+04	No		X	X		
Te-121m	52	Tellurium	154	days	4.22E-01	1.64E+00	7.01E+03	No		X			
Te-123	52	Tellurium	9.2E+16	years	9.20E+16	7.53E-18	3.16E-14	No			X		X
Te-123m	52	Tellurium	119.2	days	3.26E-01	2.12E+00	8.91E+03	No		X			
Te-125m	52	Tellurium	57.40	days	1.57E-01	4.41E+00	1.82E+04	Yes	X	X	X		
Te-127	52	Tellurium	9.35	hours	1.07E-03	6.50E+02	2.64E+06	No	X	X	X		
Te-127m	52	Tellurium	109	days	2.98E-01	2.32E+00	9.44E+03	No	X	X	X		
Te-129	52	Tellurium	69.6	minutes	1.32E-04	5.24E+03	2.10E+07	No	X	X	X		
Te-129m	52	Tellurium	33.6	days	9.20E-02	7.53E+00	3.02E+04	No	X	X	X		
Te-131	52	Tellurium	25.0	minutes	4.75E-05	1.46E+04	5.75E+07	No	X	X	X		
Te-131m	52	Tellurium	30	hours	3.42E-03	2.02E+02	7.98E+05	No	X	X	X		
Te-132	52	Tellurium	3.204	days	8.77E-03	7.90E+01	3.11E+05	No	X				
Te-133	52	Tellurium	12.5	minutes	2.38E-05	2.92E+04	1.13E+08	No	X		X		
Te-133m	52	Tellurium	55.4	minutes	1.05E-04	6.58E+03	2.55E+07	No	X				
Te-134	52	Tellurium	41.8	minutes	7.95E-05	8.72E+03	3.36E+07	No	X				
Th-226	90	Thorium	30.57	minutes	5.81E-05	1.19E+04	2.72E+07	No			X	X	
Th-227	90	Thorium	18.68	days	5.11E-02	1.36E+01	3.08E+04	Yes		X	X	X	
Th-228	90	Thorium	1.9116	years	1.91E+00	3.63E-01	8.21E+02	Yes		X	X	X	
Th-229	90	Thorium	7,340	years	7.34E+03	9.44E-05	2.13E-01	Yes			X	X	
Th-230	90	Thorium	7.538E+04	years	7.54E+04	9.19E-06	2.06E-02	Yes			X	X	
Th-231	90	Thorium	25.52	hours	2.91E-03	2.38E+02	5.32E+05	Yes		X	X	X	
Th-232 (Thorium Series)	90	Thorium	1.405E+10	years	1.41E+10	4.93E-11	1.10E-07	Yes			X	X	X
Th-234	90	Thorium	24.10	days	6.60E-02	1.05E+01	2.32E+04	Yes			X	X	
Ti-44	22	Titanium	60.0	years	6.00E+01	1.16E-02	1.36E+02	No		X			

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Ti-45	22	Titanium	184.8	minutes	3.51E-04	1.97E+03	2.26E+07	No		X			
Tl-194	81	Thallium	33.0	minutes	6.27E-05	1.10E+04	2.94E+07	No		X			
Tl-194m	81	Thallium	32.8	minutes	6.24E-05	1.11E+04	2.96E+07	No		X			
Tl-195	81	Thallium	1.16	hours	1.32E-04	5.24E+03	1.39E+07	No		X	X		
Tl-197	81	Thallium	2.84	hours	3.24E-04	2.14E+03	5.61E+06	No		X			
Tl-198	81	Thallium	5.3	hours	6.05E-04	1.15E+03	2.99E+06	No		X	X		
Tl-198m	81	Thallium	1.87	hours	2.13E-04	3.25E+03	8.47E+06	No		X			
Tl-199	81	Thallium	7.42	hours	8.46E-04	8.19E+02	2.12E+06	No		X	X		
Tl-200	81	Thallium	26.1	hours	2.98E-03	2.33E+02	6.01E+05	No		X	X		
Tl-201	81	Thallium	72.912	hours	8.32E-03	8.33E+01	2.14E+05	No		X	X		
Tl-202	81	Thallium	12.23	days	3.35E-02	2.07E+01	5.29E+04	Yes		X	X		
Tl-204	81	Thallium	3.78	years	3.78E+00	1.83E-01	4.64E+02	No		X			
Tl-206	81	Thallium	4.200	minutes	7.99E-06	8.68E+04	2.18E+08	Yes		X	X		
Tl-207	81	Thallium	4.77	minutes	9.07E-06	7.64E+04	1.91E+08	Yes			X		
Tl-208	81	Thallium	3.053	minutes	5.80E-06	1.19E+05	2.96E+08	Yes			X		
Tl-209	81	Thallium	2.161	minutes	4.11E-06	1.69E+05	4.17E+08	Yes			X		
Tl-210	81	Thallium	1.30	minutes	2.47E-06		6.89E+08	Yes			X		
Tm-162	69	Thulium	21.70	minutes	4.13E-05	1.68E+04	5.35E+07	No		X	X		
Tm-166	69	Thulium	7.70	hours	8.78E-04	7.89E+02	2.45E+06	No		X	X		
Tm-167	69	Thulium	9.25	days	2.53E-02	2.74E+01	8.46E+04	No		X	X		
Tm-170	69	Thulium	128.6	days	3.52E-01	1.97E+00	5.98E+03	No		X			
Tm-171	69	Thulium	1.92	years	1.92E+00	3.61E-01	1.09E+03	No		X	X		
Tm-172	69	Thulium	63.6	hours	7.26E-03	9.55E+01	2.87E+05	No			X		
Tm-173	69	Thulium	8.24	hours	9.40E-04	7.37E+02	2.20E+06	No		X			
Tm-175	69	Thulium	15.2	minutes	2.89E-05	2.40E+04	7.07E+07	No		X			
U-230	92	Uranium	20.8	days	5.69E-02	1.22E+01	2.73E+04	No			X	X	
U-231	92	Uranium	4.2	days	1.15E-02	6.03E+01	1.35E+05	No		X		X	
U-232	92	Uranium	68.9	years	6.89E+01	1.01E-02	2.24E+01	Yes		X	X	X	
U-233	92	Uranium	1.592E+05	years	1.59E+05	4.35E-06	9.65E-03	Yes		X	X	X	
U-234	92	Uranium	2.455E+05	years	2.46E+05	2.82E-06	6.23E-03	Yes			X	X	
U-235 (Actinium Series)	92	Uranium	7.04E+08	years	7.04E+08	9.84E-10	2.16E-06	Yes			X	X	X

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Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
U-236	92	Uranium	2.342E+07	years	2.34E+07	2.96E-08	6.47E-05	Yes		X	X	X	
U-237	92	Uranium	6.75	days	1.85E-02	3.75E+01	8.17E+04	No		X		X	
U-238 (Uranium Series)	92	Uranium	4.468E+09	years	4.47E+09	1.55E-10	3.36E-07	Yes		X	X	X	X
U-239	92	Uranium	23.45	minutes	4.46E-05	1.55E+04	3.36E+07	No		X		X	
U-240	92	Uranium	14.1	hours	1.61E-03	4.31E+02	9.27E+05	Yes		X	X	X	
V-47	23	Vanadium	32.6	minutes	6.20E-05	1.12E+04	1.23E+08	No		X			
V-48	23	Vanadium	15.9735	days	4.37E-02	1.58E+01	1.70E+05	No		X	X		
V-49	23	Vanadium	329	days	9.01E-01	7.69E-01	8.11E+03	No		X	X		
V-50	23	Vanadium	1.4E+17	years	1.40E+17	4.95E-18	5.11E-14	No					X
W-176	74	Tungsten	2.5	hours	2.85E-04	2.43E+03	7.13E+06	No		X			
W-177	74	Tungsten	132	minutes	2.51E-04	2.76E+03	8.05E+06	No		X	X		
W-178	74	Tungsten	21.6	days	5.91E-02	1.17E+01	3.40E+04	No		X	X		
W-179	74	Tungsten	37.05	minutes	7.04E-05	9.84E+03	2.84E+07	No		X			
W-181	74	Tungsten	121.20	days	3.32E-01	2.09E+00	5.96E+03	No		X	X		
W-185	74	Tungsten	75.1	days	2.06E-01	3.37E+00	9.41E+03	No		X	X		
W-187	74	Tungsten	23.72	hours	2.71E-03	2.56E+02	7.07E+05	No		X			
W-188	74	Tungsten	69.78	days	1.91E-01	3.63E+00	9.96E+03	No		X			
Xe-120	54	Xenon	40	minutes	7.61E-05	9.11E+03	3.92E+07	No		X			
Xe-121	54	Xenon	40.1	minutes	7.62E-05	9.09E+03	3.88E+07	No		X			
Xe-122	54	Xenon	20.1	hours	2.29E-03	3.02E+02	1.28E+06	No		X			
Xe-123	54	Xenon	2.08	hours	2.37E-04	2.92E+03	1.23E+07	No		X			
Xe-125	54	Xenon	16.9	hours	1.93E-03	3.59E+02	1.48E+06	No		X	X		
Xe-127	54	Xenon	36.4	days	9.97E-02	6.95E+00	2.83E+04	No		X	X		
Xe-129m	54	Xenon	8.88	days	2.43E-02	2.85E+01	1.14E+05	No		X			
Xe-131m	54	Xenon	11.934	days	3.27E-02	2.12E+01	8.36E+04	No		X			
Xe-133	54	Xenon	5.243	days	1.44E-02	4.83E+01	1.87E+05	No	X	X	X		
Xe-133m	54	Xenon	2.19	days	6.00E-03	1.16E+02	4.49E+05	No		X			
Xe-135	54	Xenon	9.14	hours	1.04E-03	6.65E+02	2.54E+06	No	X	X	X		
Xe-135m	54	Xenon	15.29	minutes	2.91E-05	2.38E+04	9.12E+07	No	X	X	X		
Xe-138	54	Xenon	14.08	minutes	2.68E-05	2.59E+04	9.69E+07	No	X				
Y-86	39	Yttrium	14.74	hours	1.68E-03	4.12E+02	2.47E+06	No		X	X		

Table A1. Radionuclide Physical Property Data

Isotope	Atomic No.	Element	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Half-Life (years)	Decay Constant	Specific Activity (curies/gram)	Isotopes Still Being Formed in 2005 (as decay products)	Fission Product	Activation Product	Decay Product	Actinide	Naturally occurring
Y-86m	39	Yttrium	48	minutes	9.13E-05	7.59E+03	4.56E+07	No		X			
Y-87	39	Yttrium	79.8	hours	9.10E-03	7.61E+01	4.52E+05	No		X			
Y-88	39	Yttrium	106.616	days	2.92E-01	2.37E+00	1.39E+04	No		X	X		
Y-90	39	Yttrium	64.053	hours	7.31E-03	9.48E+01	5.44E+05	Yes	X	X	X		
Y-90m	39	Yttrium	3.19	hours	3.64E-04	1.90E+03	1.09E+07	No		X			
Y-91	39	Yttrium	58.51	days	1.60E-01	4.33E+00	2.45E+04	No	X		X		
Y-91m	39	Yttrium	49.71	minutes	9.45E-05	7.33E+03	4.16E+07	No		X	X		
Y-92	39	Yttrium	3.54	hours	4.04E-04	1.72E+03	9.63E+06	No	X	X	X		
Y-93	39	Yttrium	10.18	hours	1.16E-03	5.97E+02	3.31E+06	No	X				
Y-94	39	Yttrium	18.7	minutes	3.56E-05	1.95E+04	1.07E+08	No	X	X			
Y-95	39	Yttrium	10.3	minutes	1.96E-05	3.54E+04	1.92E+08	No	X	X			
Yb-162	70	Ytterbium	18.87	minutes	3.59E-05	1.93E+04	6.16E+07	No		X			
Yb-165	70	Ytterbium	9.9	minutes	1.88E-05	3.68E+04	1.15E+08	No		X			
Yb-166	70	Ytterbium	56.7	hours	6.47E-03	1.07E+02	3.33E+05	No		X			
Yb-167	70	Ytterbium	17.5	minutes	3.33E-05	2.08E+04	6.44E+07	No		X			
Yb-169	70	Ytterbium	32.018	days	8.77E-02	7.91E+00	2.57E+04	No		X	X		
Yb-175	70	Ytterbium	4.185	days	1.15E-02	6.05E+01	1.78E+05	No		X	X		
Yb-177	70	Ytterbium	1.911	hours	2.18E-04	3.18E+03	9.27E+06	No		X			
Yb-178	70	Ytterbium	74	minutes	1.41E-04	4.93E+03	1.43E+07	No		X			
Zn-62	30	Zinc	9.186	hours	1.05E-03	6.61E+02	5.51E+06	No		X			
Zn-63	30	Zinc	38.47	minutes	7.31E-05	9.47E+03	7.76E+07	No		X			
Zn-65	30	Zinc	243.66	days	6.67E-01	1.04E+00	8.25E+03	No		X	X		
Zn-69	30	Zinc	56.4	minutes	1.07E-04	6.46E+03	4.84E+07	No		X	X		
Zn-69m	30	Zinc	13.76	hours	1.57E-03	4.41E+02	3.30E+06	No		X			
Zn-71m	30	Zinc	3.96	hours	4.52E-04	1.53E+03	1.12E+07	No		X			
Zn-72	30	Zinc	46.5	hours	5.30E-03	1.31E+02	9.37E+05	No	X				
Zr-86	40	Zirconium	16.5	hours	1.88E-03	3.68E+02	2.21E+06	No		X			
Zr-88	40	Zirconium	83.4	days	2.28E-01	3.03E+00	1.78E+04	No		X	X		
Zr-89	40	Zirconium	78.41	hours	8.94E-03	7.75E+01	4.49E+05	No		X	X		
Zr-93	40	Zirconium	1.53E+06	years	1.53E+06	4.53E-07	2.51E-03	No	X		X		
Zr-95	40	Zirconium	64.032	days	1.75E-01	3.95E+00	2.15E+04	No	X	X	X		
Zr-97	40	Zirconium	16.744	hours	1.91E-03	3.63E+02	1.93E+06	No	X	X			

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Ac-223	89	2.10	minutes	Daughter Pa-227 (38.3m, AP)	No	
Ac-224	89	2.78	hours	Daughter Pa-228 (22h, AP)	No	
Ac-225	89	10.0	days	AP Daughter Ra-225 (14.9d, Decay)	Yes	Descendant of Pu-241 via Np-series decay chain
Ac-226	89	29.37	hours	AP	No	
Ac-227	89	21.772	years	AP-neutrons Daughter Pa-231 (3.3E4y, Decay) Daughter Ra-227 (42.2m, AP)	Yes	Descendant of U-235 via Ac-series decay chain
Ac-228	89	6.15	hours	Daughter Ra-228 (5.7y, Decay)	Yes	Descendant of Th-232 via Th-series decay chain
Ag-102	47	12.9	minutes	AP	No	
Ag-103	47	65.7	minutes	AP	No	
Ag-104	47	69.2	minutes	AP Daughter Cd-104 (57.7m, AP)	No	
Ag-104m	47	33.5	minutes	AP	No	
Ag-105	47	41.29	days	AP	No	
Ag-106	47	23.96	minutes	AP	No	
Ag-106m	47	8.28	days	AP	No	
Ag-108	47	2.37	minutes	AP Daughter Ag-108m (438y, AP)	Yes	
Ag-108m	47	438	years	AP-neutrons	No	
Ag-109m	47	38.0	seconds	FP Daughter Pd-109 (13.7h, FP, AP)	No	
Ag-110	47	24.6	seconds	AP-neutrons Daughter Ag-110m (250d, AP)	No	
Ag-110m	47	249.76	days	AP-neutrons	No	
Ag-111	47	7.45	days	FP, AP-neutrons	No	
Ag-112	47	3.130	hours	FP, AP-neutrons	No	
Ag-115	47	20.0	minutes	FP, AP	No	
Al-26	13	7.17E+05	years	AP	No	
Al-28	13	2.2414	minutes	AP-neutrons Daughter Mg-28 (20.9h, AP)	No	
Am-237	95	73.0	minutes	AP	No	
Am-238	95	98	minutes	AP Daughter Cm-238 (2.4h, AP)	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Am-239	95	11.9	hours	AP	No	
Am-240	95	50.8	hours	AP	No	
Am-241	95	432.2	years	Daughter Pu-241 (14.3y, AP, Decay) Daughter Cm-241 (32.8d, AP)	Yes	Descendant of Pu-241 via Np-series decay chain
Am-242	95	16.02	hours	AP-neutrons, multiple n-capture Daughter Am-242m (141y, AP)	Yes	Am-242m (141y, AP) → Am-242 (16h) → Cm-242 (163d) → Pu-238 (88y) → U-234 (in Uranium Series)
Am-242m	95	141	years	AP-neutrons	No	
Am-243	95	7,370	years	AP-neutrons, multiple n-capture Daughter BK-247 (1.4E3y, AP, Decay) Daughter Pu-243 (5h, AP, Decay)	Yes	Cf-247 (3.1h, AP) → Bk-247 (1.4E3y, AP, Decay) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series); Es-255 (39.3d, AP) → Bk-251 (56m) or Fm-255 (20h) → Cf-251(9E2y) → Cm-247(1.6E7y) → Pu-243 (5h) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)
Am-244	95	10.1	hours	AP-neutrons	No	
Am-244m	95	26	minutes	AP-neutrons	No	
Am-245	95	2.05	hours	Daughter Pu-245 (10.5h, AP)	No	
Am-246	95	39	minutes	Daughter Pu-246 (10.8d, AP, Decay)	Yes	Cm-250 (8.3E3y, AP) → Pu-246 (10.8d) → Am-246 (39m) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series)
Am-246m	95	25.0	minutes	AP	No	
Ar-37	18	34.95	days	AP-neutrons	No	
Ar-39	18	269	years	AP-neutrons Daughter Cl-39 (55.6m, AP)	No	
Ar-41	18	109.61	years	AP-neutrons	No	
Ar-42	18	32.9	years	AP-neutrons	No	
As-69	33	15.2	minutes	AP	No	
As-70	33	52.6	minutes	AP Daughter Se-70 (41.1m, AP)	No	
As-71	33	65.28	hours	AP	No	
As-72	33	26.0	hours	AP Daughter Se-72 (8d, AP)	No	
As-73	33	80.30	days	AP Daughter Se-73 (7.1h, AP, Decay) Daughter Se-73m (39.8m, AP)	No	Se-73m (39.8m, AP) → Se-73 (7.1h, AP, Decay) → As-73 (80d) → Ge-73 (stable)
As-74	33	17.77	days	AP	No	
As-76	33	1.0942	days	AP-neutrons	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
As-77	33	38.83	hours	FP, AP-neutrons Daughter Ge-77 (11.3h, FP, AP)	No	
As-78	33	90.7	minutes	FP, AP-neutrons Daughter Ge-78 (88m, FP, AP)	No	
As-79	33	9.01	minutes	FP, AP-neutrons	No	
At-207	85	1.80	hours	AP	No	
At-211	85	7.214	hours	AP	No	
At-215	85	1.00E-04	seconds	Daughter Fr-219 (<1s, Decay)	No	Pa-227 (38m, AP) → Ac-223 (2.1m) → Fr-219 (<1s) → At-215 (<1s) to Bi-211 in Actinium Series; Th-227 (19d) → Ra-223 in Actinium Series
At-216	85	3.00E-04	seconds	Daughter Fr-220 (27.4s, Decay)	No	Pa-228 (22h, AP) → Ac-224 (2.8h) → Fr-220 (27s) → Bi-212 (61m) → Tl-208 (3.1m) and Po-212 (1s) → Pb-208 (stable)
At-217	85	0.0323	seconds	Daughter Fr-221 (4.9m, Decay)	Yes	Descendant of Pu-241 via Np-series decay chain
At-218	85	1.5	seconds	Daughter Po-218 (3.1m, Decay)	Yes	Descendant of U-238 via U-series decay chain
Au-193	79	17.65	hours	AP Daughter Hg-193m (11.8h, AP) Daughter Hg-193 (3.8h, AP, Decay)	No	Hg-193m (11.8h, AP) → Hg-193 (4h) → Au-193 (18h) → Pt-193 (50y) → Ir-193 (stable)
Au-194	79	38.02	hours	AP Daughter Hg-194 (444y, AP, Decay)	Yes	[Tl-194 (33m, AP) and Tl-194m (32.8m, AP)] → Hg-194 (444y) → Au-194 (38h) → Pt-194 (stable)
Au-195	79	186.098	days	AP Daughter Hg-195 (10.5h, AP, Decay) Daughter Hg-195m (41.6h, AP)	No	Hg-195m (41.6h, AP) → Hg-195 (10h) → Au-195 (186d) → Pt-195 (stable)
Au-195m	79	30.5	seconds	AP	No	
Au-198	79	2.6956	days	AP-neutrons Daughter Au-198m (2.3d, AP)	No	
Au-198m	79	2.27	days	AP	No	
Au-199	79	3.139	days	AP Daughter Pt-199 (30.8m, AP)	No	
Au-200	79	48.4	minutes	AP-neutrons Daughter Pt-200 (12.5h, AP) Daughter Au-200m (18.7h, AP)	No	
Au-200m	79	18.7	hours	AP	No	
Au-201	79	26	minutes	AP	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Ba-126	56	100	minutes	AP	No	
Ba-128	56	2.43	days	AP	No	
Ba-131	56	11.50	days	AP-neutrons Daughter Ba-131m (14.6m, AP) Daughter La-131 (59m, AP)	No	
Ba-131m	56	14.6	minutes	AP	No	
Ba-133	56	3,841	days	AP-neutrons Daughter Ba-133m (38.9h, AP)	No	
Ba-133m	56	38.9	hours	AP-neutrons	No	
Ba-135m	56	28.7	hours	AP-neutrons	No	
Ba-137m	56	2.552	minutes	FP Daughter Cs-137 (30y, FP)	Yes	
Ba-139	56	83.06	minutes	FP, AP-neutrons	No	
Ba-140	56	12.752	days	FP	No	
Ba-141	56	18.27	minutes	FP	No	
Ba-142	56	10.6	minutes	FP	No	
Be-10	4	1.51E+06	years	AP-neutrons	No	
Be-7	4	53.22	days	AP	No	
Bi-200	83	36.4	minutes	AP	No	
Bi-201	83	108	minutes	AP	No	
Bi-202	83	1.72	hours	Daughter Po-202 (45m, AP)	No	
Bi-203	83	11.76	hours	AP Daughter Po-203 (36.7m, AP) Daughter At-207 (1.8h, AP)	No	
Bi-205	83	15.31	days	AP Daughter Po-205 (1.7h, AP)	No	
Bi-206	83	6.243	days	AP	No	
Bi-207	83	32.9	years	AP Daughter Po-207 (5.8h, AP, Decay) Daughter At-211 (7.2h, AP)	No	At-207 (1.8h, AP) → Po-207 (5.8h) → Bi-207 (32y) → Pb-207 (stable)
Bi-208	83	3.68E+05	years	AP-neutrons	No	
Bi-210	83	5.012	days	AP-neutrons Daughter Pb-210 (22.2y, Decay)	Yes	Descendant of U-238 via U-series decay chain
Bi-210m	83	3.04E+06	years	AP-neutrons	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Bi-211	83	2.14	minutes	Daughter Pb-211 (36m, Decay) Daughter At-215 (<1s, Decay)	Yes	Descendant of U-235 via Ac-series decay chain
Bi-212	83	60.55	minutes	Daughter Pb-212 (10.6h, Decay) Daughter At-216 (<1s, Decay)	Yes	Descendant of Th-232 via Th-series decay chain
Bi-213	83	45.59	minutes	Daughter At-217 (<1s, Decay)	Yes	Descendant of Pu-241 via Np-series decay chain
Bi-214	83	19.9	minutes	Daughter Pb-214 (26.8m, Decay) Daughter At-218 (1.5s, Decay)	Yes	Descendant of U-238 via U-series decay chain
Bk-245	97	4.94	days	AP	No	
Bk-246	97	1.80	days	AP Daughter Es-250m (2.2h, AP)	No	
Bk-247	97	1,380	years	AP Daughter Cf-247 (3.1h, AP)	No	Cf-247 (3.1h, AP) → Bk-247 (1.4E3y) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)
Bk-249	97	330	days	AP Daughter Es-253 (20.5d, Decay) Daughter Cm-249 (64.1m, AP)	No	Md-257 (5.5h, AP) → Fm-257 (100d) → Cf-253 (18d) → Es-253 (21d) → Bk-249 (330d) → Cf-249 (3.5E2y) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series); Fm-253 (3d) → Es-253 (21d) → Bk-249 (330d) → Cf-249 (3.5E2y) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)
Bk-250	97	3.212	hours	AP-multiple n-capture Daughter Es-254 (276d, AP, Decay) Daughter Cm-250 (8.3E3y, AP)	Yes	Md-258 (51d) → Es-254 (276d) → Bk-250 (3.2h) → Cf-250 (13y) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series); Cm-250 (8.3E3y) → Bk-250 (3.2h) → Cf-250 (13y) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series)
Br-74	35	25.4	minutes	AP Daughter Kr-74 (11.5m, AP)	No	
Br-74m	35	46	minutes	AP	No	
Br-75	35	96.7	minutes	AP	No	
Br-76	35	16.2	hours	AP Daughter Kr-76 (14.8h, AP)	No	
Br-77	35	57.036	hours	AP Daughter Kr-77 (74.4m, AP)	No	
Br-80	35	17.68	minutes	AP-neutrons Daughter Br-80m (4.4h, AP)	No	
Br-80m	35	4.4205	hours	AP-neutrons	No	
Br-82	35	35.282	hours	AP-neutrons	No	
Br-83	35	2.40	hours	FP, AP-neutrons Daughter Se-83 (22.3m, FP, AP)	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Br-84	35	31.80	minutes	FP, AP-neutrons	No	
C-11	6	20.334	minutes	AP	No	
C-14	6	5700	years	AP- neutrons Naturally occurring (Cosmogenic)	No	
Ca-41	20	1.02E+05	years	AP-neutrons	No	
Ca-45	20	162.61	days	AP-neutrons Daughter K-45 (17.3m, AP)	No	
Ca-47	20	4.536	days	AP-neutrons	No	
Ca-49	20	8.718	minutes	AP-neutrons	No	
Cd-104	48	57.7	minutes	AP	No	
Cd-107	48	6.50	hours	AP-neutrons	No	
Cd-109	48	461.4	days	AP-neutrons Daughter In-109 (4.2h, AP)	No	
Cd-113	48	7.7E+15	years	FP Naturally occurring (Primordial) Daughter Cd-113m (14.1y, AP)	Yes	
Cd-113m	48	14.1	years	AP-neutrons	No	
Cd-115	48	53.46	hours	FP, AP-neutrons Daughter Ag-115 (20m, FP, AP)	No	Ag-115 (20m, FP, AP) → Cd-115m (45d) and Cd-115 (54h) → In-115 (4.4E14y) → Sn-115 (stable)
Cd-115m	48	44.56	days	FP, AP-neutrons Daughter Ag-115 (20m, FP, AP)	No	
Cd-117	48	2.49	hours	FP, AP-neutrons	No	
Cd-117m	48	3.36	hours	FP, AP-neutrons	No	
Ce-134	58	3.16	days	AP	No	
Ce-135	58	17.7	hours	AP	No	
Ce-137	58	9.0	hours	AP-neutrons Daughter Ce-137m (34.4h, AP) Daughter Pr-137 (1.3h, AP)	No	
Ce-137m	58	34.4	hours	AP-neutrons	No	
Ce-139	58	137.641	days	AP-neutrons Daughter Pr-139 (4.4h, AP, Decay)	No	Nd-139m (5.5h, AP) → Nd-139 (29.7m) → Pr-139 (4.4h) → Ce-139 (138d) → La-139 (stable)
Ce-141	58	32.508	days	FP, AP-neutrons Daughter La-141 (3.9h, FP, Decay)	No	Ba-141 (18.3m, FP) → La-141 (3.9h) → Ce-141 (33d) → Pr-141 (stable)

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Ce-142	58	2.6E+17	years	FP Naturally occurring (Primordial) Daughter La-142 (91.1m, FP, Decay)	No	Ba-142 (10.6m, FP) → La-142 (91m) → Ce-142 (2.6E17y) → Nd-142 (stable)
Ce-143	58	33.039	hours	FP, AP-neutrons Daughter La-143 (14.2m, FP)	No	
Ce-144	58	284.91	days	FP	No	
Cf-244	98	19.4	minutes	AP	No	
Cf-246	98	35.7	hours	AP	No	
Cf-247	98	3.11	hour	AP	No	
Cf-248	98	333.5	days	AP Daughter Fm-252 (25.4h, AP)	No	
Cf-249	98	351	years	AP-multiple n-capture Daughter Bk-249 (330d, AP, Decay) Daughter Fm-253 (3d, AP)	No	Md-257 (5.5h, AP) → Fm-257 (100d) → Cf-253 (18d) → Es-253 (21d) → Bk-249 (330d) → Cf-249 (3.5E2y) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series); Fm-253 (3d) → Es-253 (21d) → Bk-249 (330d) → Cf-249 (3.5E2y) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)
Cf-250	98	13.08	years	AP-multiple n-capture Daughter Bk-250 (3.2h, AP, Decay) Daughter Fm-254 (3.2h, Decay) Daughter Es-250m (2.2h, AP)	Yes	Md-258 (51d) → Es-254 (276d) → Bk-250 (3.2h) → Cf-250 (13y) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series) Cm-250 (8.3E3y) → Bk-250 (3.2h) → Cf-250 (13y) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series)
Cf-251	98	898	years	AP-multiple n-capture Daughter Fm-255 (20h, Decay) Daughter Es-251 (33h, AP)	No	Es-255 (40d, AP) → Fm-255 (20h) → Cf-251(9E2y) → Cm-247(1.6E7y) → Pu-243 (5h) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series) Es-251 (33h) → Cf-251(9E2y) → Cm-247(1.6E7y) → Pu-243 (5h) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)
Cf-252	98	3	years	AP-multiple n-capture	No	
Cf-253	98	17.81	days	AP-multiple n-capture Daughter Fm-257 (100d, AP, Decay)	No	Md-257 (5.5h) → Fm-257 (100d) → Cf-253 (18d) → Es-253 (21d) → Bk-249 (330d) → Cf-249 (3.5E2y) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)
Cf-254	98	60.5	days	AP-multiple n-capture	No	
Cl-36	17	3.01E+05	years	AP-neutrons	No	
Cl-38	17	37.24	minutes	AP-neutrons	No	
Cl-39	17	55.6	minutes	AP	No	
Cm-238	96	2.4	hours	AP	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Cm-240	96	27	days	AP Daughter Cf-244 (19.4m, AP)	No	
Cm-241	96	32.8	days	AP	No	
Cm-242	96	162.8	days	AP-multiple n-capture Daughter Cf-246 (35.7m, AP) Daughter Am-242 (16.2h, AP, Decay)	Yes	Am-242m (141y, AP) → Am-242 (16h) → Cm-242 (163d) → Pu-238 (88y) → U-234 (in Uranium Series)
Cm-243	96	29.1	years	AP-multiple n-capture	No	
Cm-244	96	18.1	years	AP-multiple n-capture Daughter Am-244 (10.1h, AP) Daughter Am-244m (26m, AP) Daughter Cf-248 (333.5d, AP, Decay)	No	Fm-252 (25h) → Cf-248 (334d) → Cm-244 (18y) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 (in Thorium Series)
Cm-245	96	8,500	years	AP-multiple n-capture Daughter Am-245 (2.0h, Decay) Daughter Cf-249 (351y, AP, Decay) Daughter Bk-245 (4.9d, AP)	Yes	Md-257 (5.5h, AP) → Fm-257 (100d) → Cf-253 (18d) → Es-253 (21d) → Bk-249 (330d) → Cf-249 (3.5E2y) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series) Pu-245 (10.5h) → Am-245 (2h) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)
Cm-246	96	4,760	years	AP-multiple n-capture Daughter Am-246 (39m, Decay) Daughter Am-246m (25m, AP) Daughter Bk-246 (1.8d, AP, Decay) Daughter Cf-250 (13.1y, AP, Decay)	Yes	Cf-250 (13y, AP) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series); Es-250m (2.2h) → Cf-250 (13y) and Bk-246 (1.8d) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series) Cm-250 (8.3E3y, AP) → Pu-246 (10.8d) → Am-246 (39m) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series)
Cm-247	96	1.56E+07	years	AP-multiple n-capture Daughter Cf-251 (898y, AP, Decay)	Yes	Es-255 (40d, AP) → Fm-255 (20h) → Cf-251(9E2y) → Cm-247(1.6E7y) → Pu-243 (5h) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series) Es-251 (33h) → Cf-251(9E2y) → Cm-247(1.6E7y) → Pu-243 (5h) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)
Cm-248	96	3.48E+05	years	AP-multiple n-capture Daughter Cf-252 (2.6y, AP)	Yes	
Cm-249	96	64.15	minutes	AP-multiple n-capture	No	
Cm-250	96	8.3E+03	years	AP-multiple n-capture	No	
Co-55	27	17.53	hours	AP	No	
Co-56	27	77.233	days	AP Daughter Ni-56 (6.1d, AP)	No	
Co-57	27	271.74	days	AP Daughter Ni-57 (35.6h, AP)	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Co-58	27	70.86	days	AP Daughter Co-58m (9h, AP)	No	
Co-58m	27	9.04	hours	AP	No	
Co-60	27	1925.28	days	AP-neutrons Daughter Co-60m (10.4m, AP, Decay)	Yes	Fe-60 (1.5E6y, AP) → Co-60m (10.4m, AP) → Co-60 (1925d) → Ni-60 (stable)
Co-60m	27	10.467	minutes	AP-neutrons Daughter Fe-60 (1.5E6y, AP)	Yes	
Co-61	27	1.650	hours	AP	No	
Co-62m	27	13.91	minutes	AP	No	
Cr-48	24	21.56	hours	AP	No	
Cr-49	24	42.3	minutes	AP	No	
Cr-51	24	27.7025	days	AP-neutrons Daughter Mn-51 (46.2m, AP)	No	
Cs-125	55	46.7	minutes	AP	No	
Cs-126	55	1.64	minutes	Daughter Ba-126 (100m, AP)	No	
Cs-127	55	6.25	hours	AP	No	
Cs-128	55	3.66	minutes	Daughter Ba-128 (2.4d, AP)	No	
Cs-129	55	32.06	hours	AP	No	
Cs-130	55	29.21	minutes	AP	No	
Cs-131	55	9.689	days	AP-neutrons Daughter Ba-131 (11.5d, AP, Decay)	No	[Ba-131m (39m, AP) and La-131 (59m, AP)] → → Ba-131 (11.5d) → Cs-131 (9.7d) → Xe-131 (stable)
Cs-132	55	6.480	days	AP-neutrons	No	
Cs-134	55	2.0652	years	AP-neutrons Daughter Cs-134m (2.9h, AP)	No	
Cs-134m	55	2.912	hours	AP-neutrons	No	
Cs-135	55	2.3E+06	years	FP Daughter Xe-135 (9.1h, FP, AP, Decay) Daughter Cs-135m (53m, AP)	No	I-135 (6.6h, FP) → Xe-135m (15.5m) → Xe-135 (9.1h) → Cs-135 (2.3E6y) → Ba-135 (stable)
Cs-135m	55	53	minutes	AP-neutrons	No	
Cs-136	55	13.04	days	AP-neutrons	No	
Cs-137	55	30.03	years	FP	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Cs-138	55	33.41	minutes	FP, AP-neutrons Daughter Xe-138 (14.1m, FP)	No	
Cu-60	29	23.7	minutes	AP	No	
Cu-61	29	3.333	hours	AP	No	
Cu-62	29	9.67	minutes	AP Daughter Zn-62 (9h, AP)	No	
Cu-64	29	12.700	hours	AP-neutrons	No	
Cu-66	29	5.120	minutes	AP-neutrons Daughter Ni-66 (54.6h, AP)	No	
Cu-67	29	61.83	hours	AP-neutrons	No	
Dy-155	66	9.9	hours	AP Daughter Ho-155 (48m, AP)	No	
Dy-157	66	8.14	hours	AP Daughter Ho-157 (12.6m, AP)	No	
Dy-159	66	144.4	days	AP-neutrons Daughter Ho-159 (33m, AP)	No	
Dy-165	66	2.334	hours	AP-neutrons	No	
Dy-166	66	81.6	hours	FP, AP-neutrons	No	
Er-161	68	3.21	hours	AP	No	
Er-165	68	10.36	hours	AP-neutrons	No	
Er-169	68	9.392	days	AP-neutrons	No	
Er-171	68	7.516	hours	AP-neutrons	No	
Er-172	68	49.3	hours	AP-neutrons	No	
Es-250m	99	2	hours	AP {Superheavy Isotope, not expected in SRS waste}	No	
Es-251	99	33	hours	AP {Superheavy Isotope, not expected in SRS waste}	No	
Es-253	99	20.47	days	Daughter Cf-253 (17.8d, AP, Decay) Daughter Fm-253 (3d, AP) Daughter Md-257 (5.5h, AP) {Superheavy Isotope, not expected in SRS waste}	No	Md-257 (5.5h, AP) → Fm-257 (100d) → Cf-253 (18d) → Es-253 (21d) → Bk-249 (330d) → Cf-249 (3.5E2y) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series); Fm-253 (3d) → Es-253 (21d) → Bk-249 (330d) → Cf-249 (3.5E2y) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Es-254	99	275.7	days	AP Daughter Md-258 (51.5d, AP) {Superheavy Isotope, not expected in SRS waste}	No	Md-258 (51d, AP) → Es-254 (276d) → Bk-250 (3.2h) → Cf-250 (13y) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series)
Es-254m	99	39.3	hours	AP {Superheavy Isotope, not expected in SRS waste}	No	
Es-255	99	39.8	days	AP-multiple n-capture {Superheavy Isotope, not in SRS waste}	No	
Eu-145	63	5.93	days	AP Daughter Gd-145 (23m, AP)	No	
Eu-146	63	4.61	days	AP Daughter Gd-146 (48.3d, AP)	No	
Eu-147	63	24.1	days	AP Daughter Gd-147 (38.1h, AP, Decay)	No	Tb-147 (1.7h, AP) → Gd-147 (38h) → Eu-147 (24d) → Sm-147 (1E6y) → Nd-143 (stable)
Eu-148	63	54.5	days	AP	No	
Eu-149	63	93.1	days	AP Daughter Gd-149 (9.3d, AP, Decay)	No	Tb-149 (4.1h, AP) → Gd-149 (124d) → Eu-149 (93d) → Sm-149 (2E15y) → Nd-145 (stable)
Eu-150	63	36.9	years	AP	No	
Eu-150m	63	12.8	hours	AP	No	
Eu-152	63	13.506	years	AP-neutrons	No	
Eu-152m	63	9.3116	hours	AP-neutrons	No	
Eu-154	63	8.590	years	AP-neutrons	No	
Eu-155	63	4.753	years	FP, AP-neutrons Daughter Sm-155 (22.3m, FP, AP)	No	
Eu-156	63	15.19	days	FP, AP-neutrons Daughter Sm-156 (9.4h, FP)	No	
Eu-157	63	15.18	hours	FP, AP	No	
Eu-158	63	45.9	minutes	FP, AP	No	
F-18	9	1.8291	hours	AP-neutrons	No	
Fe-52	26	8.275	hours	AP Daughter Fe-52m (46s, AP)	No	
Fe-52m	26	46	seconds	AP	No	
Fe-55	26	2.737	years	AP-neutrons Daughter Co-55 (17.5h, AP)	No	
Fe-59	26	44.495	days	AP-neutrons	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Fe-60	26	1.50E+06	years	AP	No	
Fm-252	100	25.39	hours	AP {Superheavy Isotope, not expected in SRS waste}	No	
Fm-253	100	3.00	days	AP {Superheavy Isotope, not expected in SRS waste}	No	
Fm-254	100	3.240	hours	Daughter Es-254m (39.3h, AP) {Superheavy Isotope, not expected in SRS waste}	No	Es-254m (39h) → Fm-254 (3.2h) → Cf-250 (13y) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series)
Fm-255	100	20.07	hours	Daughter Es-255 (40d, AP) {Superheavy Isotope, not expected in SRS waste}	No	Es-255 (39.3d) → Bk-251 (56m) or Fm-255 (20h) → Cf-251(9E2y) → Cm-247(1.6E7y) → Pu-243 (5h) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)
Fm-257	100	100.5	days	AP Daughter Md-257 (5.5h, AP) {Superheavy Isotope, not expected in SRS waste}	No	Md-257 (5.5h) → Fm-257 (100d) → Cf-253 (18d) → Es-253 (21d) → Bk-249 (330d) → Cf-249 (3.5E2y) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)
Fr-219	87	0.02	seconds	Daughter Ac-223 (2.1m, Decay)	No	Pa-227 (38m, AP) → Ac-223 (2.1m) → Fr-219 (<1s) → At-215 (<1s) to Bi-211 in Actinium Series; Th-227 (19d) → Ra-223 in Actinium Series
Fr-220	87	27.4	seconds	Daughter Ac-224 (2.8h, Decay)	No	Pa-228 (22h, AP) → Ac-224 (2.8h) → Ra-224 in Thorium Series
Fr-221	87	4.9	minutes	Daughter Ac-225 (10d, AP, Decay)	Yes	Descendant of Pu-241 via Np-series decay chain
Fr-222	87	14.2	minutes	AP	No	
Fr-223	87	22.00	minutes	Daughter Ac-227 (21.8y, AP, Decay)	Yes	Descendant of U-235 via Ac-series decay chain
Ga-65	31	15.2	minutes	AP	No	
Ga-66	31	9.49	hours	AP Daughter Ge-66 (2.3h, AP)	No	
Ga-67	31	3.2623	days	AP Daughter Ge-67 (19m, AP)	No	
Ga-68	31	67.71	minutes	AP Daughter Ge-68 (271d, AP)	No	
Ga-70	31	21.14	minutes	AP-neutrons	No	
Ga-72	31	14.095	hours	FP, AP-neutrons Daughter Zn-72 (46.5h, FP)	No	
Ga-73	31	4.86	hours	FP, AP-neutrons	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Ga-74	31	8.2	minutes	FP, AP-neutrons	No	
Gd-145	64	23.0	minutes	AP	No	
Gd-146	64	48.27	days	AP	No	
Gd-147	64	38.06	hours	AP Daughter Tb-147 (1.7h, AP)	No	
Gd-148	64	70.9	years	AP	No	
Gd-149	64	9.28	days	AP Daughter Tb-149 (4.1h, AP)	No	
Gd-150	64	1.80E+06	years	AP Daughter Tb-150 (3.5h, AP) Daughter Eu-150m (12.8h, AP)	No	
Gd-151	64	124	days	AP Daughter Tb-151 (17.6h, AP)	No	
Gd-152	64	1.08E+14	years	Naturally occurring (Primordial)	No	
Gd-153	64	240.4	days	Daughter Tb-153 (2.3d, AP)	No	
Gd-159	64	18.479	hours	FP, AP-neutrons	No	
Ge-66	32	2.26	hours	AP	No	
Ge-67	32	18.9	minutes	AP	No	
Ge-68	32	270.95	days	AP	No	
Ge-69	32	39.05	hours	AP Daughter As-69 (15m, AP)	No	
Ge-71	32	11.43	days	AP-neutrons Daughter As-71 (65.3h, AP)	No	
Ge-75	32	82.78	minutes	AP-neutrons	No	
Ge-77	32	11.30	hours	FP, AP-neutrons	No	
Ge-78	32	88.0	minutes	FP, AP-neutrons	No	
H-3	1	12.32	years	FP, AP-neutrons	No	
Hf-170	72	16.01	hours	AP	No	
Hf-172	72	1.87	years	AP Daughter Ta-172 (36.8m, AP)	No	
Hf-173	72	23.6	hours	AP Daughter Ta-173 (3.1h, AP)	No	
Hf-174	72	2.0E+15	years	Naturally occurring (Primordial)	No	
Hf-175	72	70	days	AP-neutrons Daughter Ta-175 (10.5h, AP)	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Hf-177m	72	51.4	minutes	AP	No	
Hf-178m	72	31	years	AP-neutrons	No	
Hf-179m	72	25.05	days	AP-neutrons	No	
Hf-180m	72	5.47	hours	AP-neutrons	No	
Hf-181	72	42.39	days	AP-neutrons	No	
Hf-182	72	8.9E+06	years	AP Daughter Hf-182m (61.5m, AP)	No	
Hf-182m	72	61.5	minutes	AP	No	
Hf-183	72	1.067	hours	AP-neutrons	No	
Hf-184	72	4.12	hours	AP	No	
Hg-193	80	3.80	hours	AP Daughter Hg-193m (11.8h, AP)	No	Hg-193m (11.8h, AP) → Hg-193 (4h) → Au-193 (18h) → Pt-193 (50y) → Ir-193 (stable)
Hg-193m	80	11.8	hours	AP	No	
Hg-194	80	444	years	AP Daughter Tl-194 (33m, AP) Daughter Tl-194m (32.8m, AP)	No	
Hg-195	80	10.53	hours	AP Daughter Tl-195 (1.2h, AP, Decay) Daughter Hg-195m (41.6h, AP)	No	Pb-195m (15m) → Tl-195 (1.2h) → Hg-195 (10h) → Au-195 (186d) → Pt-195 (stable)
Hg-195m	80	41.6	hours	AP	No	
Hg-197	80	64.14	hours	AP Daughter Hg-197m (23.8h, AP) Daughter Tl-197 (2.8h, AP)	No	
Hg-197m	80	23.8	hours	AP	No	
Hg-199m	80	42.67	minutes	AP-neutrons	No	
Hg-203	80	46.595	days	AP-neutrons	No	
Ho-155	67	48	minutes	AP	No	
Ho-157	67	12.6	minutes	AP	No	
Ho-159	67	33.05	minutes	AP	No	
Ho-161	67	2.48	hours	Daughter Er-161 (3.2h, AP)	No	
Ho-162	67	15.0	minutes	Daughter Ho-162m (67m, AP)	No	
Ho-162m	67	67.0	minutes	AP	No	
Ho-164	67	29	minutes	AP-neutrons Daughter Ho-164m (37.5m, AP)	No	
Ho-164m	67	37.5	minutes	AP	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Ho-166	67	26.83	hours	FP, AP-neutrons Daughter Dy-166 (81.6h, FP, AP)	No	
Ho-166m	67	1.20E+03	years	AP-neutrons	No	
Ho-167	67	3.003	hours	AP-neutrons	No	
I-120	53	81.6	minutes	AP Daughter Xe-120 (40m, AP)	No	
I-120m	53	53	minutes	AP	No	
I-121	53	2.12	hours	AP Daughter Xe-121 (40.1m, AP)	No	
I-122	53	3.63	minutes	AP Daughter Xe-122 (20.1h, AP)	No	
I-123	53	13.232	hours	AP Daughter Xe-123 (2.1h, AP)	No	
I-124	53	4.1760	days	AP	No	
I-125	53	59.400	days	AP Daughter Xe-125 (16.9h, AP, Decay)	No	Cs-125 (46.7h) → Xe-125 (16.9h) → I-125 (59d) → Te-125 (stable)
I-126	53	12.93	days	AP	No	
I-128	53	24.99	minutes	AP-neutrons	No	
I-129	53	1.57E+07	years	FP Daughter Te-129 (69.6m, FP, AP, Decay) Daughter Te-129m (33.6d, FP, AP, Decay)	No	Sb-129 (4.4h, FP) → 83.4% Te-129 (70m) and 16.6% Te-129m (33.6d); Te-129m (33.6d) → 69% Te-129 (70m) and 31% I-129 (1.6E7y) → Xe-129 (stable)
I-130	53	12.36	hours	AP-neutrons	No	
I-131	53	8.02070	days	FP Daughter Te-131 (25m, FP, AP, Decay) Daughter Te-131m (30h, FP, AP, Decay)	No	Sb-131 (23m, FP) → Te-131m (30h) and Te-131 (25m) → I-131 (8d) → Xe-131 (stable)
I-132	53	2.295	hours	FP Daughter I-132m (1.4h, AP) Daughter Te-132 (3.2d, FP)	No	
I-132m	53	1.387	hours	AP	No	
I-133	53	20.8	hours	FP Daughter Te-133 (12.5m, FP, Decay) Daughter Te-133m (55.4m, FP)	No	Te-133m (55.4m, FP) → 82.5% I-133 (21h) and 14% Te-133; Te-133 (12.5m) → I-133 (21h) → Xe-133 (5.2d) → Cs-133 (stable)
I-134	53	52.5	minutes	FP Daughter Te-134 (41.8m, FP)	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
I-135	53	6.57	hours	FP	No	
In-109	49	4.2	hours	AP	No	
In-110	49	4.9	hours	AP Daughter Sn-110 (4.1h, AP)	No	
In-110m	49	69.1	minutes	AP	No	
In-111	49	2.8047	days	AP Daughter Sn-111 (35m, AP)	No	
In-112	49	14.97	minutes	AP	No	
In-113m	49	99.476	minutes	AP	No	
In-114	49	71.9	seconds	AP-neutrons Daughter In-114m (49.5d, AP)	No	
In-114m	49	49.51	days	AP-neutrons	No	
In-115	49	4.41E+14	years	FP Naturally occurring (Primordial) Daughter In-115m (4.5h, AP) Daughter Cd-115 (53.5h, FP, AP, Decay) Daughter Cd-115m (44.6d, FP, AP, Decay)	No	Ag-115 (20m, FP, AP) → Cd-115m (45d) and Cd-115 (54h) → In-115 (4.4E14y) → Sn-115 (stable)
In-115m	49	4.486	hours	AP-neutrons	No	
In-116m	49	54.29	minutes	AP-neutrons	No	
In-117	49	43.2	minutes	FP, AP-neutrons Daughter In-117m (116m, FP, AP, Decay) Daughter Cd-117 (2.5h, FP, AP) Daughter Cd-117m (3.4h, AP, FP)	No	[Cd-117m (3.4h, FP, AP) and Cd-117 (2.5h, FP, AP)]→ In-117m (43m) and In-117 (116m) → Sn-117 (stable)
In-117m	49	116.2	minutes	FP, AP-neutrons Daughter Cd-117 (2.5h, FP, AP) Daughter Cd-117m (3.4h, AP, FP)	No	
In-119	49	2.4	minutes	FP, AP Daughter In-119m (18m, AP)	No	
In-119m	49	18.0	minutes	AP	No	
Ir-182	77	15	minutes	AP	No	
Ir-184	77	3.09	hours	AP	No	
Ir-185	77	14.4	hours	AP	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Ir-186	77	16.64	hours	AP Daughter Pt-186 (2.1h, AP) Daughter Ir-186m (1.9h, AP)	No	
Ir-186m	77	1.90	hours	AP	No	
Ir-187	77	10.5	hours	AP	No	
Ir-188	77	41.5	hours	AP Daughter Pt-188 (10.2d, AP)	No	
Ir-189	77	13.2	days	AP Daughter Pt-189 (10.9h, AP)	No	
Ir-190	77	11.78	days	AP Daughter Ir-190n (3.1h, AP) Daughter Ir-190m (1.1h, AP)	No	
Ir-190m	77	1.120	hours	AP	No	
Ir-190n	77	3.087	hours	AP	No	
Ir-191m	77	4.94	seconds	AP	No	
Ir-192	77	73.827	days	AP-neutrons Daughter Ir-192m (241y, AP)	Yes	
Ir-192m	77	241	years	AP-neutrons	No	
Ir-194	77	19.28	hours	AP-neutrons Daughter Os-194 (6y, AP)	Yes	
Ir-194m	77	171	days	AP-neutrons	No	
Ir-195	77	2.5	hours	AP-neutrons Daughter Ir-195m (3.8h, AP)	No	
Ir-195m	77	3.8	hours	AP	No	
K-38	19	7.636	minutes	AP	No	
K-40	19	1.248E+09	years	Naturally occurring (Primordial)	No	
K-42	19	12	hours	AP-neutrons Daughter Ar-42 (32.9y, AP)	No	
K-43	19	22.3	hours	AP	No	
K-44	19	22.13	minutes	AP-neutrons	No	
K-45	19	17.3	minutes	AP	No	
Kr-74	36	11.50	minutes	AP	No	
Kr-76	36	14.8	hours	AP	No	
Kr-77	36	74.4	minutes	AP	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Kr-79	36	35.04	hours	AP-neutrons Daughter Rb-79 (22.9m, AP)	No	
Kr-81	36	2.29E+05	years	AP-neutrons Daughter Kr-81m (13.1s, AP) Daughter Rb-81 (4.6h, Decay) Daughter Rb-81m (30.5m, AP)	No	[Rb-81m (30.5m, AP) and Sr-81 (22.3m, AP)] → Rb-81 (4.6h, Decay of Sr-81, Rb-81m) → Kr-81 (2.3E5y) → Br-81 (stable)
Kr-81m	36	13.10	seconds	AP	No	
Kr-83m	36	1.83	hours	FP Daughter Rb-83 (86d, AP, Decay)	No	Se-83 (22.3m, FP, AP) → Br-83 (2.4h, FP, AP, Decay of Se-83) → Kr-83m (1.8h) → Kr-83 (stable); Sr-83 (32.4h, AP) → Rb-83 (86d, AP, Decay of Sr-83) → Kr-83m (1.8h) → Kr-83 (stable)
Kr-85	36	3916.8	days	FP, AP-neutrons Daughter Kr-85m (4.5h, FP, AP)	No	
Kr-85m	36	4.480	hours	FP, AP-neutrons	No	
Kr-87	36	76.3	minutes	FP, AP-neutrons	No	
Kr-88	36	2.84	hours	FP	No	
La-131	57	59	minutes	AP	No	
La-132	57	4.8	hours	AP	No	
La-134	57	6.45	minutes	AP Daughter Ce-134 (3.2d, AP)	No	
La-135	57	19.5	hours	AP Daughter Ce-135 (17.7h, AP)	No	
La-137	57	6E+04	years	AP-neutrons Daughter Ce-137 (9h, AP, Decay)	No	Ce-137m (34h) → Ce-137 (9h) → La-137 (6E4y) → Ba-137 (stable); Pr-137 (1.3h) → Ce-137 (9h) → La-137 (6E4y) → Ba-137 (stable)
La-138	57	1.02E+11	years	Naturally occurring (Primordial)	No	
La-140	57	1.6781	days	FP, AP-neutrons Daughter Ba-140 (12.8d, FP)	No	
La-141	57	3.92	hours	FP Daughter Ba-141 (18.3m, FP)	No	
La-142	57	91.1	minutes	FP Daughter Ba-142 (10.6m, FP)	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
La-143	57	14.2	minutes	FP	No	
Lu-169	71	34.06	hours	AP	No	
Lu-170	71	2.012	days	AP Daughter Hf-170 (16h, AP)	No	
Lu-171	71	8.24	days	AP	No	
Lu-172	71	6.70	days	AP Daughter Hf-172 (1.9y, AP, Decay)	Yes	Ta-172 (36.8m, AP) → Hf-172 (1.9y) → Lu-172 (7d) → Yb-172 (stable)
Lu-173	71	1.37	years	AP Daughter Hf-173 (23.6h, AP, Decay)	No	Ta-173 (3.1h, AP) → Hf-173 (23.6h) → Lu-173 (1.4y) → Yb-173 (stable)
Lu-174	71	3.31	years	AP Daughter Lu-174m (142d, AP)	No	
Lu-174m	71	142	days	AP	No	
Lu-176	71	3.76E+10	years	Naturally occurring (Primordial)	No	
Lu-176m	71	3.664	hours	AP-neutrons	No	
Lu-177	71	6.6475	days	AP-neutrons Daughter Lu-177m (160d, AP) Daughter Yb-177 (1.9h, AP)	No	
Lu-177m	71	160.44	days	AP-neutrons	No	
Lu-178	71	28.4	minutes	AP Daughter Yb-178 (74m, AP)	No	
Lu-178m	71	23.1	minutes	AP-neutrons	No	
Lu-179	71	4.59	hours	AP	No	
Md-257	101	5.52	hours	AP {Superheavy Isotope, not expected in SRS waste}	No	
Md-258	101	51.5	days	AP {Superheavy Isotope, not expected in SRS waste}	No	
Mg-28	12	20.915	hours	AP	No	
Mn-51	25	46.2	minutes	AP	No	
Mn-52	25	5.591	days	AP Daughter Fe-52 (8.3h, AP, Decay) Daughter Fe-52m (46s, AP) Daughter Mn-52m (21.1m, AP)	No	Fe-52m (46s, AP) → Fe-52 (8.3h) → Mn-52 (5.6d) → Cr-52 (stable)
Mn-52m	25	21.1	minutes	AP	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Mn-53	25	3.74E+06	years	AP	No	
Mn-54	25	312.12	days	AP	No	
Mn-56	25	2.5789	hours	AP-neutrons	No	
Mo-101	42	14.61	minutes	FP, AP-neutrons	No	
Mo-90	42	5.56	hours	AP	No	
Mo-93	42	4.0E+03	years	AP-neutrons Daughter Mo-93m (6.8h, AP) Daughter Tc-93 (2.7h, AP, Decay) Daughter Tc-93m (43.5m, AP)	No	Tc-93m (43.5m, AP) → Tc-93 (2.75h) → Mo-93 (4E3y) → Nb-93 (stable)
Mo-93m	42	6.85	hours	AP	No	
Mo-99	42	2.7489	days	FP, AP-neutrons	No	
N-13	7	9.965	minutes	AP	No	
Na-22	11	2.6027	years	AP	No	
Na-24	11	14.951	hours	AP-neutrons	No	
Nb-88	41	14.55	minutes	AP	No	
Nb-89a	41	66	minutes	AP	No	
Nb-89b	41	2.03	hours	AP	No	
Nb-90	41	14.60	hours	AP Daughter Mo-90 (5.6h, AP)	No	
Nb-92	41	3.47E+07	years	AP	No	
Nb-93m	41	16.13	years	FP, AP-neutrons Daughter Zr-93 (1.5E6y, FP, Decay) Daughter Mo-93 (4E3y, AP, Decay)	Yes	Y-93 (10.2h, FP) → Zr-93 (1.5E6y) → Nb-93m (16.1y) → Nb-93 (stable); Tc-93m (43.5m) → Tc-93 (2.75h) → Mo-93 (4E3y) → Nb-93m (16.1y) → Nb-93 (stable)
Nb-94	41	2.03E+04	years	AP-neutrons	No	
Nb-95	41	34.991	days	FP Daughter Nb-95m (3.6d, AP) Daughter Zr-95 (64d, FP, AP, Decay)	No	Y-95 (10.3m, FP, AP) → Zr-95 (64d) → Nb-95 (35d) → Mo-95 (stable)
Nb-95m	41	3.61	days	AP	No	
Nb-96	41	23.35	hours	AP	No	
Nb-97	41	72.1	minutes	FP Daughter Nb-97m (58.7s, FP, Decay) Daughter Zr-97 (16.7h, FP, AP)	No	Zr-97 (16.7h) → Nb-97m (59s) → Nb-97 (72m) → Mo-97 (stable)

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Nb-97m	41	58.7	seconds	FP Daughter Zr-97 (16.7h, FP, AP)	No	
Nb-98	41	51.3	minutes	FP	No	
Nd-136	60	50.65	minutes	AP	No	
Nd-138	60	5.04	hours	AP	No	
Nd-139	60	29.7	minutes	Daughter Nd-139m (5.5h, AP)	No	
Nd-139m	60	5.50	hours	AP	No	
Nd-141	60	2.49	hours	AP Daughter Nd-141m (62s, AP) Daughter Pm-141 (20.9m, AP, Decay)	No	Sm-141m (22.6m, AP) → Sm-141 (10m) → Pm-141 (21m) → Nd-141 (2.5h) → Pr-141 (stable)
Nd-141m	60	62.0	seconds	AP	No	
Nd-144	60	2.29E+15	years	FP Naturally occurring (Primordial) Daughter Pm-144 (363d, AP) Daughter Pr-144 (17.3m, FP, Decay) Daughter Sm-148 (7E15y, Natural, Decay)	Yes	Ce-144 (285d, FP) → Pr-144m (7.2m) → Pr-144 (17.3m) → Nd-144 (2.3E15y) → Ce-140 (stable); Pm-148m (41.3d, AP) → Pm-148 (5.4d) → Sm-148 (7E15y) → Nd-144 (2.3E15y) → Ce-140 (stable)
Nd-147	60	10.98	days	FP, AP-neutrons Daughter Pr-147 (13.4m, FP, AP)	No	
Nd-149	60	1.728	hours	AP-neutrons	No	
Nd-151	60	12.44	minutes	AP-neutrons	No	
Ne-19	10	17.22	seconds	AP	No	
Ni-56	28	6.075	days	AP	No	
Ni-57	28	35.60	hours	AP	No	
Ni-59	28	7.6E+04	years	AP-neutrons	No	
Ni-63	28	100.1	years	AP-neutrons	No	
Ni-65	28	2.5172	hours	AP-neutrons	No	
Ni-66	28	54.6	hours	AP	No	
Np-232	93	14.7	minutes	AP	No	
Np-233	93	36.2	minutes	AP	No	
Np-234	93	4.4	days	AP Daughter Pu-234 (8.8h, AP, Decay)	No	Cm-238 (2.4h, AP) 10% → Pu-234 (8.8h) 94% → Np-234 (4.4d) → U-234 (in Uranium Series)
Np-235	93	396.1	days	AP Daughter Pu-235 (25.3m, AP)	No	
Np-236	93	1.54E+05	years	AP	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Np-236m	93	22.5	hours	AP	No	
Np-237	93	2.144E+06	years	AP-neutrons Daughter Am-241 (432y, Decay) Daughter U-237 (6.7d, AP) Daughter Pu-237 (45.2d, AP, Decay)	Yes	Descendant of Pu-241 via Np-series decay chain
Np-238	93	2.117	days	AP-neutrons	No	
Np-239	93	2.356	days	AP-neutrons Daughter Am-243 (7.4E3y, AP, Decay) Daughter U-239 (23.5m, AP)	Yes	Cf-247 (3.1h, AP) → Bk-247 (1.4E3y) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series); Es-255 (39.3d, AP) → Bk-251 (56m) or Fm-255 (20h) → Cf-251(9E2y) → Cm-247(1.6E7y) → Pu-243 (5h) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)
Np-240	93	61.9	minutes	AP Daughter U-240 (14.1h, AP, Decay)	Yes	Cf-252 (2.6y, AP) → Cm-248 (3.5E5y) → Pu-244 (8E7y) → U-240 (14h) → Np-240 (62m) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 in Thorium Series
Np-240m	93	7.22	minutes	AP	No	
O-15	8	122.24	seconds	AP	No	
Os-180	76	21.5	minutes	AP	No	
Os-181	76	105	minutes	AP	No	
Os-182	76	22.10	hours	AP Daughter Ir-182 (15m, AP)	No	
Os-185	76	93.6	days	AP-neutrons Daughter Ir-185 (14.4h, AP)	No	
Os-186	76	2E+15	years	Naturally occurring (Primordial) Daughter Ir-186 (16.6h, AP, Decay) Daughter Ir-186m (1.9h, AP) Daughter Re-186 (3.7d, AP, Decay)	Yes	Re-186m (2E5y, AP) → Re-186 (3.7d) → Os-186 (2E15y) → W-182 (stable); Ir-186m (1.9h, AP) → Ir-186 (16.6h) → Os-186 (2E15y) → W-182 (stable)
Os-189m	76	5.81	hours	AP	No	
Os-190m	76	9.9	minutes	AP-neutrons	No	
Os-191	76	15.4	days	Daughter Os-191m (13.1h, AP)	No	
Os-191m	76	13.10	hours	AP-neutrons	No	
Os-193	76	30.11	hours	AP-neutrons	No	
Os-194	76	6.0	years	AP-neutrons	No	
P-30	15	2.498	minutes	AP	No	
P-32	15	14.262	days	AP-neutrons Daughter Si-32 (132y, AP)	Yes	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
P-33	15	25.34	days	AP-neutrons	No	
Pa-227	91	38.3	minutes	AP	No	
Pa-228	91	22	hours	AP	No	
Pa-230	91	17.4	days	AP	No	
Pa-231	91	3.276E+04	years	Daughter Th-231 (25.5h, AP, Decay) Daughter U-231 (4.2d, AP)	Yes	Descendant of U-235 via Ac-series decay chain
Pa-232	91	1.31	days	AP-neutrons	No	
Pa-233	91	26.975	days	AP-neutrons Daughter Np-237 (2.1E6y, AP, Decay)	Yes	Descendant of Pu-241 via Np-series decay chain
Pa-234	91	6.70	hours	Daughter Th-234 (24.1d, Decay)	Yes	Descendant of U-238 via U-series decay chain
Pa-234m	91	1.17	minutes	AP	No	
Pb-195m	82	15.0	minutes	AP	No	
Pb-198	82	2.40	hours	AP	No	
Pb-199	82	90	minutes	AP	No	
Pb-200	82	21.5	hours	AP Daughter Bi-200 (36.4m, AP)	No	
Pb-201	82	9.33	hours	AP Daughter Bi-201 (108m, AP) Daughter Po-205 (1.7h, AP)	No	
Pb-202	82	5.25E+04	years	AP Daughter Pb-202m (3.5h, AP) Daughter Bi-202 (1.7h, Decay)	No	Po-202 (45m, AP, not on table) → Bi-202 (1.7h) → Pb-202 (5E4y) → Tl-202 and Hg-198 (stable); Tl-202 (12d) → Hg-202 (stable)
Pb-202m	82	3.53	hours	AP	No	
Pb-203	82	51.920	hours	AP Daughter Bi-203 (11.7h, AP, Decay)	No	Po-203 (26.7m, AP) → Bi-203 (12h) → Pb-203 (52h) → Tl-203 (stable) At-207 (8.7%, 1.8h, AP) → Bi-203 (12h) → Pb-203 (52h) → Tl-203 (stable)
Pb-204	82	1.4E+17	years	Naturally occurring (Primordial)	No	
Pb-205	82	1.73E+07	years	AP-neutrons Daughter Bi-205 (15.3d, AP, Decay) Daughter Po-209 (102y, AP)	Yes	Po-205 (1.7h, AP) → Bi-205 (15d) → Pb-205 (1.5E7y) → Tl-205 (stable)

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Pb-209	82	3.253	hours	AP-neutrons Daughter Tl-209 (2.2m, Decay) Daughter Po-213 (<1s, Decay)	Yes	Descendant of Pu-241 via Np-series decay chain
Pb-210	82	22.20	years	Daughter Tl-210 (1.3m, Decay) Daughter Po-214 (<1s, Decay)	Yes	Descendant of U-238 via U-series decay chain
Pb-211	82	36.1	minutes	Daughter Po-215 (<1s, AP, Decay)	Yes	Descendant of U-235 via Ac-series decay chain
Pb-212	82	10.64	hours	Daughter Po-216 (<1s, Decay)	Yes	Descendant of Th-232 via Th-series decay chain
Pb-214	82	26.8	minutes	Daughter Po-218 (3.1m, Decay)	Yes	Descendant of U-238 via U-series decay chain
Pd-100	46	3.63	days	AP	No	
Pd-101	46	8.47	hours	AP	No	
Pd-103	46	16.991	days	AP-neutrons Daughter Ag-103 (65.7m, AP)	No	
Pd-107	46	6.5E+06	years	FP Daughter Rh-107 (21.7m, FP, AP)	No	
Pd-109	46	13.7012	hours	FP, AP-neutrons	No	
Pm-141	61	20.90	minutes	AP Daughter Sm-141 (10.2, AP) Daughter Sm-141m (22.6m, AP)	No	
Pm-142	61	40.5	seconds	Daughter Sm-142 (72.5m, AP)	No	
Pm-143	61	265	days	AP	No	
Pm-144	61	363	days	AP	No	
Pm-145	61	17.7	years	AP Daughter Sm-145 (340d, AP, Decay)	No	Gd-145 (23m, AP) → Eu-145 (6d) → Sm-145 (340d) → Pm-145 (17.7y) → Nd-145 (stable)
Pm-146	61	5.53	years	AP	No	
Pm-147	61	2.6234	years	FP, AP-neutrons Daughter Nd-147 (11d, FP, AP, Decay)	No	Pr-147 (13.4m, FP, AP) → Nd-147 (11d) → Pm-147 (2.6y) → Sm-147 (1.1E11y) → Nd-143 (stable)
Pm-148	61	5.368	days	AP-neutrons Daughter Pm-148m (41.3d, AP)	No	
Pm-148m	61	41.29	days	AP-neutrons	No	
Pm-149	61	53.08	hours	FP, AP-neutrons Daughter Nd-149 (1.7h, AP)	No	
Pm-150	61	2.68	hours	AP	No	
Pm-151	61	28.40	hours	FP, AP-neutrons Daughter Nd-151 (12.4m, AP)	No	
Po-203	84	36.7	minutes	AP	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Po-205	84	1.74	hours	AP	No	
Po-207	84	5.80	hours	AP Daughter At-207 (1.8h, AP)	No	
Po-209	84	102.00	years	AP	No	
Po-210	84	138.376	days	AP-neutrons Daughter Bi-210 (5d, AP, Decay)	Yes	Descendant of U-238 via U-series decay chain
Po-211	84	0.516	seconds	Daughter Bi-211 (2.1m, Decay) Daughter At-211 (7.2h, AP)	Yes	Descendant of U-235 via Ac-series decay chain
Po-212	84	3.00E-07	seconds	Daughter Bi-212 (60.6m, Decay)	Yes	Descendant of Th-232 via Th-series decay chain
Po-212m	84	2.98E-07	seconds	AP	No	
Po-213	84	3.65E-06	seconds	Daughter Bi-213 (45.6m, Decay)	Yes	Descendant of Pu-241 via Np-series decay chain
Po-214	84	1.643E-04	seconds	Daughter Bi-214 (19.9m, Decay) Daughter Rn-218 (<1s, Decay)	Yes	Descendant of U-238 via U-series decay chain
Po-215	84	1.781E-03	seconds	AP-neutrons Daughter Rn-219 (4s, Decay)	Yes	Descendant of U-235 via Ac-series decay chain
Po-216	84	0.145	seconds	Daughter Rn-220 (55.6s, Decay)	Yes	Descendant of Th-232 via Th-series decay chain
Po-218	84	3.10	minutes	Daughter Rn-222 (3.8d, Decay)	Yes	Descendant of U-238 via U-series decay chain
Pr-136	59	13.1	minutes	AP Daughter Nd-136 (50.6m, AP)	No	
Pr-137	59	1.28	hours	AP	No	
Pr-138	59	1.45	minutes	Daughter Nd-138 (5h, AP)	No	
Pr-138m	59	2.12	hours	AP	No	
Pr-139	59	4.41	hours	AP Daughter Nd-139 (29.7m, Decay) Daughter Nd-139m (5.5h, AP)	No	Nd-139m (5.5h, AP) → Nd-139 (29.7m) → Pr-139 (4.4h) → Ce-139 (138d) → La-139 (stable)
Pr-142	59	19.12	hours	AP-neutrons Daughter Pr-142m (14.6m, AP)	No	
Pr-142m	59	14.6	minutes	AP	No	
Pr-143	59	13.57	days	FP, AP-neutrons Daughter Ce-143 (33h, FP, AP, Decay)	No	La-143 (14.2m, FP) → Ce-143 (33h) → Pr-143 (13.6m) → Nd-143 (stable)
Pr-144	59	17.28	minutes	FP Daughter Ce-144 (285d, FP) Daughter Pr-144m (7.2m, FP, Decay)	No	Ce-144 (285d, FP) → Pr-144m (7.2m) → Pr-144 (17.3m) → Nd-144 (2.3E15y) → Ce-140 (stable)
Pr-144m	59	7.2	minutes	FP Daughter Ce-144 (285d, FP)	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Pr-145	59	5.984	hours	FP	No	
Pr-147	59	13.4	minutes	FP, AP	No	
Pt-186	78	2.08	hours	AP	No	
Pt-188	78	10.2	days	AP	No	
Pt-189	78	10.87	hours	AP	No	
Pt-191	78	2.862	days	AP	No	
Pt-193	78	50	years	AP-neutrons Daughter Au-193 (17.7h, AP, Decay) Daughter Pt-193m (4.3d, AP)	No	Hg-193m (11.8h, AP) → Hg-193 (4h) → Au-193 (18h) → Pt-193 (50y) → Ir-193 (stable)
Pt-193m	78	4.33	days	AP-neutrons	No	
Pt-195m	78	4.010	days	AP-neutrons	No	
Pt-197	78	19.8915	hours	AP-neutrons Daughter Pt-197m (95.4m, AP)	No	
Pt-197m	78	95.41	minutes	AP-neutrons	No	
Pt-199	78	30.80	minutes	AP-neutrons	No	
Pt-200	78	12.5	hours	AP-neutrons	No	
Pu-234	94	8.8	hours	AP Daughter Cm-238 (2.4h, AP)	No	90% of Cm-238 (2.4h) → Am-238 (98m) → Pu-238 (88y) → U-234 (in Uranium Series); 10% of Cm-238 (2.4h) → Pu-234 (8.8h) → Np-234 (4.4d) and U-230; U-230 → Po-214 in ; U-234 (in Uranium Series)
Pu-235	94	25.3	minutes	AP	No	
Pu-236	94	2.858	years	AP Daughter Cm-240 (27d, AP, Decay) Daughter Np-236 (1.5E5y, AP) Daughter Np-236m (22.5h, AP)	Yes	Cf-244 (19.4m) → Cm-240 (27d) → Pu-236 (2.8y) → U-232 (69y) → Th-228 (in Thorium Series)
Pu-237	94	45.2	days	AP Daughter Am-237 (73m, AP) Daughter Cm-241 (32.8d, AP)	No	
Pu-238	94	87.7	years	Daughter Am-238 (98m, AP, Decay) Daughter Cm-242 (162.8d, AP, Decay) Daughter Np-238 (2.1d, AP)	No	Cm-238 (2.4h, AP) → Am-238 (98m) → Pu-238 (88y) → U-234 (in Uranium Series); Am-242m (141y, AP) → Am-242 (16h) → Cm-242 (163d) → Pu-238 (88y) → U-234 (in Uranium Series)

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Pu-239	94	24,110	years	AP-neutrons Daughter Am-239 (11.9h, AP) Daughter Cm-243 (29.1y, AP) Daughter Np-239 (2.4d, AP, Decay)	No	U-239 (24m) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)
Pu-240	94	6,561	years	AP-multiple n-capture Daughter Am-240 (50.8h, AP) Daughter Np-240m (7.2m, AP) Daughter Cm-244 18.1y, AP, Decay) Daughter Np-240 (61.9m, AP, Decay)	Yes	[Am-244m (26m, AP) and Am-244 (10h, AP)] → Cm-244 (18y, AP, Decay) → Pu-240 (6.6E3y, AP, Decay) → U-236 (2.3E7y, AP, Decay) → Th-232 (in Thorium Series) (1.4E10, Decay, Primordial); Cf-252 (2.6y) → Cm-248 (3.5E5y) → Pu-244 (8E7y) → U-240 (14h) → Np-240 (62m) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 (in Thorium Series)
Pu-241 (Neptunium Series)	94	14.290	years	AP-multiple n-capture Daughter Cm-245 (8.5E3y, AP, Decay)	Yes	Cm-250 (8.3E3y, AP) → Pu-246 (11d) → Am-246 (39m) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)
Pu-242	94	3.75E+05	years	AP-multiple n-capture Daughter Am-242 (16.2h, AP, Decay) Daughter Cm-246 (4.8E3y, AP, Decay)	Yes	Am-242m (141y, AP) → Am-242 (16h) → Cm-242 (163d) → Pu-238 (88y) → U-234 (in Uranium Series); Am-242 (16h) → Pu-242 (3.75E5y) → U-238 (in Uranium Series); Cm-250 (8.3E3y) → Bk-250 (3.2h) → Cf-250 (13y) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series)
Pu-243	94	4.956	hours	AP-neutrons Daughter Cm-247 (1.6E7y, AP, Decay)	Yes	Cf-251(9E2y, AP) → Cm-247(1.6E7y) → Pu-243 (5h) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)
Pu-244	94	8.00E+07	years	AP-multiple n-capture Daughter Cm-248 (3.5E8y, AP, Decay)	Yes	Cf-252 (2.6y, AP) → Cm-248 (3.5E5y) → Pu-244 (8E7y) → U-240 (14h) → Np-240 (62m) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 in Thorium Series
Pu-245	94	10.5	hours	AP-neutrons, multiple n-capture	No	
Pu-246	94	10.84	days	AP-multiple n-capture Daughter Cm-250 (8.3E3y, AP)	Yes	
Ra-222	88	38.0	seconds	Daughter Fr-222 (14.2m, AP) Daughter Th-226 (30.6m, Decay)	No	Ac-226 (29.4h) → Th-226 (31m) → Ra-222 (38s) → Rn-218 (<1s) → Po-214 in Uranium Series
Ra-223	88	11.430	days	Daughter Ac-223 (2.1m, Decay) Daughter Fr-223 (22m, Decay) Daughter Th-227 (18.7d, AP, Decay)	Yes	Descendant of U-235 via Ac-series decay chain
Ra-224	88	3.63	days	Daughter Th-228 (1.9y, AP, Decay) Daughter Ac-224 (2.8h, Decay)	Yes	Descendant of Th-232 via Th-series decay chain
Ra-225	88	14.9	days	Daughter Th-229 (7.3E3y, Decay)	Yes	Descendant of Pu-241 via Np-series decay chain

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Ra-226	88	1,600	years	Daughter Th-230 (7.5E4y, Decay) Daughter Ac-226 (29.4h, AP)	Yes	Descendant of U-238 via U-series decay chain
Ra-227	88	42.2	minutes	AP-neutrons	No	
Ra-228	88	5.75	years	Daughter Th-232 (1.4E10y, Natural, Decay)	Yes	Descendant of Th-232 via Th-series decay chain
Rb-79	37	22.9	minutes	AP	No	
Rb-80	37	33.4	seconds	Daughter Sr-80 (106.3m, AP)	No	
Rb-81	37	4.570	hours	Daughter Sr-81 (22.3m, AP) Daughter Rb-81m (30.5m, AP)	No	
Rb-81m	37	30.5	minutes	AP	No	
Rb-82	37	1.273	minutes	Daughter Sr-82 (25.6d, AP)	No	
Rb-82m	37	6.472	hours	AP	No	
Rb-83	37	86.2	days	AP Daughter Sr-83 (32.4h, AP)	No	
Rb-84	37	33.1	days	AP	No	
Rb-86	37	18.642	days	AP-neutrons	No	
Rb-87	37	4.97E+10	years	FP Naturally occurring (Primordial) Daughter Kr-87 (76.3m, FP, AP) Daughter Sr-87m (2.8h, AP)	No	[Kr-87 (76.3m, FP, AP) and Sr-87m (2.8h, AP)] → Rb-87 (4.7E10y) → Sr-87 (stable)
Rb-88	37	17.773	minutes	FP, AP-neutrons Daughter Kr-88 (2.8h, FP)	No	
Rb-89	37	15.15	minutes	FP	No	
Re-177	75	14	minutes	AP	No	
Re-178	75	13.2	minutes	AP	No	
Re-180	75	2.44	minutes	AP Daughter Os-180 (21.5m, AP)	No	
Re-181	75	19.9	hours	AP Daughter Os-181 (105m, AP)	No	
Re-182	75	64.0	hours	AP Daughter Os-182 (22.1h, AP, Decay)	No	Ir-182 (15m, AP) → Os-182 (22h) → Re-182 (64h) → W-182 (stable)
Re-182m	75	12.7	hours	AP	No	
Re-184	75	38.0	days	AP-neutrons Daughter Re-184m (169d, AP)	No	
Re-184m	75	169	days	AP-neutrons	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Re-186	75	3.7186	days	AP Daughter Re-186m (2E5y, AP)	Yes	
Re-186m	75	2.0E+05	years	AP	No	
Re-187	75	4.12E+10	years	Naturally occurring (Primordial) Daughter W-187 (23.7h, AP)	No	
Re-188	75	17.003	hours	AP-neutrons Daughter Re-188m (18.6m, AP) Daughter W-188 (69.8d, AP)	No	
Re-188m	75	18.59	minutes	AP-neutrons	No	
Re-189	75	24.3	hours	AP-neutrons	No	
Rh-100	45	20.8	hours	AP Daughter Pd-100 (3.6d, AP)	No	
Rh-101	45	3.3	years	AP Daughter Rh-101m (4.3d, AP) Daughter Pd-101 (8.5h, AP)	No	
Rh-101m	45	4.34	days	AP	No	
Rh-102	45	208	days	AP Daughter Rh-102m (2.9y, AP)	Yes	
Rh-102m	45	2.9	years	AP	No	
Rh-103m	45	56.114	minutes	FP Daughter Ru-103 (39.3d, FP, AP)	No	
Rh-105	45	35.36	hours	FP, AP-neutrons Daughter Ru-105 (4.4h, FP, AP) Daughter Rh-105m (56m, FP, Decay)	No	Ru-105 (4.4h, FP, AP) → Rh-105m (56m) → Rh-105 (35 h) → Pd-105 (stable)
Rh-105m	45	56.00	minutes	FP Daughter Ru-105 (4.4h, FP, AP)	No	
Rh-106	45	29.80	seconds	FP Daughter Ru-106 (374d, FP)	No	
Rh-106m	45	131	minutes	AP-neutrons	No	
Rh-107	45	21.7	minutes	FP, AP	No	
Rh-99	45	16.1	days	AP	No	
Rh-99m	45	4.7	hours	AP	No	
Rn-218	86	0.035	seconds	Daughter Ra-222 (38s, Decay)	No	10% of Cm-238 (2.4h, AP) → Pu-234 (8.8h, AP, Decay) → U-230 (21d) → Th-226 (31m) → Ra-222 (38s) → Rn-218 (<1s) → Po-214 (in Uranium Series)
Rn-219	86	3.96	seconds	Daughter Ra-223 (11.4d, Decay)	Yes	Descendant of U-235 via Ac-series decay chain

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Rn-220	86	55.6	seconds	Daughter Ra-224 (3.6d, Decay)	Yes	Descendant of Th-232 via Th-series decay chain
Rn-222	86	3.8235	days	Daughter Ra-226 (1.6E3y, Decay)	Yes	Descendant of U-238 via U-series decay chain
Ru-103	44	39.26	days	FP, AP-neutrons	No	
Ru-105	44	4.44	hours	FP, AP-neutrons	No	
Ru-106	44	373.59	days	FP	No	
Ru-94	44	51.8	minutes	AP	No	
Ru-97	44	2.791	days	AP-neutrons	No	
S-35	16	87.51	days	AP-neutrons	No	
Sb-115	51	32.1	minutes	AP	No	
Sb-116	51	15.8	minutes	AP Daughter Te-116 (2.5h, AP)	No	
Sb-116m	51	60.3	minutes	AP	No	
Sb-117	51	2.80	hours	AP	No	
Sb-118m	51	5.00	hours	AP	No	
Sb-119	51	38.19	hours	AP	No	
Sb-120	51	15.89	minutes	AP	No	
Sb-120m	51	5.76	days	AP	No	
Sb-122	51	2.7238	days	AP-neutrons	No	
Sb-124	51	60.11	days	AP-neutrons Daughter Sb-124n (20.2m, AP) Daughter Sb-124m (93s, AP)	No	
Sb-124m	51	93	seconds	AP-neutrons	No	
Sb-124n	51	20.2	minutes	AP-neutrons	No	
Sb-125	51	2.75856	years	FP, AP-neutrons Daughter Sn-125 (9.6d, FP, AP)	No	
Sb-126	51	12.35	days	FP Daughter Sb-126m (19.1m, FP, AP, Decay) Daughter Sn-126 (2.3E5y, FP)	Yes	Sn-126 (2.3E5y, FP) → Sb-126m (19.5m) and Sb-126 (12.3d) → Te-126 (stable)
Sb-126m	51	19.15	minutes	FP, AP-neutrons Daughter Sn-126 (2.3E5y, FP)	Yes	Sn-126 (2.3E5y, FP) → Sb-126m (19.5m) and Sb-126 (12.3d) → Te-126 (stable)
Sb-127	51	3.85	days	FP Daughter Sn-127 (2.1h, FP, AP)	No	
Sb-128	51	9.01	hours	AP-neutrons Daughter Sb-128m (10.4m, FP, AP, Decay)	No	Sn-128 (59m, FP) → [Sb-128m (10m) and Sb-128 (9h)] → Te-128 (stable)

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Sb-128m	51	10.4	minutes	FP, AP-neutrons Daughter (Sn-128, 59m, FP)	No	
Sb-129	51	4.40	hours	FP	No	
Sb-130	51	39.5	minutes	FP, AP-neutrons	No	
Sb-131	51	23.03	minutes	FP	No	
Sc-43	21	3.891	hours	AP	No	
Sc-44	21	3.97	hours	AP Daughter Sc-44m (58.6h, AP) Daughter Ti-44 (60y, AP)	Yes	
Sc-44m	21	58.61	hours	AP	No	
Sc-46	21	83.79	days	AP-neutrons	No	
Sc-47	21	3.3492	days	Daughter Ca-47 (4.5d, AP)	No	
Sc-48	21	43.67	hours	AP-neutrons	No	
Sc-49	21	57.2	minutes	AP Daughter Ca-49 (8.7m, AP)	No	
Se-70	34	41.1	minutes	AP	No	
Se-73	34	7.15	hours	AP Daughter Se-73m (39.8m, AP)	No	
Se-73m	34	39.8	minutes	AP	No	
Se-75	34	119.779	days	AP-neutrons Daughter Br-75 (96.7m, AP)	No	
Se-77m	34	17.36	seconds	AP-neutrons	No	
Se-79	34	2.95E+05	years	FP Daughter Se-79m (3.9m, FP, AP, Decay) Daughter As-79 (9m, FP, AP)	No	As-79 (9m, FP, AP) → Se-79m (3.9m, FP, AP, Decay) → Se-79 (3E5y) → Br-79 (stable)
Se-79m	34	3.9	minutes	FP, AP-neutrons Daughter As-79 (9m, FP, AP)	No	
Se-81	34	18.45	minutes	FP, AP Daughter Se-81m (57.3m, FP, AP)	No	
Se-81m	34	57.28	minutes	FP, AP-neutrons	No	
Se-83	34	22.3	minutes	FP, AP-neutrons	No	
Si-31	14	157.3	minutes	AP-neutrons	No	
Si-32	14	132	years	AP	No	
Sm-141	62	10.2	minutes	AP	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Sm-141m	62	22.6	minutes	AP	No	
Sm-142	62	72.49	minutes	AP	No	
Sm-145	62	340	days	AP-neutrons Daughter Eu-145 (5.9d, AP, Decay)	No	Gd-145 (23m, AP) → Eu-145 (6d) → Sm-145 (340d) → Pm-145 (17.7y) → Nd-145 (stable)
Sm-146	62	1.03E+08	years	AP-neutrons Daughter Eu-146 (4.6d, AP, Decay) Daughter Pm-146 (5.5y, AP) Daughter Gd-150 (1.8E6y, AP, Decay)	Yes	[Gd-146 (48d) and Tb-150 (3.5h)] → Eu-146 (4.6d) → Sm-146 (1E8y) → Nd-142 (stable); Eu-150m (12.8h) → Gd-150 (1.8E6y) → Sm-146 (1.03E8y) → Nd-142 (stable)
Sm-147	62	1.06E+11	years	FP Naturally occurring (Primordial) Daughter Pm-147 (2.6y, FP, AP, Decay) Daughter Eu-147 (24.1d, AP, Decay)	Yes	Pr-147 (13.4m) → Nd-147 (11d) → Pm-147 (2.6y) → Sm-147 (1.1E11y) → Nd-143 (stable); Tb-147 (1.7h) → Gd-147 (38h) → Eu-147 (24d) → Sm-147 (1E6y) → Nd-143 (stable)
Sm-148	62	7E+15	years	Naturally occurring (Primordial) Daughter Pm-148 (5.4d, AP, Decay) Daughter Pm-148m (41.3d, AP) Daughter Eu-148 (54.5d, AP) Daughter Gd-152 (1.1E14y, Natural)	Yes	Pm-148m (41.3d, AP) → Pm-148 (5.4d) → Sm-148 (7E15y) → Nd-144 (2.3E15y) → Ce-140 (stable)
Sm-149	62	2E+15	years	FP Daughter Pm-149 (53.1h, FP, AP, Decay)	No	Nd-149 (1.7h, AP) → Pm-149 (53h) → Sm-149 (2E15y) → Nd-145 (stable)
Sm-151	62	90	years	FP Daughter Pm-151 (28.4h, FP, AP, Decay)	No	Nd-151 (12.4m) → Pm-151 (28h) → Sm-151 (90y) → Eu-151 (stable)
Sm-153	62	46.284	hours	FP, AP-neutrons	No	
Sm-155	62	22.3	minutes	FP, AP-neutrons	No	
Sm-156	62	9.4	hours	FP	No	
Sn-110	50	4.11	hours	AP	No	
Sn-111	50	35.3	minutes	AP	No	
Sn-113	50	115.09	days	AP-neutrons	No	
Sn-117m	50	13.76	days	AP-neutrons	No	
Sn-119m	50	293.1	days	AP-neutrons	No	
Sn-121	50	27.03	hours	FP, AP-neutrons Daughter Sn-121m (43.9y, FP, AP)	Yes	Sn-121m (43.9y, FP, AP) → Sn-121 (27h) → Sb-121 (stable)

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Sn-121m	50	43.9	years	FP, AP-neutrons	No	
Sn-123	50	129.2	days	FP, AP-neutrons	No	
Sn-123m	50	40.06	minutes	FP, AP-neutrons	No	
Sn-125	50	9.64	days	FP, AP-neutrons	No	
Sn-126	50	2.3E+05	years	FP	No	
Sn-127	50	2.10	hours	FP, AP-neutrons	No	
Sn-128	50	59.07	minutes	FP	No	
Sr-80	38	106.3	minutes	AP	No	
Sr-81	38	22.3	minutes	AP	No	
Sr-82	38	25.55	days	AP	No	
Sr-83	38	32.41	hours	AP	No	
Sr-85	38	64.84	days	AP-neutrons Daughter Sr-85m (67.6m, AP)	No	
Sr-85m	38	67.63	minutes	AP-neutrons	No	
Sr-87m	38	2.815	hours	AP-neutrons	No	
Sr-89	38	50.57	days	FP, AP-neutrons Daughter Rb-89 (15.1m, FP)	No	
Sr-90	38	28.90	years	FP	No	
Sr-91	38	9.63	hours	FP, AP-neutrons	No	
Sr-92	38	2.66	hours	FP	No	
Ta-172	73	36.8	minutes	AP	No	
Ta-173	73	3.14	hours	AP	No	
Ta-174	73	1.14	hours	AP	No	
Ta-175	73	10.5	hours	AP	No	
Ta-176	73	8.09	hours	AP Daughter W-176 (2.5h, AP)	No	
Ta-177	73	56.56	hours	AP Daughter W-177 (132m, AP, Decay)	No	Re-177 (14m, AP) → W-177 (135m) → Ta-177 (57h) → Hf-177 (stable)
Ta-178	73	9.31	minutes	Daughter W-178 (21.6d, AP, Decay)	No	Re-178 (13.2m, AP) → W-178 (22d) → Ta-178 (9m) → Hf-178 (stable)
Ta-178m	73	2.36	hours	AP	No	
Ta-179	73	1.82	years	AP Daughter W-179 (37.1m, AP)	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Ta-180	73	8.154	hours	AP-neutrons	No	
Ta-180m	73	1.2E+15	years	Naturally occurring (Primordial)	No	
Ta-182	73	114.43	days	AP-neutrons Daughter Hf-182 (8.9E6y, AP, Decay) Daughter Hf-182m (61.5m, AP) Daughter Ta-182m (15.9m, AP)	Yes	Hf-182m (61.5m, AP) → Hf-182 (9E6y) → Ta-182 (114d) → W-182 (stable)
Ta-182m	73	15.84	minutes	AP-neutrons	No	
Ta-183	73	5.1	days	AP-neutrons Daughter Hf-183 (1.1h, AP)	No	
Ta-184	73	8.7	hours	AP-neutrons Daughter Hf-184 (4.1h, AP)	No	
Ta-185	73	49.4	minutes	AP-neutrons	No	
Ta-186	73	10.5	minutes	AP-neutrons	No	
Tb-147	65	1.7	hours	AP	No	
Tb-149	65	4.118	hours	AP	No	
Tb-150	65	3.48	hours	AP	No	
Tb-151	65	17.609	hours	AP	No	
Tb-153	65	2.34	days	AP	No	
Tb-154	65	21.5	hours	AP	No	
Tb-155	65	5.32	days	AP Daughter Dy-155 (9.9h, AP, Decay)	No	Ho-155 (48m, AP) → Dy-155 (9.9h) → Tb-155 (5.3d) → Gd-155 (stable)
Tb-156	65	5.35	days	AP Daughter Tb-156m (24.4h, AP)	No	
Tb-156m	65	24.4	hours	AP	No	
Tb-156n	65	5.3	hours	AP	No	
Tb-157	65	71	years	AP-neutrons Daughter Dy-157 (8.1h, AP, Decay)	No	Ho-157 (12.6m, AP) → Dy-157 (8.1h) → Tb-157 (71y) → Gd-157 (stable)
Tb-158	65	180	years	AP-neutrons	No	
Tb-160	65	72.3	days	AP-neutrons	No	
Tb-161	65	6.906	days	FP, AP-neutrons	No	
Tc-101	43	14.22	minutes	FP, AP-neutrons Daughter Mo-101 (14.6m, FP, AP)	No	
Tc-104	43	18.3	minutes	FP, AP-neutrons	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Tc-93	43	2.75	hours	AP Daughter Tc-93m (43.5m, AP)	No	
Tc-93m	43	43.5	minutes	AP	No	
Tc-94	43	293	minutes	AP Daughter Ru-94 (51.8m, AP)	No	
Tc-94m	43	52.0	minutes	AP	No	
Tc-95	43	20.0	hours	AP Daughter Tc-95m (61d, AP)	No	
Tc-95m	43	61	days	AP	No	
Tc-96	43	4.28	days	AP Daughter Tc-96m (51.5m, AP)	No	
Tc-96m	43	51.5	minutes	AP	No	
Tc-97	43	4.21E+06	years	AP-neutrons Daughter Ru-97 (2.8d, AP) Daughter Tc-97m (91.4d, AP)	No	
Tc-97m	43	91.4	days	AP-neutrons	No	
Tc-98	43	4.2E+06	years	AP-neutrons	No	
Tc-99	43	2.111E+05	years	FP, AP-neutrons Daughter Tc-99m (6h, FP, Decay) Daughter Mo-99 (2.7d, FP, AP)	No	Mo-99 (2.7d, FP, AP) → Tc-99m (6h) → Tc-99 (2.1E5y) → Ru-99 (stable)
Tc-99m	43	6.0058	hours	FP Daughter Mo-99 (2.7d, FP, AP)	No	
Te-116	52	2.49	hours	AP	No	
Te-118	52	6.00	days	AP	No	
Te-121	52	19.16	days	AP-neutrons Daughter Te-121m (154d, AP) Daughter I-121 (2.1h, AP, Decay)	No	Xe-121 (40m, AP) → I-121 (2.1h) → Te-121 (19d) → Sb-121 (stable)
Te-121m	52	154	days	AP-neutrons	No	
Te-123	52	9.2E+16	years	Naturally occurring (Primordial) Daughter Te-123m (119d, AP) Daughter I-123 (13.2h, AP, Decay)	No	Xe-123 (2.1h, AP) → I-123 (13.3h) → Te-123 (6E14y) → Sb-123 (stable)
Te-123m	52	119.2	days	AP-neutrons	No	
Te-125m	52	57.40	days	FP, AP-neutrons Daughter Sb-125 (2.8y, FP, AP, Decay)	Yes	Sn-125 (9.6d, FP, AP) → Sb-125 (2.8y) → Te-125m (57.4d) → Te-125 (stable)

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Te-127	52	9.35	hours	FP, AP-neutrons Daughter Te-127m (109d, FP, AP, Decay) Daughter Sb-127 (3.8d, FP, Decay)	No	Sn-127 (2.1h, FP, AP) → Sb-127 (3.8d) → 83.2% Te-127 (9.35h) and 16.8% Te-127m (109d); Te-127m (109d) → 97.6% Te-127 (9.3h) and 2.4% I-127 (stable); Te-127 (9.35h) → I-127 (stable);
Te-127m	52	109	days	FP, AP-neutrons Daughter Sb-127 (3.8d, FP, Decay)	No	Sn-127 (2.1h, FP, AP) → Sb-127 (3.8d) → 83.2% Te-127 (9.35h) and 16.8% Te-127m; Te-127m (109d) → 97.6% Te-127 (9.3h) and 2.4% I-127 (stable); Te-127 (9.35h) → I-127 (stable);
Te-129	52	69.6	minutes	FP, AP-neutrons Daughter Te-129m (33.6d, FP, AP, Decay) Daughter Sb-129 (4.4h, FP)	No	Sb-129 (4.4h, FP) → 83.4% Te-129 (70m) and 16.6% Te-129m (33.6d); Te-129m (33.6d) → 69% Te-129 (70m) and 31% I-129 (1.6E7y) → Xe-129 (stable)
Te-129m	52	33.6	days	FP, AP-neutrons Daughter Sb-129 (4.4h, FP)	No	
Te-131	52	25.0	minutes	FP, AP-neutrons Daughter Te-131m (30h, FP, AP, Decay) Daughter Sb-131 (23m, FP)	No	Sb-131 (23m, FP) → Te-131m (30h) and Te-131 (25m) → I-131 (8d) → Xe-131 (stable)
Te-131m	52	30	hours	FP, AP-neutrons Daughter Sb-131 (23m, FP)	No	
Te-132	52	3.204	days	FP	No	
Te-133	52	12.5	minutes	FP Daughter Te-133m (55.4m, FP)	No	
Te-133m	52	55.4	minutes	FP	No	
Te-134	52	41.8	minutes	FP	No	
Th-226	90	30.57	minutes	Daughter U-230 (20.8d, Decay) Daughter Ac-226 (29.4h, AP)	No	10% of Cm-238 (2.4h, AP) → Pu-234 (8.8h, AP, Decay) → U-230 (21d) → Th-226 (31m) → Ra-222 (38s) → Rn-218 (<1s) → Po-214 (in Uranium Series)
Th-227	90	18.68	days	AP-neutrons Daughter Ac-227 (21.8y, AP, Decay) Daughter Pa-227 (38.3m, AP)	Yes	Descendant of U-235 via Ac-series decay chain
Th-228	90	1.9116	years	AP-neutrons Daughter Ac-228 (6.1h, Decay) Daughter U-232 (68.9y, AP, Decay) Daughter Pa-228 (22h, AP)	Yes	Descendant of Th-232 via Th-series decay chain
Th-229	90	7,340	years	Daughter U-233 (1.6E5y, AP, Decay)	Yes	Descendant of Pu-241 via Np-series decay chain

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Th-230	90	7.538E+04	years	Daughter U-234 (2.5E5y, Decay) Daughter Pa-230 (17.4d, Decay)	Yes	Descendant of U-238 via U-series decay chain
Th-231	90	25.52	hours	AP-neutrons Daughter U-235 (7E8y, Natural, Decay)	Yes	Descendant of U-235 via Ac-series decay chain
Th-232 (Thorium Series)	90	1.405E+10	years	Naturally occurring (Primordial) Daughter U-236 (2.3E7y, AP, Decay)	Yes	Fm-252 (25h) → Cf-248 (334d) → Cm-244 (18y) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 (in Thorium Series); Cf-252 (2.6y) → Cm-248 (3.5E5y) → Pu-244 (8E7y) → U-240 (14h) → Np-240 (62m) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 (in Thorium Series)
Th-234	90	24.10	days	Daughter U-238 (4.5E9y, AP, Natural, Decay)	Yes	Descendant of U-238 via U-series decay chain
Ti-44	22	60.0	years	AP	No	
Ti-45	22	184.8	minutes	AP	No	
Tl-194	81	33.0	minutes	AP	No	
Tl-194m	81	32.8	minutes	AP	No	
Tl-195	81	1.16	hours	AP Daughter Pb-195m (15m, AP)	No	
Tl-197	81	2.84	hours	AP	No	
Tl-198	81	5.3	hours	AP Daughter Tl-198m (1.9h, AP) Daughter Pb-198 (2.4h, AP)	No	
Tl-198m	81	1.87	hours	AP	No	
Tl-199	81	7.42	hours	AP Daughter Pb-199 (90m, AP)	No	
Tl-200	81	26.1	hours	AP Daughter Pb-200 (21.5h, AP, Decay)	No	Bi-200 (36m, AP) → Pb-200 (21h) → Tl-200 (26h) → Hg-200 (stable)
Tl-201	81	72.912	hours	AP Daughter Pb-201 (9.3h, AP, Decay)	No	Bi-201 (108m, AP) → Pb-201 (9h) → Tl-200 (26h) → Hg-200 (stable)
Tl-202	81	12.23	days	AP Pb-202 (5.2E4y, AP, Decay) Pb-202m (3.5h, AP)	Yes	Po-202 (45m, AP, not on table) → Bi-202 (1.7h) → Pb-202 (5E4y) → Tl-202 (12d) and Hg-198 (stable); Tl-202 (12d) → Hg-202 (stable)
Tl-204	81	3.78	years	AP-neutrons	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Tl-206	81	4.200	minutes	AP-neutrons Daughter Bi-210m (3E6y, AP)	Yes	
Tl-207	81	4.77	minutes	Daughter Bi-211 (2.1m, Decay)	Yes	Descendant of U-235 via Ac-series decay chain
Tl-208	81	3.053	minutes	Daughter Bi-212 (60.6m, Decay)	Yes	Descendant of Th-232 via Th-series decay chain
Tl-209	81	2.161	minutes	Daughter Bi-213 (45.6m, Decay)	Yes	Descendant of Pu-241 via Np-series decay chain
Tl-210	81	1.30	minutes	Daughter Bi-214 (19.9m, Decay)	Yes	Descendant of U-238 via U-series decay chain
Tm-162	69	21.70	minutes	AP Daughter Yb-162 (18.9m, AP)	No	
Tm-166	69	7.70	hours	AP Daughter Yb-166 (56.7h, AP)	No	
Tm-167	69	9.25	days	AP Daughter Yb-167 (17.5m, AP)	No	
Tm-170	69	128.6	days	AP-neutrons	No	
Tm-171	69	1.92	years	AP-neutrons Daughter Er-171 (7.5h, AP)	No	
Tm-172	69	63.6	hours	Daughter Er-172 (49.3h, AP)	No	
Tm-173	69	8.24	hours	AP-neutrons	No	
Tm-175	69	15.2	minutes	AP	No	
U-230	92	20.8	days	Daughter Pu-234 (8.8h, AP, Decay) Daughter Pa-230 (17.4d, AP)	No	10% of Cm-238 (2.4h, AP) → Pu-234 (8.8h) → U-230 (21d) → Th-226 (31m) → Ra-222 (38s) → Rn-218 (<1s) → Po-214 (in Uranium Series)
U-231	92	4.2	days	AP	No	
U-232	92	68.9	years	AP Daughter Pa-232 (1.3d, AP) Daughter Np-232 (14.7m, AP) Daughter Pu-236 (2.9y, AP, Decay)	Yes	{Pa-232 (1.3d, AP) and Np-232 (14.7m, AP) and Pu-236 (2.9y, AP, Decay) and Np-232 (14.7m, AP)} → U-232 (69y) → Th-228 (in Thorium Series); Cf-244 (19.4m) → Cm-240 (27d) → Pu-236 (2.8y) → U-232 (69y) → Th-228 (in Thorium Series)
U-233	92	1.592E+05	years	AP-neutrons Daughter Pa-233 (27d, AP, Decay) Daughter Np-233 (36.2m, AP)	Yes	Descendant of Pu-241 via Np-series decay chain
U-234	92	2.455E+05	years	Daughter Pa-234 (6.7h, Decay) Daughter Np-234 (4.4d, AP, Decay) Daughter Pu-238 (87.7y, Decay) Daughter Pa-234m (1.2m, AP)	Yes	Descendant of U-238 via U-series decay chain

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
U-235 (Actinium Series)	92	7.04E+08	years	Naturally occurring (Primordial) Daughter Pu-239 (2.4E3y, AP, Decay) Daughter Np-235 (396d, AP, Decay)	Yes	Am-239 (11.9h, AP) → Pu-239 (2.4E4y) → U-235 (in Actinium Series); Cm-243 (29.1y, AP) → Pu-239 (2.4E4y) → U-235 (in Actinium Series); Pu-235 (25m, AP) → Np-235 (396d) → U-235 (in Actinium Series)
U-236	92	2.342E+07	years	AP-neutrons Daughter Np-236 (1.5E5y, AP) Daughter Np-236m (22.5h, AP) Daughter Pu-240 (6.6E3y, AP, Decay)	Yes	Fm-252 (25h) → Cf-248 (334d) → Cm-244 (18y) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 (in Thorium Series); Cf-252 (2.6y) → Cm-248 (3.5E5y) → Pu-244 (8E7y) → U-240 (14h) → Np-240 (62m) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 (in Thorium Series)
U-237	92	6.75	days	AP-neutrons	No	
U-238 (Uranium Series)	92	4.468E+09	years	AP-neutrons Naturally occurring (Primordial) Daughter Pu-242 (3.7E5y, AP, Decay)	Yes	Am-242m (141y, AP) → Am-242 (16h) → Pu-242 (3.75E5y) → U-238 (in Uranium Series)
U-239	92	23.45	minutes	AP-neutrons	No	
U-240	92	14.1	hours	AP-multiple n-capture Daughter Pu-244 (8E7y, AP, Decay)	Yes	Cf-252 (2.6y, AP) → Cm-248 (3.5E5y) → Pu-244 (8E7y) → U-240 (14h) → Np-240 (62m) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 in Thorium Series
V-47	23	32.6	minutes	AP	No	
V-48	23	15.9735	days	AP Daughter Cr-48 (21.6h, AP)	No	
V-49	23	329	days	AP Daughter Cr-49 (42m, AP)	No	
V-50	23	1.4E+17	years	Naturally occurring (Primordial)	No	
W-176	74	2.5	hours	AP	No	
W-177	74	132	minutes	AP Daughter Re-177 (14m, AP)	No	
W-178	74	21.6	days	AP Daughter Re-178 (13.2m, AP)	No	
W-179	74	37.05	minutes	AP	No	
W-181	74	121.20	days	AP Daughter Re-181 (19.9h, AP, Decay)	No	
W-185	74	75.1	days	AP-neutrons Daughter Ta-185 (49.4m, AP)	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
W-187	74	23.72	hours	AP-neutrons	No	
W-188	74	69.78	days	AP-neutrons	No	
Xe-120	54	40	minutes	AP	No	
Xe-121	54	40.1	minutes	AP	No	
Xe-122	54	20.1	hours	AP	No	
Xe-123	54	2.08	hours	AP	No	
Xe-125	54	16.9	hours	AP-neutrons Daughter Cs-125 (46.7m, AP)	No	
Xe-127	54	36.4	days	AP-neutrons Daughter Cs-127 (6.2h, AP)	No	
Xe-129m	54	8.88	days	AP-neutrons	No	
Xe-131m	54	11.934	days	AP-neutrons	No	
Xe-133	54	5.243	days	FP, AP-neutrons Daughter I-133 (20.8h, FP, Decay) Daughter Xe-133m (2.2d, AP)	No	Te-133m (55.4m, FP) → 82.5% I-133 (21h) and 14% Te-133; Te-133 (12.5m) → I-133 (21h) → Xe-133 (5.2d) → Cs-133 (stable)
Xe-133m	54	2.19	days	AP-neutrons	No	
Xe-135	54	9.14	hours	FP, AP-neutrons Daughter I-135 (6.6h, FP) Daughter Xe-135m (15.3m, FP, AP)	No	
Xe-135m	54	15.29	minutes	FP, AP-neutrons Daughter I-135 (6.6h, FP)	No	
Xe-138	54	14.08	minutes	FP	No	
Y-86	39	14.74	hours	AP Daughter Y-86m (48m, AP) Daughter Zr-86 (16.5h, AP)	No	
Y-86m	39	48	minutes	AP	No	
Y-87	39	79.8	hours	AP	No	
Y-88	39	106.616	days	AP Daughter Zr-88 (83.4d, AP, Decay)	No	Nb-88 (14.6m, AP) → Zr-88 (83.4d, AP, Decay) → Y-88 (107d) → Sr-88 (stable)
Y-90	39	64.053	hours	FP, AP-neutrons Daughter Sr-90 (28.9y, FP) Daughter Y-90m (3.2h, AP)	Yes	
Y-90m	39	3.19	hours	AP-neutrons	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Y-91	39	58.51	days	FP Daughter Sr-91 (9.6h, FP,AP) Daughter Y-91m (49.7m, AP, Decay)	No	Sr-91 (9.6h, FP, AP) → Y-91 (59d) and Y-91m (50m) → Zr-91 (stable)
Y-91m	39	49.71	minutes	AP Daughter Sr-91 (9.6h, FP,AP)	No	
Y-92	39	3.54	hours	FP, AP-neutrons Daughter Sr-92 (2.7h, FP)	No	
Y-93	39	10.18	hours	FP	No	
Y-94	39	18.7	minutes	FP, AP	No	
Y-95	39	10.3	minutes	FP, AP	No	
Yb-162	70	18.87	minutes	AP	No	
Yb-165	70	9.9	minutes	AP	No	
Yb-166	70	56.7	hours	AP	No	
Yb-167	70	17.5	minutes	AP	No	
Yb-169	70	32.018	days	AP-neutrons Daughter Lu-169 (34h, AP)	No	
Yb-175	70	4.185	days	AP-neutrons Daughter Tm-175 (15.2m, AP)	No	
Yb-177	70	1.911	hours	AP-neutrons	No	
Yb-178	70	74	minutes	AP	No	
Zn-62	30	9.186	hours	AP	No	
Zn-63	30	38.47	minutes	AP	No	
Zn-65	30	243.66	days	AP-neutrons Daughter Ga-65 (15m, AP)	No	
Zn-69	30	56.4	minutes	AP-neutrons Daughter Zn-69m (13.8h, AP)	No	
Zn-69m	30	13.76	hours	AP-neutrons	No	
Zn-71m	30	3.96	hours	AP-neutrons	No	
Zn-72	30	46.5	hours	FP	No	
Zr-86	40	16.5	hours	AP	No	
Zr-88	40	83.4	days	AP Daughter Nb-88 (14.6m, AP)	No	
Zr-89	40	78.41	hours	AP Daughter Nb-89a (66m, AP) Daughter Nb-89b (2h, AP)	No	

Table A2. Radionuclide Creation Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Possible Creation Mechanism (FP = Fission product, AP= Activation Product)	Isotopes Still Being Formed in 2005 (as decay products)	Ancestor Chain
Zr-93	40	1.53E+06	years	FP Daughter Y-93 (10.2h, FP)	No	Y-93 (10.2h, FP) → Zr-93 (1.5E6y, FP, Decay of Y-93) → Nb-93m (16.1y) → Nb-93 (stable)
Zr-95	40	64.032	days	FP, AP-neutrons Daughter Y-95 (10.3m, FP, AP)	No	
Zr-97	40	16.744	hours	FP, AP-neutrons	No	

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Ac-223	89	2.10	minutes	No	α , 99%, Fr-219 EC, 1%, Ra-223	Ac-223 (2.1m) \rightarrow Fr-219 (<1s) \rightarrow At-215 (<1s) \rightarrow Bi-211 (in Actinium Series); Ac-223 (2.1m) \rightarrow Ra-223 (in Actinium Series)		
Ac-224	89	2.78	hours	No	EC, 90.9%, Ra-224 α , 9.1%, Fr-220	See Ra-224 (in Thorium Series); Fr-220 (27s) \rightarrow At-216 (<1s) \rightarrow Bi-212 (in Thorium Series)		
Ac-225	89	10.0	days	Yes	α , Fr-221	See Fr-221 (in Neptunium Series)	Np	8
Ac-226	89	29.37	hours	No	β^- , 83%, Th-226 EC, 17%, Ra-226	Ac-226 (29.4h) \rightarrow Th-226 (31m) \rightarrow Ra-222 (38s) \rightarrow Rn-218 (<1s) \rightarrow Po-214 (in Uranium Series)		
Ac-227	89	21.772	years	Yes	β^- , 98.6%, Th-227 α , 1.4 %, Fr-223	See Th-227 and Fr-223 (in Actinium Series)	Ac	4
Ac-228	89	6.15	hours	Yes	β^- , Th-228	See Th-228 (in Thorium Series)	Th	3
Ag-102	47	12.9	minutes	No	EC, Pd-102 (stable)	No further daughters		
Ag-103	47	65.7	minutes	No	EC, Pd-103	Ag-103 (66m) \rightarrow Pd-103 (17d) \rightarrow Rh-103 (stable)		
Ag-104	47	69.2	minutes	No	EC, Pd-104 (stable)	No further daughters		
Ag-104m	47	33.5	minutes	No	EC, Pd-104 (stable)	No further daughters		
Ag-105	47	41.29	days	No	EC, Pd-105 (stable)	No further daughters		
Ag-106	47	23.96	minutes	No	EC, Pd-106 (stable)	No further daughters		
Ag-106m	47	8.28	days	No	EC, Pd-106 (stable)	No further daughters		
Ag-108	47	2.37	minutes	Yes	β^- , 97.15%, Cd-108 (stable) EC, 2.85%, Pd-108 (stable)	No further daughters		
Ag-108m	47	438	years	No	EC, 91.3%, Pd-108 (stable) IT, 8.7%, Ag-108	Ag-108m (438y) \rightarrow Ag-108 (2.4m) \rightarrow Cd-108 (stable) and Pd-108 (stable)		
Ag-109m	47	38.0	seconds	No	IT, Ag-109 (stable)	No further daughters		
Ag-110	47	24.6	seconds	No	β^- , 99.7%, Cd-110 (stable) EC, 0.3%, Pd-110 (stable)	No further daughters		
Ag-110m	47	249.76	days	No	β^- , 98.6%, Cd-110 (stable) IT, 1.4%, Ag-110	Ag-110m (250d) \rightarrow Ag-110 (25s) \rightarrow Cd-110 (stable) and Pd-110 (stable)		
Ag-111	47	7.45	days	No	β^- , Cd-111 (stable)	No further daughters		
Ag-112	47	3.130	hours	No	β^- , Cd-112 (stable)	No further daughters		
Ag-115	47	20.0	minutes	No	β^- , 88%, Cd-115 β^- , 12%, Cd-115m	Ag-115 (20m) \rightarrow Cd-115m (45d) \rightarrow Cd-115 (54h) \rightarrow In-115 (4.4E14y) \rightarrow Sn-115 (stable)		
Al-26	13	7.17E+05	years	No	EC, Mg-26 (stable)	No further daughters		
Al-28	13	2.2414	minutes	No	β^- , Si-28 (stable)	No further daughters		
Am-237	95	73.0	minutes	No	EC, 98.98%, Pu-237 α , 0.03%, Np-233	Am-237 (73m) \rightarrow Pu-237 (45d) \rightarrow Np-237 (in Neptunium Series)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Am-238	95	98	minutes	No	EC, Pu-238	Am-238 (98m) → Pu-238 (88y) → U-234 (in Uranium Series)		
Am-239	95	11.9	hours	No	EC, 99.99%, Pu-239 α, 0.01%, Np-235	Am-239 (11.9h) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)		
Am-240	95	50.8	hours	No	EC, Pu-240	Am-240 (50.8m) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 (in Thorium Series)		
Am-241	95	432.2	years	Yes	α, Np-237	See Np-237 (in Neptunium Series)	Np	2
Am-242	95	16.02	hours	Yes	β-, 82.7%, Cm-242 EC, 17.3%, Pu-242	Am-242 (16h) → Cm-242 (163d) → Pu-238 (88y) → U-234 (in Uranium Series); Am-242 (16h) → Pu-242 (3.75E5y) → U-238 (in Uranium Series)		
Am-242m	95	141	years	No	IT, 99.54%, Am-242 α, 0.46%, Np-238	Am-242m (141y) → Am-242 (16h) → Cm-242 (163d) → Pu-238 (88y) → U-234 (in Uranium Series); Am-242 (16h) → Pu-242 (3.75E5y) → U-238 (in Uranium Series)		
Am-243	95	7,370	years	Yes	α, Np-239	Am-243 (7.4E3Y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)		
Am-244	95	10.1	hours	No	β-, Cm-244	Am-244 (10h) → Cm-244 (18y) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 (in Thorium Series)		
Am-244m	95	26	minutes	No	β-, 99.96%, Cm-244 α, 0.04%, Pu-244	Am-244m (26m) → Cm-244 (18y) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 (in Thorium Series)		
Am-245	95	2.05	hours	No	β-, Cm-245	Am-245 (2h) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)		
Am-246	95	39	minutes	Yes	β-, Cm-246	Am-246 (39m) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series)		
Am-246m	95	25.0	minutes	No	β-, Cm-246	Am-246m (25m) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series)		
Ar-37	18	34.95	days	No	EC, Cl-37 (stable)	No further daughters		
Ar-39	18	269	years	No	β-, K-39 (stable)	No further daughters		
Ar-41	18	109.61	years	No	β-, K-41 (stable)	No further daughters		
Ar-42	18	32.9	years	No	β-, K-42	Ar-42 (32.9y) → K-42 (12.4h) → Ca-42 (stable)		
As-69	33	15.2	minutes	No	EC, Ge-69	As-69 (15m) → Ge-69 (39h) → Ga-69 (stable)		
As-70	33	52.6	minutes	No	EC, Ge-70 (stable)	No further daughters		
As-71	33	65.28	hours	No	EC, Ge-71	As-71 (65h) → Ge-71 (11.4d) → Ga-71 (stable)		
As-72	33	26.0	hours	No	EC, Ge-72 (stable)	No further daughters		
As-73	33	80.30	days	No	EC, Ge-73 (stable)	No further daughters		
As-74	33	17.77	days	No	EC, 66%, Ge-74 (stable) β, 34%, Se-74 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
As-76	33	1.0942	days	No	β^- , Se-76 (stable)	No further daughters		
As-77	33	38.83	hours	No	β^- , Se-77 (stable)	No further daughters		
As-78	33	90.7	minutes	No	β^- , Se-78 (stable)	No further daughters		
As-79	33	9.01	minutes	No	β^- , 98.94%, Se-79m β^- , 1.06%, Se-79	As-79 (9m) \rightarrow Se-79m (3.9m) \rightarrow Se-79 (3E5y) \rightarrow Br-79 (stable)		
At-207	85	1.80	hours	No	EC, 91.4%, Po-207 α , 8.6%, Bi-203	At-207 (1.8h) \rightarrow Po-207 (5.8h) \rightarrow Bi-207 (32y) \rightarrow Pb-207 (stable); At-207 (1.8h) \rightarrow Bi-203 (12h) \rightarrow Pb-203 (52h) \rightarrow Tl-203 (stable)		
At-211	85	7.214	hours	No	EC, 58.2%, Po-211 α , 41.8%, Bi-207	At-211 (7.2h) \rightarrow Po-211 (<1s) \rightarrow Pb-207 (stable); At-211 (7.2h) \rightarrow Bi-207 (32y) \rightarrow Pb-207 (stable)		
At-215	85	1.00E-04	seconds	No	α , Bi-211	See Bi-211 (in Actinium Series)		
At-216	85	3.00E-04	seconds	No	α , Bi-212	See Bi-212 (in Thorium Series)		
At-217	85	0.0323	seconds	Yes	α , 99.9%, Bi-213 β^- , 0.1%, Rn-217	See Bi-213 (in Neptunium Series)	Np	10
At-218	85	1.5	seconds	Yes	α , 99.9%, Bi-214 β^- , 0.1%, Rn-218	See Bi-214 (in Uranium Series)	U	10
Au-193	79	17.65	hours	No	EC, Pt-193	Au-193 (17.7h) \rightarrow Pt-193 (50y) \rightarrow Ir-193 (stable)		
Au-194	79	38.02	hours	Yes	EC, Pt-194 (stable)	No further daughters		
Au-195	79	186.098	days	No	EC, Pt-195 (stable)	No further daughters		
Au-195m	79	30.5	seconds	No	IT, Au-195 (stable)	No further daughters		
Au-198	79	2.6956	days	No	β^- , Hg-198 (stable)	No further daughters		
Au-198m	79	2.27	days	No	IT, Au-198	Au-198m (2.3d) \rightarrow Au-198 (2.7d) \rightarrow Hg-198 (stable)		
Au-199	79	3.139	days	No	β^- , Hg-199 (stable)	No further daughters		
Au-200	79	48.4	minutes	No	β^- , Hg-200 (stable)	No further daughters		
Au-200m	79	18.7	hours	No	β^- , 82%, Hg-200 (stable) IT, 18%, Au-200	Au-200m (18.7h) \rightarrow Au-200 (48m) \rightarrow Hg-200 (stable)		
Au-201	79	26	minutes	No	β^- , Hg-201 (stable)	No further daughters		
Ba-126	56	100	minutes	No	EC, Cs-126	Ba-126 (100m) \rightarrow Cs-126 (1.6m) \rightarrow Xe-126 (stable)		
Ba-128	56	2.43	days	No	EC, Cs-128	Ba-128 (2.4d) \rightarrow Cs-128 (3.6m) \rightarrow Xe-128 (stable)		
Ba-131	56	11.50	days	No	EC, Cs-131	Ba-131 (11.5d) \rightarrow Cs-131 (9.7d) \rightarrow Xe-131 (stable)		
Ba-131m	56	14.6	minutes	No	IT, Ba-131	Ba-131m (39m) \rightarrow Ba-131 (11.5d) \rightarrow Cs-131 (9.7d) \rightarrow Xe-131 (stable)		
Ba-133	56	3,841	days	No	EC, Cs-133 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Ba-133m	56	38.9	hours	No	IT, 99.99%, Ba-133 EC, 0.01%, Cs-133 (stable)	Ba-133m (39h) → Ba-133 (3849d) → Cs-133 (stable)		
Ba-135m	56	28.7	hours	No	IT, Ba-135 (stable)	No further daughters		
Ba-137m	56	2.552	minutes	Yes	IT, Ba-137 (stable)	No further daughters		
Ba-139	56	83.06	minutes	No	β-, La-139 (stable)	No further daughters		
Ba-140	56	12.752	days	No	β-, La-140	Ba-140 (12.8d) → La-140 (1.7d) → Ce-140 (stable)		
Ba-141	56	18.27	minutes	No	β-, La-141	Ba-141 (18.3m) → La-141 (3.9h) → Ce-141 (33d) → Pr-141 (stable)		
Ba-142	56	10.6	minutes	No	β-, La-142	Ba-142 (10.6m) → La-142 (91m) → Ce-142 (stable)		
Be-10	4	1.51E+06	years	No	β-, B-10 (stable)	No further daughters		
Be-7	4	53.22	days	No	EC, Li-7 (stable)	No further daughters		
Bi-200	83	36.4	minutes	No	EC, Pb-200	Bi-200 (36m) → Pb-200 (21h) → Tl-200 (26h) → Hg-200 (stable)		
Bi-201	83	108	minutes	No	EC, Pb-201	Bi-201 (108m) → Pb-201 (9h) → Tl-200 (26h) → Hg-200 (stable)		
Bi-202	83	1.72	hours	No	EC, Pb-202	Bi-202 (1.7h) → Pb-202 (5E4y) → Tl-202 and Hg-198 (stable); Tl-202 (12d) → Hg-202 (stable)		
Bi-203	83	11.76	hours	No	EC, Pb-203	Bi-203 (11.8h) → Pb-203 (52h) → Tl-203 (stable)		
Bi-205	83	15.31	days	No	EC, Pb-205	Bi-205 (15.3d) → Pb-205 (2E7y) → Tl-205 (stable)		
Bi-206	83	6.243	days	No	EC, Pb-206 (stable)	No further daughters		
Bi-207	83	32.9	years	No	EC, Pb-207 (stable)	No further daughters		
Bi-208	83	3.68E+05	years	No	EC, Pb-208 (stable)	No further daughters		
Bi-210	83	5.012	days	Yes	β-, Po-210	See Po-210 (in Uranium Series)	U	15
Bi-210m	83	3.04E+06	years	No	α, Tl-206	Bi-210m (3E6y) → Tl-206 (4.2m) → Pb-206 (stable)		
Bi-211	83	2.14	minutes	Yes	α, 99.727%, Tl-207 β-, 0.273%, Po-211	See Tl-207 (in Actinium Series)	Ac	11
Bi-212	83	60.55	minutes	Yes	β-, 64.06%, Po-212 α, 35.94%, Tl-208	See Po-212 and Tl-208 (in Thorium Series)	Th	9
Bi-213	83	45.59	minutes	Yes	β-, 97.84%, Po-213 α, 2.16%, Tl-209	See Po-213 and Tl-209 (in Neptunium Series)	Np	11
Bi-214	83	19.9	minutes	Yes	β-, 99.98%, Po-214 α, 0.02%, Tl-210	See Po-214 (in Uranium Series)	U	11
Bk-245	97	4.94	days	No	EC, 99.88%, Cm-245 α, 0.12%, Am-241	Bk-245 (4.9d) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Bk-246	97	1.80	days	No	EC, 99.8%, Cm-246 α , 0.2%, Am-242	Bk-246 (1.8d) \rightarrow Cm-246 (4.8E3y) \rightarrow Pu-242 (3.7E5y) \rightarrow U-238 (in Uranium Series)		
Bk-247	97	1,380	years	No	α , Am-243	Bk-247 (1.4E3y) \rightarrow Am-243 (7.4E7y) \rightarrow Np-239 (2.4d) \rightarrow Pu-239 (2.4E4y) \rightarrow U-235 (in Actinium Series)		
Bk-249	97	330	days	No	β^- , Cf-249	Bk-249 (330d) \rightarrow Cf-249 (3.5E2y) \rightarrow Cm-245 (8.5E3y) \rightarrow Pu-241 (in Neptunium Series)		
Bk-250	97	3.212	hours	Yes	β^- , Cf-250	Bk-250 (3.2h) \rightarrow Cf-250 (13y) \rightarrow Cm-246 (4.8E3y) \rightarrow Pu-242 (3.7E5y) \rightarrow U-238 (in Uranium Series)		
Br-74	35	25.4	minutes	No	EC, Se-74 (stable)	No further daughters		
Br-74m	35	46	minutes	No	EC, Se-74 (stable)	No further daughters		
Br-75	35	96.7	minutes	No	EC, Se-75	Br-75 (96.7m) \rightarrow Se-75 (120d) \rightarrow As-75 (stable)		
Br-76	35	16.2	hours	No	EC, Se-76 (stable)	No further daughters		
Br-77	35	57.036	hours	No	EC, Se-77 (stable)	No further daughters		
Br-80	35	17.68	minutes	No	β^- , 91.7%, Kr-80 (stable) EC, 8.3%, Se-80 (stable)	No further daughters		
Br-80m	35	4.4205	hours	No	IT, Br-80	Br-80m (4.4h) \rightarrow Br-80 (18m) \rightarrow Kr-80 (stable) and Se-80 (stable)		
Br-82	35	35.282	hours	No	β^- , Kr-82 (stable)	No further daughters		
Br-83	35	2.40	hours	No	β^- , Kr-83 (stable)	No further daughters		
Br-84	35	31.80	minutes	No	β^- , Kr-84 (stable)	No further daughters		
C-11	6	20.334	minutes	No	EC, B-11 (stable)	No further daughters		
C-14	6	5700	years	No	β^- , N-14 (stable)	No further daughters		
Ca-41	20	1.02E+05	years	No	EC, K-41 (stable)	No further daughters		
Ca-45	20	162.61	days	No	β^- , Sc-45 (stable)	No further daughters		
Ca-47	20	4.536	days	No	β^- , Sc-47	Ca-47 (4.5d) \rightarrow Sc-47 (3.3d) \rightarrow Ti-47 (stable)		
Ca-49	20	8.718	minutes	No	β^- , Sc-49	Ca-49 (8.7m) \rightarrow Sc-49 (57.2m) \rightarrow Ti-49 (stable)		
Cd-104	48	57.7	minutes	No	EC, Ag-104	Cd-104 (57.7m) \rightarrow Ag-104 (69m) \rightarrow Pd-104 (stable)		
Cd-107	48	6.50	hours	No	EC, Ag-107 (stable)	No further daughters		
Cd-109	48	461.4	days	No	EC, Ag-109 (stable)	No further daughters		
Cd-113	48	7.7E+15	years	Yes	β^- , In-113 (stable)	No further daughters		
Cd-113m	48	14.1	years	No	β^- , 99.9%, In-113 (stable) EC, 0.1%, Cd-113	Cd-113m (14.1y) \rightarrow Cd-113 (7.7E15y) \rightarrow In-113 (stable)		
Cd-115	48	53.46	hours	No	β^- , In-115	Cd-115 (53h) \rightarrow In-115 (4.4E14y) \rightarrow Sn-115 (stable)		
Cd-115m	48	44.56	days	No	β^- , In-115	Cd-115m (44.6d) \rightarrow In-115 (4.4E14y) \rightarrow Sn-115 (stable)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Cd-117	48	2.49	hours	No	β^- , 91.6%, In-117m β^- , 8.4%, In-117	Cd-117 (2.5h) \rightarrow In-117m (43m) and In-117 (116m) \rightarrow Sn-117 (stable)		
Cd-117m	48	3.36	hours	No	β^- , 98.6%, In-117 β^- , 1.4%, In-117m	Cd-117m (3.4h) \rightarrow In-117m (43m) and In-117 (116m) \rightarrow Sn-117 (stable)		
Ce-134	58	3.16	days	No	EC, La-134	Ce-134 (3.2d) \rightarrow La-134 (6.4m) \rightarrow Ba-134 (stable)		
Ce-135	58	17.7	hours	No	EC, La-135	Ce-135 (17.7h) \rightarrow La-135 (19.5h) \rightarrow Ba-135 (stable)		
Ce-137	58	9.0	hours	No	EC, La-137	Ce-137 (9h) \rightarrow La-137 (6E4y) \rightarrow Ba-137 (stable)		
Ce-137m	58	34.4	hours	No	IT, 99.22%, Ce-137 EC, 0.78%, La-137	Ce-137m (34h) \rightarrow Ce-137 (9h) decays \rightarrow La-137 (6E4y) \rightarrow Ba-137 (stable)		
Ce-139	58	137.641	days	No	EC, La-139 (stable)	No further daughters		
Ce-141	58	32.508	days	No	β^- , Pr-141 (stable)	No further daughters		
Ce-142	58	2.6E+17	years	No	2 β^- , Nd-142 (stable)	No further daughters		
Ce-143	58	33.039	hours	No	β^- , Pr-143	Ce-143 (33h) \rightarrow Pr-143 (13.6d) \rightarrow Nd-143 (stable)		
Ce-144	58	284.91	days	No	β^- , 98.5%, Pr-144 β^- , 1.5%, Pr-144m	Ce-144 (285d) \rightarrow Pr-144m (7.2m) \rightarrow Pr-144 (17.3m) \rightarrow Nd-144 (2.3E15y) \rightarrow Ce-140 (stable)		
Cf-244	98	19.4	minutes	No	α , Cm-240	Cf-244 (19.4m) \rightarrow Cm-240 (27d) \rightarrow Pu-236 (2.8y) \rightarrow U-232 (69y) \rightarrow Th-228 (in Thorium Series)		
Cf-246	98	35.7	hours	No	α , Cm-242	Cf-246 (36m) \rightarrow Cm-242 (163d) \rightarrow Pu-238 (88y) \rightarrow U-234 (in Uranium Series)		
Cf-247	98	3.11	hour	No	EC, 99.97%, Bk-247 α , 0.03%, Cm-243	Cf-247 (3.1h) \rightarrow Bk-247 (1.4E3y) \rightarrow Am-243 (7.4E7y) \rightarrow Np-239 (2.4d) \rightarrow Pu-239 (2.4E4y) \rightarrow U-235 (in Actinium Series)		
Cf-248	98	333.5	days	No	α , Cm-244	Cf-248 (333d) \rightarrow Cm-244 (18y) \rightarrow Pu-240 (6.6E3y) \rightarrow U-236 (2.3E7y) \rightarrow Th-232 (in Thorium Series)		
Cf-249	98	351	years	No	α , Cm-245	Cf-249 (3.5E2y) \rightarrow Cm-245 (8.5E3y) \rightarrow Pu-241 (in Neptunium Series)		
Cf-250	98	13.08	years	Yes	α , 99.92%, Cm-246 SPF, 0.08%, FP	Cf-250 (13.1y) \rightarrow Cm-246 (4.8E3y) \rightarrow Pu-242 (3.7E5y) \rightarrow U-238 (in Uranium Series)		
Cf-251	98	898	years	No	α , Cm-247	Cf-251 (9E2y) \rightarrow Cm-247 (1.6E7y) \rightarrow Pu-243 (5h) \rightarrow Am-243 (7.4E7y) \rightarrow Np-239 (2.4d) \rightarrow Pu-239 (2.4E4y) \rightarrow U-235 (in Actinium Series)		
Cf-252	98	3	years	No	α , 96.908%, Cm-248 SPF, 3.092%, FP	Cf-252 (2.6y) \rightarrow Cm-248 (3.5E5y) \rightarrow Pu-244 (8E7y) \rightarrow U-240 (14h) \rightarrow Np-240 (62m) \rightarrow Pu-240 (6.6E3y) \rightarrow U-236 (2.3E7y) \rightarrow Th-232 (in Thorium Series)		
Cf-253	98	17.81	days	No	β^- , 99.69%, Es-253 α , 0.31%, Cm-249	Cf-253 (17.81d) \rightarrow Es-253 (21d) \rightarrow Bk-249 (330d) \rightarrow Cf-249 (3.5E2y) \rightarrow Cm-245 (8.5E3y) \rightarrow Pu-241 (in Neptunium Series)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Cf-254	98	60.5	days	No	SF, 99.69%, FP α , 0.31%, Cm-250	Cf-254 (60.5d) → Cm-250 (8.3E3y) → Pu-246 (10.8d) → Am-246 (39m) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)		
Cl-36	17	3.01E+05	years	No	β^- , 98.1%, Ar-36 (stable) EC, 1.9%, S-36 (stable)	No further daughters		
Cl-38	17	37.24	minutes	No	β^- , Ar-38 (stable)	No further daughters		
Cl-39	17	55.6	minutes	No	β^- , Ar-39	Cl-39 (56m) → Ar-39 (269y) → K-39 (stable)		
Cm-238	96	2.4	hours	No	EC, 90%, Am-238 α , 10%, Pu-234	90% of Cm-238 (2.4h) → Am-238 (98m) → Pu-238 (88y) → U-234 (in Uranium Series); 10% of Cm-238 (2.4h) → Pu-234 (8.8h); 94% of Pu-234 (8.8h) → Np-234 (4.4d) → U-234 (in Uranium Series) 6% of Pu-234 (8.8h) → U-230 (20.8d) → multiple rapid steps → Pb-206 (stable)		
Cm-240	96	27	days	No	α , 99.5%, Pu-236 EC, 0.5%, Am-240	Cm-240 (27d) → Pu-236 (2.8y) → U-232 (69y) → Th-228 (in Thorium Series)		
Cm-241	96	32.8	days	No	EC, 99%, Am-241 α , 1%, Pu-237	Cm-241 (33d) → Am-241 (432y) → See Am-241 (in Neptunium Series)		
Cm-242	96	162.8	days	Yes	α , Pu-238	Cm-242 (163d) → Pu-238 (88y) → U-234 (in Uranium Series)		
Cm-243	96	29.1	years	No	α , 99.76%, Pu-239 EC, 0.24%, Am-243	Cm-243 (29.1y) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)		
Cm-244	96	18.1	years	No	α , Pu-240	Cm-244 (18.1y) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 (in Thorium Series)		
Cm-245	96	8,500	years	Yes	α , Pu-241	Cm-245 (8.5E3) → Pu-241 (in Neptunium Series)		
Cm-246	96	4,760	years	Yes	α , 99.97%, Pu-242 SPF, 0.03%, FP	Cm-246 (4.7E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series)		
Cm-247	96	1.56E+07	years	Yes	α , Pu-243	Cm-247 (1.6E7y) → Pu-243 (5h) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)		
Cm-248	96	3.48E+05	years	Yes	α , 91.74%, Pu-244 SPF, 8.26%, FP	Cm-248 (3.5E5y) → Pu-244 (8E7y) → U-240 (14h) to Np-240 (62h) → Pu-240 (6.6E3y) → U-236 (2.3E7y) → Th-232 (in Thorium Series)		
Cm-249	96	64.15	minutes	No	β^- , Bk-249	Cm-249 (64m) → Bk-249 (330d) → Cf-249 (3.5E2y) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Cm-250	96	8.3E+03	years	No	SPF, 80%, FP α, 11%, Pu-246 β-, 9%, Bk-250	Cm-250 (8.3E3y) → Pu-246 (11d) → Am-246 (39m) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series); Cm-250 (8.3E3y) → Bk-250 (3.2h) → Cf-250 (13y) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series)		
Co-55	27	17.53	hours	No	EC, Fe-55	Co-55 (17.5h) → Fe-55 (2.7y) → Mn-55 (stable)		
Co-56	27	77.233	days	No	EC, Fe-56 (stable)	No further daughters		
Co-57	27	271.74	days	No	EC, Fe-57 (stable)	No further daughters		
Co-58	27	70.86	days	No	EC, Fe-58 (stable)	No further daughters		
Co-58m	27	9.04	hours	No	IT, Co-58	Co-58m (9h) → Co-58 (71d) → Fe-58 (stable)		
Co-60	27	1925.28	days	Yes	β-, Ni-60 (stable)	No further daughters		
Co-60m	27	10.467	minutes	Yes	IT, 99.75% Co-60 β-, 0.25%, Ni-60 (stable)	Co-60m (10.5m) → Co-60 (1925d) → Ni-60 (stable)		
Co-61	27	1.650	hours	No	β-, Ni-61 (stable)	No further daughters		
Co-62m	27	13.91	minutes	No	β, Ni-62 (stable)	No further daughters		
Cr-48	24	21.56	hours	No	EC, V-48	Cr-48 (21.6m) → V-48 (16d) → Ti-48 (stable)		
Cr-49	24	42.3	minutes	No	EC, V-49	Cr-49 (42.3m) → V-49 (330d) → Ti-49 (stable)		
Cr-51	24	27.7025	days	No	EC, V-51 (stable)	No further daughters		
Cs-125	55	46.7	minutes	No	EC, Xe-125	Cs-125 (46.7h) → Xe-125 (16.9h) → I-125 (59d) → Te-125 (stable)		
Cs-126	55	1.64	minutes	No	EC, Xe-126 (stable)	No further daughters		
Cs-127	55	6.25	hours	No	EC, Xe-127	Cs-127 (6.2h) → Xe-127 (36d) → I-127 (stable)		
Cs-128	55	3.66	minutes	No	EC, Xe-128 (stable)	No further daughters		
Cs-129	55	32.06	hours	No	EC, Xe-129 (stable)	No further daughters		
Cs-130	55	29.21	minutes	No	EC, Xe-130 (stable)	No further daughters		
Cs-131	55	9.689	days	No	EC, Xe-131 (stable)	No further daughters		
Cs-132	55	6.480	days	No	EC, 98.13%, Xe-131 (stable) β-, 1.87%, Ba-132 (stable)	No further daughters		
Cs-134	55	2.0652	years	No	β-, Ba-134 (stable)	No further daughters		
Cs-134m	55	2.912	hours	No	IT, Cs-134	Cs-134m (2.9h) → Cs-134 (754d) → Ba-134 (stable)		
Cs-135	55	2.3E+06	years	No	β-, Ba-135 (stable)	No further daughters		
Cs-135m	55	53	minutes	No	IT, Cs-135	Cs-135m (53m) → Cs-135 (2.3E6y) → Ba-135 (stable)		
Cs-136	55	13.04	days	No	β-, Ba-136 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Cs-137	55	30.03	years	No	β^- , 94.6%, Ba-137m β^- , 5.4%, Ba-137 (stable)	Cs-137 (30y) \rightarrow Ba-137m (2.55m) \rightarrow Ba-137 (stable)		
Cs-138	55	33.41	minutes	No	β^- , Ba-138 (stable)	No further daughters		
Cu-60	29	23.7	minutes	No	EC, Ni-60 (stable)	No further daughters		
Cu-61	29	3.333	hours	No	EC, Ni-61 (stable)	No further daughters		
Cu-62	29	9.67	minutes	No	EC, Ni-62 (stable)	No further daughters		
Cu-64	29	12.700	hours	No	EC, 61%, Ni-64 (stable) β^- , 39%, Zn-64 (stable)	No further daughters		
Cu-66	29	5.120	minutes	No	β^- , Zn-66 (stable)	No further daughters		
Cu-67	29	61.83	hours	No	β^- , Zn-67 (stable)	No further daughters		
Dy-155	66	9.9	hours	No	EC, Tb-155	Dy-155 (9.9h) \rightarrow Tb-155 (5.3d) \rightarrow Gd-155 (stable)		
Dy-157	66	8.14	hours	No	EC, Tb-157	Dy-157 (8.1h) \rightarrow Tb-157 (71y) \rightarrow Gd-157 (stable)		
Dy-159	66	144.4	days	No	EC, Tb-159 (stable)	No further daughters		
Dy-165	66	2.334	hours	No	β^- , Ho-165 (stable)	No further daughters		
Dy-166	66	81.6	hours	No	β^- , Ho-166	Dy-166 (81.6h) \rightarrow Ho-166 (26.9h) \rightarrow Er-166 (stable)		
Er-161	68	3.21	hours	No	EC, Ho-161	Er-161 (3.2h) \rightarrow Ho-161 (2.5h) \rightarrow Dy-161 (stable)		
Er-165	68	10.36	hours	No	EC, Ho-165 (stable)	No further daughters		
Er-169	68	9.392	days	No	β^- , Tm-169 (stable)	No further daughters		
Er-171	68	7.516	hours	No	β^- , Tm-171	Er-171 (7.5h) \rightarrow Tm-171 (1.92y) \rightarrow Yb-171 (stable)		
Er-172	68	49.3	hours	No	β^- , Tm-172	Er-172 (49.3h) \rightarrow Tm-171 (64h) \rightarrow Yb-172 (stable)		
Es-250m	99	2	hours	No	EC, 97%, Cf-250 α , 3%, Bk-246	Es-250m (2.2h) \rightarrow Cf-250 (13y) and Bk-246 (1.8d) \rightarrow Cm-246 (4.8E3y) \rightarrow Pu-242 (3.7E5y) \rightarrow U-238 (in Uranium Series)		
Es-251	99	33	hours	No	EC, 99.51%, Cf-251 α , 0.49%, Bk-247	Es-251 (33h) \rightarrow Cf-251(9E2y) \rightarrow Cm-247(1.6E7y) \rightarrow Pu-243 (5h) \rightarrow Am-243 (7.4E7y) \rightarrow Np-239 (2.4d) \rightarrow Pu-239 (2.4E4y) \rightarrow U-235 (in Actinium Series)		
Es-253	99	20.47	days	No	α , Bk-249	Es-253 (20.5d) \rightarrow Bk-249 (330d) \rightarrow Cf-249 (3.5E2y) \rightarrow Cm-245 (8.5E3y) \rightarrow Pu-241 (in Neptunium Series)		
Es-254	99	275.7	days	No	α , Bk-250	Es-254 (276d) \rightarrow Bk-250 (3.2h) \rightarrow Cf-250 (13y) \rightarrow Cm-246 (4.8E3y) \rightarrow Pu-242 (3.7E5y) \rightarrow U-238 (in Uranium Series)		
Es-254m	99	39.3	hours	No	β^- , 98%, Fm-254 IT, <3%, Es-254 α , 0.33%, Bk-250 EC, 0.08%, Cf-254	Es-254m (39h) \rightarrow Fm-254 (3.2h) \rightarrow Cf-250 (13y) \rightarrow Cm-246 (4.8E3y) \rightarrow Pu-242 (3.7E5y) \rightarrow U-238 (in Uranium Series)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Es-255	99	39.8	days	No	β^- , 92%, Fm-255 α , 8%, Bk-251	Es-255 (39.3d) \rightarrow Bk-251 (56m) or Fm-255 (20h) \rightarrow Cf-251(9E2y) \rightarrow Cm-247(1.6E7y) \rightarrow Pu-243 (5h) \rightarrow Am-243 (7.4E7y) \rightarrow Np-239 (2.4d) \rightarrow Pu-239 (2.4E4y) \rightarrow U-235 (in Actinium Series)		
Eu-145	63	5.93	days	No	EC, Sm-145	Eu-145 (4.6d) \rightarrow Sm-145 (340d) \rightarrow Pm-145 (17.7y) \rightarrow Nd-145 (stable)		
Eu-146	63	4.61	days	No	EC, Sm-146	Eu-146 (4.6d) \rightarrow Sm-146 (1E8y) \rightarrow Nd-142 (stable)		
Eu-147	63	24.1	days	No	EC, Sm-147	Eu-147 (24.1d) \rightarrow Sm-147 (1E11y) \rightarrow Nd-143 (stable).		
Eu-148	63	54.5	days	No	EC, Sm-148	Eu-148 (54.5d) \rightarrow Sm-148 (7E15y) \rightarrow Nd-144 (2.3E15y) \rightarrow Ce-140 (stable).		
Eu-149	63	93.1	days	No	EC, Sm-149 (stable)	No further daughters		
Eu-150	63	36.9	years	No	EC, Sm-150 (stable)	No further daughters		
Eu-150m	63	12.8	hours	No	β^- , 89%, Gd-150 EC, 11%, Sm-150 (stable)	Eu-150m (12.8h) \rightarrow Gd-150 (1.8E6y) \rightarrow Sm-146 (1.03E8y) \rightarrow Nd-142 (stable)		
Eu-152	63	13.506	years	No	EC, 72.08%, Sm-152 (stable) β^- , 27.92%, Gd-152 (stable)	No further daughters		
Eu-152m	63	9.3116	hours	No	β^- , 72%, Gd-152 (stable) EC, 28%, Sm-152 (stable)	No further daughters		
Eu-154	63	8.590	years	No	β^- , 99.98%, Gd-154 (stable) EC, 0.02%, Sm-154 (stable)	No further daughters		
Eu-155	63	4.753	years	No	β^- , Gd-155 (stable)	No further daughters		
Eu-156	63	15.19	days	No	β^- , Gd-156 (stable)	No further daughters		
Eu-157	63	15.18	hours	No	β^- , Gd-157 (stable)	No further daughters		
Eu-158	63	45.9	minutes	No	β^- , Gd-158 (stable)	No further daughters		
F-18	9	1.8291	hours	No	EC, O-18 (stable)	No further daughters		
Fe-52	26	8.275	hours	No	EC, Mn-52	Fe-52 (8.3h) \rightarrow Mn-52 (5.6d) \rightarrow Cr-52 (stable)		
Fe-52m	26	46	seconds	No	EC, 80%, Mn-52 IT, 20%, Fe-52	Fe-52m (46s) \rightarrow Fe-52 (8.3h) \rightarrow Mn-52 (5.6d) \rightarrow Cr-52 (stable)		
Fe-55	26	2.737	years	No	EC, Mn-55 (stable)	No further daughters		
Fe-59	26	44.495	days	No	β^- , Co-59 (stable)	No further daughters		
Fe-60	26	1.50E+06	years	No	β^- , Co-60m	Fe-60 (1.5E6y) \rightarrow Co-60m (10.5m) \rightarrow Co-60 (1925d) \rightarrow Ni-60 (stable)		
Fm-252	100	25.39	hours	No	α , Cf-248	Fm-252 (25h) \rightarrow Cf-248 (334d) \rightarrow Cm-244 (18y) \rightarrow Pu-240 (6.6E3y) \rightarrow U-236 (2.3E7y) \rightarrow Th-232 (in Thorium Series)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Fm-253	100	3.00	days	No	EC, 88%, Es-253 α, 12%, Cf-249	Fm-253 (3d) → Es-253 (21d) → Bk-249 (330d) → Cf-249 (3.5E2y) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)		
Fm-254	100	3.240	hours	No	α, 99.94%, Cf-250 SPF, 0.06%, FP	Fm-254 (3.2h) → Cf-250 (13y) → Cm-246 (4.8E3y) → Pu-242 (3.7E5y) → U-238 (in Uranium Series)		
Fm-255	100	20.07	hours	No	α, Cf-251	Fm-255 (20h) → Cf-251(9E2y) → Cm-247(1.6E7y) → Pu-243 (5h) → Am-243 (7.4E7y) → Np-239 (2.4d) → Pu-239 (2.4E4y) → U-235 (in Actinium Series)		
Fm-257	100	100.5	days	No	α, 99.79%, Cf-253 SPF, 0.21%, FP	Fm-257 (100d) → Cf-253 (18d) → Es-253 (21d) → Bk-249 (330d) → Cf-249 (3.5E2y) → Cm-245 (8.5E3y) → Pu-241 (in Neptunium Series)		
Fr-219	87	0.02	seconds	No	α, At-215	Fr-219 (<1s) → At-215 (<1s) → Bi-211 (in Actinium Series)		
Fr-220	87	27.4	seconds	No	α, 99.65%, At-216 β-, 0.35%, Ra-220	Fr-220 (27s) → At-216 (<1s) → Bi-212 (in Thorium Series)		
Fr-221	87	4.9	minutes	Yes	α, At-217	See At-217 (in Neptunium Series)	Np	9
Fr-222	87	14.2	minutes	No	β-, Ra-222	Fr-222 (14.2m) → Ra-222 (38s) → Rn-218 (<1s) → Po-214 (in Uranium Series)		
Fr-223	87	22.00	minutes	Yes	β-, 99.99%, Ra-223 α, 0.01%, At-219	See Ra-223 and At-219 (in Actinium Series)	Ac	6
Ga-65	31	15.2	minutes	No	EC, Zn-65	Ga-65 (15m) → Zn-65 (244d) → Cu-65 (stable)		
Ga-66	31	9.49	hours	No	EC, Zn-66 (stable)	No further daughters		
Ga-67	31	3.2623	days	No	EC, Zn-67 (stable)	No further daughters		
Ga-68	31	67.71	minutes	No	EC, Zn-68 (stable)	No further daughters		
Ga-70	31	21.14	minutes	No	β-, Ge-70 (stable)	No further daughters		
Ga-72	31	14.095	hours	No	β-, Ge-72 (stable)	No further daughters		
Ga-73	31	4.86	hours	No	β-, Ge-73 (stable)	No further daughters		
Ga-74	31	8.2	minutes	No	β-, Ge-74 (stable)	No further daughters		
Gd-145	64	23.0	minutes	No	EC, Eu-145	Gd-145 (23m) → Eu-145 (6d) → Sm-145 (340d) → Pm-145 (17.7y) → Nd-145 (stable)		
Gd-146	64	48.27	days	No	EC, Eu-146	Gd-146 (48d) → Eu-146 (4.6d) → Sm-146 (1E8y) → Nd-142 (stable)		
Gd-147	64	38.06	hours	No	EC, Eu-147	Gd-147 (38h) → Eu-147 (24d) → Sm-147 (1E6y) → Nd-143 (stable)		
Gd-148	64	70.9	years	No	α, Sm-144 (stable)	No further daughters		
Gd-149	64	9.28	days	No	EC, Eu-149	Gd-149 (9.3d) → Eu-149 (93d) → Sm-149 (stable)		
Gd-150	64	1.80E+06	years	No	α, Sm-146	Gd-150 (1.8E6y) → Sm-146 (1.0E8y) → Nd-142 (stable)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Gd-151	64	124	days	No	EC, Eu-151 (stable)	No further daughters		
Gd-152	64	1.08E+14	years	No	α , Sm-148	Gd-152 (1.1E14y) \rightarrow Sm-148 (7E15y) \rightarrow Nd-144 (2.3E15y) \rightarrow Ce-140 (stable)		
Gd-153	64	240.4	days	No	EC, Eu-153 (stable)	No further daughters		
Gd-159	64	18.479	hours	No	β^- , Te-159 (stable)	No further daughters		
Ge-66	32	2.26	hours	No	EC, Ga-66	Ge-66 (2.3h) \rightarrow Ga-66 (9.5h) \rightarrow Zn-66 (stable)		
Ge-67	32	18.9	minutes	No	EC, Ga-67	Ge-67 (18.9m) \rightarrow Ga-67 (3.3d) \rightarrow Zn-67 (stable)		
Ge-68	32	270.95	days	No	EC, Ga-68	Ge-68 (271d) \rightarrow Ga-68 (68m) \rightarrow Zn-68 (stable)		
Ge-69	32	39.05	hours	No	EC, Ga-69 (stable)	No further daughters		
Ge-71	32	11.43	days	No	EC, Ga-71 (stable)	No further daughters		
Ge-75	32	82.78	minutes	No	β^- , As-75 (stable)	No further daughters		
Ge-77	32	11.30	hours	No	β^- , As-77	Ge-77 (11.3h) \rightarrow As-77 (39h) \rightarrow Se-77 (stable)		
Ge-78	32	88.0	minutes	No	β^- , As-78	Ge-78 (88m) \rightarrow As-78 (91m) \rightarrow Se-78 (stable)		
H-3	1	12.32	years	No	β^- , He-3 (stable)	No further daughters		
Hf-170	72	16.01	hours	No	EC, Lu-170	Hf-170 (16h) \rightarrow Lu-170 (2d) \rightarrow Yb-170 (stable)		
Hf-172	72	1.87	years	No	EC, Lu-172	Hf-172 (1.9y) \rightarrow Lu-172 (7d) \rightarrow Yb-172 (stable)		
Hf-173	72	23.6	hours	No	EC, Lu-173	Hf-173 (23.6h) \rightarrow Lu-173 (1.4y) \rightarrow Yb-173 (stable)		
Hf-174	72	2.0E+15	years	No	α , Yb-170 (stable)	No further daughters		
Hf-175	72	70	days	No	EC, Lu-175 (stable)	No further daughters		
Hf-177m	72	51.4	minutes	No	IT, Hf-177(stable)	No further daughters		
Hf-178m	72	31	years	No	IT, Hf-178 (stable)	No further daughters		
Hf-179m	72	25.05	days	No	IT, Hf-179 (stable)	No further daughters		
Hf-180m	72	5.47	hours	No	IT, 99.7%, Hf-180 (stable) β^- , 0.3%, Ta-180	Hf-180m (5.5h) \rightarrow Ta-180 (1E15y) \rightarrow Hf-180 (stable) and W-180 (stable)		
Hf-181	72	42.39	days	No	β^- , Ta-181 (stable)	No further daughters		
Hf-182	72	8.9E+06	years	No	β^- , Ta-182	Hf-182 (8.9E6y) \rightarrow Ta-182 (114d) \rightarrow W-182 (stable)		
Hf-182m	72	61.5	minutes	No	β^- , 58%, Ta-182 IT, 42%, Hf-182	Hf-182m (61.5m) \rightarrow Hf-182 (9E6y) \rightarrow Ta-182 (114d) \rightarrow W-182 (stable)		
Hf-183	72	1.067	hours	No	β^- , Ta-183	Hf-183 (1.1h) \rightarrow Ta-183 (5d) \rightarrow W-183 (stable).		
Hf-184	72	4.12	hours	No	β^- , Ta-184	Hf-184 (4.1h) \rightarrow Ta-184 (9h) \rightarrow W-184 (stable)		
Hg-193	80	3.80	hours	No	EC, Au-193	Hg-193 (3.8h) \rightarrow Au-193 (18h) \rightarrow Pt-193 (50y) \rightarrow Ir-193 (stable)		
Hg-193m	80	11.8	hours	No	EC, 92.8%, Au-193 IT, 7.2%, Hg-193	Hg-193m (11.8h) \rightarrow Hg-193 (4h) \rightarrow Au-193 (18h) \rightarrow Pt-193 (50y) \rightarrow Ir-193 (stable)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Hg-194	80	444	years	No	EC, Au-194	Hg-194 (4.4E2y) → Au-194 (38h) → Pt-194 (stable)		
Hg-195	80	10.53	hours	No	EC, Au-195	Hg-195 (10.5h) → Au-195 (186d) → Pt-195 (stable)		
Hg-195m	80	41.6	hours	No	IT, 54.2%, Hg-195 EC, 45.8%, Au-195	Hg-195m (41.6h) → Hg-195 (10h) → Au-195 (186d) → Pt-195 (stable)		
Hg-197	80	64.14	hours	No	EC, Au-197 (stable)	No further daughters		
Hg-197m	80	23.8	hours	No	IT, 91.4%, Hg-197 EC, 8.6%, Au-197 (stable)	Hg-197m (23.8h) → Hg-197 (64h) → Au-197 (stable)		
Hg-199m	80	42.67	minutes	No	IT, Hg-199 (stable)	No further daughters		
Hg-203	80	46.595	days	No	β-, Tl-203 (stable)	No further daughters		
Ho-155	67	48	minutes	No	EC, Dy-155	Ho-155 (48m) → Dy-155 (9.9h) → Tb-155 (5.3d) → Gd-155 (stable)		
Ho-157	67	12.6	minutes	No	EC, Dy-157	Ho-157 (12.6m) → Dy-157 (8.1h) → Tb-157 (71y) → Gd-157 (stable)		
Ho-159	67	33.05	minutes	No	EC, Dy-159	Ho-159 (33m) → Dy-159 (144d) → Tb-159 (stable)		
Ho-161	67	2.48	hours	No	EC, Dy-161 (stable)	No further daughters		
Ho-162	67	15.0	minutes	No	EC, Dy-162 (stable)	No further daughters		
Ho-162m	67	67.0	minutes	No	IT, 62%, Ho-162 EC, 38%, Dy-162 (stable)	Ho-162 (67m) → Ho-162 (15m) → Dy-162 (stable)		
Ho-164	67	29	minutes	No	EC, 60%, Dy-164 (stable) β-, 40%, Er-164 (stable)	No further daughters		
Ho-164m	67	37.5	minutes	No	IT, Ho-164	Ho-164m (67m) → Ho-164 (29m) → Dy-164 (stable) and Er-164 (stable)		
Ho-166	67	26.83	hours	No	β-, Er-166 (stable)	No further daughters		
Ho-166m	67	1.20E+03	years	No	β-, Er-166 (stable)	No further daughters		
Ho-167	67	3.003	hours	No	β-, Er-167 (stable)	No further daughters		
I-120	53	81.6	minutes	No	EC, Te-120 (stable)	No further daughters		
I-120m	53	53	minutes	No	EC, Te-120 (stable)	No further daughters		
I-121	53	2.12	hours	No	EC, Te-121	I-121 (2.1h) → Te-121 (19d) → Sb-121 (stable)		
I-122	53	3.63	minutes	No	EC, Te-122 (stable)	No further daughters		
I-123	53	13.232	hours	No	EC, Te-123	I-123 (13.2h) → Te-123 (6E14y) → Sb-123 (stable)		
I-124	53	4.1760	days	No	EC, Te-124 (stable)	No further daughters		
I-125	53	59.400	days	No	EC, Te-125 (stable)	No further daughters		
I-126	53	12.93	days	No	EC, 56.3%, Te-126 (stable) β-, 43.7%, Xe-126 (stable)	No further daughters		
I-128	53	24.99	minutes	No	β-, Xe-128 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
I-129	53	1.57E+07	years	No	β^- , Xe-129 (stable)	No further daughters		
I-130	53	12.36	hours	No	β^- , Xe-130 (stable)	No further daughters		
I-131	53	8.02070	days	No	β^- , Xe-131 (stable)	No further daughters		
I-132	53	2.295	hours	No	β^- , Xe-132 (stable)	No further daughters		
I-132m	53	1.387	hours	No	IT, 86%, I-132 β^- , 14%, Xe-132 (stable)	I-132m (1.4h) \rightarrow Xe-132 (2.3h) \rightarrow Xe-132 (stable)		
I-133	53	20.8	hours	No	β^- , Xe-133	I-133 (20.8h) \rightarrow Xe-133 (5.2d) \rightarrow Cs-133 (stable)		
I-134	53	52.5	minutes	No	β^- , Xe-134 (stable)	No further daughters		
I-135	53	6.57	hours	No	β^- , 84.5%, Xe-135 β^- , 15.5%, Xe-135m	I-135 (6.6h) \rightarrow Xe-135m (15.5m) \rightarrow Xe-135 (9.1h) \rightarrow Cs-135 (2.3E6y) \rightarrow Ba-135 (stable)		
In-109	49	4.2	hours	No	EC, Cd-109	In-109 (4.2h) \rightarrow Cd-109 (461d) \rightarrow Ag-109 (stable)		
In-110	49	4.9	hours	No	EC, Cd-110 (stable)	No further daughters		
In-110m	49	69.1	minutes	No	EC, Cd-110 (stable)	No further daughters		
In-111	49	2.8047	days	No	EC, Cd-111 (stable)	No further daughters		
In-112	49	14.97	minutes	No	EC, Cd-112 (stable)	No further daughters		
In-113m	49	99.476	minutes	No	IT, In-113 (stable)	No further daughters		
In-114	49	71.9	seconds	No	β^- , 99.5%, Sn-114 (stable) EC, 0.5%, Cd-114 (stable)	No further daughters		
In-114m	49	49.51	days	No	IT, 96.75%, In-114 EC, 3.25%, Cd-114 (stable)	In-114m (49.5d) \rightarrow In-114 (72s) \rightarrow Sn-114 (stable) and Cd-114 (stable)		
In-115	49	4.41E+14	years	No	β^- , Sn-115 (stable)	No further daughters		
In-115m	49	4.486	hours	No	IT, 95%, In-115 β^- , 5%, Sn-115 (stable)	In-115m (4.5h) \rightarrow In-115 (4.4E14y) \rightarrow Sn-115 (stable)		
In-116m	49	54.29	minutes	No	β^- , Sn-116 (stable)	No further daughters		
In-117	49	43.2	minutes	No	β^- , Sn-117 (stable)	No further daughters		
In-117m	49	116.2	minutes	No	β^- , 52.9%, Sn-117 (stable) IT, 47.1%, In-117	In-117m (116m) \rightarrow In-117 (43m) \rightarrow Sn-117 (stable)		
In-119	49	2.4	minutes	No	β^- , Sn-119 (stable)	No further daughters		
In-119m	49	18.0	minutes	No	β^- , 94.4%, Sn-119 (stable) IT, 5.6%, In-119	In-119m (18m) \rightarrow In-119 (2.4m) \rightarrow Sn-119 (stable)		
Ir-182	77	15	minutes	No	EC, Os-182	Ir-182 (15m) \rightarrow Os-182 (22h) \rightarrow Re-182 (64h) \rightarrow W-182 (stable)		
Ir-184	77	3.09	hours	No	EC, Os-184 (stable)	No further daughters		
Ir-185	77	14.4	hours	No	EC, Os-185	Ir-185 (14.4h) \rightarrow Os-185 (94d) \rightarrow Re-185 (stable)		
Ir-186	77	16.64	hours	No	EC, Os-186	Ir-186 (16.6h) \rightarrow Os-186 (2E15y) \rightarrow W-182 (stable)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Ir-186m	77	1.90	hours	No	EC, 75%, Os-186 IT, 25%, Ir-186	Ir-186m (1.9h) → Ir-186 (16.6h) → Os-186 (2E15y) → W-182 (stable)		
Ir-187	77	10.5	hours	No	EC, Os-187 (stable)	No further daughters		
Ir-188	77	41.5	hours	No	EC, Os-188 (stable)	No further daughters		
Ir-189	77	13.2	days	No	EC, Os-189 (stable)	No further daughters		
Ir-190	77	11.78	days	No	EC, Os-190 (stable)	No further daughters		
Ir-190m	77	1.120	hours	No	IT, Ir-190	Ir-190m (241y) → Ir-190 (12d) → Os-190 (stable)		
Ir-190n	77	3.087	hours	No	EC, 94.4%, Os-190 (stable) IT, 5.6%, Ir-190	Ir-190n (3.1h) → Ir-190 (12d, 1h) all decay to Os-190 (stable)		
Ir-191m	77	4.94	seconds	No	IT, Ir-191 (stable)	No further daughters		
Ir-192	77	73.827	days	Yes	β-, 95.4%, Pt-192 (stable) EC, 4.6%, Os-192 (stable)	No further daughters		
Ir-192m	77	241	years	No	IT, 99.98%, Ir-192 β-, 0.02%, Pt-192 (stable)	Ir-192m (241y) → Ir-192 (74d) → Pt-192 (stable) or Os-192 (stable)		
Ir-194	77	19.28	hours	Yes	β-, Pt-194 (stable)	No further daughters		
Ir-194m	77	171	days	No	β-, Pt-194 (stable)	No further daughters		
Ir-195	77	2.5	hours	No	β-, Pt-195 (stable)	No further daughters		
Ir-195m	77	3.8	hours	No	β-, 95%, Pt-195 (stable) IT, 5%, Ir-195	Ir-195m (3.8h) → Ir-195 (2.5h) → Pt-195 (stable)		
K-38	19	7.636	minutes	No	EC, Ar-38 (stable)	No further daughters		
K-40	19	1.248E+09	years	No	β-, 89.3%, Ca-40 (stable) EC, 10.7%, Ar-40 (stable)	No further daughters		
K-42	19	12	hours	No	β-, Ca-42 (stable)	No further daughters		
K-43	19	22.3	hours	No	β-, Ca-43 (stable)	No further daughters		
K-44	19	22.13	minutes	No	β-, Ca-44 (stable)	No further daughters		
K-45	19	17.3	minutes	No	β-, Ca-45	K-45 (17m) → Ca-45 (162.6d) → Sc-45 (stable)		
Kr-74	36	11.50	minutes	No	EC, Br-74	Kr-74 (11.5m) → Br-74 (25m) → Se-74 (stable)		
Kr-76	36	14.8	hours	No	EC, Br-76	Kr-76 (14.8h) → Br-76 (16h) → Se-76 (stable)		
Kr-77	36	74.4	minutes	No	EC, Br-77	Kr-77 (74m) → Br-77 (57h) → Se-77 (stable)		
Kr-79	36	35.04	hours	No	EC, Br-79 (stable)	No further daughters		
Kr-81	36	2.29E+05	years	No	EC, Br-81 (stable)	No further daughters		
Kr-81m	36	13.10	seconds	No	IT, Kr-81	Kr-81m (13.1s) → Kr-81 (2.3e5y) → Br-81 (stable)		
Kr-83m	36	1.83	hours	No	IT, Kr-83 (stable)	No further daughters		
Kr-85	36	3916.8	days	No	β-, Rb-85 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Kr-85m	36	4.480	hours	No	β^- , 78.6%, Rb-85 (stable) IT, 21.4%, Kr-85	Kr-85m (4.48h) \rightarrow Kr-85 (3934d) \rightarrow Rb-85 (stable)		
Kr-87	36	76.3	minutes	No	β^- , Rb-87	Kr-87 (76m) \rightarrow Rb-87 (4.7E10y) \rightarrow Sr-87 (stable)		
Kr-88	36	2.84	hours	No	β^- , Rb-88	Kr-88 (2.8h) \rightarrow Rb-88 (18m) \rightarrow Sr-88 (stable)		
La-131	57	59	minutes	No	EC, Ba-131	La-131 (59m) \rightarrow Ba-131 (11.5d) \rightarrow Cs-131 (9.7d) \rightarrow Xe-131 (stable)		
La-132	57	4.8	hours	No	EC, Ba-132 (stable)	No further daughters		
La-134	57	6.45	minutes	No	EC, Ba-134 (stable)	No further daughters		
La-135	57	19.5	hours	No	EC, Ba-135 (stable)	No further daughters		
La-137	57	6E+04	years	No	EC, Ba-137 (stable)	No further daughters		
La-138	57	1.02E+11	years	No	EC, 66.4%, Ba-138 (stable) β^- , 33.6%, Ce-138 (stable)	No further daughters		
La-140	57	1.6781	days	No	β^- , Ce-140 (stable)	No further daughters		
La-141	57	3.92	hours	No	β^- , Ce-141	La-141 (3.9h) \rightarrow Ce-141 (32.5d) \rightarrow Pr-141 (stable)		
La-142	57	91.1	minutes	No	β^- , Ce-142	La-142 (91m) \rightarrow Ce-142 (2.6E17y) \rightarrow Nd-142 (stable)		
La-143	57	14.2	minutes	No	β^- , Ce-143	La-143 (14.2m) \rightarrow Ce-143 (33h) \rightarrow Pr-143 (13.6m) \rightarrow Nd-143 (stable)		
Lu-169	71	34.06	hours	No	EC, Yb-169	Lu-169 (34h) \rightarrow Yb-169 (32d) \rightarrow Tm-169 (stable)		
Lu-170	71	2.012	days	No	EC, Yb-170 (stable)	No further daughters		
Lu-171	71	8.24	days	No	EC, Yb-171 (stable)	No further daughters		
Lu-172	71	6.70	days	Yes	EC, Yb-172 (stable)	No further daughters		
Lu-173	71	1.37	years	No	EC, Yb-173 (stable)	No further daughters		
Lu-174	71	3.31	years	No	EC, Yb-174 (stable)	No further daughters		
Lu-174m	71	142	days	No	IT, 99.38%, Lu-174 EC, 0.62%, Yb-174 (stable)	Lu-174m(142d) \rightarrow Lu-174 (3y) \rightarrow Yb-174 (stable)		
Lu-176	71	3.76E+10	years	No	β^- , Hf-176 (stable)	No further daughters		
Lu-176m	71	3.664	hours	No	β^- , 99.9%, Hf-176 (stable) EC, 0.1%, Yb-176 (stable)	No further daughters		
Lu-177	71	6.6475	days	No	β^- , Hf-177 (stable)	No further daughters		
Lu-177m	71	160.44	days	No	β^- , 78.3%, Hf-177 (stable) IT, 21.7%, Lu-177	Lu-177m (160d) \rightarrow Lu-177 (7d) \rightarrow Hf-177 (stable)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Lu-178	71	28.4	minutes	No	β^- , Hf-178 (stable)	No further daughters		
Lu-178m	71	23.1	minutes	No	β^- , Hf-178 (stable)	No further daughters		
Lu-179	71	4.59	hours	No	β^- , Hf-179 (stable)	No further daughters		
Md-257	101	5.52	hours	No	EC, 90%, Fm-257 α , 10%, Es-253	Md-257 (5.5h) \rightarrow Fm-257 (100d) \rightarrow Cf-253 (18d) \rightarrow Es-253 (21d) \rightarrow Bk-249 (330d) \rightarrow Cf-249 (3.5E2y) \rightarrow Cm-245 (8.5E3y) \rightarrow Pu-241 (in Neptunium Series)		
Md-258	101	51.5	days	No	α , Es-254	Md-258 (51d) \rightarrow Es-254 (276d) \rightarrow Bk-250 (3.2h) \rightarrow Cf-250 (13y) \rightarrow Cm-246 (4.8E3y) \rightarrow Pu-242 (3.7E5y) \rightarrow U-238 (in Uranium Series)		
Mg-28	12	20.915	hours	No	β^- , Al-28	Mg-28 (20.9h) \rightarrow Al-28 (2.2m) \rightarrow Si-28 (stable)		
Mn-51	25	46.2	minutes	No	EC, Cr-51	Mn-51 (46m) \rightarrow Cr-51 (27.7d) \rightarrow V-51 (stable)		
Mn-52	25	5.591	days	No	EC, Cr-52 (stable)	No further daughters		
Mn-52m	25	21.1	minutes	No	EC, 98.25%, Cr-52 (stable) IT, 1.75%, Mn-52	Mn-52m (21m) \rightarrow Mn-52 (5.6d) \rightarrow Cr-52 (stable)		
Mn-53	25	3.74E+06	years	No	EC, Cr-53 (stable)	No further daughters		
Mn-54	25	312.12	days	No	EC, Cr-54 (stable)	No further daughters		
Mn-56	25	2.5789	hours	No	β^- , Fe-56 (stable)	No further daughters		
Mo-101	42	14.61	minutes	No	β^- , Tc-101	Mo-101 (14m) \rightarrow Tc-101 (14m) \rightarrow Ru-101 (stable)		
Mo-90	42	5.56	hours	No	EC, Nb-90	Mo-90 (5.6h) \rightarrow Nb-90 (14.6h) \rightarrow Zr-90 (stable)		
Mo-93	42	4.0E+03	years	No	EC, 85%, Nb-93m EC, 15%, Nb-93 (stable)	Mo-93 (4E3y) \rightarrow Nb-93m (16.1y) \rightarrow Nb-93 (stable)		
Mo-93m	42	6.85	hours	No	IT, 99.88%, Mo-93 EC, 0.12%, Nb-93 (stable)	Mo-93m (6.8h) \rightarrow Mo-93 (4E3y) \rightarrow Nb-93 (stable)		
Mo-99	42	2.7489	days	No	β^- , 88.1%, Tc-99m β^- , 11.9%, Tc-99	Mo-99 (2.7d) \rightarrow Tc-99m (6h) \rightarrow Tc-99 (2.1E5y) \rightarrow Ru-99 (stable)		
N-13	7	9.965	minutes	No	EC, C-13 (stable)	No further daughters		
Na-22	11	2.6027	years	No	EC, Ne-22 (stable)	No further daughters		
Na-24	11	14.951	hours	No	β^- , Mg-24 (stable)	No further daughters		
Nb-88	41	14.55	minutes	No	EC, Zr-88	Nb-88 (14.6m) \rightarrow Zr-88 (83d) \rightarrow Y-88 (107d) \rightarrow Sr-88 (stable)		
Nb-89a	41	66	minutes	No	EC, Zr-89	Nb-89a (66m) \rightarrow Zr-89 (78h) \rightarrow Y-89 (stable)		
Nb-89b	41	2.03	hours	No	EC, Zr-89	Nb-89b (2h) \rightarrow Zr-89 (78h) \rightarrow Y-89 (stable)		
Nb-90	41	14.60	hours	No	EC, Zr-90 (stable)	No further daughters		
Nb-92	41	3.47E+07	years	No	EC, Zr-92 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Nb-93m	41	16.13	years	Yes	IT, Nb-93 (stable)	No further daughters		
Nb-94	41	2.03E+04	years	No	β^- , Mo-94 (stable)	No further daughters		
Nb-95	41	34.991	days	No	β^- , Mo-95 (stable)	No further daughters		
Nb-95m	41	3.61	days	No	IT, 94.4%, Nb-95 β^- , 5.6%, Mo-95 (stable)	Nb-95m (3.6d) \rightarrow Nb-95 (35d) \rightarrow Mo-95 (stable)		
Nb-96	41	23.35	hours	No	β^- , Mo-96 (stable)	No further daughters		
Nb-97	41	72.1	minutes	No	β^- , Mo-97 (stable)	No further daughters		
Nb-97m	41	58.7	seconds	No	IT, Nb-97	Nb-97m (89s) \rightarrow Nb-97 (72m) \rightarrow Mo-97 (stable)		
Nb-98	41	51.3	minutes	No	β^- , Mo-98 (stable)	No further daughters		
Nd-136	60	50.65	minutes	No	EC, Pr-136	Nd-136 (50.7m) \rightarrow Pr-136 (13.1m) \rightarrow Ce-136 (stable)		
Nd-138	60	5.04	hours	No	EC, Pr-138	Nd-138 (5h) \rightarrow Pr-138 (1.45m) \rightarrow Ce-138 (stable)		
Nd-139	60	29.7	minutes	No	EC, Pr-139	Nd-139 (29.7m) \rightarrow Pr-139 (4.4h) \rightarrow Ce-139 (138d) \rightarrow La-139 (stable)		
Nd-139m	60	5.50	hours	No	EC, 88.2%, Pr-139 IT, 11.8%, Nd-139	Nd-139m (5.5h) \rightarrow Nd-139 (29.7m) \rightarrow Pr-139 (4.4h) \rightarrow Ce-139 (138d) \rightarrow La-139 (stable)		
Nd-141	60	2.49	hours	No	EC, Pr-141 (stable)	No further daughters		
Nd-141m	60	62.0	seconds	No	IT, Nd-141	Nd-141m (62s) \rightarrow Nd-141 (2.49h) \rightarrow Pr-141 (stable)		
Nd-144	60	2.29E+15	years	Yes	α , Ce-140 (stable)	No further daughters		
Nd-147	60	10.98	days	No	β^- , Pm-147	Nd-147 (11d) \rightarrow Pm-147 (3y) \rightarrow Sm-147 (1.06E11y) \rightarrow Nd-143 (stable)		
Nd-149	60	1.728	hours	No	β^- , Pm-149	Nd-149 (1.7h) \rightarrow Pm-149 (53h) \rightarrow Sm-149 (stable)		
Nd-151	60	12.44	minutes	No	β^- , Pm-151	Nd-151 (12.4m) \rightarrow Pm-151 (28h) \rightarrow Sm-151 (stable)		
Ne-19	10	17.22	seconds	No	EC, F-19 (stable)	No further daughters		
Ni-56	28	6.075	days	No	EC, Co-56	Ni-56 (6.1d) \rightarrow Co-56 (77d) \rightarrow Fe-56 (stable)		
Ni-57	28	35.60	hours	No	EC, Co-57	Ni-57 (35.6h) \rightarrow Co-57 (272d) \rightarrow Fe-57 (stable)		
Ni-59	28	7.6E+04	years	No	EC, Co-59 (stable)	No further daughters		
Ni-63	28	100.1	years	No	β^- , Cu-63 (stable)	No further daughters		
Ni-65	28	2.5172	hours	No	β^- , Cu-65 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Ni-66	28	54.6	hours	No	β^- , Cu-66	Ni-66 (54.6h) \rightarrow Cu-66 (5.1m) \rightarrow Zn-66 (stable)		
Np-232	93	14.7	minutes	No	EC, U-232	Np-232 (14.7m) \rightarrow U-232 (69y) \rightarrow Th-228 (in Thorium Series)		
Np-233	93	36.2	minutes	No	EC, U-233	Np-233 (36m) \rightarrow U-233 (1.6E5y in Neptunium Series)		
Np-234	93	4.4	days	No	EC, U-234	Np-234 (4.4d) \rightarrow U-234 (2.5E5y in Uranium Series)		
Np-235	93	396.1	days	No	EC, U-235	Np-235 (396d) \rightarrow U-235 (7.04E8y in Actinium Series)		
Np-236	93	1.54E+05	years	No	EC, 87.3%, U-236 β^- , 12.5%, Pu-236 α , 0.16%, Pa-232	Np-236 (1.5E5y) \rightarrow U-236 (2.3E7y) \rightarrow Th-232 (in Thorium Series); Np-236 (1.5E5y) \rightarrow Pu-236 (2.8y) Np-236a (1.5E5y) \rightarrow U-232 (69y) to Th-228 (in Thorium Series)		
Np-236m	93	22.5	hours	No	EC, 52%, U-236 β^- , 48%, Pu-236	Np-236m (22.5h) \rightarrow U-236 (2.3E7y) \rightarrow Th-232 (in Thorium Series); Np-236m (22.5h) \rightarrow Pu-236 (2.8y) \rightarrow U-232 (69y) \rightarrow Th-228 (in Thorium Series)		
Np-237	93	2.144E+06	years	Yes	α , Pa-233	See Pa-233 (in Neptunium Series)	Np	3
Np-238	93	2.117	days	No	β^- , Pu-238	Np-238 (2.1d) \rightarrow Pu-238 (88y) \rightarrow U-234 (in Uranium Series)		
Np-239	93	2.356	days	Yes	β^- , Pu-239	Np-239 (2.4d) \rightarrow Pu-239 (2.4E4y) \rightarrow U-235 c		
Np-240	93	61.9	minutes	Yes	β^- , Pu-240	Np-240 (61.9m) \rightarrow Pu-240 (6.6E3y) \rightarrow U-236 (2.3E7y) \rightarrow Th-232 (in Thorium Series)		
Np-240m	93	7.22	minutes	No	β^- , Pu-240	Np-240m (7.2m) \rightarrow Pu-240 (6.6E3y) \rightarrow U-236 (2.3E7y) \rightarrow Th-232 (in Thorium Series)		
O-15	8	122.24	seconds	No	EC, N-15 (stable)	No further daughters		
Os-180	76	21.5	minutes	No	EC, Re-180	Os-180 (21.5m) \rightarrow Re-180 (2m) \rightarrow W-180 (stable)		
Os-181	76	105	minutes	No	EC, Re-181	Os-181 (105m) \rightarrow Re-181 (20h) \rightarrow W-181 (121d) \rightarrow Ta-181 (stable)		
Os-182	76	22.10	hours	No	EC, Re-182a EC, Re-182b	Os-182 (22h) \rightarrow Re-182 (64h) \rightarrow W-182 (stable)		
Os-185	76	93.6	days	No	EC, Re-185 (stable)	No further daughters		
Os-186	76	2E+15	years	Yes	α , W-182 (stable)	No further daughters		
Os-189m	76	5.81	hours	No	IT, Os-189 (stable)	No further daughters		
Os-190m	76	9.9	minutes	No	IT, Os-190 (stable)	No further daughters		
Os-191	76	15.4	days	No	β^- , Ir-191 (stable)	No further daughters		
Os-191m	76	13.10	hours	No	IT, Os-191	Os-191m (13h) \rightarrow Os-191 (15d) \rightarrow Ir-191 (stable)		
Os-193	76	30.11	hours	No	β^- , Ir-193 (stable)	No further daughters		
Os-194	76	6.0	years	No	β^- , Ir-194	Os-194 (6y) \rightarrow Ir-194 (19h) \rightarrow Pt-194 (stable)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
P-30	15	2.498	minutes	No	EC, Si-30 (stable)	No further daughters		
P-32	15	14.262	days	Yes	β^- , S-32 (stable)	No further daughters		
P-33	15	25.34	days	No	β^- , S-33 (stable)	No further daughters		
Pa-227	91	38.3	minutes	No	α , 85%, Ac-223 EC, 15%, Th-227	Pa-227 (38m) \rightarrow Ac-223 (2.1m) \rightarrow Fr-219 (<1s) \rightarrow At-215 (<1s) to Bi-211 (in Actinium Series); Th-227 (19d) \rightarrow Ra-223 (in Actinium Series)		
Pa-228	91	22	hours	No	EC, 98%, Th-228 α , 2%, Ac-224	Pa-228 (22h) \rightarrow Th-228 (1.9y in Thorium Series) \rightarrow Pb-208 (stable); Pa-228 (22h) \rightarrow Ac-224 (2.8h) \rightarrow Ra-224 (in Thorium Series) \rightarrow Pb-208 (stable)		
Pa-230	91	17.4	days	No	EC, 91.6%, Th-230 β^- , 8.4%, U-230 α , 0.0032%, Ac-226	Th-230 (in Uranium Series); Pa-230 (17.4d) \rightarrow U-230 (21d) \rightarrow Th-226 (31m) \rightarrow Ra-222 (38s) \rightarrow Rn-218 (<1s) \rightarrow Po-214 (in Uranium Series)		
Pa-231	91	3.276E+04	years	Yes	α , Ac-227	See Ac-227 (in Actinium Series)	Ac	3
Pa-232	91	1.31	days	No	β^- , U-232	Pa-232 (1.3d) \rightarrow U-232 (69y) \rightarrow Th-228 (in Neptunium Series)		
Pa-233	91	26.975	days	Yes	β^- , U-233	See U-233 (in Neptunium Series)	Np	4
Pa-234	91	6.70	hours	Yes	β^- , U-234	See U-234 (in Uranium Series)	U	3
Pa-234m	91	1.17	minutes	No	β^- , 99.87%, U-234 IT, 0.13%, Pa-234	See U-234 and Pa-234 (in Uranium Series)		
Pb-195m	82	15.0	minutes	No	EC, Tl-195	Pb-195m (15m) \rightarrow Tl-195 (1.2h) \rightarrow Hg-195 (10h) \rightarrow Au-195 (186d) \rightarrow Pt-195 (stable)		
Pb-198	82	2.40	hours	No	EC, Tl-198	Pb-198 (2.4h) \rightarrow Tl-198 (5h) \rightarrow Hg-198 (stable)		
Pb-199	82	90	minutes	No	EC, Tl-199	Pb-199 (90m) \rightarrow Tl-199 (7h) \rightarrow Hg-199 (stable)		
Pb-200	82	21.5	hours	No	EC, Tl-200	Pb-200 (21.5h) \rightarrow Tl-200 (26h) \rightarrow Hg-200 (stable)		
Pb-201	82	9.33	hours	No	EC, Tl-201	Pb-201 (9.3h) \rightarrow Tl-201 (73h) \rightarrow Hg-201 (stable)		
Pb-202	82	5.25E+04	years	No	EC, 99%, Tl-202 α , 1%, Hg-198 (stable)	Pb-202 (5.2E4y) \rightarrow Tl-202 (12d) \rightarrow Hg-202 (stable)		
Pb-202m	82	3.53	hours	No	IT, 90.5%, Pb-202 EC, 9.5%, Tl-202	Pb-202m (3.5h) \rightarrow Pb-202 (5.2E5y) \rightarrow Tl-202 (12d) \rightarrow Hg-202 (stable)		
Pb-203	82	51.920	hours	No	EC, Tl-203 (stable)	No further daughters		
Pb-204	82	1.4E+17	years	No	α , Hg-200 (stable)	No further daughters		
Pb-205	82	1.73E+07	years	Yes	EC, Tl-205 (stable)	No further daughters		
Pb-209	82	3.253	hours	Yes	β^- , Bi-209 (stable)	No further daughters	Np	14
Pb-210	82	22.20	years	Yes	β^- , Bi-210	See Bi-210 in Uranium Series	U	14
Pb-211	82	36.1	minutes	Yes	β^- , Bi-211	See Bi-211 in Actinium Series	Ac	10

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Pb-212	82	10.64	hours	Yes	β^- , Bi-212	See Bi-212 in Thorium Series	Th	8
Pb-214	82	26.8	minutes	Yes	β^- , Bi-214	See Bi-214 (in Uranium Series)	U	9
Pd-100	46	3.63	days	No	EC, Rh-100	Pd-100 (3.6d) \rightarrow Rh-100 (21h) \rightarrow Ru-100 (stable)		
Pd-101	46	8.47	hours	No	EC, Rh-101	Pd-101 (8.5h) \rightarrow Rh-101 (3.3y) \rightarrow Ru-101 (stable)		
Pd-103	46	16.991	days	No	EC, Rh-103m	Pd-103 (17d) \rightarrow Rh-103m (56m) \rightarrow Rh-103 (stable)		
Pd-107	46	6.5E+06	years	No	β^- , Ag-107 (stable)	No further daughters		
Pd-109	46	13.7012	hours	No	β^- , Ag-109m	Pd-109 (13.7h) \rightarrow Ag-109m (38s) \rightarrow Ag-109 (stable)		
Pm-141	61	20.90	minutes	No	EC, Nd-141	Pm-141 (21m) \rightarrow Nd-141 (3h) \rightarrow Pr-141 (stable)		
Pm-142	61	40.5	seconds	No	EC, Nd-142 (stable)	No further daughters		
Pm-143	61	265	days	No	EC, Nd-143 (stable)	No further daughters		
Pm-144	61	363	days	No	EC, Nd-144	Pm-144 (363d) \rightarrow Nd-144 (2.3E15y) \rightarrow Ce-140 (stable)		
Pm-145	61	17.7	years	No	EC, Nd-145 (stable)	No further daughters		
Pm-146	61	5.53	years	No	EC, 66.1%, Nd-146 (stable) β^- , 33.9%, Sm-146	Pm-146 (5.5y) \rightarrow Sm-146 (1E8y) \rightarrow Nd-142 (stable)		
Pm-147	61	2.6234	years	No	β^- , Sm-147	Pm-147 (2.6y) \rightarrow Sm-147 (1.06E11y) \rightarrow Nd-143 (stable)		
Pm-148	61	5.368	days	No	β^- , Sm-148	Pm-148 (5.4d) \rightarrow Sm-148 (7E15y) \rightarrow Nd-144 (2.3E15y) \rightarrow Ce-140 (stable)		
Pm-148m	61	41.29	days	No	β^- , 95.4%, Sm-148 IT, 4.6%, Pm-148	Pm-148m (41.3d) \rightarrow Pm-148 (5.4d) \rightarrow Sm-148 (7E15y) \rightarrow Nd-144 (2.3E15y) \rightarrow Ce-140 (stable)		
Pm-149	61	53.08	hours	No	β^- , Sm-149	Pm-149 (53h) \rightarrow Sm-149 (2E15y) \rightarrow Nd-144 (stable)		
Pm-150	61	2.68	hours	No	β^- , Sm-150 (stable)	No further daughters		
Pm-151	61	28.40	hours	No	β^- , Sm-151	Pm-151 (28.4h) \rightarrow Sm-151 (90y) \rightarrow Eu-151 (stable)		
Po-203	84	36.7	minutes	No	EC, 99.89%, Bi-203 α , 0.11%, Pb-199	Po-203 (37m) \rightarrow Bi-203 (12h) \rightarrow Pb-203 (52h) \rightarrow Tl-203 (stable)		
Po-205	84	1.74	hours	No	EC, 99.96%, Bi-205 α , 0.04%, Pb-201	Po-205 (1.7h) \rightarrow Bi-205 (15d) \rightarrow Pb-205 (1.5E7y) \rightarrow Tl-205 (stable)		
Po-207	84	5.80	hours	No	EC, 99.98%, Bi-207 α , 0.02%, Pb-203	Po-207 (5.8h) \rightarrow Bi-207 (32y) \rightarrow Pb-207 (stable)		
Po-209	84	102.00	years	No	α , 99.5%, Pb-205 EC, 0.5%, Bi-209 (stable)	Po-209 (102y) \rightarrow Pb-205 (1.5E7y) \rightarrow Tl-205 (stable)		
Po-210	84	138.376	days	Yes	α , Pb-206 (stable)	No further daughters	U	16
Po-211	84	0.516	seconds	Yes	β^- , Pb-207 (stable)	No further daughters	Ac	12
Po-212	84	3.00E-07	seconds	Yes	α , Pb-208 (stable)	No further daughters	Th	10
Po-212m	84	2.98E-07	seconds	No	α , Pb-208 (stable)	No further daughters		
Po-213	84	3.65E-06	seconds	Yes	α , Pb-209	See Pb-209 (in Neptunium Series)	Np	12

Savannah River Site

High-Level Waste Tank Farm Closure
Radionuclide Screening Process (First-Level)
Development and Application

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Po-214	84	1.643E-04	seconds	Yes	α , Pb-210	See Pb-210 (in Uranium Series)	U	12
Po-215	84	1.781E-03	seconds	Yes	α , Pb-211	See Pb-211 (in Actinium Series)	Ac	9
Po-216	84	0.145	seconds	Yes	α , Pb-212	See Pb-212 (in Thorium Series)	Th	7
Po-218	84	3.10	minutes	Yes	α , 99.98%, Pb-214 β^- , 0.02%, At-218	See Pb-214 (in Uranium Series)	U	8
Pr-136	59	13.1	minutes	No	EC, Ce-136 (stable)	No further daughters		
Pr-137	59	1.28	hours	No	EC, Ce-137	Pr-137 (1.3h) \rightarrow Ce-137 (9h) \rightarrow La-137 (6E4y) \rightarrow Ba-137 (stable)		
Pr-138	59	1.45	minutes	No	EC, Ce-138 (stable)	No further daughters		
Pr-138m	59	2.12	hours	No	EC, Ce-138 (stable)	No further daughters		
Pr-139	59	4.41	hours	No	EC, Ce-139	Pr-139 (4.4h) \rightarrow Ce-139 (137.7d) \rightarrow La-139 (stable)		
Pr-142	59	19.12	hours	No	β^- , 99.98%, Nd-142 (stable) EC, 0.02%, Ce-142 (stable)	No further daughters		
Pr-142m	59	14.6	minutes	No	IT, Pr-142	Pr-142m (7.2m) \rightarrow Pr-142 (19h) \rightarrow Nd-142 (stable) and Ce-142 (stable)		
Pr-143	59	13.57	days	No	β^- , Nd-143 (stable)	No further daughters		
Pr-144	59	17.28	minutes	No	β^- , Nd-144	Pr-144 (17m) \rightarrow Nd-144 (2.3E15y) \rightarrow Ce-140 (stable)		
Pr-144m	59	7.2	minutes	No	IT, 99.93%, Pr-144 β^- , 0.07%, Nd-144	Pr-144m (7.2m) \rightarrow Pr-144 (17.3m) \rightarrow Nd-144 (2.3E15y) \rightarrow Ce-140 (stable).		
Pr-145	59	5.984	hours	No	β^- , Nd-145 (stable)	No further daughters		
Pr-147	59	13.4	minutes	No	β^- , Nd-147	Pr-147 (13.4m) \rightarrow Nd-147 (11d) \rightarrow Pm-147 (2.6y) \rightarrow Sm-147 (1.1E11y) \rightarrow Nd-143 (stable)		
Pt-186	78	2.08	hours	No	EC, Ir-186	Pt-186 (2.1h) \rightarrow Ir-186 (17h, 2h) \rightarrow Os-186 (2E15y) \rightarrow W-182 (stable)		
Pt-188	78	10.2	days	No	EC, Ir-188	Pt-188 (10.2d) \rightarrow Ir-188 (41h) \rightarrow Os-188 (stable)		
Pt-189	78	10.87	hours	No	EC, Ir-189	Pt-189 (10.9h) \rightarrow Ir-189 (13d) \rightarrow Os-189 (stable)		
Pt-191	78	2.862	days	No	EC, Ir-191 (stable)	No further daughters		
Pt-193	78	50	years	No	EC, Ir-193 (stable)	No further daughters		
Pt-193m	78	4.33	days	No	IT, Pt-193	Pt-193m (4.3d) \rightarrow Pt-193 (50y) \rightarrow Ir-193 (stable)		
Pt-195m	78	4.010	days	No	IT, Pt-195 (stable)	No further daughters		
Pt-197	78	19.8915	hours	No	β^- , Au-197 (stable)	No further daughters		
Pt-197m	78	95.41	minutes	No	IT, 96.7%, Pt-197 β^- , 3.3%, Au-197 (stable)	Pt-197m (95.4m) \rightarrow Pt-197 (20h) \rightarrow Au-197 (stable)		
Pt-199	78	30.80	minutes	No	β^- , Au-199	Pt-199 (31m) \rightarrow Au-199 (3d) \rightarrow Hg-199 (stable)		
Pt-200	78	12.5	hours	No	β^- , Au-200	Pt-200 (12.5h) \rightarrow Au-200 (48m) \rightarrow Hg-200 (stable)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Pu-234	94	8.8	hours	No	EC, 94%, Np-234 α , 6%, U-230	Pu-234 (8.8h) \rightarrow Np-234 (4.4d) \rightarrow U-234 (2.5E5y in Uranium Series); Pu-234 (8.8h) \rightarrow U-230 (21d) \rightarrow Th-226 (31m) \rightarrow Ra-222 (38s) \rightarrow Rn-218 (<1s) \rightarrow Po-214 (in Uranium Series)		
Pu-235	94	25.3	minutes	No	EC, Np-235	Pu-235 (25m) \rightarrow Np-235 (396d) \rightarrow U-235 (in Actinium Series)		
Pu-236	94	2.858	years	Yes	α , U-232	Pu-236 (2.9y) \rightarrow U-232 (69y) \rightarrow Th-228 (in Thorium Series)		
Pu-237	94	45.2	days	No	EC, Np-237	Pu-237 (45d) \rightarrow Np-237 (2.1E6y in Neptunium Series)		
Pu-238	94	87.7	years	No	α , U-234	See U-234 (in Uranium Series)		
Pu-239	94	24,110	years	No	α , U-235	Pu-239 (2.4E4y) \rightarrow 100% U-235m (26m) \rightarrow U-235 (7E8y) (in Actinium Series) (U-235m not on table)		
Pu-240	94	6,561	years	Yes	α , U-236	Pu-240 (6.6E3y) \rightarrow U-236 (2.3E7y) \rightarrow Th-232 (in Thorium Series)		
Pu-241 (Neptunium Series)	94	14.290	years	Yes	β^- , Am-241	Neptunium Series Pu-241 (14y) \rightarrow Am-241(4.3E2y) \rightarrow Np-237(2.1E6y) \rightarrow Pa-233 (27d) \rightarrow U-233 (1.6E5y) \rightarrow Th-229 (7.3E3y) \rightarrow Ra-225 (15d) \rightarrow Ac-225 (10d) \rightarrow Fr-221 (5m) \rightarrow At-217 (<1s) \rightarrow Bi-213 (46m) \rightarrow Po-213 (<1s) and Tl-209 (2.2m) \rightarrow Pb-209 (3.3h) \rightarrow Bi-209 (stable)	Np	1
Pu-242	94	3.75E+05	years	Yes	α , U-238	See U-238 in (Uranium Series)		
Pu-243	94	4.956	hours	Yes	β^- , Am-243	Pu-243 (5h) \rightarrow Am-243 (7.4E7y) \rightarrow Np-239 (2.4d) \rightarrow Pu-239 (2.4E4y) \rightarrow U-235 (in Actinium Series)		
Pu-244	94	8.00E+07	years	Yes	α , 99.875%, U-240 SPF, 0.125%, FP	Pu-244 (8E7y) \rightarrow U-240 (14h) \rightarrow Np-240 (62h) \rightarrow Pu-240 (6.6E3y) \rightarrow U-236 (2.3E7y) \rightarrow Th-232 (in Thorium Series)		
Pu-245	94	10.5	hours	No	β^- , Am-245	Pu-245 (10.5h) \rightarrow Am-245 (2h) \rightarrow Cm-245 (8.5E3y) \rightarrow Pu-241 (in Neptunium Series)		
Pu-246	94	10.84	days	Yes	β^- , Am-246	Pu-246 (11d) \rightarrow Am-246 (39m) \rightarrow Cm-245 (8.5E3y) \rightarrow Pu-241 (in Neptunium Series)		
Ra-222	88	38.0	seconds	No	α , Rn-218	Ra-222 (38s) \rightarrow Rn-218 (<1s) \rightarrow Po-214 (in Uranium Series)		
Ra-223	88	11.430	days	Yes	α , Rn-219	See Rn-219 (in Actinium Series)	Ac	7
Ra-224	88	3.63	days	Yes	α , Rn-220	See Rn-220 (in Thorium Series)	Th	5
Ra-225	88	14.9	days	Yes	β^- , Ac-225	See Ac-225 (in Neptunium Series)	Np	7
Ra-226	88	1,600	years	Yes	α , Rn-222	See Rn-222 (in Uranium Series)	U	6
Ra-227	88	42.2	minutes	No	β^- , Ac-227	Ra-227 (42.2m) \rightarrow Ac-227 (21.8y in Actinium Series)		
Ra-228	88	5.75	years	Yes	β^- , Ac-228	See Ac-228 (in Thorium Series)	Th	2

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Rb-79	37	22.9	minutes	No	EC, Kr-79	Rb-79 (22.9m) → Kr-79 (35 h) → Br-79 (stable)		
Rb-80	37	33.4	seconds	No	EC, Kr-80 (stable)	No further daughters		
Rb-81	37	4.570	hours	No	EC, Kr-81	Rb-81 (4.6h) → Kr-81 (2.3E5y) → Br-81 (stable)		
Rb-81m	37	30.5	minutes	No	IT, 97.6%, Rb-81 EC, 2.4%, Kr-81	Rb-81m (30.5m) → Rb-81 (4.6h) → Kr-81 (2.3E5y) → Br-81 (stable)		
Rb-82	37	1.273	minutes	No	EC, Kr-82 (stable)	No further daughters		
Rb-82m	37	6.472	hours	No	EC, Kr-82 (stable)	No further daughters		
Rb-83	37	86.2	days	No	EC, 75%, Kr-83m EC, 25%, Kr-83 (stable)	Rb-83 (86d) → Kr-83m (1.8h) → Kr-83 (stable)		
Rb-84	37	33.1	days	No	EC, Kr-84 (stable)	No further daughters		
Rb-86	37	18.642	days	No	β-, Sr-86 (stable)	No further daughters		
Rb-87	37	4.97E+10	years	No	β-, Sr-87 (stable)	No further daughters		
Rb-88	37	17.773	minutes	No	β-, Sr-88 (stable)	No further daughters		
Rb-89	37	15.15	minutes	No	β-, Sr-89	Rb-89 (15.1m) → Sr-89 (51d) → Y89 (stable)		
Re-177	75	14	minutes	No	EC, W-177	Re-177 (14m) → W-177 (135m) → Ta-177 (57h) → Hf-177 (stable)		
Re-178	75	13.2	minutes	No	EC, W-178	Re-178 (13.2m) → W-178 (22d) → Ta-178 (9m) → Hf-178 (stable)		
Re-180	75	2.44	minutes	No	EC, W-180 (stable)	No further daughters		
Re-181	75	19.9	hours	No	EC, W-181	Re-181 (19.9h) → W-181 (121d) → Ta-181 (stable)		
Re-182	75	64.0	hours	No	EC, W-182 (stable)	No further daughters		
Re-182m	75	12.7	hours	No	EC, W-182 (stable)	No further daughters		
Re-184	75	38.0	days	No	EC, W-184 (stable)	No further daughters		
Re-184m	75	169	days	No	IT, 75.4%, Re-184 EC, 24.6%, W-184 (stable)	Re-184m (169d) → Re-184 (38d) → W-184 (stable)		
Re-186	75	3.7186	days	Yes	β-, 92.53%, Os-186 EC, 7.47%, W-186 (stable)	Re-186 (3.7d) → Os-186 (2E15y) → W-182 (stable)		
Re-186m	75	2.0E+05	years	No	IT, Re-186	Re-186m (2E5y) → Re-186 (3.7d) → Os-186 (2E15y) → W-182 (stable)		
Re-187	75	4.12E+10	years	No	β-, Os-187 (stable)	No further daughters		
Re-188	75	17.003	hours	No	β-, Os-188 (stable)	No further daughters		
Re-188m	75	18.59	minutes	No	IT, Re-188	Re-188m (2E5y) → Re-188 (17h) → Os188 (stable)		
Re-189	75	24.3	hours	No	β-, Os-189 (stable)	No further daughters		
Rh-100	45	20.8	hours	No	EC, Ru-100 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Rh-101	45	3.3	years	No	EC, Ru-101 (stable)	No further daughters		
Rh-101m	45	4.34	days	No	EC, 92.8%, Ru-101 (stable) IT, 7.2%, Rh-101	Rh-101m (4.3d) → Rh-101(3.3y) → Ru-101 (stable)		
Rh-102	45	208	days	Yes	EC, 80%, Ru-102 (stable) β-, 20%, Pd-102 (stable)	Rh-102 (208d) → Ru-102 (stable) and Pd-102 (stable)		
Rh-102m	45	2.9	years	No	EC, 99.77%, Ru-102 (stable) IT, 0.23%, Rh-102	Rh-102m (2.9y) → Rh-102 (208d) → Ru-102 (stable) and Pd-102 (stable)		
Rh-103m	45	56.114	minutes	No	IT, Rh-103 (stable)	No further daughters		
Rh-105	45	35.36	hours	No	β-, Pd-105 (stable)	No further daughters		
Rh-105m	45	56.00	minutes	No	IT, Rh-105	Rh-105m (56m) → Rh-105 (35h) → Pd-105 (stable)		
Rh-106	45	29.80	seconds	No	β-, Pd-106 (stable)	No further daughters		
Rh-106m	45	131	minutes	No	β-, Pd-106 (stable)	No further daughters		
Rh-107	45	21.7	minutes	No	β-, Pd-107	Rh-107 (21.7m) → Pd-107 (6.5E6y) → Ag-107 (stable)		
Rh-99	45	16.1	days	No	EC, Ru-99 (stable)	No further daughters		
Rh-99m	45	4.7	hours	No	EC, 99.84%, Ru-99 (stable) IT, 0.16%, Rh-99	Rh-99m (4.7h) → Rh-99 (16d) → Ru-99 (stable)		
Rn-218	86	0.035	seconds	No	α, Po-214	See Po-214 (in Uranium Series)		
Rn-219	86	3.96	seconds	Yes	α, Po-215	See Po-215 (in Actinium Series)	Ac	8
Rn-220	86	55.6	seconds	Yes	α, Po-216	See Po-216 (in Thorium Series)	Th	6
Rn-222	86	3.8235	days	Yes	α, Po-218	See Po-218 (in Uranium Series)	U	7
Ru-103	44	39.26	days	No	β-, 98.85%, Rh-103m β-, 1.15%, Rh-103 (stable)	Ru-103 (39d) → Rh-103m (56m) → Rh-103 (stable)		
Ru-105	44	4.44	hours	No	β-, 72%, Rh-105 β-, 28%, Rh-105m	Ru-105 (4.44h) → Rh-105m (56m) → Rh-105 (35 h) → Pd-105 (stable)		
Ru-106	44	373.59	days	No	β-, Rh-106	Ru-106 (374d) → Rh-106 (30s) → Pd-106 (stable)		
Ru-94	44	51.8	minutes	No	EC, Tc-94	Ru-94 (51.8m) → Tc-94 (293m) → Mo-94 (stable)		
Ru-97	44	2.791	days	No	EC, Tc-97	Ru-97 (2.8d) → Tc-97 (4E6y) → Mo-97 (stable)		
S-35	16	87.51	days	No	β-, Cl-35 (stable)	No further daughters		
Sb-115	51	32.1	minutes	No	EC, Sn-115 (stable)	No further daughters		
Sb-116	51	15.8	minutes	No	EC, Sn-116 (stable)	No further daughters		
Sb-116m	51	60.3	minutes	No	EC, Sn-116 (stable)	No further daughters		
Sb-117	51	2.80	hours	No	EC, Sn-117 (stable)	No further daughters		
Sb-118m	51	5.00	hours	No	EC, Sn-118 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Sb-119	51	38.19	hours	No	EC, Sn-119 (stable)	No further daughters		
Sb-120	51	15.89	minutes	No	EC, Sn-120 (stable)	No further daughters		
Sb-120m	51	5.76	days	No	EC, Sn-120 (stable)	No further daughters		
Sb-122	51	2.7238	days	No	β^- , Te-122 (stable)	No further daughters		
Sb-124	51	60.11	days	No	β^- , Te-124 (stable)	No further daughters		
Sb-124m	51	93	seconds	No	IT, 75%, Sb-124 β^- , 25%, Te-124 (stable)	Sb-124m (93s) \rightarrow Sb-124 (60d) \rightarrow Te-124 (stable)		
Sb-124n	51	20.2	minutes	No	IT, Sb-124	Sb-124n (20.2m) \rightarrow Sb-124 (60d) \rightarrow Te-124 (stable)		
Sb-125	51	2.75856	years	No	β^- , 76.4%, Te-125 (stable) β^- , 23.6%, Te-125m	Sb-125 (2.8y) \rightarrow Te-125m (57.4d) \rightarrow Te-125 (stable)		
Sb-126	51	12.35	days	Yes	β^- , Te-126 (stable)	No further daughters		
Sb-126m	51	19.15	minutes	Yes	β^- , 86%, Te-126 (stable) IT, 14%, Sb-126	Sb-126m \rightarrow 14% Sb-126 (12.5d) and 86% Te-126 (stable); Sb-126 (12.5d) \rightarrow 86% Te-126 (stable)		
Sb-127	51	3.85	days	No	β^- , 83.2%, Te-127 β^- , 16.8%, Te-127m	Sb-127 (3.8d) \rightarrow 83.2% Te-127 (9.35h) and 16.8% Te-127m (109d); Te-127m (109d) \rightarrow 97.6% Te-127 (9.3h) and 2.4% I-127 (stable); Te-127 (9.35h) \rightarrow I-127 (stable);		
Sb-128	51	9.01	hours	No	β^- , Te-128 (stable)	No further daughters		
Sb-128m	51	10.4	minutes	No	β^- , 96.4%, Te-128 (stable) IT, 3.6%, Sb-128	Sb-128m (10.4m) \rightarrow Sb-128b (9h) \rightarrow Te-128 (stable)		
Sb-129	51	4.40	hours	No	β^- , 83.4%, Te-129 β^- , 16.6%, Te-129m	Sb-129 (4.4h) \rightarrow 83.4% Te-129 (70m) and 16.6% Te-129m (33.6d); Te-129m (33.6d) \rightarrow 69% Te-129 (70m) and 31% I-129 (1.6E7y) \rightarrow Xe-129 (stable)		
Sb-130	51	39.5	minutes	No	β^- , Te-130 (stable)	No further daughters		
Sb-131	51	23.03	minutes	No	β^- , 93.2%, Te-131 β^- , 6.8%, Te-131m	Sb-131 (23m) \rightarrow Te-131m (30h) and Te-131 (25m) \rightarrow I-131 (8d) \rightarrow Xe-131 (stable)		
Sc-43	21	3.891	hours	No	EC, Ca-43 (stable)	No further daughters		
Sc-44	21	3.97	hours	Yes	EC, Ca-44 (stable)	No further daughters		
Sc-44m	21	58.61	hours	No	IT, 98.8%, Sc-44 EC, 1.2%, Ca-44 (stable)	Sc-44m (58.6h) \rightarrow Sc-44 (3.97h) \rightarrow Ca-44 (stable)		
Sc-46	21	83.79	days	No	β^- , Ti-46 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Sc-47	21	3.3492	days	No	β^- , Ti-47 (stable)	No further daughters		
Sc-48	21	43.67	hours	No	β^- , Ti-48 (stable)	No further daughters		
Sc-49	21	57.2	minutes	No	β^- , Ti-49 (stable)	No further daughters		
Se-70	34	41.1	minutes	No	EC, As-70	Se-70 (41m) \rightarrow As-70 (53m) \rightarrow Ge-70 (stable)		
Se-73	34	7.15	hours	No	EC, As-73	Se-73 (7.1h) \rightarrow As-73 (80d) \rightarrow Ge-73 (stable)		
Se-73m	34	39.8	minutes	No	IT, 72.6%, Se-73 EC, 27.4%, As-73	Se-73m (39.8m) \rightarrow Se-73 (7.2h) \rightarrow As-73 (80d) \rightarrow Ge-73 (stable)		
Se-75	34	119.779	days	No	EC, As-75 (stable)	No further daughters		
Se-77m	34	17.36	seconds	No	IT, Se-77 (stable)	No further daughters		
Se-79	34	2.95E+05	years	No	β^- , Br-79 (stable)	No further daughters		
Se-79m	34	3.9	minutes	No	IT, Se-79	Se-79m (3.9m) \rightarrow Se-79 (3E5y) \rightarrow Br-79 (stable)		
Se-81	34	18.45	minutes	No	β^- , Br-81 (stable)	No further daughters		
Se-81m	34	57.28	minutes	No	IT, 99.95%, Se-81 β^- , 0.05%, Br-81 (stable)	Se-81m (57.3m) \rightarrow Se-81 (18m) \rightarrow Br-81 (stable)		
Se-83	34	22.3	minutes	No	β^- , Br-83	Se-83 (22m) \rightarrow Br-83 (2.4h) \rightarrow Kr-83m (1.8h) \rightarrow Kr-83 (stable)		
Si-31	14	157.3	minutes	No	β^- , P-31 (stable)	No further daughters		
Si-32	14	132	years	No	β^- , P-32	Si-32 (1.3E2y) \rightarrow P-32 (14.3d) \rightarrow S-32 (stable)		
Sm-141	62	10.2	minutes	No	EC, Pm-141	Sm-141 (10.2m) \rightarrow Pm-141 (21m) \rightarrow Nd-141 (2.5h) \rightarrow Pr-141 (stable)		
Sm-141m	62	22.6	minutes	No	EC, 99.7%, Pm-141 IT, 0.3%, Sm-141	Sm-141m (22.6m) \rightarrow Sm-141 (10m) \rightarrow Pm-141 (21m) \rightarrow Nd-141 (2.5h) \rightarrow Pr-141 (stable)		
Sm-142	62	72.49	minutes	No	EC, Pm-142	Sm-142 (72.5m) \rightarrow Pm-142 (41s) \rightarrow Nd-142 (stable)		
Sm-145	62	340	days	No	EC, Pm-145	Sm-145 (340d) \rightarrow Pm-145 (17.7y) \rightarrow Nd-145 (stable)		
Sm-146	62	1.03E+08	years	Yes	α , Nd-142 (stable)	No further daughters		
Sm-147	62	1.06E+11	years	Yes	α , Nd-143 (stable)	No further daughters		
Sm-148	62	7E+15	years	Yes	α , Nd-144	Sm-148 (7E15y) \rightarrow Nd-144 (2.3E15y) \rightarrow Ce-140 (stable)		
Sm-149	62	2E+15	years	No	α , Nd-145 (stable)	No further daughters		
Sm-151	62	90	years	No	β^- , Eu-151 (stable)	No further daughters		
Sm-153	62	46.284	hours	No	β^- , Eu-153 (stable)	No further daughters		
Sm-155	62	22.3	minutes	No	β^- , Eu-155	Sm-155 (22m) \rightarrow Eu-155 (4.8y) \rightarrow Gd-155 (stable)		
Sm-156	62	9.4	hours	No	β^- , Eu-156	Sm-156 (9h) \rightarrow Eu-156 (15d) \rightarrow Gd-156 (stable)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Sn-110	50	4.11	hours	No	EC, In-110	Sn-110 (4.1h) → In-110 (4.9h) → Cd-110 (stable)		
Sn-111	50	35.3	minutes	No	EC, In-111	Sn-111 (35m) → In-111 (2.8d) → Cd-111 (stable)		
Sn-113	50	115.09	days	No	EC, In-113 (stable)	No further daughters		
Sn-117m	50	13.76	days	No	IT, Sn-117 (stable)	No further daughters		
Sn-119m	50	293.1	days	No	IT, Sn-119 (stable)	No further daughters		
Sn-121	50	27.03	hours	Yes	β-, Sb-121 (stable)	No further daughters		
Sn-121m	50	43.9	years	No	IT, 77.6%, Sn-121 β-, 22.4%, Sb-121 (stable)	Sn-121m (43.9y) → Sn-121 (27h) → Sb-121 (stable)		
Sn-123	50	129.2	days	No	β-, Sb-123 (stable)	No further daughters		
Sn-123m	50	40.06	minutes	No	β-, Sb-123 (stable)	No further daughters		
Sn-125	50	9.64	days	No	β-, Sb-125	Sn-125 (9.6d) → Sb-125 (2.8y) → Te-125m (57.4d) → Te-125 (stable)		
Sn-126	50	2.3E+05	years	No	β-, 66.8%, Sb-126 β-, 33.2%, Sb-126m	Sn-126 (2.3E5y) → 33.2% Sb-126m (19.5m) and 66.8% Sb-126 (12.3d); Sb-126m (19.5m) → 14% Sb-126 (12.5d) and 86% Te-126 (stable)		
Sn-127	50	2.10	hours	No	β-, Sb-127	Sn-127 (2.1h) → Sb-127 (3.8d) → 83.2% Te-127 (9.35h) and 16.8% Te-127m (109d); Te-127m (109d) → 97.6% Te-127 (9.3h) and 2.4% I-127 (stable); Te-127 (9.35h) → I-127 (stable);		
Sn-128	50	59.07	minutes	No	β-, Sb-128m	Sn-128 (59m) → Sb-128m (10m) → Te-128 (stable)		
Sr-80	38	106.3	minutes	No	EC, Rb-80	Sr-80 (106m) → Rb-80 (33s) → stable Kr-80 (stable)		
Sr-81	38	22.3	minutes	No	EC, Rb-81	Sr-81 (22.3m) → Rb-81 (4.6h) → Kr-81 (2.3E5y) → Br-81 (stable)		
Sr-82	38	25.55	days	No	EC, Rb-82	Sr-82 (25.6d) → Rb-82 (1.3m) → Kr-82 (stable)		
Sr-83	38	32.41	hours	No	EC, Rb-83	Sr-83 (32.4h) → Rb-83 (86 d) → Kr-83 (stable)		
Sr-85	38	64.84	days	No	EC, Rb-85 (stable)	No further daughters		
Sr-85m	38	67.63	minutes	No	IT, 86.6%, Sr-85 EC, 13.4%, Rb-85 (stable)	Sr-85m (67.6m) → Sr-85 (65d) → Rb-85 (stable)		
Sr-87m	38	2.815	hours	No	IT, 99.7%, Sr-87 (stable) EC, 0.3%, Rb-87	Sr-87m (2.8h) → Rb-87(4.8E10y) → Sr-87 (stable)		
Sr-89	38	50.57	days	No	β-, Y-89 (stable)	No further daughters		
Sr-90	38	28.90	years	No	β-, Y-90	Sr-90 (28.9y) → Y-90 (64h) → Zr-90 (stable)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Sr-91	38	9.63	hours	No	β^- , 50%, Y-91 β^- , 50%, Y-91m	Sr-91 (9.6h) \rightarrow Y-91 (59d) and Y-91m (50m) \rightarrow Zr-91 (stable)		
Sr-92	38	2.66	hours	No	β^- , Y-92	Sr-92 (2.7h) \rightarrow Y-92 (3.5h) \rightarrow Zr-92 (stable)		
Ta-172	73	36.8	minutes	No	EC, Hf-172	Ta-172 (37m) \rightarrow Hf-172 (1.9y) \rightarrow Lu-172 (7d) \rightarrow Yb-172 (stable)		
Ta-173	73	3.14	hours	No	EC, Hf-173	Ta-173 (3.1h) \rightarrow Hf-173 (1.1h) \rightarrow Lu-173 (1.4y) \rightarrow Yb-173 (stable)		
Ta-174	73	1.14	hours	No	EC, Hf-174 (stable)	No further daughters		
Ta-175	73	10.5	hours	No	EC, Hf-175	Ta-175 (10.5h) \rightarrow Hf-175 (70d) \rightarrow Lu-175 (stable)		
Ta-176	73	8.09	hours	No	EC, Hf-176 (stable)	No further daughters		
Ta-177	73	56.56	hours	No	EC, Hf-177 (stable)	No further daughters		
Ta-178	73	9.31	minutes	No	EC, Hf-178 (stable)	No further daughters		
Ta-178m	73	2.36	hours	No	EC, Hf-178 (stable)	No further daughters		
Ta-179	73	1.82	years	No	EC, Hf-179 (stable)	No further daughters		
Ta-180	73	8.154	hours	No	EC, 81.9%, Hf-180 (stable) β^- , 18.1%, W-180 (stable)	No further daughters		
Ta-180m	73	1.2E+15	years	No	EC, 80%, Hf-180 (stable) β^- , 20%, W-180 (stable)	No further daughters		
Ta-182	73	114.43	days	Yes	β^- , W-182 (stable)	No further daughters		
Ta-182m	73	15.84	minutes	No	IT, Ta-182	Ta-182m (15.8m) \rightarrow Ta-182 (114d) \rightarrow W-182 (stable)		
Ta-183	73	5.1	days	No	β^- , W-183 (stable)	No further daughters		
Ta-184	73	8.7	hours	No	β^- , W-184 (stable)	No further daughters		
Ta-185	73	49.4	minutes	No	β^- , W-185	Ta-185 (49.4m) \rightarrow W-185 (75d) \rightarrow Re-185 (stable)		
Ta-186	73	10.5	minutes	No	β^- , W-186 (stable)	No further daughters		
Tb-147	65	1.7	hours	No	EC, Gd-147	Tb-147 (1.7h) \rightarrow Gd-147 (38h) \rightarrow Eu-147 (24d) \rightarrow Sm-147 (1E6y) \rightarrow Nd-143 (stable)		
Tb-149	65	4.118	hours	No	EC, Gd-149	Tb-149 (4.1h) \rightarrow Gd-149 (124d) \rightarrow Eu-149 (93d) \rightarrow Sm-149 (stable)		
Tb-150	65	3.48	hours	No	EC, Gd-150	Tb-150 (3.5h) \rightarrow Gd-150 (2E6y) \rightarrow Sm-146 (1.1E11y) \rightarrow Nd-142 (stable)		
Tb-151	65	17.609	hours	No	EC, Gd-151	Tb-151 (17.6h) \rightarrow Gd-151 (124d) \rightarrow Eu-151 (stable)		
Tb-153	65	2.34	days	No	EC, Gd-153	Tb-153 (2.3d) \rightarrow Gd-153 (240d) \rightarrow Eu-153 (stable)		
Tb-154	65	21.5	hours	No	EC, Gd-154 (stable)	No further daughters		
Tb-155	65	5.32	days	No	EC, Gd-155 (stable)	No further daughters		
Tb-156	65	5.35	days	No	EC, Gd-156 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Tb-156m	65	24.4	hours	No	IT, Tb-156	Tb-156m (24h) → Tb-156 (24.4h) → Gd-156 (stable)		
Tb-156n	65	5.3	hours	No	EC, Gd-156 (stable)	No further daughters		
Tb-157	65	71	years	No	EC, Gd-157 (stable)	No further daughters		
Tb-158	65	180	years	No	EC, 83.4%, Gd-158 (stable) β-, 16.6%, Dy-158 (stable)	No further daughters		
Tb-160	65	72.3	days	No	β-, Dy-160 (stable)	No further daughters		
Tb-161	65	6.906	days	No	β-, Dy-161 (stable)	No further daughters		
Tc-101	43	14.22	minutes	No	β-, Ru-101 (stable)	No further daughters		
Tc-104	43	18.3	minutes	No	β-, Ru-104 (stable)	No further daughters		
Tc-93	43	2.75	hours	No	EC, Mo-93	Tc-93 (2.7h) → Mo-93 (4E3y) → Nb-93 (stable)		
Tc-93m	43	43.5	minutes	No	IT, 76.6%, Tc-93 EC, 23.4%, Mo-93	Tc-93m (43.5m) → Tc-93 (2.75h) → Mo-93 (4E3y) → Nb-93 (stable)		
Tc-94	43	293	minutes	No	EC, Mo-94 (stable)	No further daughters		
Tc-94m	43	52.0	minutes	No	EC, Mo-94 (stable)	No further daughters		
Tc-95	43	20.0	hours	No	EC, Mo-95 (stable)	No further daughters		
Tc-95m	43	61	days	No	EC, 96.12%, Mo-95 (stable) IT, 3.88%, Tc-95	Tc-95m (61d) → Tc-95 (20h) → Mo-95 (stable)		
Tc-96	43	4.28	days	No	EC, Mo-96 (stable)	No further daughters		
Tc-96m	43	51.5	minutes	No	IT, 98%, Tc-96 EC, 2%, Mo-96 (stable)	Tc-96m (51.5m) → Tc-96 (4.3d) → Mo-96 (stable)		
Tc-97	43	4.21E+06	years	No	EC, Mo-97 (stable)	No further daughters		
Tc-97m	43	91.4	days	No	IT, Tc-97	Tc-97m (91.4d) → Tc-97 (4E6y) → Mo-97 (stable)		
Tc-98	43	4.2E+06	years	No	β-, Ru-98 (stable)	No further daughters		
Tc-99	43	2.11E+05	years	No	β-, Ru-99 (stable)	No further daughters		
Tc-99m	43	6.0058	hours	No	IT, Tc-99	Tc-99m (6h) → Tc-99 (2.1E5y) → Ru-99 (stable)		
Te-116	52	2.49	hours	No	EC, Sb-116	Te-116 (2.5h) → Sb-116 (16m) → Sn-116 (stable)		
Te-118	52	6.00	days	No	EC, Sb-118 (not on table)	Te-118 (6d) → Sb-118 (3.6m) (not on table) → Sn-118 (stable)		
Te-121	52	19.16	days	No	EC, Sb-121 (stable)	No further daughters		
Te-121m	52	154	days	No	IT, 88.6%, Te-121 EC, 11.4%, Sb-121 (stable)	Te-121m (154d) → Te-121 (19d) → Sb-121 (stable)		
Te-123	52	9.2E+16	years	No	EC, Sb-123 (stable)	No further daughters		
Te-123m	52	119.2	days	No	IT, Te-123	Te-123m (119d) → Te-123 (6E14y) → Sb-123 (stable)		
Te-125m	52	57.40	days	Yes	IT, Te-125 (stable)	No further daughters		
Te-127	52	9.35	hours	No	β-, I-127 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Te-127m	52	109	days	No	IT, 97.6%, Te-127 β^- , 2.4%, I-127 (stable)	Te-127m (109d) \rightarrow 97.6% Te-127 (9.3h) and 2.4% I-127 (stable); Te-127 (9.35h) \rightarrow I-127 (stable);		
Te-129	52	69.6	minutes	No	β^- , I-129	Te-129 (69.6m) \rightarrow I-129 (1.6E7y) \rightarrow Xe-129 (stable)		
Te-129m	52	33.6	days	No	IT, 69%, Te-129 β^- , 31%, I-129	Te-129m (33.6d) \rightarrow Te-129 (1.2h) \rightarrow I-129 (1.6E7y) \rightarrow Xe-129 (stable)		
Te-131	52	25.0	minutes	No	β^- , I-131	Te-131 (25m) \rightarrow I-131 (8d) \rightarrow Xe-131 (stable)		
Te-131m	52	30	hours	No	β^- , 77.8%, I-131 IT, 22.2%, Te-131	Te-131m (30h) \rightarrow 77.8% I-131(8d) and 22.2% Te-131 (25m); Te-131 (25m) \rightarrow I-131 (8d) \rightarrow Xe-131 (stable).		
Te-132	52	3.204	days	No	β^- , I-132	Te-132 (3.2d) \rightarrow I-132 (2.3h) \rightarrow Xe-132 (stable)		
Te-133	52	12.5	minutes	No	β^- , I-133	Te-133 (12.5m) \rightarrow I-133 (20.8h) \rightarrow Xe-133 (5.2d) \rightarrow Cs-133 (stable)		
Te-133m	52	55.4	minutes	No	β^- , 82.5%, I-133 IT, 17.5%, Te-133	Te-133m (55.4m) \rightarrow 82.5% I-133 (21h) and 14% Te-133; Te-133 (12.5m) \rightarrow I-133 (21h) \rightarrow Xe-133 (5.2d) \rightarrow Cs-133 (stable)		
Te-134	52	41.8	minutes	No	β^- , I-134	Te-134 (41.8m) \rightarrow I-134 (53m) \rightarrow Xe-134 (stable)		
Th-226	90	30.57	minutes	No	α , Ra-222	Th-226 (30.6m) \rightarrow Ra-222 (38s) \rightarrow Rn-218 (<1s) \rightarrow Po-214 (in Uranium Series)		
Th-227	90	18.68	days	Yes	α , Ra-223	See Ra-223 (in Actinium Series)	Ac	5
Th-228	90	1.9116	years	Yes	α , Ra-224	See Ra-224 (in Thorium Series)	Th	4
Th-229	90	7,340	years	Yes	α , Ra-225	See Ra-225 (in Neptunium Series)	Np	6
Th-230	90	7.538E+04	years	Yes	α , Ra-226	See Ra-226 (in Uranium Series)	U	5
Th-231	90	25.52	hours	Yes	β^- , Pa-231	See Pa-231 (in Actinium Series)	Ac	2
Th-232 (Thorium Series)	90	1.405E+10	years	Yes	α , Ra-228	Thorium Series Th-232 (1.4E10y) \rightarrow Ra-228 (5.7y) \rightarrow Ac-228 (6.1h) \rightarrow Th-228 (1.9y) \rightarrow Ra-224 (3.7d) \rightarrow Rn-220 (56s) \rightarrow Po-216 (<1s) \rightarrow Pb-212 (11h) \rightarrow Bi-212 (61m) \rightarrow Tl-208 (3.1m) and Po-212 (1s) \rightarrow Pb-208 (stable)	Th	1
Th-234	90	24.10	days	Yes	β^- , Pa-234	See Pa-234 (in Uranium Series)	U	2
Ti-44	22	60.0	years	No	EC, Sc-44	Ti-44 (60y) \rightarrow Sc-44 (3.97h) \rightarrow Ca-44 (stable)		
Ti-45	22	184.8	minutes	No	EC, Sc-45 (stable)	No further daughters		
Tl-194	81	33.0	minutes	No	EC, Hg-194	Tl-194 (33m) \rightarrow Hg-194 (444y) \rightarrow Au-194 (38h) \rightarrow Pt-194 (stable)		
Tl-194m	81	32.8	minutes	No	EC, Hg-194	Tl-194m (32.8m) \rightarrow Hg-194 (444y) \rightarrow Au-194 (38h) \rightarrow Pt-194 (stable)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Tl-195	81	1.16	hours	No	EC, Hg-195	Tl-195 (1.16h) → Hg-195 (10h) → Au-195 (186d) → Pt-195 (stable)		
Tl-197	81	2.84	hours	No	EC, Hg-197	Tl-197 (2.8h) → Hg-197 (64h) → Au-197 (stable)		
Tl-198	81	5.3	hours	No	EC, Hg-198 (stable)	No further daughters		
Tl-198m	81	1.87	hours	No	EC, 54%, Hg-198 (stable) IT, 46%, Tl-198	Tl-198m (1.87h) → Tl-198 (5h) → Hg-198 (stable)		
Tl-199	81	7.42	hours	No	EC, Hg-199 (stable)	No further daughters		
Tl-200	81	26.1	hours	No	EC, Hg-200 (stable)	No further daughters		
Tl-201	81	72.912	hours	No	EC, Hg-201 (stable)	No further daughters		
Tl-202	81	12.23	days	Yes	EC, Hg-202 (stable)	No further daughters		
Tl-204	81	3.78	years	No	β-, 97.1%, Pb-204 (stable) EC, 2.9%, Hg-204 (stable)	No further daughters		
Tl-206	81	4.200	minutes	Yes	β-, Pb-206 (stable)	No further daughters		
Tl-207	81	4.77	minutes	Yes	β-, Pb-207 (stable)	No further daughters	Ac	13
Tl-208	81	3.053	minutes	Yes	β-, Pb-208 (stable)	No further daughters	Th	11
Tl-209	81	2.161	minutes	Yes	β-, Pb-209	See Pb-209 (in Neptunium Series)	Np	13
Tl-210	81	1.30	minutes	Yes	β-, Pb-210	See Pb-210 (in Uranium Series)	U	13
Tm-162	69	21.70	minutes	No	EC, Er-162 (stable)	No further daughters		
Tm-166	69	7.70	hours	No	EC, Er-166 (stable)	No further daughters		
Tm-167	69	9.25	days	No	EC, Er-167 (stable)	No further daughters		
Tm-170	69	128.6	days	No	β-, 99.87%, Yb-170 (stable) EC, 0.13%, Er-170 (stable)	No further daughters		
Tm-171	69	1.92	years	No	β-, Yb-171 (stable)	No further daughters		
Tm-172	69	63.6	hours	No	β-, Yb-172 (stable)	No further daughters		
Tm-173	69	8.24	hours	No	β-, Yb-173 (stable)	No further daughters		
Tm-175	69	15.2	minutes	No	β-, Yb-175	Tm-175 (15m) → Yb-175 (4d) → Lu-175 (stable)		
U-230	92	20.8	days	No	α, Th-226	U-230 (20.8d) → Th-226 (31m) → Ra-222 (38s) → Rn-218 (<1s) → Po-214 (in Uranium Series)		
U-231	92	4.2	days	No	EC, Pa-231	See Pa-231 (in Actinium Series)		
U-232	92	68.9	years	Yes	α, Th-228	See Th-228 (in Thorium Series)		
U-233	92	1.592E+05	years	Yes	α, Th-229	See Th-229 (in Neptunium Series)	Np	5
U-234	92	2.455E+05	years	Yes	α, Th-230	See Th-230 (in Uranium Series)	U	4

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
U-235 (Actinium Series)	92	7.04E+08	years	Yes	α , Th-231	Actinium Series U-235 (7E8y) \rightarrow Th-231 (25h) \rightarrow Pa-231 (3.3E4y) \rightarrow Ac-227 (22y) \rightarrow Th-227 (19d) and Fr-223 (22m) \rightarrow Ra-223 (11d) \rightarrow Rn-219 (4s) \rightarrow Po-215 (<1s) \rightarrow Pb-211 (36m) \rightarrow Bi-211 (2m) \rightarrow Tl-207 (5m) and Po-211 (<1s) \rightarrow Pb-207 (stable)	Ac	1
U-236	92	2.342E+07	years	Yes	α , Th-232	See Th-232 (in Thorium Series)		
U-237	92	6.75	days	No	β^- , Np-237	U-237 (6.7d) \rightarrow Np-237 (2.1E6y in Neptunium Series)		
U-238 (Uranium Series)	92	4.468E+09	years	Yes	α , Th-234	Uranium Series U-238 (4.5E9y) \rightarrow Th-234 (24d) \rightarrow Pa-234 (6.7h) \rightarrow U-234 (2.5E5y) \rightarrow Th-230 (7.5E4y) \rightarrow Ra-226 (1.6E3y) \rightarrow Rn-222 (3.8d) \rightarrow Po-218 (3.1m) \rightarrow Pb-214 (27m) and At-218 (1.5s) \rightarrow Bi-214 (20m) \rightarrow Po-214 (<1s) and Tl-210 (1.3m) \rightarrow Pb-210 (22y) \rightarrow Bi-210 (5d) \rightarrow Po-210 (138d) \rightarrow Pb-206 (stable)	U	1
U-239	92	23.45	minutes	No	β^- , Np-239	U-239 (24m) \rightarrow Np-239 (2.4d) \rightarrow Pu-239 (2.4E4y) \rightarrow U-235 (in Actinium Series)		
U-240	92	14.1	hours	Yes	β^- , Np-240	U-240 (14h) \rightarrow Np-240 (62m) \rightarrow Pu-240 (6.6E3y) \rightarrow U-236 (2.3E7y) \rightarrow Th-232 (in Thorium Series)		
V-47	23	32.6	minutes	No	EC, Ti-47 (stable)	No further daughters		
V-48	23	15.9735	days	No	EC, Ti-48 (stable)	No further daughters		
V-49	23	329	days	No	EC, Ti-49 (stable)	No further daughters		
V-50	23	1.4E+17	years	No	EC, 83%, Ti-50 (stable) β^- , 17%, Cr-50 (stable)	No further daughters		
W-176	74	2.5	hours	No	EC, Ta-176	W-176 (2.5h) \rightarrow Ta-176 (8h) \rightarrow Hf-176 (stable)		
W-177	74	132	minutes	No	EC, Ta-177	W-177 (132m) \rightarrow Ta-177 (57h) \rightarrow Hf-177 (stable)		
W-178	74	21.6	days	No	EC, Ta-178	W-178 (21.6d) \rightarrow Ta-178 (9m) \rightarrow Hf-178 (stable)		
W-179	74	37.05	minutes	No	EC, Ta-179	W-179 (37m) \rightarrow Ta-179 (1.8y) \rightarrow Hf-179 (stable)		
W-181	74	121.20	days	No	β^- , Ta-181 (stable)	No further daughters		
W-185	74	75.1	days	No	β^- , Re-185 (stable)	No further daughters		
W-187	74	23.72	hours	No	β^- , Re-187	W-187 (23.7h) \rightarrow Re-187 (4E10y) \rightarrow Os-187 (stable)		
W-188	74	69.78	days	No	β^- , Re-188	W-188 (69.8d) \rightarrow Re-188 (17h) \rightarrow Os-188 (stable)		
Xe-120	54	40	minutes	No	EC, I-120	Xe-120 (40m) \rightarrow I-120 (81m) \rightarrow Te-120 (stable)		
Xe-121	54	40.1	minutes	No	EC, I-121	Xe-121 (40m) \rightarrow I-121 (2.1h) \rightarrow Te-121 (19d) \rightarrow Sb-121 (stable)		
Xe-122	54	20.1	hours	No	EC, I-122	Xe-122 (20h) \rightarrow I-122 (3.6m) \rightarrow Te-122 (stable)		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Xe-123	54	2.08	hours	No	EC, I-123	Xe-123 (2.1h) → I-123 (13.3h) → Te-123 (6E14y)→Sb-123 (stable)		
Xe-125	54	16.9	hours	No	EC, I-125	Xe-125 (16.9h) → I-125 (59d) → Te-125 (stable)		
Xe-127	54	36.4	days	No	EC, I-127 (stable)	No further daughters		
Xe-129m	54	8.88	days	No	IT, Xe-129 (stable)	No further daughters		
Xe-131m	54	11.934	days	No	IT, Xe-131 (stable)	No further daughters		
Xe-133	54	5.243	days	No	β-, Cs-133 (stable)	No further daughters		
Xe-133m	54	2.19	days	No	IT, Xe-133	Xe-133m (2.2h) → Xe-133 (5.2d) → Cs-133 (stable)		
Xe-135	54	9.14	hours	No	β-, Cs-135	Xe-135 (9h) → Cs-135 (2.3E6y) → Ba-135 (stable)		
Xe-135m	54	15.29	minutes	No	IT, 99.4%, Xe-135 β-, 0.6%, Cs-135	Xe-135m (15.3h) → Xe-135 (9h) → Cs-135 (2.3E6y) → Ba-135 (stable)		
Xe-138	54	14.08	minutes	No	β-, Cs-138	Xe-138 (14m) → Cs-138 (33.4m) → Ba-138 (stable)		
Y-86	39	14.74	hours	No	EC, Sr-86 (stable)	No further daughters		
Y-86m	39	48	minutes	No	IT, 99.31%, Y-86 EC, 0.7%, Sr-86 (stable)	Y-86m (48m) → Y-86 (14.7h) → Sr-86 (stable)		
Y-87	39	79.8	hours	No	EC, Sr-87 (stable)	No further daughters		
Y-88	39	106.616	days	No	EC, Sr-88 (stable)	No further daughters		
Y-90	39	64.053	hours	Yes	β-, Zr-90 (stable)	No further daughters		
Y-90m	39	3.19	hours	No	IT, Y-90	Y-90m (3.2h) → Y-90 (64h) → Zr-90 (stable)		
Y-91	39	58.51	days	No	β-, Zr-91 (stable)	No further daughters		
Y-91m	39	49.71	minutes	No	IT, 98.5%, Y-91 β- 1.5%, Zr-91(stable)	Y-91m (49.7m) → Y-91 (59d) → Zr-91 (stable)		
Y-92	39	3.54	hours	No	β-, Zr-92 (stable)	No further daughters		
Y-93	39	10.18	hours	No	β-, Zr-93	Y-93 (10h) → Zr-93 (1.5E6y) → Nb-93m (16.1y) → Nb-93 (stable)		
Y-94	39	18.7	minutes	No	β-, Zr-94 (stable)	No further daughters		
Y-95	39	10.3	minutes	No	β-, Zr-95	Y-95 (10.3m) → Zr-95 (64d)→ Nb-95 (35d) → Mo-95 (stable)		
Yb-162	70	18.87	minutes	No	EC, Tm-162	Yb-162 (18.9m) → Tm-162 (22m) → Er-162 (stable)		
Yb-165	70	9.9	minutes	No	EC, Tm-165 (not on table)	Yb-165 (9.9m) → Tm-165 (1.3d) (not on table)→ Er-165 (10h) → Ho-165 (stable)		
Yb-166	70	56.7	hours	No	EC, Tm-166	Yb-166 (56.7h) → Tm-166 (8h) → Er-166 (stable)		
Yb-167	70	17.5	minutes	No	EC, Tm-167	Yb-167 (17.5m) → Tm-167 (9d) → Er-167 (stable)		
Yb-169	70	32.018	days	No	EC, Tm-169 (stable)	No further daughters		
Yb-175	70	4.185	days	No	β-, Lu-175 (stable)	No further daughters		

Table A3. Radionuclide Decay Mechanisms

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Isotopes Still Being Formed in 2005 (as decay products)	Decay Mode, Daughters	Decay Mode to Stable or Series	Decay Series	Decay Member No.
Yb-177	70	1.911	hours	No	β^- , Lu-177	Yb-177 (1.9h) \rightarrow Lu-177 (7d) \rightarrow Hf-177 (stable)		
Yb-178	70	74	minutes	No	β^- , Lu-178	Yb-178 (74h) \rightarrow Lu-178 (28m) \rightarrow Hf-178 (stable)		
Zn-62	30	9.186	hours	No	EC, Cu-62	Zn-62 (9.2h) \rightarrow Cu-62 (9.7m) \rightarrow Ni-62 (stable)		
Zn-63	30	38.47	minutes	No	EC, Cu-63 (stable)	No further daughters		
Zn-65	30	243.66	days	No	EC, Cu-65 (stable)	No further daughters		
Zn-69	30	56.4	minutes	No	β^- , Ga-69 (stable)	No further daughters		
Zn-69m	30	13.76	hours	No	IT, 99.97%, Zn-69 β^- , 0.03 %, Ga-69 (stable)	Zn-69m (13.8h) \rightarrow Zn-69 (56m) \rightarrow Ga-69 (stable)		
Zn-71m	30	3.96	hours	No	β^- , Ga-71 (stable)	No further daughters		
Zn-72	30	46.5	hours	No	β^- , Ga-72	Zn-72 (46.5h) \rightarrow Ga-72 (14h) \rightarrow Ge-72 (stable)		
Zr-86	40	16.5	hours	No	EC, Y-86	Zr-86 (16.5h) \rightarrow Y-86 (14.7h) \rightarrow Sr-86 (stable)		
Zr-88	40	83.4	days	No	EC, Y-88	Zr-88 (83.4d) \rightarrow Y-88 (107d) \rightarrow Sr-88 (stable)		
Zr-89	40	78.41	hours	No	EC, Y-89 (stable)	No further daughters		
Zr-93	40	1.53E+06	years	No	β^- , 2.5%, Nb-93 (stable) β^- , 97.5%, Nb-93m	Zr-93 (1.5E6y) \rightarrow Nb-93m (16.1y) \rightarrow Nb-93 (stable)		
Zr-95	40	64.032	days	No	β^- , Nb-95	Zr-95 (64d) \rightarrow Nb-95 (35d) \rightarrow Mo-95 (stable)		
Zr-97	40	16.744	hours	No	β^- , 94.7%, Nb-97m β^- , 5.3%, Nb-97	Zr-97 (16.7h) \rightarrow Nb-97m (59s) \rightarrow Nb-97 (72m) \rightarrow Mo-97 (stable)		

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Ac-225	89	10.0	days	1	X			
Ac-227	89	21.772	years	1	X	X		
Ac-228	89	6.15	hours	1	X			
Am-241	95	432.2	years	1	X	X		
At-217	85	0.0323	seconds	1	X			X
At-218	85	1.5	seconds	1	X			
Bi-210	83	5.012	days	1	X			
Bi-211	83	2.14	minutes	1	X			X
Bi-212	83	60.55	minutes	1	X			X
Bi-213	83	45.59	minutes	1	X			X
Bi-214	83	19.9	minutes	1	X			
Fr-221	87	4.9	minutes	1	X			X
Fr-223	87	22.00	minutes	1	X			
Np-237	93	2.144E+06	years	1	X	X		
Pa-231	91	3.276E+04	years	1	X	X		
Pa-233	91	26.975	days	1	X			
Pa-234	91	6.70	hours	1	X			
Pb-209	82	3.253	hours	1	X			X
Pb-210	82	22.20	years	1	X			
Pb-211	82	36.1	minutes	1	X			X
Pb-212	82	10.64	hours	1	X			X
Pb-214	82	26.8	minutes	1	X			
Po-210	84	138.376	days	1	X			
Po-211	84	0.516	seconds	1	X			X
Po-212	84	3.00E-07	seconds	1	X			X
Po-213	84	3.65E-06	seconds	1	X			X
Po-214	84	1.643E-04	seconds	1	X			X
Po-215	84	1.781E-03	seconds	1	X			X
Po-216	84	0.145	seconds	1	X			X
Po-218	84	3.10	minutes	1	X			
Pu-241 (Neptunium Series)	94	14.290	years	1	X	X		

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Ra-223	88	11.430	days	1	X			
Ra-224	88	3.63	days	1	X			X
Ra-225	88	14.9	days	1	X			
Ra-226	88	1,600	years	1	X	X		
Ra-228	88	5.75	years	1	X	X		
Rn-219	86	3.96	seconds	1	X			X
Rn-220	86	55.6	seconds	1	X			X
Rn-222	86	3.8235	days	1	X			
Th-227	90	18.68	days	1	X			
Th-228	90	1.9116	years	1	X			
Th-229	90	7,340	years	1	X	X		
Th-230	90	7.538E+04	years	1	X	X		
Th-231	90	25.52	hours	1	X			
Th-232 (Thorium Series)	90	1.405E+10	years	1	X	X		
Th-234	90	24.10	days	1	X			
Tl-207	81	4.77	minutes	1	X			X
Tl-208	81	3.053	minutes	1	X			X
Tl-209	81	2.161	minutes	1	X			X
Tl-210	81	1.30	minutes	1	X		X	
U-233	92	1.592E+05	years	1	X	X		
U-234	92	2.455E+05	years	1	X	X		
U-235 (Actinium Series)	92	7.04E+08	years	1	X	X		
U-238 (Uranium Series)	92	4.468E+09	years	1	X	X		
Al-26	13	7.17E+05	years	2		X		
Am-242m	95	141	years	2		X		
Am-243	95	7,370	years	2		X		
Ba-137m	56	2.552	minutes	2		X		X
Bk-249	97	330	days	2		X		
C-14	6	5700	years	2		X		
Ce-144	58	284.91	days	2		X		

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Cf-249	98	351	years	2		X		
Cf-251	98	898	years	2		X		
Cf-252	98	3	years	2		X		
Cm-242	96	162.8	days	2		X		
Cm-243	96	29.1	years	2		X		
Cm-244	96	18.1	years	2		X		
Cm-245	96	8,500	years	2		X		
Cm-247	96	1.56E+07	years	2		X		
Cm-248	96	3.48E+05	years	2		X		
Co-60	27	1925.28	days	2		X		
Cs-134	55	2.0652	years	2		X		
Cs-135	55	2.3E+06	years	2		X		
Cs-137	55	30.03	years	2		X		
Eu-152	63	13.506	years	2		X		
Eu-154	63	8.590	years	2		X		
Eu-155	63	4.753	years	2		X		
H-3	1	12.32	years	2		X		
I-129	53	1.57E+07	years	2		X		
Na-22	11	2.6027	years	2		X		
Nb-94	41	2.03E+04	years	2		X		
Ni-59	28	7.6E+04	years	2		X		
Ni-63	28	100.1	years	2		X		
Pm-147	61	2.6234	years	2		X		
Pr-144	59	17.28	minutes	2		X		X
Pu-238	94	87.7	years	2		X		
Pu-239	94	24,110	years	2		X		
Pu-240	94	6,561	years	2		X		
Pu-242	94	3.75E+05	years	2		X		
Pu-244	94	8.00E+07	years	2		X		
Rh-106	45	29.80	seconds	2		X		X
Ru-106	44	373.59	days	2		X		
Sb-125	51	2.75856	years	2		X		

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Sb-126	51	12.35	days	2		X		
Sb-126m	51	19.15	minutes	2		X		
Se-79	34	2.95E+05	years	2		X		
Sm-151	62	90	years	2		X		
Sn-126	50	2.3E+05	years	2		X		
Sr-90	38	28.90	years	2		X		
Tc-99	43	2.111E+05	years	2		X		
Te-125m	52	57.40	days	2		X		
U-232	92	68.9	years	2		X		
U-236	92	2.342E+07	years	2		X		
Y-90	39	64.053	hours	2		X		X
Ar-42	18	32.9	years	3			X	
As-79	33	9.01	minutes	3			X	
Bi-208	83	3.68E+05	years	3			X	
Ce-142	58	2.6E+17	years	3			X	
Cf-247	98	3.11	hour	3			X	
Es-255	99	39.8	days	3			X	
Fe-52m	26	46	seconds	3			X	
Ga-74	31	8.2	minutes	3			X	
Gd-150	64	1.80E+06	years	3			X	
Nb-92	41	3.47E+07	years	3			X	
Nd-144	60	2.29E+15	years	3			X	
Os-186	76	2E+15	years	3			X	
Pb-204	82	1.4E+17	years	3			X	
Po-209	84	102.00	years	3			X	
Po-212m	84	2.98E-07	seconds	3			X	
Rh-105m	45	56.00	minutes	3			X	
Se-79m	34	3.9	minutes	3			X	
Sm-148	62	7E+15	years	3			X	
Sm-149	62	2E+15	years	3			X	
Te-118	52	6.00	days	3			X	
V-50	23	1.4E+17	years	3			X	

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Yb-165	70	9.9	minutes	3			X	
Ac-223	89	2.10	minutes	4				X
Ac-224	89	2.78	hours	4				X
Ag-102	47	12.9	minutes	4				X
Ag-104	47	69.2	minutes	4				X
Ag-104m	47	33.5	minutes	4				X
Ag-106	47	23.96	minutes	4				X
Ag-108	47	2.37	minutes	4				X
Ag-109m	47	38.0	seconds	4				X
Ag-110	47	24.6	seconds	4				X
Ag-112	47	3.130	hours	4				X
Al-28	13	2.2414	minutes	4				X
Ar-37	18	34.95	days	4				X
Ar-39	18	269	years	4				X
Ar-41	18	109.61	years	4				X
As-69	33	15.2	minutes	4				X
As-70	33	52.6	minutes	4				X
As-72	33	26.0	hours	4				X
As-76	33	1.0942	days	4				X
As-77	33	38.83	hours	4				X
As-78	33	90.7	minutes	4				X
At-215	85	1.00E-04	seconds	4				X
At-216	85	3.00E-04	seconds	4				X
Au-194	79	38.02	hours	4				X
Au-198	79	2.6956	days	4				X
Au-198m	79	2.27	days	4				X
Au-199	79	3.139	days	4				X
Au-200	79	48.4	minutes	4				X
Au-200m	79	18.7	hours	4				X
Au-201	79	26	minutes	4				X
Ba-126	56	100	minutes	4				X
Ba-128	56	2.43	days	4				X

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Ba-135m	56	28.7	hours	4				X
Ba-139	56	83.06	minutes	4				X
Ba-142	56	10.6	minutes	4				X
Bi-200	83	36.4	minutes	4				X
Bi-201	83	108	minutes	4				X
Bi-203	83	11.76	hours	4				X
Bi-206	83	6.243	days	4				X
Br-74	35	25.4	minutes	4				X
Br-74m	35	46	minutes	4				X
Br-76	35	16.2	hours	4				X
Br-77	35	57.036	hours	4				X
Br-80	35	17.68	minutes	4				X
Br-80m	35	4.4205	hours	4				X
Br-82	35	35.282	hours	4				X
Br-83	35	2.40	hours	4				X
Br-84	35	31.80	minutes	4				X
C-11	6	20.334	minutes	4				X
Ca-47	20	4.536	days	4				X
Ca-49	20	8.718	minutes	4				X
Cd-104	48	57.7	minutes	4				X
Cd-107	48	6.50	hours	4				X
Cd-115	48	53.46	hours	4				X
Ce-134	58	3.16	days	4				X
Ce-135	58	17.7	hours	4				X
Cl-38	17	37.24	minutes	4				X
Cl-39	17	55.6	minutes	4				X
Co-61	27	1.650	hours	4				X
Co-62m	27	13.91	minutes	4				X
Cs-126	55	1.64	minutes	4				X
Cs-128	55	3.66	minutes	4				X
Cs-129	55	32.06	hours	4				X
Cs-130	55	29.21	minutes	4				X

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Cs-132	55	6.480	days	4				X
Cs-135m	55	53	minutes	4				X
Cs-138	55	33.41	minutes	4				X
Cu-60	29	23.7	minutes	4				X
Cu-61	29	3.333	hours	4				X
Cu-62	29	9.67	minutes	4				X
Cu-64	29	12.700	hours	4				X
Cu-66	29	5.120	minutes	4				X
Cu-67	29	61.83	hours	4				X
Dy-155	66	9.9	hours	4				X
Dy-165	66	2.334	hours	4				X
Dy-166	66	81.6	hours	4				X
Er-161	68	3.21	hours	4				X
Er-165	68	10.36	hours	4				X
Er-172	68	49.3	hours	4				X
Eu-146	63	4.61	days	4				X
Eu-150m	63	12.8	hours	4				X
Eu-152m	63	9.3116	hours	4				X
Eu-157	63	15.18	hours	4				X
Eu-158	63	45.9	minutes	4				X
F-18	9	1.8291	hours	4				X
Fe-52	26	8.275	hours	4				X
Fr-219	87	0.02	seconds	4				X
Fr-220	87	27.4	seconds	4				X
Ga-66	31	9.49	hours	4				X
Ga-67	31	3.2623	days	4				X
Ga-68	31	67.71	minutes	4				X
Ga-70	31	21.14	minutes	4				X
Ga-72	31	14.095	hours	4				X
Ga-73	31	4.86	hours	4				X
Gd-159	64	18.479	hours	4				X
Ge-66	32	2.26	hours	4				X

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Ge-67	32	18.9	minutes	4				X
Ge-69	32	39.05	hours	4				X
Ge-75	32	82.78	minutes	4				X
Ge-77	32	11.30	hours	4				X
Ge-78	32	88.0	minutes	4				X
Hf-170	72	16.01	hours	4				X
Hf-174	72	2.0E+15	years	4				X
Hf-177m	72	51.4	minutes	4				X
Hf-180m	72	5.47	hours	4				X
Hf-183	72	1.067	hours	4				X
Hf-184	72	4.12	hours	4				X
Hg-197	80	64.14	hours	4				X
Hg-197m	80	23.8	hours	4				X
Hg-199m	80	42.67	minutes	4				X
Ho-155	67	48	minutes	4				X
Ho-161	67	2.48	hours	4				X
Ho-162	67	15.0	minutes	4				X
Ho-162m	67	67.0	minutes	4				X
Ho-164	67	29	minutes	4				X
Ho-164m	67	37.5	minutes	4				X
Ho-166	67	26.83	hours	4				X
Ho-167	67	3.003	hours	4				X
I-120	53	81.6	minutes	4				X
I-120m	53	53	minutes	4				X
I-122	53	3.63	minutes	4				X
I-124	53	4.1760	days	4				X
I-128	53	24.99	minutes	4				X
I-130	53	12.36	hours	4				X
I-132	53	2.295	hours	4				X
I-132m	53	1.387	hours	4				X
I-133	53	20.8	hours	4				X
I-134	53	52.5	minutes	4				X

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
I-135	53	6.57	hours	4				X
In-110	49	4.9	hours	4				X
In-110m	49	69.1	minutes	4				X
In-111	49	2.8047	days	4				X
In-112	49	14.97	minutes	4				X
In-113m	49	99.476	minutes	4				X
In-114	49	71.9	seconds	4				X
In-115m	49	4.486	hours	4				X
In-116m	49	54.29	minutes	4				X
Ir-182	77	15	minutes	4				X
Ir-184	77	3.09	hours	4				X
Ir-186	77	16.64	hours	4				X
Ir-186m	77	1.90	hours	4				X
Ir-187	77	10.5	hours	4				X
Ir-188	77	41.5	hours	4				X
Ir-191m	77	4.94	seconds	4				X
Ir-194	77	19.28	hours	4				X
Ir-195	77	2.5	hours	4				X
Ir-195m	77	3.8	hours	4				X
K-38	19	7.636	minutes	4				X
K-42	19	12	hours	4				X
K-43	19	22.3	hours	4				X
K-44	19	22.13	minutes	4				X
Kr-74	36	11.50	minutes	4				X
Kr-76	36	14.8	hours	4				X
Kr-77	36	74.4	minutes	4				X
Kr-79	36	35.04	hours	4				X
Kr-81m	36	13.10	seconds	4				X
Kr-83m	36	1.83	hours	4				X
Kr-87	36	76.3	minutes	4				X
Kr-88	36	2.84	hours	4				X
La-132	57	4.8	hours	4				X

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
La-134	57	6.45	minutes	4				X
La-135	57	19.5	hours	4				X
La-140	57	1.6781	days	4				X
La-142	57	91.1	minutes	4				X
Lu-170	71	2.012	days	4				X
Lu-172	71	6.70	days	4				X
Lu-176m	71	3.664	hours	4				X
Lu-177	71	6.6475	days	4				X
Lu-178	71	28.4	minutes	4				X
Lu-178m	71	23.1	minutes	4				X
Lu-179	71	4.59	hours	4				X
Md-257	101	5.52	hours	4				X
Mg-28	12	20.915	hours	4				X
Mn-52	25	5.591	days	4				X
Mn-52m	25	21.1	minutes	4				X
Mn-56	25	2.5789	hours	4				X
Mo-101	42	14.61	minutes	4				X
Mo-90	42	5.56	hours	4				X
N-13	7	9.965	minutes	4				X
Na-24	11	14.951	hours	4				X
Nb-89a	41	66	minutes	4				X
Nb-89b	41	2.03	hours	4				X
Nb-90	41	14.60	hours	4				X
Nb-96	41	23.35	hours	4				X
Nb-97	41	72.1	minutes	4				X
Nb-97m	41	58.7	seconds	4				X
Nb-98	41	51.3	minutes	4				X
Nd-136	60	50.65	minutes	4				X
Nd-138	60	5.04	hours	4				X
Nd-141	60	2.49	hours	4				X
Nd-141m	60	62.0	seconds	4				X
Nd-149	60	1.728	hours	4				X

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Ne-19	10	17.22	seconds	4				X
Ni-65	28	2.5172	hours	4				X
Ni-66	28	54.6	hours	4				X
O-15	8	122.24	seconds	4				X
Os-180	76	21.5	minutes	4				X
Os-182	76	22.10	hours	4				X
Os-189m	76	5.81	hours	4				X
Os-190m	76	9.9	minutes	4				X
Os-193	76	30.11	hours	4				X
P-30	15	2.498	minutes	4				X
Pa-234m	91	1.17	minutes	4				X
Pb-198	82	2.40	hours	4				X
Pb-199	82	90	minutes	4				X
Pb-200	82	21.5	hours	4				X
Pb-201	82	9.33	hours	4				X
Pb-203	82	51.920	hours	4				X
Pd-100	46	3.63	days	4				X
Pd-109	46	13.7012	hours	4				X
Pm-141	61	20.90	minutes	4				X
Pm-142	61	40.5	seconds	4				X
Pm-148	61	5.368	days	4				X
Pm-149	61	53.08	hours	4				X
Pm-150	61	2.68	hours	4				X
Po-203	84	36.7	minutes	4				X
Pr-136	59	13.1	minutes	4				X
Pr-138	59	1.45	minutes	4				X
Pr-138m	59	2.12	hours	4				X
Pr-142	59	19.12	hours	4				X
Pr-142m	59	14.6	minutes	4				X
Pr-144m	59	7.2	minutes	4				X
Pr-145	59	5.984	hours	4				X
Pt-186	78	2.08	hours	4				X

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Pt-191	78	2.862	days	4				X
Pt-195m	78	4.010	days	4				X
Pt-197	78	19.8915	hours	4				X
Pt-197m	78	95.41	minutes	4				X
Pt-199	78	30.80	minutes	4				X
Pt-200	78	12.5	hours	4				X
Rb-79	37	22.9	minutes	4				X
Rb-80	37	33.4	seconds	4				X
Rb-81m	37	30.5	minutes	4				X
Rb-82	37	1.273	minutes	4				X
Rb-82m	37	6.472	hours	4				X
Rb-88	37	17.773	minutes	4				X
Re-177	75	14	minutes	4				X
Re-180	75	2.44	minutes	4				X
Re-182	75	64.0	hours	4				X
Re-182m	75	12.7	hours	4				X
Re-186	75	3.7186	days	4				X
Re-188	75	17.003	hours	4				X
Re-188m	75	18.59	minutes	4				X
Re-189	75	24.3	hours	4				X
Rh-100	45	20.8	hours	4				X
Rh-103m	45	56.114	minutes	4				X
Rh-105	45	35.36	hours	4				X
Rh-106m	45	131	minutes	4				X
Rh-107	45	21.7	minutes	4				X
Rh-99m	45	4.7	hours	4				X
Rn-218	86	0.035	seconds	4				X
Ru-105	44	4.44	hours	4				X
Ru-94	44	51.8	minutes	4				X
Sb-115	51	32.1	minutes	4				X
Sb-116	51	15.8	minutes	4				X
Sb-116m	51	60.3	minutes	4				X

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Sb-117	51	2.80	hours	4				X
Sb-118m	51	5.00	hours	4				X
Sb-119	51	38.19	hours	4				X
Sb-120	51	15.89	minutes	4				X
Sb-120m	51	5.76	days	4				X
Sb-122	51	2.7238	days	4				X
Sb-128	51	9.01	hours	4				X
Sb-128m	51	10.4	minutes	4				X
Sb-130	51	39.5	minutes	4				X
Sc-43	21	3.891	hours	4				X
Sc-44	21	3.97	hours	4				X
Sc-44m	21	58.61	hours	4				X
Sc-47	21	3.3492	days	4				X
Sc-48	21	43.67	hours	4				X
Sc-49	21	57.2	minutes	4				X
Se-70	34	41.1	minutes	4				X
Se-77m	34	17.36	seconds	4				X
Se-81	34	18.45	minutes	4				X
Se-81m	34	57.28	minutes	4				X
Se-83	34	22.3	minutes	4				X
Si-31	14	157.3	minutes	4				X
Sm-141	62	10.2	minutes	4				X
Sm-141m	62	22.6	minutes	4				X
Sm-142	62	72.49	minutes	4				X
Sm-153	62	46.284	hours	4				X
Sn-110	50	4.11	hours	4				X
Sn-111	50	35.3	minutes	4				X
Sn-121	50	27.03	hours	4				X
Sn-123m	50	40.06	minutes	4				X
Sn-128	50	59.07	minutes	4				X
Sr-80	38	106.3	minutes	4				X
Sr-81	38	22.3	minutes	4				X

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Sr-87m	38	2.815	hours	4				X
Sr-92	38	2.66	hours	4				X
Ta-174	73	1.14	hours	4				X
Ta-176	73	8.09	hours	4				X
Ta-177	73	56.56	hours	4				X
Ta-178	73	9.31	minutes	4				X
Ta-178m	73	2.36	hours	4				X
Ta-180	73	8.154	hours	4				X
Ta-183	73	5.1	days	4				X
Ta-184	73	8.7	hours	4				X
Ta-186	73	10.5	minutes	4				X
Tb-150	65	3.48	hours	4				X
Tb-154	65	21.5	hours	4				X
Tb-155	65	5.32	days	4				X
Tb-156	65	5.35	days	4				X
Tb-156m	65	24.4	hours	4				X
Tb-156n	65	5.3	hours	4				X
Tb-161	65	6.906	days	4				X
Tc-101	43	14.22	minutes	4				X
Tc-104	43	18.3	minutes	4				X
Tc-94	43	293	minutes	4				X
Tc-94m	43	52.0	minutes	4				X
Tc-95	43	20.0	hours	4				X
Tc-96	43	4.28	days	4				X
Tc-96m	43	51.5	minutes	4				X
Te-116	52	2.49	hours	4				X
Te-127	52	9.35	hours	4				X
Te-129	52	69.6	minutes	4				X
Te-132	52	3.204	days	4				X
Te-133	52	12.5	minutes	4				X
Te-133m	52	55.4	minutes	4				X
Te-134	52	41.8	minutes	4				X

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Ti-45	22	184.8	minutes	4				X
Tl-197	81	2.84	hours	4				X
Tl-198	81	5.3	hours	4				X
Tl-198m	81	1.87	hours	4				X
Tl-199	81	7.42	hours	4				X
Tl-200	81	26.1	hours	4				X
Tl-201	81	72.912	hours	4				X
Tl-206	81	4.200	minutes	4				X
Tm-162	69	21.70	minutes	4				X
Tm-166	69	7.70	hours	4				X
Tm-172	69	63.6	hours	4				X
Tm-173	69	8.24	hours	4				X
Tm-175	69	15.2	minutes	4				X
V-47	23	32.6	minutes	4				X
W-176	74	2.5	hours	4				X
W-177	74	132	minutes	4				X
W-187	74	23.72	hours	4				X
Xe-120	54	40	minutes	4				X
Xe-122	54	20.1	hours	4				X
Xe-129m	54	8.88	days	4				X
Xe-131m	54	11.934	days	4				X
Xe-133	54	5.243	days	4				X
Xe-133m	54	2.19	days	4				X
Xe-135m	54	15.29	minutes	4				X
Xe-138	54	14.08	minutes	4				X
Y-86	39	14.74	hours	4				X
Y-86m	39	48	minutes	4				X
Y-87	39	79.8	hours	4				X
Y-90m	39	3.19	hours	4				X
Y-92	39	3.54	hours	4				X
Y-94	39	18.7	minutes	4				X
Yb-162	70	18.87	minutes	4				X

Table A4. Screening Process Application (Steps 1 through 4)

					Step 1 (Inclusion)	Step 2 (Inclusion)	Step 3 (Exclusion)	Step 4 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	CODE	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)
Yb-166	70	56.7	hours	4				X
Yb-175	70	4.185	days	4				X
Yb-177	70	1.911	hours	4				X
Yb-178	70	74	minutes	4				X
Zn-62	30	9.186	hours	4				X
Zn-63	30	38.47	minutes	4				X
Zn-69	30	56.4	minutes	4				X
Zn-69m	30	13.76	hours	4				X
Zn-71m	30	3.96	hours	4				X
Zn-72	30	46.5	hours	4				X
Zr-86	40	16.5	hours	4				X
Zr-89	40	78.41	hours	4				X
Zr-97	40	16.744	hours	4				X

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Ac-225	89	10.0	days	7.30E-37	2.70E-21	2.70E-15	X	7.12E-11	X	
Ac-227	89	21.772	years	6.50E-11	240500	2.41E+11		7.90E+12		
Ac-228	89	6.15	hours	2.60E-16	9.62E-01	9.62E+05		9.77E+11		
Am-241	95	432.2	years	8.40E-12	31080	3.11E+10		4.85E+10		
At-217	85	0.0323	seconds	****	****					
At-218	85	1.5	seconds	4.50E-18	0.01665	1.67E+04		2.61E+14		
Bi-210	83	5.012	days	1.60E-15	5.92	5.92E+06		3.34E+11		
Bi-211	83	2.14	minutes	****	****					
Bi-212	83	60.55	minutes	****	****					
Bi-213	83	45.59	minutes	****	****					
Bi-214	83	19.9	minutes	4.70E-17	0.1739	1.74E+05		3.49E+12		
Fr-221	87	4.9	minutes	****	****					
Fr-223	87	22.00	minutes	7.50E-34	2.775E-18	2.78E-12	X	4.83E-05	X	
Np-237	93	2.144E+06	years	3.00E-10	1110000	1.11E+12		3.55E+08		
Pa-231	91	3.276E+04	years	1.70E-10	629000	6.29E+11		1.35E+10		
Pa-233	91	26.975	days	2.10E-18	0.00777	7.77E+03		7.33E+07		
Pa-234	91	6.70	hours	8.10E-21	0.00002997	3.00E+01		2.72E+07		
Pb-209	82	3.253	hours	****	****					
Pb-210	82	22.20	years	2.10E-11	77700	7.77E+10		2.71E+12		
Pb-211	82	36.1	minutes	****	****					
Pb-212	82	10.64	hours	****	****					
Pb-214	82	26.8	minutes	4.80E-17	0.1776	1.78E+05		2.65E+12		
Po-210	84	138.376	days	3.30E-14	122.1	1.22E+08		2.49E+11		
Po-211	84	0.516	seconds	****	****					
Po-212	84	3.00E-07	seconds	****	****					
Po-213	84	3.65E-06	seconds	****	****					
Po-214	84	1.643E-04	seconds	****	****					
Po-215	84	1.781E-03	seconds	****	****					
Po-216	84	0.145	seconds	****	****					
Po-218	84	3.10	minutes	6.60E-18	0.02442	2.44E+04		3.09E+12		
Pu-241	94	14.290	years	2.90E-13	1073	1.07E+09		5.06E+10		
Ra-223	88	11.430	days	1.40E-33	5.18E-18	5.18E-12	X	1.21E-07	X	

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Ra-224	88	3.63	days	****	****					
Ra-225	88	14.9	days	6.10E-29	2.257E-13	2.26E-07	X	3.99E-03	X	
Ra-226	88	1,600	years	8.00E-11	296000	2.96E+11		1.33E+11		
Ra-228	88	5.75	years	3.00E-11	111000	1.11E+11		1.38E+13		
Rn-219	86	3.96	seconds	****	****					
Rn-220	86	55.6	seconds	****	****					
Rn-222	86	3.8235	days	4.70E-12	17390	1.74E+10		1.22E+15		
Th-227	90	18.68	days	2.80E-26	1.036E-10	1.04E-04	X	1.45E+00	X	
Th-228	90	1.9116	years	7.10E-13	2627	2.63E+09		9.79E+11		
Th-229	90	7,340	years	3.20E-11	118400	1.18E+11		1.14E+10		
Th-230	90	7.538E+04	years	4.30E-11	159100	1.59E+11		1.49E+09		
Th-231	90	25.52	hours	1.10E-17	0.0407	4.07E+04		9.83E+09		
Th-232	90	1.405E+10	years	9.90E-11	366300	3.66E+11		1.83E+04		
Th-234	90	24.10	days	7.90E-17	0.2923	2.92E+05		3.08E+09		
Tl-207	81	4.77	minutes	****	****					
Tl-208	81	3.053	minutes	****	****					
Tl-209	81	2.161	minutes	****	****					
Tl-210	81	1.30	minutes	Not on table	Not on table					
U-233	92	1.592E+05	years	1.50E-11	55500	5.55E+10		2.43E+08		
U-234	92	2.455E+05	years	5.80E-12	21460	2.15E+10		6.07E+07		
U-235	92	7.04E+08	years	2.00E-11	7.40E+04	7.40E+10		7.27E+04		
U-238	92	4.468E+09	years	1.70E-10	629000	6.29E+11		9.61E+04		
Al-26	13	7.17E+05	years	3.00E-11	111000	1.11E+11		9.67E+08		
Am-242m	95	141	years	5.20E-11	192400	1.92E+11		9.16E+11		
Am-243	95	7,370	years	1.10E-11	40700	4.07E+10		3.69E+09		
Ba-137m	56	2.552	minutes	****	****					
Bk-249	97	330	days	2.90E-12	10730	1.07E+10		7.75E+12		
C-14	6	5700	years	1.70E-11	62900	6.29E+10		1.28E+11		
Ce-144	58	284.91	days	3.60E-15	13.32	1.33E+07		1.93E+10		
Cf-249	98	351	years	1.50E-11	55500	5.55E+10		1.03E+11		
Cf-251	98	898	years	1.30E-11	48100	4.81E+10		3.47E+10		

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Cf-252	98	3	years	3.50E-13	1295	1.30E+09		3.16E+11		
Cm-242	96	162.8	days	3.30E-14	122.1	1.22E+08		1.84E+11		
Cm-243	96	29.1	years	5.50E-12	20350	2.04E+10		4.67E+11		
Cm-244	96	18.1	years	3.00E-12	11100	1.11E+10		4.08E+11		
Cm-245	96	8,500	years	1.70E-11	62900	6.29E+10		4.91E+09		
Cm-247	96	1.56E+07	years	1.50E-11	55500	5.55E+10		2.34E+06		
Cm-248	96	3.48E+05	years	3.00E-11	111000	1.11E+11		2.09E+08		
Co-60	27	1925.28	days	6.60E-12	24420	2.44E+10		1.25E+13		
Cs-134	55	2.0652	years	1.00E-12	3700	3.70E+09		2.17E+12		
Cs-135	55	2.3E+06	years	1.70E-12	6290	6.29E+09		3.29E+06		
Cs-137	55	30.03	years	1.40E-11	51800	5.18E+10		2.05E+12		
Eu-152	63	13.506	years	6.60E-12	24420	2.44E+10		1.93E+12		
Eu-154	63	8.590	years	5.40E-12	19980	2.00E+10		2.45E+12		
Eu-155	63	4.753	years	1.70E-13	629	6.29E+08		1.39E+11		
H-3	1	12.32	years	3.10E-13	1147	1.15E+09		5.04E+12		
I-129	53	1.57E+07	years	2.00E-10	740000	7.40E+11		5.94E+07		
Na-22	11	2.6027	years	1.40E-12	5180	5.18E+09		1.47E+13		
Nb-94	41	2.03E+04	years	1.70E-11	62900	6.29E+10		5.35E+09		
Ni-59	28	7.6E+04	years	1.90E-14	70.3	7.03E+07		2.55E+06		
Ni-63	28	100.1	years	4.10E-14	151.7	1.52E+08		3.91E+09		
Pm-147	61	2.6234	years	1.70E-15	6.29	6.29E+06		2.65E+09		
Pr-144	59	17.28	minutes	****	****					
Pu-238	94	87.7	years	7.90E-12	29230	2.92E+10		2.27E+11		
Pu-239	94	24,110	years	9.50E-12	35150	3.52E+10		9.91E+08		
Pu-240	94	6,561	years	9.40E-12	34780	3.48E+10		3.59E+09		
Pu-242	94	3.75E+05	years	9.00E-12	33300	3.33E+10		5.96E+07		
Pu-244	94	8.00E+07	years	3.10E-11	114700	1.15E+11		9.55E+05		
Rh-106	45	29.80	seconds	****	****					
Ru-106	44	373.59	days	6.50E-14	240.5	2.41E+08		3.60E+11		
Sb-125	51	2.75856	years	3.50E-13	1295	1.30E+09		6.10E+11		
Sb-126	51	12.35	days	1.30E-32	4.81E-17	4.81E-11	X	1.83E-06	X	
Sb-126m	51	19.15	minutes	1.90E-36	7.03E-21	7.03E-15	X	2.49E-07	X	

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Se-79	34	2.95E+05	years	7.20E-13	2664	2.66E+09		1.86E+07		
Sm-151	62	90	years	3.00E-15	11.1	1.11E+07		1.33E+08		
Sn-126	50	2.3E+05	years	3.00E-11	111000	1.11E+11		6.22E+08		
Sr-90	38	28.90	years	3.60E-11	133200	1.33E+11		8.32E+12		
Tc-99	43	2.111E+05	years	1.30E-11	48100	4.81E+10		3.74E+08		
Te-125m	52	57.40	days	4.70E-19	0.001739	1.74E+03		1.44E+07		
U-232	92	68.9	years	6.70E-11	247900	2.48E+11		2.52E+12		
U-236	92	2.342E+07	years	4.70E-12	17390	1.74E+10		5.11E+05		
Y-90	39	64.053	hours	****	****					
Ar-42	18	32.9	years	Not on table	Not on table					X
As-79	33	9.01	minutes	Not on table	Not on table					
Bi-208	83	3.68E+05	years	Not on table	Not on table					
Ce-142	58	2.6E+17	years	Not on table	Not on table					
Cf-247	98	3.11	hour	Not on table	Not on table					
Es-255	99	39.8	days	Not on table	Not on table					
Fe-52m	26	46	seconds	Not on table	Not on table					
Ga-74	31	8.2	minutes	Not on table	Not on table					
Gd-150	64	1.80E+06	years	Not on table	Not on table					
Nb-92	41	3.47E+07	years	Not on table	Not on table					
Nd-144	60	2.29E+15	years	Not on table	Not on table					

Table A5. Screening Process Application (Steps 5 through 7)

								Step 5 (Exclusion)	Step 6 (Exclusion)	Step 7 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Calculation of mrem in 1000 lbs	Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Physical Properties (Gas) (no new formation) (30 Isotopes)
Os-186	76	2E+15	years	Not on table	Not on table					
Pb-204	82	1.4E+17	years	Not on table	Not on table					
Po-209	84	102.00	years	Not on table	Not on table					
Po-212m	84	2.98E-07	seconds	Not on table	Not on table					
Rh-105m	45	56.00	minutes	Not on table	Not on table					
Se-79m	34	3.9	minutes	Not on table	Not on table					
Sm-148	62	7E+15	years	Not on table	Not on table					
Sm-149	62	2E+15	years	Not on table	Not on table					
Te-118	52	6.00	days	Not on table	Not on table					
V-50	23	1.4E+17	years	Not on table	Not on table					
Yb-165	70	9.9	minutes	Not on table	Not on table					
Ac-223	89	2.10	minutes	****	****					
Ac-224	89	2.78	hours	****	****					
Ag-102	47	12.9	minutes	****	****					
Ag-104	47	69.2	minutes	****	****					
Ag-104m	47	33.5	minutes	****	****					
Ag-106	47	23.96	minutes	****	****					
Ag-108	47	2.37	minutes	****	****					
Ag-109m	47	38.0	seconds	****	****					
Ag-110	47	24.6	seconds	****	****					
Ag-112	47	3.130	hours	****	****					

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Al-28	13	2.2414	minutes	****	****					
Ar-37	18	34.95	days	****	****					X
Ar-39	18	269	years	****	****					X
Ar-41	18	109.61	years	****	****					X
As-69	33	15.2	minutes	****	****					
As-70	33	52.6	minutes	****	****					
As-72	33	26.0	hours	****	****					
As-76	33	1.0942	days	****	****					
As-77	33	38.83	hours	****	****					
As-78	33	90.7	minutes	****	****					
At-215	85	1.00E-04	seconds	****	****					
At-216	85	3.00E-04	seconds	****	****					
Au-194	79	38.02	hours	****	****					
Au-198	79	2.6956	days	****	****					
Au-198m	79	2.27	days	****	****					
Au-199	79	3.139	days	****	****					
Au-200	79	48.4	minutes	****	****					
Au-200m	79	18.7	hours	****	****					
Au-201	79	26	minutes	****	****					
Ba-126	56	100	minutes	****	****					
Ba-128	56	2.43	days	****	****					
Ba-135m	56	28.7	hours	****	****					
Ba-139	56	83.06	minutes	****	****					
Ba-142	56	10.6	minutes	****	****					
Bi-200	83	36.4	minutes	****	****					
Bi-201	83	108	minutes	****	****					
Bi-203	83	11.76	hours	****	****					
Bi-206	83	6.243	days	****	****					
Br-74	35	25.4	minutes	****	****					
Br-74m	35	46	minutes	****	****					
Br-76	35	16.2	hours	****	****					
Br-77	35	57.036	hours	****	****					

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Br-80	35	17.68	minutes	****	****					
Br-80m	35	4.4205	hours	****	****					
Br-82	35	35.282	hours	****	****					
Br-83	35	2.40	hours	****	****					
Br-84	35	31.80	minutes	****	****					
C-11	6	20.334	minutes	****	****					
Ca-47	20	4.536	days	****	****					
Ca-49	20	8.718	minutes	****	****					
Cd-104	48	57.7	minutes	****	****					
Cd-107	48	6.50	hours	****	****					
Cd-115	48	53.46	hours	****	****					
Ce-134	58	3.16	days	****	****					
Ce-135	58	17.7	hours	****	****					
Cl-38	17	37.24	minutes	****	****					
Cl-39	17	55.6	minutes	****	****					
Co-61	27	1.650	hours	****	****					
Co-62m	27	13.91	minutes	****	****					
Cs-126	55	1.64	minutes	****	****					
Cs-128	55	3.66	minutes	****	****					
Cs-129	55	32.06	hours	****	****					
Cs-130	55	29.21	minutes	****	****					
Cs-132	55	6.480	days	****	****					
Cs-135m	55	53	minutes	****	****					
Cs-138	55	33.41	minutes	****	****					
Cu-60	29	23.7	minutes	****	****					
Cu-61	29	3.333	hours	****	****					
Cu-62	29	9.67	minutes	****	****					
Cu-64	29	12.700	hours	****	****					
Cu-66	29	5.120	minutes	****	****					
Cu-67	29	61.83	hours	****	****					
Dy-155	66	9.9	hours	****	****					
Dy-165	66	2.334	hours	****	****					

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Dy-166	66	81.6	hours	****	****					
Er-161	68	3.21	hours	****	****					
Er-165	68	10.36	hours	****	****					
Er-172	68	49.3	hours	****	****					
Eu-146	63	4.61	days	****	****					
Eu-150m	63	12.8	hours	****	****					
Eu-152m	63	9.3116	hours	****	****					
Eu-157	63	15.18	hours	****	****					
Eu-158	63	45.9	minutes	****	****					
F-18	9	1.8291	hours	****	****					
Fe-52	26	8.275	hours	****	****					
Fr-219	87	0.02	seconds	****	****					
Fr-220	87	27.4	seconds	****	****					
Ga-66	31	9.49	hours	****	****					
Ga-67	31	3.2623	days	****	****					
Ga-68	31	67.71	minutes	****	****					
Ga-70	31	21.14	minutes	****	****					
Ga-72	31	14.095	hours	****	****					
Ga-73	31	4.86	hours	****	****					
Gd-159	64	18.479	hours	****	****					
Ge-66	32	2.26	hours	****	****					
Ge-67	32	18.9	minutes	****	****					
Ge-69	32	39.05	hours	****	****					
Ge-75	32	82.78	minutes	****	****					
Ge-77	32	11.30	hours	****	****					
Ge-78	32	88.0	minutes	****	****					
Hf-170	72	16.01	hours	****	****					
Hf-174	72	2.0E+15	years	****	****					
Hf-177m	72	51.4	minutes	****	****					
Hf-180m	72	5.47	hours	****	****					
Hf-183	72	1.067	hours	****	****					
Hf-184	72	4.12	hours	****	****					

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Hg-197	80	64.14	hours	****	****					
Hg-197m	80	23.8	hours	****	****					
Hg-199m	80	42.67	minutes	****	****					
Ho-155	67	48	minutes	****	****					
Ho-161	67	2.48	hours	****	****					
Ho-162	67	15.0	minutes	****	****					
Ho-162m	67	67.0	minutes	****	****					
Ho-164	67	29	minutes	****	****					
Ho-164m	67	37.5	minutes	****	****					
Ho-166	67	26.83	hours	****	****					
Ho-167	67	3.003	hours	****	****					
I-120	53	81.6	minutes	****	****					
I-120m	53	53	minutes	****	****					
I-122	53	3.63	minutes	****	****					
I-124	53	4.1760	days	****	****					
I-128	53	24.99	minutes	****	****					
I-130	53	12.36	hours	****	****					
I-132	53	2.295	hours	****	****					
I-132m	53	1.387	hours	****	****					
I-133	53	20.8	hours	****	****					
I-134	53	52.5	minutes	****	****					
I-135	53	6.57	hours	****	****					
In-110	49	4.9	hours	****	****					
In-110m	49	69.1	minutes	****	****					
In-111	49	2.8047	days	****	****					
In-112	49	14.97	minutes	****	****					
In-113m	49	99.476	minutes	****	****					
In-114	49	71.9	seconds	****	****					
In-115m	49	4.486	hours	****	****					
In-116m	49	54.29	minutes	****	****					
Ir-182	77	15	minutes	****	****					
Ir-184	77	3.09	hours	****	****					

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Ir-186	77	16.64	hours	****	****					
Ir-186m	77	1.90	hours	****	****					
Ir-187	77	10.5	hours	****	****					
Ir-188	77	41.5	hours	****	****					
Ir-191m	77	4.94	seconds	****	****					
Ir-194	77	19.28	hours	****	****					
Ir-195	77	2.5	hours	****	****					
Ir-195m	77	3.8	hours	****	****					
K-38	19	7.636	minutes	****	****					
K-42	19	12	hours	****	****					
K-43	19	22.3	hours	****	****					
K-44	19	22.13	minutes	****	****					
Kr-74	36	11.50	minutes	****	****					X
Kr-76	36	14.8	hours	****	****					X
Kr-77	36	74.4	minutes	****	****					X
Kr-79	36	35.04	hours	****	****					X
Kr-81m	36	13.10	seconds	****	****					X
Kr-83m	36	1.83	hours	****	****					X
Kr-87	36	76.3	minutes	****	****					X
Kr-88	36	2.84	hours	****	****					X
La-132	57	4.8	hours	****	****					
La-134	57	6.45	minutes	****	****					
La-135	57	19.5	hours	****	****					
La-140	57	1.6781	days	****	****					
La-142	57	91.1	minutes	****	****					
Lu-170	71	2.012	days	****	****					
Lu-172	71	6.70	days	****	****					
Lu-176m	71	3.664	hours	****	****					
Lu-177	71	6.6475	days	****	****					
Lu-178	71	28.4	minutes	****	****					
Lu-178m	71	23.1	minutes	****	****					
Lu-179	71	4.59	hours	****	****					

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Md-257	101	5.52	hours	****	****					
Mg-28	12	20.915	hours	****	****					
Mn-52	25	5.591	days	****	****					
Mn-52m	25	21.1	minutes	****	****					
Mn-56	25	2.5789	hours	****	****					
Mo-101	42	14.61	minutes	****	****					
Mo-90	42	5.56	hours	****	****					
N-13	7	9.965	minutes	****	****					
Na-24	11	14.951	hours	****	****					
Nb-89a	41	66	minutes	****	****					
Nb-89b	41	2.03	hours	****	****					
Nb-90	41	14.60	hours	****	****					
Nb-96	41	23.35	hours	****	****					
Nb-97	41	72.1	minutes	****	****					
Nb-97m	41	58.7	seconds	****	****					
Nb-98	41	51.3	minutes	****	****					
Nd-136	60	50.65	minutes	****	****					
Nd-138	60	5.04	hours	****	****					
Nd-141	60	2.49	hours	****	****					
Nd-141m	60	62.0	seconds	****	****					
Nd-149	60	1.728	hours	****	****					
Ne-19	10	17.22	seconds	****	****					X
Ni-65	28	2.5172	hours	****	****					
Ni-66	28	54.6	hours	****	****					
O-15	8	122.24	seconds	****	****					
Os-180	76	21.5	minutes	****	****					
Os-182	76	22.10	hours	****	****					
Os-189m	76	5.81	hours	****	****					
Os-190m	76	9.9	minutes	****	****					
Os-193	76	30.11	hours	****	****					
P-30	15	2.498	minutes	****	****					
Pa-234m	91	1.17	minutes	****	****					

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Pb-198	82	2.40	hours	****	****					
Pb-199	82	90	minutes	****	****					
Pb-200	82	21.5	hours	****	****					
Pb-201	82	9.33	hours	****	****					
Pb-203	82	51.920	hours	****	****					
Pd-100	46	3.63	days	****	****					
Pd-109	46	13.7012	hours	****	****					
Pm-141	61	20.90	minutes	****	****					
Pm-142	61	40.5	seconds	****	****					
Pm-148	61	5.368	days	****	****					
Pm-149	61	53.08	hours	****	****					
Pm-150	61	2.68	hours	****	****					
Po-203	84	36.7	minutes	****	****					
Pr-136	59	13.1	minutes	****	****					
Pr-138	59	1.45	minutes	****	****					
Pr-138m	59	2.12	hours	****	****					
Pr-142	59	19.12	hours	****	****					
Pr-142m	59	14.6	minutes	****	****					
Pr-144m	59	7.2	minutes	****	****					
Pr-145	59	5.984	hours	****	****					
Pt-186	78	2.08	hours	****	****					
Pt-191	78	2.862	days	****	****					
Pt-195m	78	4.010	days	****	****					
Pt-197	78	19.8915	hours	****	****					
Pt-197m	78	95.41	minutes	****	****					
Pt-199	78	30.80	minutes	****	****					
Pt-200	78	12.5	hours	****	****					
Rb-79	37	22.9	minutes	****	****					
Rb-80	37	33.4	seconds	****	****					
Rb-81m	37	30.5	minutes	****	****					
Rb-82	37	1.273	minutes	****	****					
Rb-82m	37	6.472	hours	****	****					

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Rb-88	37	17.773	minutes	****	****					
Re-177	75	14	minutes	****	****					
Re-180	75	2.44	minutes	****	****					
Re-182	75	64.0	hours	****	****					
Re-182m	75	12.7	hours	****	****					
Re-186	75	3.7186	days	****	****					
Re-188	75	17.003	hours	****	****					
Re-188m	75	18.59	minutes	****	****					
Re-189	75	24.3	hours	****	****					
Rh-100	45	20.8	hours	****	****					
Rh-103m	45	56.114	minutes	****	****					
Rh-105	45	35.36	hours	****	****					
Rh-106m	45	131	minutes	****	****					
Rh-107	45	21.7	minutes	****	****					
Rh-99m	45	4.7	hours	****	****					
Rn-218	86	0.035	seconds	****	****					X
Ru-105	44	4.44	hours	****	****					
Ru-94	44	51.8	minutes	****	****					
Sb-115	51	32.1	minutes	****	****					
Sb-116	51	15.8	minutes	****	****					
Sb-116m	51	60.3	minutes	****	****					
Sb-117	51	2.80	hours	****	****					
Sb-118m	51	5.00	hours	****	****					
Sb-119	51	38.19	hours	****	****					
Sb-120	51	15.89	minutes	****	****					
Sb-120m	51	5.76	days	****	****					
Sb-122	51	2.7238	days	****	****					
Sb-128	51	9.01	hours	****	****					
Sb-128m	51	10.4	minutes	****	****					
Sb-130	51	39.5	minutes	****	****					
Sc-43	21	3.891	hours	****	****					
Sc-44	21	3.97	hours	****	****					

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Sc-44m	21	58.61	hours	****	****					
Sc-47	21	3.3492	days	****	****					
Sc-48	21	43.67	hours	****	****					
Sc-49	21	57.2	minutes	****	****					
Se-70	34	41.1	minutes	****	****					
Se-77m	34	17.36	seconds	****	****					
Se-81	34	18.45	minutes	****	****					
Se-81m	34	57.28	minutes	****	****					
Se-83	34	22.3	minutes	****	****					
Si-31	14	157.3	minutes	****	****					
Sm-141	62	10.2	minutes	****	****					
Sm-141m	62	22.6	minutes	****	****					
Sm-142	62	72.49	minutes	****	****					
Sm-153	62	46.284	hours	****	****					
Sn-110	50	4.11	hours	****	****					
Sn-111	50	35.3	minutes	****	****					
Sn-121	50	27.03	hours	****	****					
Sn-123m	50	40.06	minutes	****	****					
Sn-128	50	59.07	minutes	****	****					
Sr-80	38	106.3	minutes	****	****					
Sr-81	38	22.3	minutes	****	****					
Sr-87m	38	2.815	hours	****	****					
Sr-92	38	2.66	hours	****	****					
Ta-174	73	1.14	hours	****	****					
Ta-176	73	8.09	hours	****	****					
Ta-177	73	56.56	hours	****	****					
Ta-178	73	9.31	minutes	****	****					
Ta-178m	73	2.36	hours	****	****					
Ta-180	73	8.154	hours	****	****					
Ta-183	73	5.1	days	****	****					
Ta-184	73	8.7	hours	****	****					
Ta-186	73	10.5	minutes	****	****					

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Tb-150	65	3.48	hours	****	****					
Tb-154	65	21.5	hours	****	****					
Tb-155	65	5.32	days	****	****					
Tb-156	65	5.35	days	****	****					
Tb-156m	65	24.4	hours	****	****					
Tb-156n	65	5.3	hours	****	****					
Tb-161	65	6.906	days	****	****					
Tc-101	43	14.22	minutes	****	****					
Tc-104	43	18.3	minutes	****	****					
Tc-94	43	293	minutes	****	****					
Tc-94m	43	52.0	minutes	****	****					
Tc-95	43	20.0	hours	****	****					
Tc-96	43	4.28	days	****	****					
Tc-96m	43	51.5	minutes	****	****					
Te-116	52	2.49	hours	****	****					
Te-127	52	9.35	hours	****	****					
Te-129	52	69.6	minutes	****	****					
Te-132	52	3.204	days	****	****					
Te-133	52	12.5	minutes	****	****					
Te-133m	52	55.4	minutes	****	****					
Te-134	52	41.8	minutes	****	****					
Ti-45	22	184.8	minutes	****	****					
Tl-197	81	2.84	hours	****	****					
Tl-198	81	5.3	hours	****	****					
Tl-198m	81	1.87	hours	****	****					
Tl-199	81	7.42	hours	****	****					
Tl-200	81	26.1	hours	****	****					
Tl-201	81	72.912	hours	****	****					
Tl-206	81	4.200	minutes	****	****					
Tm-162	69	21.70	minutes	****	****					
Tm-166	69	7.70	hours	****	****					
Tm-172	69	63.6	hours	****	****					

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Tm-173	69	8.24	hours	****	****					
Tm-175	69	15.2	minutes	****	****					
V-47	23	32.6	minutes	****	****					
W-176	74	2.5	hours	****	****					
W-177	74	132	minutes	****	****					
W-187	74	23.72	hours	****	****					
Xe-120	54	40	minutes	****	****					X
Xe-122	54	20.1	hours	****	****					X
Xe-129m	54	8.88	days	****	****					X
Xe-131m	54	11.934	days	****	****					X
Xe-133	54	5.243	days	****	****					X
Xe-133m	54	2.19	days	****	****					X
Xe-135m	54	15.29	minutes	****	****					X
Xe-138	54	14.08	minutes	****	****					X
Y-86	39	14.74	hours	****	****					
Y-86m	39	48	minutes	****	****					
Y-87	39	79.8	hours	****	****					
Y-90m	39	3.19	hours	****	****					
Y-92	39	3.54	hours	****	****					
Y-94	39	18.7	minutes	****	****					
Yb-162	70	18.87	minutes	****	****					
Yb-166	70	56.7	hours	****	****					
Yb-175	70	4.185	days	****	****					
Yb-177	70	1.911	hours	****	****					
Yb-178	70	74	minutes	****	****					
Zn-62	30	9.186	hours	****	****					
Zn-63	30	38.47	minutes	****	****					
Zn-69	30	56.4	minutes	****	****					
Zn-69m	30	13.76	hours	****	****					
Zn-71m	30	3.96	hours	****	****					
Zn-72	30	46.5	hours	****	****					
Zr-86	40	16.5	hours	****	****					

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Zr-89	40	78.41	hours	****	****					
Zr-97	40	16.744	hours	****	****					
Ag-103	47	65.7	minutes	1.30E-31	4.81E-16	4.81E-10	X	6.07E-03	X	
Ag-106m	47	8.28	days	8.60E-42	3.182E-26	3.18E-20	X	2.15E-15	X	
Ag-111	47	7.45	days	4.20E-45	1.554E-29	1.55E-23	X	1.11E-18	X	
Ag-115	47	20.0	minutes	3.60E-24	1.332E-08	1.33E-02	X	4.95E+05		
Am-237	95	73.0	minutes	8.80E-24	3.256E-08	3.26E-02	X	1.61E+05		
As-71	33	65.28	hours	1.50E-37	5.55E-22	5.55E-16	X	1.71E-10	X	
As-74	33	17.77	days	6.70E-28	2.479E-12	2.48E-06	X	1.12E-01	X	
Ba-131	56	11.50	days	3.70E-34	1.369E-18	1.37E-12	X	5.39E-08	X	
Ba-131m	56	14.6	minutes	3.20E-37	1.184E-21	1.18E-15	X	5.29E-08	X	
Ba-140	56	12.752	days	6.80E-32	2.516E-16	2.52E-10	X	8.36E-06	X	
Ba-141	56	18.27	minutes	3.60E-25	1.332E-09	1.33E-03	X	4.42E+04		
Bi-205	83	15.31	days	6.30E-23	2.331E-07	2.33E-01	X	4.41E+03		
Cd-117	48	2.49	hours	2.50E-36	9.25E-21	9.25E-15	X	4.52E-08	X	
Cd-117m	48	3.36	hours	6.40E-36	2.368E-20	2.37E-14	X	8.58E-08	X	
Ce-141	58	32.508	days	9.60E-23	3.552E-07	3.55E-01	X	4.60E+03		
Ce-143	58	33.039	hours	2.60E-33	9.62E-18	9.62E-12	X	2.90E-06	X	
Cr-48	24	21.56	hours	1.80E-29	6.66E-14	6.66E-08	X	9.16E-02	X	
Cr-51	24	27.7025	days	3.70E-24	1.369E-08	1.37E-02	X	5.75E+02		
Cs-127	55	6.25	hours	1.40E-45	5.18E-30	5.18E-24	X	9.29E-18	X	
Cs-131	55	9.689	days	3.70E-40	1.369E-24	1.37E-18	X	6.40E-14	X	
Cs-136	55	13.04	days	1.90E-32	7.03E-17	7.03E-11	X	2.35E-06	X	
Er-169	68	9.392	days	7.90E-38	2.923E-22	2.92E-16	X	1.09E-11	X	
Eu-147	63	24.1	days	4.40E-22	1.628E-06	1.63E+00	X	2.73E+04		
Eu-156	63	15.19	days	5.20E-30	1.924E-14	1.92E-08	X	4.82E-04	X	
Gd-147	64	38.06	hours	2.90E-23	1.073E-07	1.07E-01	X	2.73E+04		
Ge-71	32	11.43	days	4.60E-35	1.702E-19	1.70E-13	X	1.24E-08	X	
Hf-179m	72	25.05	days	4.90E-22	1.813E-06	1.81E+00	X	2.40E+04		
I-121	53	2.12	hours	3.00E-29	1.11E-13	1.11E-07	X	6.16E-01	X	
I-126	53	12.93	days	3.50E-29	1.295E-13	1.30E-07	X	4.72E-03	X	
I-131	53	8.02070	days	5.60E-40	2.072E-24	2.07E-18	X	1.17E-13	X	

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
In-117	49	43.2	minutes	1.40E-37	5.18E-22	5.18E-16	X	8.76E-09	X	
In-117m	49	116.2	minutes	1.80E-37	6.66E-22	6.66E-16	X	4.19E-09	X	
In-119	49	2.4	minutes	1.90E-22	7.03E-07	7.03E-01	X	2.10E+08		
In-119m	49	18.0	minutes	3.70E-23	1.369E-07	1.37E-01	X	5.46E+06		
Ir-189	77	13.2	days	1.20E-32	4.44E-17	4.44E-11	X	1.06E-06	X	
Ir-190	77	11.78	days	1.10E-33	4.07E-18	4.07E-12	X	1.08E-07	X	
Ir-190m	77	1.120	hours	4.60E-36	1.702E-20	1.70E-14	X	1.14E-07	X	
Ir-190n	77	3.087	hours	6.00E-37	2.22E-21	2.22E-15	X	5.39E-09	X	
La-131	57	59	minutes	5.60E-38	2.072E-22	2.07E-16	X	2.29E-09	X	
La-141	57	3.92	hours	2.00E-25	7.4E-10	7.40E-04	X	1.91E+03		
La-143	57	14.2	minutes	7.90E-36	2.923E-20	2.92E-14	X	1.23E-06	X	
Lu-171	71	8.24	days	8.40E-41	3.108E-25	3.11E-19	X	1.31E-14	X	
Mn-51	25	46.2	minutes	2.60E-27	9.62E-12	9.62E-06	X	3.49E+02		
Nb-95	41	34.991	days	7.00E-22	0.00000259	2.59E+00	X	4.62E+04		
Nb-95m	41	3.61	days	8.00E-23	2.96E-07	2.96E-01	X	5.12E+04		
Nd-151	60	12.44	minutes	7.90E-22	2.923E-06	2.92E+00	X	1.33E+08		
Os-191	76	15.4	days	2.80E-30	1.036E-14	1.04E-08	X	2.09E-04	X	
Os-191m	76	13.10	hours	1.00E-31	3.7E-16	3.70E-10	X	2.11E-04	X	
P-32	15	14.262	days	1.30E-29	4.81E-14	4.81E-08	X	6.25E-03	X	
P-33	15	25.34	days	1.20E-23	4.44E-08	4.44E-02	X	3.15E+03		
Pa-227	91	38.3	minutes	3.80E-29	1.406E-13	1.41E-07	X	1.38E+00	X	
Pd-103	46	16.991	days	8.10E-29	2.997E-13	3.00E-07	X	1.02E-02	X	
Po-205	84	1.74	hours	1.80E-32	6.66E-17	6.66E-11	X	2.66E-04	X	
Pr-137	59	1.28	hours	6.40E-22	2.368E-06	2.37E+00	X	1.92E+07		
Pr-143	59	13.57	days	4.80E-32	1.776E-16	1.78E-10	X	5.43E-06	X	
Pt-188	78	10.2	days	3.60E-35	1.332E-19	1.33E-13	X	4.12E-09	X	
Pt-189	78	10.87	hours	3.30E-32	1.221E-16	1.22E-10	X	8.46E-05	X	
Rb-81	37	4.570	hours	3.40E-22	1.258E-06	1.26E+00	X	4.84E+06		
Rb-86	37	18.642	days	1.10E-26	4.07E-11	4.07E-05	X	1.51E+00	X	
Rb-89	37	15.15	minutes	2.50E-22	9.25E-07	9.25E-01	X	5.86E+07		
Re-178	75	13.2	minutes	1.30E-28	4.81E-13	4.81E-07	X	1.75E+01		
Rh-99	45	16.1	days	2.80E-29	1.036E-13	1.04E-07	X	3.86E-03	X	

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Sb-129	51	4.40	hours	7.40E-24	2.738E-08	2.74E-02	X	6.87E+04		
Sb-131	51	23.03	minutes	3.10E-44	1.147E-28	1.15E-22	X	3.25E-15	X	
Se-73m	34	39.8	minutes	6.50E-22	2.405E-06	2.41E+00	X	7.07E+07		
Sm-156	62	9.4	hours	1.40E-31	5.18E-16	5.18E-10	X	5.03E-04	X	
Sn-117m	50	13.76	days	6.00E-32	2.22E-16	2.22E-10	X	8.18E-06	X	
Sr-82	38	25.55	days	1.90E-22	7.03E-07	7.03E-01	X	1.99E+04		
Tb-147	65	1.7	hours	1.30E-24	4.81E-09	4.81E-03	X	2.74E+04		
Te-121	52	19.16	days	4.80E-29	1.776E-13	1.78E-07	X	4.55E-03	X	
Te-131	52	25.0	minutes	9.80E-45	3.626E-29	3.63E-23	X	9.46E-16	X	
Te-131m	52	30	hours	8.80E-43	3.256E-27	3.26E-21	X	1.18E-15	X	
Tl-202	81	12.23	days	9.60E-35	3.552E-19	3.55E-13	X	8.53E-09	X	
Tm-167	69	9.25	days	7.90E-38	2.923E-22	2.92E-16	X	1.12E-11	X	
V-48	23	15.9735	days	7.40E-27	2.738E-11	2.74E-05	X	2.12E+00	X	
W-178	74	21.6	days	4.20E-26	1.554E-10	1.55E-04	X	2.40E+00	X	
Xe-121	54	40.1	minutes	6.00E-29	2.22E-13	2.22E-07	X	3.91E+00	X	X
Xe-127	54	36.4	days	2.40E-43	8.88E-28	8.88E-22	X	1.14E-17	X	X
Y-91m	39	49.71	minutes	9.10E-22	3.367E-06	3.37E+00	X	6.36E+07		
Y-93	39	10.18	hours	2.20E-23	8.14E-08	8.14E-02	X	1.22E+05		
Y-95	39	10.3	minutes	3.10E-22	1.147E-06	1.15E+00	X	1.00E+08		
Yb-167	70	17.5	minutes	1.00E-40	3.7E-25	3.70E-19	X	1.08E-11	X	
Cd-113	48	7.7E+15	years	5.60E-11	207200	2.07E+11		3.87E-02	X	
Gd-152	64	1.08E+14	years	1.60E-12	5920	5.92E+09		5.86E-02	X	
In-115	49	4.41E+14	years	8.00E-13	2960	2.96E+09		9.48E-03	X	
Re-187	75	4.12E+10	years	4.40E-15	16.28	1.63E+07		3.43E-01	X	
Ta-180m	73	1.2E+15	years	7.50E-12	27750	2.78E+10		2.09E-02	X	
Te-123	52	9.2E+16	years	3.40E-13	1258	1.26E+09		1.81E-05	X	
Kr-81	36	2.29E+05	years	8.00E-14	296	2.96E+08		2.59E+06		X
Kr-85	36	3916.8	days	6.90E-15	25.53	2.55E+07		4.55E+09		X
Kr-85m	36	4.480	hours	1.20E-19	0.000444	4.44E+02		1.66E+09		X
Xe-123	54	2.08	hours	2.80E-21	0.00001036	1.04E+01		5.77E+07		X
Xe-125	54	16.9	hours	1.10E-16	0.407	4.07E+05		2.74E+11		X
Xe-135	54	9.14	hours	9.90E-21	0.00003663	3.66E+01		4.23E+07		X

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Ag-105	47	41.29	days	8.60E-21	0.00003182	3.18E+01		4.35E+05		
As-73	33	80.30	days	2.40E-18	0.00888	8.88E+03		8.99E+07		
Au-195	79	186.098	days	8.20E-16	3.034	3.03E+06		4.96E+09		
Au-195m	79	30.5	seconds	1.60E-21	0.00000592	5.92E+00		5.10E+09		
Be-7	4	53.22	days	4.10E-21	0.00001517	1.52E+01		2.42E+06		
Ca-45	20	162.61	days	4.20E-15	15.54	1.55E+07		1.26E+11		
Cd-109	48	461.4	days	2.80E-14	103.6	1.04E+08		1.22E+11		
Ce-139	58	137.641	days	1.70E-17	0.0629	6.29E+04		1.95E+08		
Co-56	27	77.233	days	5.50E-17	0.2035	2.04E+05		2.74E+09		
Co-57	27	271.74	days	1.10E-15	4.07	4.07E+06		1.56E+10		
Co-58	27	70.86	days	6.90E-18	0.02553	2.55E+04		3.69E+08		
Dy-159	66	144.4	days	3.10E-15	11.47	1.15E+07		2.96E+10		
Eu-149	63	93.1	days	1.70E-19	0.000629	6.29E+02		2.69E+06		
Fe-59	26	44.495	days	4.80E-20	0.0001776	1.78E+02		4.01E+06		
Gd-151	64	124	days	1.40E-17	0.0518	5.18E+04		1.64E+08		
Gd-153	64	240.4	days	2.50E-16	0.925	9.25E+05		1.49E+09		
Hf-175	72	70	days	1.70E-16	0.629	6.29E+05		3.05E+09		
Hf-181	72	42.39	days	2.80E-18	0.01036	1.04E+04		8.01E+07		
Hg-203	80	46.595	days	6.70E-19	0.002479	2.48E+03		1.55E+07		
I-125	53	59.400	days	1.40E-15	5.18	5.18E+06		4.14E+10		
Ir-194m	77	171	days	1.60E-15	5.92	5.92E+06		1.06E+10		
Lu-173	71	1.37	years	1.50E-13	555	5.55E+08		3.80E+11		
Mn-54	25	312.12	days	3.80E-15	14.06	1.41E+07		4.95E+10		
Os-185	76	93.6	days	1.00E-17	0.037	3.70E+04		1.27E+08		
Pm-143	61	265	days	2.20E-16	0.814	8.14E+05		1.27E+09		
Rb-84	37	33.1	days	2.50E-21	0.00000925	9.25E+00		1.97E+05		
Re-184	75	38.0	days	2.60E-20	0.0000962	9.62E+01		8.16E+05		
S-35	16	87.51	days	3.90E-17	0.1443	1.44E+05		2.80E+09		
Sb-124	51	60.11	days	7.70E-18	0.02849	2.85E+04		2.27E+08		
Sc-46	21	83.79	days	8.90E-18	0.03293	3.29E+04		5.07E+08		
Se-75	34	119.779	days	1.80E-16	0.666	6.66E+05		4.40E+09		
Sn-113	50	115.09	days	8.40E-17	0.3108	3.11E+05		1.42E+09		

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Sn-119m	50	293.1	days	9.40E-16	3.478	3.48E+06		5.92E+09		
Sn-123	50	129.2	days	4.30E-16	1.591	1.59E+06		5.94E+09		
Sr-85	38	64.84	days	6.80E-18	0.02516	2.52E+04		2.71E+08		
Sr-89	38	50.57	days	4.10E-18	0.01517	1.52E+04		2.00E+08		
Ta-179	73	1.82	years	5.10E-14	188.7	1.89E+08		9.41E+10		
Tb-160	65	72.3	days	4.70E-18	0.01739	1.74E+04		8.92E+07		
Tm-170	69	128.6	days	2.80E-14	103.6	1.04E+08		2.81E+11		
Tm-171	69	1.92	years	1.00E-13	370	3.70E+08		1.83E+11		
V-49	23	329	days	5.40E-15	19.98	2.00E+07		7.35E+10		
W-181	74	121.20	days	1.40E-17	0.0518	5.18E+04		1.40E+08		
W-185	74	75.1	days	5.20E-18	0.01924	1.92E+04		8.22E+07		
Y-88	39	106.616	days	5.20E-17	0.1924	1.92E+05		1.22E+09		
Y-91	39	58.51	days	1.50E-18	0.00555	5.55E+03		6.18E+07		
Yb-169	70	32.018	days	2.80E-20	0.0001036	1.04E+02		1.21E+06		
Zn-65	30	243.66	days	2.90E-15	10.73	1.07E+07		4.02E+10		
Ag-110m	47	249.76	days	5.20E-15	19.24	1.92E+07		4.16E+10		
Br-75	35	96.7	minutes	1.00E-18	0.0037	3.70E+03		4.36E+10		
Co-58m	27	9.04	hours	3.70E-20	0.0001369	1.37E+02		3.72E+08		
Cr-49	24	42.3	minutes	2.00E-20	0.000074	7.40E+01		3.05E+09		
Ga-65	31	15.2	minutes	2.10E-17	0.0777	7.77E+04		6.72E+12		
Gd-149	64	9.28	days	2.00E-19	0.00074	7.40E+02		3.18E+07		
Ge-68	32	270.95	days	6.80E-14	251.6	2.52E+08		8.10E+11		
Hf-172	72	1.87	years	1.90E-12	7030	7.03E+09		3.55E+12		
Hg-195	80	10.53	hours	2.90E-18	0.01073	1.07E+04		7.44E+09		
Ho-159	67	33.05	minutes	2.60E-21	0.00000962	9.62E+00		1.56E+08		
In-114m	49	49.51	days	2.10E-19	0.000777	7.77E+02		8.17E+06		
Ir-185	77	14.4	hours	1.30E-19	0.000481	4.81E+02		2.57E+08		
K-45	19	17.3	minutes	1.80E-19	0.000666	6.66E+02		7.31E+10		
Lu-169	71	34.06	hours	1.30E-21	0.00000481	4.81E+00		1.19E+06		
Lu-177m	71	160.44	days	8.90E-14	329.3	3.29E+08		6.88E+11		
Ni-56	28	6.075	days	6.90E-19	0.002553	2.55E+03		4.45E+08		
Ni-57	28	35.60	hours	9.20E-19	0.003404	3.40E+03		2.39E+09		

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Pr-139	59	4.41	hours	4.80E-20	0.0001776	1.78E+02		4.13E+08		
Rb-83	37	86.2	days	6.90E-17	0.2553	2.55E+05		2.12E+09		
Re-181	75	19.9	hours	6.80E-19	0.002516	2.52E+03		9.95E+08		
Re-184m	75	169	days	6.50E-15	24.05	2.41E+07		4.59E+10		
Ru-103	44	39.26	days	1.40E-20	0.0000518	5.18E+01		7.60E+05		
Sb-124m	51	93	seconds	1.10E-22	4.07E-07	4.07E-01		1.81E+08		
Sb-124n	51	20.2	minutes	1.40E-21	4.07E-07	4.07E-01		1.39E+07		
Se-73	34	7.15	hours	7.10E-21	0.00002627	2.63E+01		7.17E+07		
Sr-83	38	32.41	hours	3.80E-18	0.01406	1.41E+04		7.44E+09		
Sr-85m	38	67.63	minutes	4.50E-21	0.00001665	1.67E+01		2.47E+08		
Sr-91	38	9.63	hours	1.30E-19	0.000481	4.81E+02		7.82E+08		
Ta-175	73	10.5	hours	1.10E-18	0.00407	4.07E+03		3.15E+09		
Ta-182m	73	15.84	minutes	1.70E-18	0.00629	6.29E+03		1.86E+11		
Ta-185	73	49.4	minutes	2.00E-19	0.00074	7.40E+02		6.92E+09		
Tb-151	65	17.609	hours	8.80E-20	0.0003256	3.26E+02		1.74E+08		
Tb-153	65	2.34	days	2.40E-18	0.00888	8.88E+03		1.47E+09		
Tc-95m	43	61	days	1.70E-16	0.629	6.29E+05		6.44E+09		
Te-121m	52	154	days	5.30E-16	1.961	1.96E+06		6.24E+09		
Te-127m	52	109	days	1.30E-16	0.481	4.81E+05		2.06E+09		
W-188	74	69.78	days	1.90E-17	0.0703	7.03E+04		3.18E+08		
Zr-88	40	83.4	days	4.90E-17	0.1813	1.81E+05		1.47E+09		
Zr-95	40	64.032	days	8.80E-19	0.003256	3.26E+03		3.18E+07		
Cs-125	55	46.7	minutes	3.40E-21	0.00001258	1.26E+01		1.84E+08		
Hf-173	72	23.6	hours	3.40E-16	1.258	1.26E+06		4.39E+11		
Hg-195m	80	41.6	hours	1.20E-17	0.0444	4.44E+04		7.79E+09		
Nb-88	41	14.55	minutes	2.10E-20	0.0000777	7.77E+01		5.18E+09		
Nd-139	60	29.7	minutes	5.20E-21	0.00001924	1.92E+01		3.98E+08		
Nd-139m	60	5.50	hours	5.80E-20	0.0002146	2.15E+02		4.00E+08		
Os-181	76	105	minutes	4.50E-21	0.00001665	1.67E+01		7.49E+07		
Pa-228	91	22	hours	9.20E-16	3.404	3.40E+06		9.66E+11		
Pb-195m	82	15.0	minutes	5.60E-21	0.00002072	2.07E+01		6.05E+08		
Sb-127	51	3.85	days	2.60E-18	0.00962	9.62E+03		1.17E+09		

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Sn-127	50	2.10	hours	2.00E-20	0.000074	7.40E+01		3.95E+08		
Tb-149	65	4.118	hours	1.20E-18	0.00444	4.44E+03		1.03E+10		
Tl-195	81	1.16	hours	1.70E-20	0.0000629	6.29E+01		3.96E+08		
Ac-226	89	29.37	hours	2.40E-15	8.88E+00	8.88E+06		1.91E+12		
Am-238	95	98	minutes	1.40E-17	0.0518	5.18E+04		1.90E+11		
Am-239	95	11.9	hours	4.50E-19	0.001665	1.67E+03		8.34E+08		
Am-240	95	50.8	hours	7.10E-18	0.02627	2.63E+04		3.07E+09		
Am-244	95	10.1	hours	2.10E-16	0.777	7.77E+05		4.49E+11		
Am-244m	95	26	minutes	8.50E-18	0.03145	3.15E+04		4.24E+11		
Am-245	95	2.05	hours	4.20E-19	0.001554	1.55E+03		4.41E+09		
Am-246m	95	25.0	minutes	8.50E-20	0.0003145	3.15E+02		4.37E+09		
At-207	85	1.80	hours	7.40E-17	0.2738	2.74E+05		1.05E+12		
At-211	85	7.214	hours	1.40E-16	0.518	5.18E+05		4.85E+11		
Au-193	79	17.65	hours	1.00E-18	0.0037	3.70E+03		1.55E+09		
Ba-133m	56	38.9	hours	9.10E-16	3.367	3.37E+06		9.27E+11		
Bi-202	83	1.72	hours	3.70E-21	0.00001369	1.37E+01		5.61E+07		
Bk-245	97	4.94	days	2.70E-15	9.99	9.99E+06		4.90E+11		
Bk-246	97	1.80	days	1.00E-15	3.7	3.70E+06		4.96E+11		
Cd-115m	48	44.56	days	4.00E-19	0.00148	1.48E+03		1.71E+07		
Ce-137	58	9.0	hours	4.50E-21	0.00001665	1.67E+01		1.92E+07		
Ce-137m	58	34.4	hours	1.70E-20	0.0000629	6.29E+01		1.90E+07		
Cf-244	98	19.4	minutes	2.90E-17	0.1073	1.07E+05		1.94E+12		
Cf-246	98	35.7	hours	2.70E-15	9.99	9.99E+06		1.62E+12		
Cf-248	98	333.5	days	2.00E-13	740	7.40E+08		5.31E+11		
Cf-253	98	17.81	days	2.10E-15	7.77	7.77E+06		1.02E+11		
Cf-254	98	60.5	days	1.30E-16	0.481	4.81E+05		1.86E+09		
Cm-238	96	2.4	hours	1.60E-16	0.592	5.92E+05		1.48E+12		
Cm-240	96	27	days	3.90E-14	144.3	1.44E+08		1.32E+12		
Cm-241	96	32.8	days	1.70E-15	6.29	6.29E+06		4.72E+10		
Cm-249	96	64.15	minutes	4.50E-18	0.01665	1.67E+04		8.91E+10		
Co-55	27	17.53	hours	2.00E-18	0.0074	7.40E+03		1.05E+10		
Cs-134m	55	2.912	hours	1.60E-16	0.592	5.92E+05		2.16E+12		

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Dy-157	66	8.14	hours	6.90E-19	0.002553	2.55E+03		2.84E+09		
Er-171	68	7.516	hours	5.00E-17	0.185	1.85E+05		2.05E+11		
Es-250m	99	2	hours	8.50E-15	31.45	3.15E+07		8.07E+13		
Es-251	99	33	hours	5.00E-15	18.5	1.85E+07		3.18E+12		
Es-253	99	20.47	days	2.00E-13	740	7.40E+08		8.48E+12		
Es-254	99	275.7	days	3.40E-11	125800	1.26E+11		1.07E+14		
Es-254m	99	39.3	hours	1.60E-13	592	5.92E+08		8.44E+13		
Eu-145	63	5.93	days	2.00E-16	0.74	7.40E+05		5.11E+10		
Eu-148	63	54.5	days	1.80E-14	66.6	6.66E+07		4.90E+11		
Fm-252	100	25.39	hours	1.00E-13	370	3.70E+08		8.23E+13		
Fm-253	100	3.00	days	2.80E-14	103.6	1.04E+08		8.10E+12		
Fm-254	100	3.240	hours	1.30E-14	48.1	4.81E+07		8.32E+13		
Fm-255	100	20.07	hours	3.00E-15	11.1	1.11E+07		3.09E+12		
Fm-257	100	100.5	days	1.10E-12	4070	4.07E+09		9.35E+12		
Fr-222	87	14.2	minutes	1.90E-15	7.03	7.03E+06		1.91E+14		
Gd-145	64	23.0	minutes	5.40E-19	0.001998	2.00E+03		5.12E+10		
Gd-146	64	48.27	days	1.30E-19	0.000481	4.81E+02		4.05E+06		
Hf-182m	72	61.5	minutes	3.50E-18	0.01295	1.30E+04		9.88E+10		
Hg-193	80	3.80	hours	2.10E-19	0.000777	7.77E+02		1.51E+09		
Hg-193m	80	11.8	hours	6.70E-19	0.002479	2.48E+03		1.55E+09		
Ho-157	67	12.6	minutes	7.50E-21	0.00002775	2.78E+01		1.20E+09		
I-123	53	13.232	hours	2.80E-21	0.00001036	1.04E+01		9.06E+06		
In-109	49	4.2	hours	6.30E-18	0.02331	2.33E+04		7.25E+10		
Lu-174m	71	142	days	6.30E-14	233.1	2.33E+08		5.60E+11		
Md-258	101	51.5	days	8.10E-16	2.997	3.00E+06		1.34E+10		
Mo-93m	42	6.85	hours	5.90E-20	0.0002183	2.18E+02		4.88E+08		
Mo-99	42	2.7489	days	5.30E-19	0.001961	1.96E+03		4.28E+08		
Nd-147	60	10.98	days	2.00E-17	0.074	7.40E+04		2.72E+09		
Np-232	93	14.7	minutes	5.10E-17	0.1887	1.89E+05		4.73E+12		
Np-233	93	36.2	minutes	1.50E-20	0.0000555	5.55E+01		5.62E+08		
Np-234	93	4.4	days	1.00E-18	0.0037	3.70E+03		2.13E+08		
Np-235	93	396.1	days	6.50E-15	24.05	2.41E+07		1.53E+10		

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Np-236m	93	22.5	hours	1.80E-14	66.6	6.66E+07		1.79E+13		
Np-238	93	2,117	days	1.30E-14	48.1	4.81E+07		5.66E+12		
Np-240m	93	7.22	minutes	4.80E-19	0.001776	1.78E+03		8.76E+10		
Pa-230	91	17.4	days	3.80E-15	14.06	1.41E+07		2.08E+11		
Pa-232	91	1.31	days	1.80E-15	6.66	6.66E+06		1.30E+12		
Pb-202m	82	3.53	hours	7.10E-21	0.00002627	2.63E+01		5.25E+07		
Pd-101	46	8.47	hours	7.30E-18	0.02701	2.70E+04		4.50E+10		
Pm-144	61	363	days	1.10E-14	40.7	4.07E+07		4.62E+10		
Pm-148m	61	41.29	days	1.60E-20	0.0000592	5.92E+01		5.75E+05		
Pm-151	61	28.40	hours	1.10E-19	0.000407	4.07E+02		1.35E+08		
Po-207	84	5.80	hours	2.30E-16	0.851	8.51E+05		1.01E+12		
Pr-147	59	13.4	minutes	1.70E-20	0.0000629	6.29E+01		2.73E+09		
Pt-193m	78	4.33	days	2.10E-17	0.0777	7.77E+04		5.52E+09		
Pu-234	94	8.8	hours	5.00E-17	0.185	1.85E+05		1.28E+11		
Pu-235	94	25.3	minutes	3.10E-21	0.00001147	1.15E+01		1.65E+08		
Pu-237	94	45.2	days	4.00E-18	0.0148	1.48E+04		8.20E+07		
Pu-245	94	10.5	hours	2.90E-18	0.01073	1.07E+04		5.94E+09		
Ra-222	88	38.0	seconds	1.00E-18	0.0037	3.70E+03		2.25E+12		
Ra-227	88	42.2	minutes	2.40E-16	0.888	8.88E+05		7.92E+12		
Rh-101m	45	4.34	days	8.80E-17	0.3256	3.26E+05		4.41E+10		
Ru-97	44	2,791	days	5.10E-21	0.00001887	1.89E+01		4.14E+06		
Sm-145	62	340	days	1.20E-14	44.4	4.44E+07		5.34E+10		
Sm-155	62	22.3	minutes	1.40E-18	0.00518	5.18E+03		1.28E+11		
Sn-125	50	9.64	days	3.30E-15	12.21	1.22E+07		6.01E+11		
Ta-172	73	36.8	minutes	7.40E-17	0.2738	2.74E+05		3.70E+12		
Ta-173	73	3.14	hours	5.10E-17	0.1887	1.89E+05		4.95E+11		
Tc-93	43	2.75	hours	2.70E-19	0.000999	9.99E+02		5.56E+09		
Tc-93m	43	43.5	minutes	7.20E-20	0.0002664	2.66E+02		5.63E+09		
Tc-97m	43	91.4	days	3.00E-15	11.1	1.11E+07		7.43E+10		
Tc-99m	43	6.0058	hours	6.20E-20	0.0002294	2.29E+02		5.49E+08		
Te-123m	52	119.2	days	1.00E-16	0.37	3.70E+05		1.50E+09		
Te-129m	52	33.6	days	8.00E-20	0.000296	2.96E+02		4.05E+06		

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Th-226	90	30.57	minutes	4.30E-17	0.1591	1.59E+05		1.97E+12		
Tl-194	81	33.0	minutes	2.00E-17	0.074	7.40E+04		9.88E+11		
Tl-194m	81	32.8	minutes	1.90E-17	0.0703	7.03E+04		9.44E+11		
U-230	92	20.8	days	3.10E-13	1147	1.15E+09		1.42E+13		
U-231	92	4.2	days	2.10E-16	0.777	7.77E+05		4.75E+10		
U-237	92	6.75	days	1.30E-18	0.00481	4.81E+03		1.78E+08		
U-239	92	23.45	minutes	1.50E-19	0.000555	5.55E+02		8.46E+09		
W-179	74	37.05	minutes	2.80E-19	0.001036	1.04E+03		1.33E+10		
Ba-133	56	3,841	days	2.20E-12	8140	8.14E+09		9.45E+11		
Fe-55	26	2,737	years	9.90E-16	3,663	3.66E+06		3.95E+09		
Lu-174	71	3.31	years	3.30E-13	1221	1.22E+09		3.44E+11		
Os-194	76	6.0	years	5.40E-13	1998	2.00E+09		2.79E+11		
Rh-101	45	3.3	years	3.30E-13	1221	1.22E+09		5.95E+11		
Rh-102	45	208	days	1.80E-12	6660	6.66E+09		1.86E+13		
Rh-102m	45	2.9	years	2.20E-14	81.4	8.14E+07		4.47E+10		
Tl-204	81	3.78	years	1.10E-13	407	4.07E+08		8.57E+10		
Cd-113m	48	14.1	years	3.10E-11	114700	1.15E+11		1.17E+13		
Pm-146	61	5.53	years	2.10E-12	7770	7.77E+09		1.56E+12		
Ag-108m	47	438	years	1.60E-11	59200	5.92E+10		2.03E+11		
Am-242	95	16.02	hours	9.40E-16	3,478	3.48E+06		1.28E+12		
Am-246	95	39	minutes	1.30E-19	0.000481	4.81E+02		4.28E+09		
Be-10	4	1.51E+06	years	5.60E-14	207.2	2.07E+08		2.23E+06		
Bi-207	83	32.9	years	1.30E-11	48100	4.81E+10		1.15E+12		
Bi-210m	83	3.04E+06	years	1.10E-11	40700	4.07E+10		1.04E+07		
Bk-247	97	1,380	years	1.10E-09	4070000	4.07E+12		1.94E+12		
Bk-250	97	3,212	hours	1.30E-14	48.1	4.81E+07		8.53E+13		
Ca-41	20	1.02E+05	years	6.40E-13	2368	2.37E+09		9.20E+07		
Cf-250	98	13.08	years	3.20E-12	11840	1.18E+10		5.88E+11		
Cl-36	17	3.01E+05	years	7.10E-11	262700	2.63E+11		3.94E+09		
Cm-246	96	4,760	years	8.10E-12	29970	3.00E+10		4.16E+09		
Cm-250	96	8.3E+03	years	1.90E-10	703000	7.03E+11		5.50E+10		
Co-60m	27	10.467	minutes	2.50E-17	0.0925	9.25E+04		1.26E+13		

Table A5. Screening Process Application (Steps 5 through 7)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Step 5 (Exclusion) Calculation of mrem in 1000 lbs	Step 6 (Exclusion) Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Step 7 (Exclusion) Physical Properties (Gas) (no new formation) (30 Isotopes)
Eu-150	63	36.9	years	1.30E-11	48100	4.81E+10		1.41E+12		
Fe-60	26	1.50E+06	years	2.60E-11	96200	9.62E+10		1.77E+08		
Gd-148	64	70.9	years	2.00E-12	7400	7.40E+09		1.15E+11		
Hf-178m	72	31	years	2.50E-11	92500	9.25E+10		2.72E+12		
Hf-182	72	8.9E+06	years	2.30E-11	85100	8.51E+10		8.53E+06		
Hg-194	80	444	years	8.60E-11	318200	3.18E+11		6.00E+11		
Ho-166m	67	1.20E+03	years	1.60E-11	59200	5.92E+10		4.83E+10		
Ir-192	77	73.827	days	1.30E-17	0.0481	4.81E+04		2.01E+08		
Ir-192m	77	241	years	1.10E-11	40700	4.07E+10		1.43E+11		
K-40	19	1.248E+09	years	8.60E-12	31820	3.18E+10		1.04E+05		
La-137	57	6E+04	years	2.60E-13	962	9.62E+08		1.90E+07		
La-138	57	1.02E+11	years	1.20E-11	44400	4.44E+10		5.12E+02		
Lu-176	71	3.76E+10	years	8.60E-12	31820	3.18E+10		7.81E+02		
Mn-53	25	3.74E+06	years	4.50E-14	166.5	1.67E+08		1.36E+05		
Mo-93	42	4.0E+03	years	2.60E-13	962	9.62E+08		4.20E+08		
Nb-93m	41	16.13	years	1.30E-14	48.1	4.81E+07		5.21E+09		
Np-236	93	1.54E+05	years	1.60E-07	592000000	5.92E+14		2.65E+12		
Np-239	93	2.356	days	5.90E-17	0.2183	2.18E+05		2.30E+10		
Np-240	93	61.9	minutes	4.20E-18	0.01554	1.55E+04		8.94E+10		
Pb-202	82	5.25E+04	years	5.70E-12	21090	2.11E+10		3.23E+08		
Pb-205	82	1.73E+07	years	1.80E-14	66.6	6.66E+07		3.05E+03		
Pd-107	46	6.5E+06	years	2.80E-14	103.6	1.04E+08		2.42E+04		
Pm-145	61	17.7	years	2.00E-13	740	7.40E+08		4.68E+10		
Pt-193	78	50	years	7.90E-14	292.3	2.92E+08		4.92E+09		
Pu-236	94	2.858	years	1.50E-12	5550	5.55E+09		1.34E+12		
Pu-243	94	4.956	hours	9.50E-19	0.003515	3.52E+03		4.16E+09		
Pu-246	94	10.84	days	6.20E-17	0.2294	2.29E+05		5.10E+09		
Rb-87	37	4.97E+10	years	1.20E-12	4440	4.44E+09		1.67E+02		
Re-186m	75	2.0E+05	years	3.70E-12	13690	1.37E+10		5.98E+07		
Si-32	14	132	years	1.60E-11	59200	5.92E+10		2.28E+12		
Sm-146	62	1.03E+08	years	1.10E-12	4070	4.07E+09		4.40E+04		
Sm-147	62	1.06E+11	years	1.00E-12	3700	3.70E+09		3.86E+01		

Table A5. Screening Process Application (Steps 5 through 7)

								Step 5 (Exclusion)	Step 6 (Exclusion)	Step 7 (Exclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Screening Factor Sv/Bq	Screening Factor mrem/Ci	Calculation of mrem in 1E6 Ci	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Calculation of mrem in 1000 lbs	Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Physical Properties (Gas) (no new formation) (30 Isotopes)
Sn-121m	50	43.9	years	1.00E-12	3700	3.70E+09		1.13E+11		
Ta-182	73	114.43	days	1.60E-14	59.2	5.92E+07		1.69E+11		
Tb-157	65	71	years	4.70E-14	173.9	1.74E+08		2.53E+09		
Tb-158	65	180	years	7.90E-12	29230	2.92E+10		1.67E+11		
Tc-97	43	4.21E+06	years	1.50E-12	5550	5.55E+09		2.21E+06		
Tc-98	43	4.2E+06	years	4.70E-11	173900	1.74E+11		6.86E+07		
Ti-44	22	60.0	years	2.90E-11	107300	1.07E+11		6.60E+12		
U-240	92	14.1	hours	2.00E-17	0.074	7.40E+04		3.11E+10		
Zr-93	40	1.53E+06	years	2.60E-14	96.2	9.62E+07		1.10E+05		

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Ac-225	89	10.0	days	548	Yes		N/A		N/A	N/A	
Ac-227	89	21.772	years	1	No		N/A		N/A	N/A	
Ac-228	89	6.15	hours	2.1E+04	Yes		N/A		N/A	N/A	
Am-241	95	432.2	years	0	No		N/A		N/A	N/A	
At-217	85	0.0323	seconds	1.5E+10	Yes		N/A		N/A	N/A	
At-218	85	1.5	seconds	3.2E+08	Yes		N/A		N/A	N/A	
Bi-210	83	5.012	days	1.1E+03	Yes		N/A		N/A	N/A	
Bi-211	83	2.14	minutes	3.7E+06	Yes		N/A		N/A	N/A	
Bi-212	83	60.55	minutes	1.3E+05	Yes		N/A		N/A	N/A	
Bi-213	83	45.59	minutes	1.7E+05	Yes		N/A		N/A	N/A	
Bi-214	83	19.9	minutes	4.0E+05	Yes		N/A		N/A	N/A	
Fr-221	87	4.9	minutes	1.6E+06	Yes		N/A		N/A	N/A	
Fr-223	87	22.00	minutes	3.6E+05	Yes		N/A		N/A	N/A	
Np-237	93	2.144E+06	years	0	No		N/A		N/A	N/A	
Pa-231	91	3.276E+04	years	0	No		N/A		N/A	N/A	
Pa-233	91	26.975	days	203	Yes		N/A		N/A	N/A	
Pa-234	91	6.70	hours	2.0E+04	Yes		N/A		N/A	N/A	
Pb-209	82	3.253	hours	4.0E+04	Yes		N/A		N/A	N/A	
Pb-210	82	22.20	years	1	No		N/A		N/A	N/A	
Pb-211	82	36.1	minutes	2.2E+05	Yes		N/A		N/A	N/A	
Pb-212	82	10.64	hours	1.2E+04	Yes		N/A		N/A	N/A	
Pb-214	82	26.8	minutes	2.9E+05	Yes		N/A		N/A	N/A	
Po-210	84	138.376	days	40	Yes		N/A		N/A	N/A	
Po-211	84	0.516	seconds	9.2E+08	Yes		N/A		N/A	N/A	
Po-212	84	3.00E-07	seconds	1.6E+15	Yes		N/A		N/A	N/A	
Po-213	84	3.65E-06	seconds	1.3E+14	Yes		N/A		N/A	N/A	
Po-214	84	1.643E-04	seconds	2.9E+12	Yes		N/A		N/A	N/A	
Po-215	84	1.781E-03	seconds	2.7E+11	Yes		N/A		N/A	N/A	
Po-216	84	0.145	seconds	3.3E+09	Yes		N/A		N/A	N/A	
Po-218	84	3.10	minutes	2.5E+06	Yes		N/A		N/A	N/A	
Pu-241	94	14.290	years	1	No		N/A		N/A	N/A	
Ra-223	88	11.430	days	479	Yes		N/A		N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Ra-224	88	3.63	days	1.5E+03	Yes		N/A		N/A	N/A	
Ra-225	88	14.9	days	368	Yes		N/A		N/A	N/A	
Ra-226	88	1,600	years	0	No		N/A		N/A	N/A	
Ra-228	88	5.75	years	3	No		N/A		N/A	N/A	
Rn-219	86	3.96	seconds	1.2E+08	Yes		N/A		N/A	N/A	
Rn-220	86	55.6	seconds	8.5E+06	Yes		N/A		N/A	N/A	
Rn-222	86	3.8235	days	1.4E+03	Yes		N/A		N/A	N/A	
Th-227	90	18.68	days	293	Yes		N/A		N/A	N/A	
Th-228	90	1.9116	years	8	Yes		N/A		N/A	N/A	
Th-229	90	7,340	years	0	No		N/A		N/A	N/A	
Th-230	90	7.538E+04	years	0	No		N/A		N/A	N/A	
Th-231	90	25.52	hours	5.2E+03	Yes		N/A		N/A	N/A	
Th-232	90	1.405E+10	years	0	No		N/A		N/A	N/A	
Th-234	90	24.10	days	227	Yes		N/A		N/A	N/A	
Tl-207	81	4.77	minutes	1.7E+06	Yes		N/A		N/A	N/A	
Tl-208	81	3.053	minutes	2.6E+06	Yes		N/A		N/A	N/A	
Tl-209	81	2.161	minutes	3.7E+06	Yes		N/A		N/A	N/A	
Tl-210	81	1.30	minutes	6.1E+06	Yes		N/A		N/A	N/A	
U-233	92	1.592E+05	years	0	No		N/A		N/A	N/A	
U-234	92	2.455E+05	years	0	No		N/A		N/A	N/A	
U-235	92	7.04E+08	years	0	No		N/A		N/A	N/A	
U-238	92	4.468E+09	years	0	No		N/A		N/A	N/A	
Al-26	13	7.17E+05	years	0	No		Yes		N/A	N/A	
Am-242m	95	141	years	0	No		No		N/A	N/A	
Am-243	95	7,370	years	0	No		N/A		N/A	N/A	
Ba-137m	56	2.552	minutes	3.1E+06	Yes		N/A		N/A	N/A	
Bk-249	97	330	days	17	Yes	X	No		No	N/A	
C-14	6	5700	years	0	No		Yes		N/A	N/A	
Ce-144	58	284.91	days	19	Yes	X	No		No	N/A	
Cf-249	98	351	years	0	No		No		N/A	N/A	
Cf-251	98	898	years	0	No		No		N/A	N/A	
Cf-252	98	3	years	6	No		No		N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Cm-242	96	162.8	days	34	Yes		N/A		No	N/A	
Cm-243	96	29.1	years	1	No		No		N/A	N/A	
Cm-244	96	18.1	years	1	No		No		N/A	N/A	
Cm-245	96	8,500	years	0	No		N/A		N/A	N/A	
Cm-247	96	1.56E+07	years	0	No		N/A		N/A	N/A	
Cm-248	96	3.48E+05	years	0	No		N/A		N/A	N/A	
Co-60	27	1925.28	days	3	No		N/A		N/A	N/A	
Cs-134	55	2.0652	years	7	Yes	X	Yes	X	N/A	N/A	
Cs-135	55	2.3E+06	years	0	No		Yes		N/A	N/A	
Cs-137	55	30.03	years	0	No		No		N/A	N/A	
Eu-152	63	13.506	years	1	No		Yes		N/A	N/A	
Eu-154	63	8.590	years	2	No		Yes		N/A	N/A	
Eu-155	63	4.753	years	3	No		Yes		N/A	N/A	
H-3	1	12.32	years	1	No		Yes		N/A	N/A	
I-129	53	1.57E+07	years	0	No		Yes		N/A	N/A	
Na-22	11	2.6027	years	6	No		Yes		N/A	N/A	
Nb-94	41	2.03E+04	years	0	No		Yes		N/A	N/A	
Ni-59	28	7.6E+04	years	0	No		Yes		N/A	N/A	
Ni-63	28	100.1	years	0	No		Yes		N/A	N/A	
Pm-147	61	2.6234	years	6	No		No		N/A	N/A	
Pr-144	59	17.28	minutes	4.6E+05	Yes	X	No		Yes	No	
Pu-238	94	87.7	years	0	No		No		N/A	N/A	
Pu-239	94	24,110	years	0	No		No		N/A	N/A	
Pu-240	94	6,561	years	0	No		N/A		N/A	N/A	
Pu-242	94	3.75E+05	years	0	No		N/A		N/A	N/A	
Pu-244	94	8.00E+07	years	0	No		N/A		N/A	N/A	
Rh-106	45	29.80	seconds	1.6E+07	Yes	X	Yes	X	N/A	N/A	
Ru-106	44	373.59	days	15	Yes	X	No		Yes	Yes	X
Sb-125	51	2.75856	years	5	No		No		N/A	N/A	
Sb-126	51	12.35	days	444	Yes		N/A		N/A	N/A	
Sb-126m	51	19.15	minutes	4.1E+05	Yes		N/A		N/A	Yes	
Se-79	34	2.95E+05	years	0	No		Yes		N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Sm-151	62	90	years	0	No		Yes		N/A	N/A	
Sn-126	50	2.3E+05	years	0	No		No		N/A	N/A	
Sr-90	38	28.90	years	1	No		No		N/A	N/A	
Tc-99	43	2.111E+05	years	0	No		Yes		N/A	N/A	
Te-125m	52	57.40	days	95	Yes		N/A		N/A	N/A	
U-232	92	68.9	years	0	No		N/A		N/A	N/A	
U-236	92	2.342E+07	years	0	No		N/A		N/A	N/A	
Y-90	39	64.053	hours	2.1E+03	Yes		N/A		N/A	N/A	
Ar-42	18	32.9	years	0	No		No		N/A	N/A	
As-79	33	9.01	minutes	8.8E+05	Yes	X	No		No	N/A	
Bi-208	83	3.68E+05	years	0	No		Yes		N/A	N/A	
Ce-142	58	2.6E+17	years	0	No		Yes		N/A	N/A	
Cf-247	98	3.11	hour	4.2E+04	Yes	X	No		No	N/A	
Es-255	99	39.8	days	138	Yes	X	No		No	N/A	
Fe-52m	26	46	seconds	1.0E+07	Yes	X	No		No	N/A	
Ga-74	31	8.2	minutes	9.6E+05	Yes	X	Yes	X	N/A	N/A	
Gd-150	64	1.80E+06	years	0	No		No		N/A	N/A	
Nb-92	41	3.47E+07	years	0	No		Yes		N/A	N/A	
Nd-144	60	2.29E+15	years	0	No		N/A		N/A	N/A	
Os-186	76	2E+15	years	0	No		N/A		N/A	N/A	
Pb-204	82	1.4E+17	years	0	No		Yes		N/A	N/A	
Po-209	84	102.00	years	0	No		No		N/A	N/A	
Po-212m	84	2.98E-07	seconds	1.6E+15	Yes	X	Yes	X	N/A	N/A	
Rh-105m	45	56.00	minutes	1.4E+05	Yes	X	No		Yes	Yes	X
Se-79m	34	3.9	minutes	2.0E+06	Yes	X	No		Yes	No	
Sm-148	62	7E+15	years	0	No		N/A		N/A	N/A	
Sm-149	62	2E+15	years	0	No		Yes		N/A	N/A	
Te-118	52	6.00	days	913	Yes	X	No		Yes	Yes	X
V-50	23	1.4E+17	years	0	No		Yes		N/A	N/A	
Yb-165	70	9.9	minutes	8.0E+05	Yes	X	No		No	N/A	
Ac-223	89	2.10	minutes	3.8E+06	Yes	X	No		No	N/A	
Ac-224	89	2.78	hours	4.7E+04	Yes	X	No		No	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Ag-102	47	12.9	minutes	6.1E+05	Yes	X	Yes	X	N/A	N/A	
Ag-104	47	69.2	minutes	1.1E+05	Yes	X	Yes	X	N/A	N/A	
Ag-104m	47	33.5	minutes	2.4E+05	Yes	X	Yes	X	N/A	N/A	
Ag-106	47	23.96	minutes	3.3E+05	Yes	X	Yes	X	N/A	N/A	
Ag-108	47	2.37	minutes	3.3E+06	Yes		N/A		N/A	N/A	
Ag-109m	47	38.0	seconds	1.2E+07	Yes	X	Yes	X	N/A	N/A	
Ag-110	47	24.6	seconds	1.9E+07	Yes	X	Yes	X	N/A	N/A	
Ag-112	47	3.130	hours	4.2E+04	Yes	X	Yes	X	N/A	N/A	
Al-28	13	2.2414	minutes	3.5E+06	Yes	X	Yes	X	N/A	N/A	
Ar-37	18	34.95	days	156.76	Yes	X	Yes	X	N/A	N/A	
Ar-39	18	269	years	0	No		Yes		N/A	N/A	
Ar-41	18	109.61	years	0	No		Yes		N/A	N/A	
As-69	33	15.2	minutes	5.2E+05	Yes	X	No		Yes	Yes	X
As-70	33	52.6	minutes	1.5E+05	Yes	X	Yes	X	N/A	N/A	
As-72	33	26.0	hours	5.1E+03	Yes	X	Yes	X	N/A	N/A	
As-76	33	1.0942	days	5.0E+03	Yes	X	Yes	X	N/A	N/A	
As-77	33	38.83	hours	3.4E+03	Yes	X	Yes	X	N/A	N/A	
As-78	33	90.7	minutes	8.7E+04	Yes	X	Yes	X	N/A	N/A	
At-215	85	1.00E-04	seconds	4.7E+12	Yes	X	No		No	N/A	
At-216	85	3.00E-04	seconds	1.6E+12	Yes	X	No		No	N/A	
Au-194	79	38.02	hours	3.5E+03	Yes		N/A		N/A	N/A	
Au-198	79	2.6956	days	2.0E+03	Yes	X	Yes	X	N/A	N/A	
Au-198m	79	2.27	days	2.4E+03	Yes	X	No		Yes	Yes	X
Au-199	79	3.139	days	1.7E+03	Yes	X	Yes	X	N/A	N/A	
Au-200	79	48.4	minutes	1.6E+05	Yes	X	Yes	X	N/A	N/A	
Au-200m	79	18.7	hours	7.0E+03	Yes	X	No		Yes	Yes	X
Au-201	79	26	minutes	3.0E+05	Yes	X	Yes	X	N/A	N/A	
Ba-126	56	100	minutes	7.9E+04	Yes	X	No		Yes	Yes	X
Ba-128	56	2.43	days	2.3E+03	Yes	X	No		Yes	Yes	X
Ba-135m	56	28.7	hours	4.6E+03	Yes	X	Yes	X	N/A	N/A	
Ba-139	56	83.06	minutes	9.5E+04	Yes	X	Yes	X	N/A	N/A	
Ba-142	56	10.6	minutes	7.4E+05	Yes	X	No		Yes	Yes	X

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Bi-200	83	36.4	minutes	2.2E+05	Yes	X	No		No	N/A	
Bi-201	83	108	minutes	7.3E+04	Yes	X	No		No	N/A	
Bi-203	83	11.76	hours	1.1E+04	Yes	X	No		Yes	Yes	X
Bi-206	83	6.243	days	878	Yes	X	Yes	X	N/A	N/A	
Br-74	35	25.4	minutes	3.1E+05	Yes	X	Yes	X	N/A	N/A	
Br-74m	35	46	minutes	1.7E+05	Yes	X	Yes	X	N/A	N/A	
Br-76	35	16.2	hours	8.1E+03	Yes	X	Yes	X	N/A	N/A	
Br-77	35	57.036	hours	2.3E+03	Yes	X	Yes	X	N/A	N/A	
Br-80	35	17.68	minutes	4.5E+05	Yes	X	Yes	X	N/A	N/A	
Br-80m	35	4.4205	hours	3.0E+04	Yes	X	No		Yes	Yes	X
Br-82	35	35.282	hours	3.7E+03	Yes	X	Yes	X	N/A	N/A	
Br-83	35	2.40	hours	5.5E+04	Yes	X	Yes	X	N/A	N/A	
Br-84	35	31.80	minutes	2.5E+05	Yes	X	Yes	X	N/A	N/A	
C-11	6	20.334	minutes	3.9E+05	Yes	X	Yes	X	N/A	N/A	
Ca-47	20	4.536	days	1.2E+03	Yes	X	No		Yes	Yes	X
Ca-49	20	8.718	minutes	9.0E+05	Yes	X	No		Yes	Yes	X
Cd-104	48	57.7	minutes	1.4E+05	Yes	X	No		Yes	Yes	X
Cd-107	48	6.50	hours	2.0E+04	Yes	X	Yes	X	N/A	N/A	
Cd-115	48	53.46	hours	2.5E+03	Yes	X	No		Yes	No	
Ce-134	58	3.16	days	1.7E+03	Yes	X	No		Yes	Yes	X
Ce-135	58	17.7	hours	7.4E+03	Yes	X	No		Yes	Yes	X
Cl-38	17	37.24	minutes	2.1E+05	Yes	X	Yes	X	N/A	N/A	
Cl-39	17	55.6	minutes	1.4E+05	Yes	X	No		Yes	No	
Co-61	27	1.650	hours	8.0E+04	Yes	X	Yes	X	N/A	N/A	
Co-62m	27	13.91	minutes	5.7E+05	Yes	X	Yes	X	N/A	N/A	
Cs-126	55	1.64	minutes	4.8E+06	Yes	X	Yes	X	N/A	N/A	
Cs-128	55	3.66	minutes	2.2E+06	Yes	X	Yes	X	N/A	N/A	
Cs-129	55	32.06	hours	4.1E+03	Yes	X	Yes	X	N/A	N/A	
Cs-130	55	29.21	minutes	2.7E+05	Yes	X	Yes	X	N/A	N/A	
Cs-132	55	6.480	days	845	Yes	X	Yes	X	N/A	N/A	
Cs-135m	55	53	minutes	1.5E+05	Yes	X	No		Yes	No	
Cs-138	55	33.41	minutes	2.4E+05	Yes	X	Yes	X	N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Cu-60	29	23.7	minutes	3.3E+05	Yes	X	Yes	X	N/A	N/A	
Cu-61	29	3.333	hours	3.9E+04	Yes	X	Yes	X	N/A	N/A	
Cu-62	29	9.67	minutes	8.2E+05	Yes	X	Yes	X	N/A	N/A	
Cu-64	29	12.700	hours	1.0E+04	Yes	X	Yes	X	N/A	N/A	
Cu-66	29	5.120	minutes	1.5E+06	Yes	X	Yes	X	N/A	N/A	
Cu-67	29	61.83	hours	2.1E+03	Yes	X	Yes	X	N/A	N/A	
Dy-155	66	9.9	hours	1.3E+04	Yes	X	No		Yes	Yes	X
Dy-165	66	2.334	hours	5.6E+04	Yes	X	Yes	X	N/A	N/A	
Dy-166	66	81.6	hours	1.6E+03	Yes	X	No		Yes	Yes	X
Er-161	68	3.21	hours	4.1E+04	Yes	X	No		Yes	Yes	X
Er-165	68	10.36	hours	1.3E+04	Yes	X	Yes	X	N/A	N/A	
Er-172	68	49.3	hours	2.7E+03	Yes	X	No		Yes	Yes	X
Eu-146	63	4.61	days	1.2E+03	Yes	X	No		Yes	No	
Eu-150m	63	12.8	hours	1.0E+04	Yes	X	No		No	N/A	
Eu-152m	63	9.3116	hours	1.4E+04	Yes	X	Yes	X	N/A	N/A	
Eu-157	63	15.18	hours	8.7E+03	Yes	X	Yes	X	N/A	N/A	
Eu-158	63	45.9	minutes	1.7E+05	Yes	X	Yes	X	N/A	N/A	
F-18	9	1.8291	hours	7.2E+04	Yes	X	Yes	X	N/A	N/A	
Fe-52	26	8.275	hours	1.6E+04	Yes	X	No		Yes	Yes	X
Fr-219	87	0.02	seconds	2.4E+10	Yes	X	No		No	N/A	
Fr-220	87	27.4	seconds	1.7E+07	Yes	X	No		No	N/A	
Ga-66	31	9.49	hours	1.4E+04	Yes	X	Yes	X	N/A	N/A	
Ga-67	31	3.2623	days	1.7E+03	Yes	X	Yes	X	N/A	N/A	
Ga-68	31	67.71	minutes	1.2E+05	Yes	X	Yes	X	N/A	N/A	
Ga-70	31	21.14	minutes	3.7E+05	Yes	X	Yes	X	N/A	N/A	
Ga-72	31	14.095	hours	9.3E+03	Yes	X	Yes	X	N/A	N/A	
Ga-73	31	4.86	hours	2.7E+04	Yes	X	Yes	X	N/A	N/A	
Gd-159	64	18.479	hours	7.1E+03	Yes	X	Yes	X	N/A	N/A	
Ge-66	32	2.26	hours	5.8E+04	Yes	X	No		Yes	Yes	X
Ge-67	32	18.9	minutes	4.2E+05	Yes	X	No		Yes	Yes	X
Ge-69	32	39.05	hours	3.4E+03	Yes	X	Yes	X	N/A	N/A	
Ge-75	32	82.78	minutes	9.5E+04	Yes	X	Yes	X	N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Ge-77	32	11.30	hours	1.2E+04	Yes	X	No		Yes	Yes	X
Ge-78	32	88.0	minutes	9.0E+04	Yes	X	No		Yes	Yes	X
Hf-170	72	16.01	hours	8.2E+03	Yes	X	No		Yes	Yes	X
Hf-174	72	2.0E+15	years	0	No		Yes		N/A	N/A	
Hf-177m	72	51.4	minutes	1.5E+05	Yes	X	Yes	X	N/A	N/A	
Hf-180m	72	5.47	hours	2.4E+04	Yes	X	No		Yes	No	
Hf-183	72	1.067	hours	1.2E+05	Yes	X	No		Yes	Yes	X
Hf-184	72	4.12	hours	3.2E+04	Yes	X	No		Yes	Yes	X
Hg-197	80	64.14	hours	2.1E+03	Yes	X	Yes	X	N/A	N/A	
Hg-197m	80	23.8	hours	5.5E+03	Yes	X	No		Yes	Yes	X
Hg-199m	80	42.67	minutes	1.8E+05	Yes	X	Yes	X	N/A	N/A	
Ho-155	67	48	minutes	1.6E+05	Yes	X	No		No	N/A	
Ho-161	67	2.48	hours	5.3E+04	Yes	X	Yes	X	N/A	N/A	
Ho-162	67	15.0	minutes	5.3E+05	Yes	X	Yes	X	N/A	N/A	
Ho-162m	67	67.0	minutes	1.2E+05	Yes	X	No		Yes	Yes	X
Ho-164	67	29	minutes	2.7E+05	Yes	X	Yes	X	N/A	N/A	
Ho-164m	67	37.5	minutes	2.1E+05	Yes	X	No		Yes	Yes	X
Ho-166	67	26.83	hours	4.9E+03	Yes	X	Yes	X	N/A	N/A	
Ho-167	67	3.003	hours	4.4E+04	Yes	X	Yes	X	N/A	N/A	
I-120	53	81.6	minutes	9.7E+04	Yes	X	Yes	X	N/A	N/A	
I-120m	53	53	minutes	1.5E+05	Yes	X	Yes	X	N/A	N/A	
I-122	53	3.63	minutes	2.2E+06	Yes	X	Yes	X	N/A	N/A	
I-124	53	4.1760	days	1.3E+03	Yes	X	Yes	X	N/A	N/A	
I-128	53	24.99	minutes	3.2E+05	Yes	X	Yes	X	N/A	N/A	
I-130	53	12.36	hours	1.1E+04	Yes	X	Yes	X	N/A	N/A	
I-132	53	2.295	hours	5.7E+04	Yes	X	Yes	X	N/A	N/A	
I-132m	53	1.387	hours	9.5E+04	Yes	X	No		Yes	Yes	X
I-133	53	20.8	hours	6.3E+03	Yes	X	No		Yes	Yes	X
I-134	53	52.5	minutes	1.5E+05	Yes	X	Yes	X	N/A	N/A	
I-135	53	6.57	hours	2.0E+04	Yes	X	No		No	N/A	
In-110	49	4.9	hours	2.7E+04	Yes	X	Yes	X	N/A	N/A	
In-110m	49	69.1	minutes	1.1E+05	Yes	X	Yes	X	N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
In-111	49	2.8047	days	2.0E+03	Yes	X	Yes	X	N/A	N/A	
In-112	49	14.97	minutes	5.3E+05	Yes	X	Yes	X	N/A	N/A	
In-113m	49	99.476	minutes	7.9E+04	Yes	X	Yes	X	N/A	N/A	
In-114	49	71.9	seconds	6.6E+06	Yes	X	Yes	X	N/A	N/A	
In-115m	49	4.486	hours	2.9E+04	Yes	X	No		Yes	No	
In-116m	49	54.29	minutes	1.5E+05	Yes	X	Yes	X	N/A	N/A	
Ir-182	77	15	minutes	5.3E+05	Yes	X	No		No	N/A	
Ir-184	77	3.09	hours	4.3E+04	Yes	X	Yes	X	N/A	N/A	
Ir-186	77	16.64	hours	7.9E+03	Yes	X	No		Yes	No	
Ir-186m	77	1.90	hours	6.9E+04	Yes	X	No		No	N/A	
Ir-187	77	10.5	hours	1.3E+04	Yes	X	Yes	X	N/A	N/A	
Ir-188	77	41.5	hours	3.2E+03	Yes	X	Yes	X	N/A	N/A	
Ir-191m	77	4.94	seconds	9.6E+07	Yes	X	Yes	X	N/A	N/A	
Ir-194	77	19.28	hours	6.8E+03	Yes		N/A		N/A	N/A	
Ir-195	77	2.5	hours	5.3E+04	Yes	X	Yes	X	N/A	N/A	
Ir-195m	77	3.8	hours	3.5E+04	Yes	X	No		Yes	Yes	X
K-38	19	7.636	minutes	1.0E+06	Yes	X	Yes	X	N/A	N/A	
K-42	19	12	hours	10672	Yes	X	Yes	X	N/A	N/A	
K-43	19	22.3	hours	5.9E+03	Yes	X	Yes	X	N/A	N/A	
K-44	19	22.13	minutes	3.6E+05	Yes	X	Yes	X	N/A	N/A	
Kr-74	36	11.50	minutes	6.9E+05	Yes	X	No		Yes	Yes	X
Kr-76	36	14.8	hours	8.9E+03	Yes	X	No		Yes	Yes	X
Kr-77	36	74.4	minutes	1.1E+05	Yes	X	No		Yes	Yes	X
Kr-79	36	35.04	hours	3.8E+03	Yes	X	Yes	X	N/A	N/A	
Kr-81m	36	13.10	seconds	3.6E+07	Yes	X	No		Yes	No	
Kr-83m	36	1.83	hours	7.2E+04	Yes	X	Yes	X	N/A	N/A	
Kr-87	36	76.3	minutes	1.0E+05	Yes	X	No		Yes	No	
Kr-88	36	2.84	hours	4.6E+04	Yes	X	No		Yes	Yes	X
La-132	57	4.8	hours	2.7E+04	Yes	X	Yes	X	N/A	N/A	
La-134	57	6.45	minutes	1.2E+06	Yes	X	Yes	X	N/A	N/A	
La-135	57	19.5	hours	6.7E+03	Yes	X	Yes	X	N/A	N/A	
La-140	57	1.6781	days	3.3E+03	Yes	X	Yes	X	N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
La-142	57	91.1	minutes	8.7E+04	Yes	X	No		Yes	No	
Lu-170	71	2.012	days	2.7E+03	Yes	X	Yes	X	N/A	N/A	
Lu-172	71	6.70	days	818	Yes		N/A		N/A	N/A	
Lu-176m	71	3.664	hours	3.6E+04	Yes	X	Yes	X	N/A	N/A	
Lu-177	71	6.6475	days	824	Yes	X	Yes	X	N/A	N/A	
Lu-178	71	28.4	minutes	2.8E+05	Yes	X	Yes	X	N/A	N/A	
Lu-178m	71	23.1	minutes	3.4E+05	Yes	X	Yes	X	N/A	N/A	
Lu-179	71	4.59	hours	2.9E+04	Yes	X	Yes	X	N/A	N/A	
Md-257	101	5.52	hours	2.4E+04	Yes	X	No		No	N/A	
Mg-28	12	20.915	hours	6.3E+03	Yes	X	No		Yes	Yes	X
Mn-52	25	5.591	days	980	Yes	X	Yes	X	N/A	N/A	
Mn-52m	25	21.1	minutes	3.7E+05	Yes	X	No		Yes	Yes	X
Mn-56	25	2.5789	hours	5.1E+04	Yes	X	Yes	X	N/A	N/A	
Mo-101	42	14.61	minutes	5.4E+05	Yes	X	No		Yes	Yes	X
Mo-90	42	5.56	hours	2.4E+04	Yes	X	No		Yes	Yes	X
N-13	7	9.965	minutes	7.9E+05	Yes	X	Yes	X	N/A	N/A	
Na-24	11	14.951	hours	8.8E+03	Yes	X	Yes	X	N/A	N/A	
Nb-89a	41	66	minutes	1.2E+05	Yes	X	No		Yes	Yes	X
Nb-89b	41	2.03	hours	6.5E+04	Yes	X	No		Yes	Yes	X
Nb-90	41	14.60	hours	9.0E+03	Yes	X	Yes	X	N/A	N/A	
Nb-96	41	23.35	hours	5.6E+03	Yes	X	Yes	X	N/A	N/A	
Nb-97	41	72.1	minutes	1.1E+05	Yes	X	Yes	X	N/A	N/A	
Nb-97m	41	58.7	seconds	8.1E+06	Yes	X	No		Yes	Yes	X
Nb-98	41	51.3	minutes	1.5E+05	Yes	X	Yes	X	N/A	N/A	
Nd-136	60	50.65	minutes	1.6E+05	Yes	X	No		Yes	Yes	X
Nd-138	60	5.04	hours	2.6E+04	Yes	X	No		Yes	Yes	X
Nd-141	60	2.49	hours	5.3E+04	Yes	X	Yes	X	N/A	N/A	
Nd-141m	60	62.0	seconds	7.6E+06	Yes	X	No		Yes	Yes	X
Nd-149	60	1.728	hours	7.6E+04	Yes	X	No		Yes	Yes	X
Ne-19	10	17.22	seconds	2.7E+07	Yes	X	Yes	X	N/A	N/A	
Ni-65	28	2.5172	hours	5.2E+04	Yes	X	Yes	X	N/A	N/A	
Ni-66	28	54.6	hours	2.4E+03	Yes	X	No		Yes	Yes	X

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
O-15	8	122.24	seconds	3.9E+06	Yes	X	Yes	X	N/A	N/A	
Os-180	76	21.5	minutes	3.7E+05	Yes	X	No		Yes	Yes	X
Os-182	76	22.10	hours	5.9E+03	Yes	X	No		Yes	Yes	X
Os-189m	76	5.81	hours	2.3E+04	Yes	X	Yes	X	N/A	N/A	
Os-190m	76	9.9	minutes	8.0E+05	Yes	X	Yes	X	N/A	N/A	
Os-193	76	30.11	hours	4.4E+03	Yes	X	Yes	X	N/A	N/A	
P-30	15	2.498	minutes	3.2E+06	Yes	X	Yes	X	N/A	N/A	
Pa-234m	91	1.17	minutes	6.7E+06	Yes	X	No		No	N/A	
Pb-198	82	2.40	hours	5.5E+04	Yes	X	No		Yes	Yes	X
Pb-199	82	90	minutes	8.8E+04	Yes	X	No		Yes	Yes	X
Pb-200	82	21.5	hours	6.1E+03	Yes	X	No		Yes	Yes	X
Pb-201	82	9.33	hours	1.4E+04	Yes	X	No		Yes	Yes	X
Pb-203	82	51.920	hours	2.5E+03	Yes	X	Yes	X	N/A	N/A	
Pd-100	46	3.63	days	1.5E+03	Yes	X	No		Yes	Yes	X
Pd-109	46	13.7012	hours	9.6E+03	Yes	X	No		Yes	Yes	X
Pm-141	61	20.90	minutes	3.8E+05	Yes	X	No		Yes	Yes	X
Pm-142	61	40.5	seconds	1.2E+07	Yes	X	Yes	X	N/A	N/A	
Pm-148	61	5.368	days	1.0E+03	Yes	X	No		No	N/A	
Pm-149	61	53.08	hours	2.5E+03	Yes	X	No		Yes	No	
Pm-150	61	2.68	hours	4.9E+04	Yes	X	Yes	X	N/A	N/A	
Po-203	84	36.7	minutes	2.1E+05	Yes	X	No		No	N/A	
Pr-136	59	13.1	minutes	6.0E+05	Yes	X	Yes	X	N/A	N/A	
Pr-138	59	1.45	minutes	5.4E+06	Yes	X	Yes	X	N/A	N/A	
Pr-138m	59	2.12	hours	6.2E+04	Yes	X	Yes	X	N/A	N/A	
Pr-142	59	19.12	hours	6.9E+03	Yes	X	Yes	X	N/A	N/A	
Pr-142m	59	14.6	minutes	5.4E+05	Yes	X	No		Yes	Yes	X
Pr-144m	59	7.2	minutes	1.1E+06	Yes	X	No		No	N/A	
Pr-145	59	5.984	hours	2.2E+04	Yes	X	Yes	X	N/A	N/A	
Pt-186	78	2.08	hours	6.3E+04	Yes	X	No		No	N/A	
Pt-191	78	2.862	days	1.9E+03	Yes	X	Yes	X	N/A	N/A	
Pt-195m	78	4.010	days	1.4E+03	Yes	X	Yes	X	N/A	N/A	
Pt-197	78	19.8915	hours	6.6E+03	Yes	X	Yes	X	N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Pt-197m	78	95.41	minutes	8.3E+04	Yes	X	No		Yes	Yes	X
Pt-199	78	30.80	minutes	2.6E+05	Yes	X	No		Yes	Yes	X
Pt-200	78	12.5	hours	1.1E+04	Yes	X	No		Yes	Yes	X
Rb-79	37	22.9	minutes	3.4E+05	Yes	X	No		Yes	Yes	X
Rb-80	37	33.4	seconds	1.4E+07	Yes	X	Yes	X	N/A	N/A	
Rb-81m	37	30.5	minutes	2.6E+05	Yes	X	No		No	N/A	
Rb-82	37	1.273	minutes	6.2E+06	Yes	X	Yes	X	N/A	N/A	
Rb-82m	37	6.472	hours	2.0E+04	Yes	X	Yes	X	N/A	N/A	
Rb-88	37	17.773	minutes	4.4E+05	Yes	X	Yes	X	N/A	N/A	
Re-177	75	14	minutes	5.6E+05	Yes	X	No		No	N/A	
Re-180	75	2.44	minutes	3.2E+06	Yes	X	Yes	X	N/A	N/A	
Re-182	75	64.0	hours	2.1E+03	Yes	X	Yes	X	N/A	N/A	
Re-182m	75	12.7	hours	1.0E+04	Yes	X	Yes	X	N/A	N/A	
Re-186	75	3.7186	days	1.5E+03	Yes		N/A		N/A	No	
Re-188	75	17.003	hours	7.7E+03	Yes	X	Yes	X	N/A	N/A	
Re-188m	75	18.59	minutes	4.2E+05	Yes	X	No		Yes	Yes	X
Re-189	75	24.3	hours	5.4E+03	Yes	X	Yes	X	N/A	N/A	
Rh-100	45	20.8	hours	6.3E+03	Yes	X	Yes	X	N/A	N/A	
Rh-103m	45	56.114	minutes	1.4E+05	Yes	X	Yes	X	N/A	N/A	
Rh-105	45	35.36	hours	3.7E+03	Yes	X	Yes	X	N/A	N/A	
Rh-106m	45	131	minutes	6.0E+04	Yes	X	Yes	X	N/A	N/A	
Rh-107	45	21.7	minutes	3.6E+05	Yes	X	No		Yes	No	
Rh-99m	45	4.7	hours	2.8E+04	Yes	X	No		Yes	Yes	X
Rn-218	86	0.035	seconds	1.4E+10	Yes	X	No		No	N/A	
Ru-105	44	4.44	hours	3.0E+04	Yes	X	No		No	N/A	
Ru-94	44	51.8	minutes	1.5E+05	Yes	X	No		Yes	Yes	X
Sb-115	51	32.1	minutes	2.5E+05	Yes	X	Yes	X	N/A	N/A	
Sb-116	51	15.8	minutes	5.0E+05	Yes	X	Yes	X	N/A	N/A	
Sb-116m	51	60.3	minutes	1.3E+05	Yes	X	Yes	X	N/A	N/A	
Sb-117	51	2.80	hours	4.7E+04	Yes	X	Yes	X	N/A	N/A	
Sb-118m	51	5.00	hours	2.6E+04	Yes	X	Yes	X	N/A	N/A	
Sb-119	51	38.19	hours	3.4E+03	Yes	X	Yes	X	N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Sb-120	51	15.89	minutes	5.0E+05	Yes	X	Yes	X	N/A	N/A	
Sb-120m	51	5.76	days	951	Yes	X	Yes	X	N/A	N/A	
Sb-122	51	2.7238	days	2.0E+03	Yes	X	Yes	X	N/A	N/A	
Sb-128	51	9.01	hours	1.5E+04	Yes	X	Yes	X	N/A	N/A	
Sb-128m	51	10.4	minutes	7.6E+05	Yes	X	No		Yes	Yes	X
Sb-130	51	39.5	minutes	2.0E+05	Yes	X	Yes	X	N/A	N/A	
Sc-43	21	3.891	hours	3.4E+04	Yes	X	Yes	X	N/A	N/A	
Sc-44	21	3.97	hours	3.3E+04	Yes		N/A		N/A	N/A	
Sc-44m	21	58.61	hours	2.2E+03	Yes	X	No		Yes	Yes	X
Sc-47	21	3.3492	days	1.6E+03	Yes	X	Yes	X	N/A	N/A	
Sc-48	21	43.67	hours	3.0E+03	Yes	X	Yes	X	N/A	N/A	
Sc-49	21	57.2	minutes	1.4E+05	Yes	X	Yes	X	N/A	N/A	
Se-70	34	41.1	minutes	1.9E+05	Yes	X	No		Yes	Yes	X
Se-77m	34	17.36	seconds	2.7E+07	Yes	X	Yes	X	N/A	N/A	
Se-81	34	18.45	minutes	4.3E+05	Yes	X	Yes	X	N/A	N/A	
Se-81m	34	57.28	minutes	1.4E+05	Yes	X	No		Yes	Yes	X
Se-83	34	22.3	minutes	3.5E+05	Yes	X	No		No	N/A	
Si-31	14	157.3	minutes	5.0E+04	Yes	X	Yes	X	N/A	N/A	
Sm-141	62	10.2	minutes	7.7E+05	Yes	X	No		No	N/A	
Sm-141m	62	22.6	minutes	3.5E+05	Yes	X	No		No	N/A	
Sm-142	62	72.49	minutes	1.1E+05	Yes	X	No		Yes	Yes	X
Sm-153	62	46.284	hours	2.8E+03	Yes	X	Yes	X	N/A	N/A	
Sn-110	50	4.11	hours	3.2E+04	Yes	X	No		Yes	Yes	X
Sn-111	50	35.3	minutes	2.2E+05	Yes	X	No		Yes	Yes	X
Sn-121	50	27.03	hours	4.9E+03	Yes		N/A		N/A	N/A	
Sn-123m	50	40.06	minutes	2.0E+05	Yes	X	Yes	X	N/A	N/A	
Sn-128	50	59.07	minutes	1.3E+05	Yes	X	No		No	N/A	
Sr-80	38	106.3	minutes	7.4E+04	Yes	X	No		Yes	Yes	X
Sr-81	38	22.3	minutes	3.5E+05	Yes	X	No		No	N/A	
Sr-87m	38	2.815	hours	4.7E+04	Yes	X	No		Yes	No	
Sr-92	38	2.66	hours	4.9E+04	Yes	X	No		Yes	Yes	X
Ta-174	73	1.14	hours	1.2E+05	Yes	X	Yes	X	N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Ta-176	73	8.09	hours	1.6E+04	Yes	X	Yes	X	N/A	N/A	
Ta-177	73	56.56	hours	2.3E+03	Yes	X	Yes	X	N/A	N/A	
Ta-178	73	9.31	minutes	8.5E+05	Yes	X	Yes	X	N/A	N/A	
Ta-178m	73	2.36	hours	5.6E+04	Yes	X	Yes	X	N/A	N/A	
Ta-180	73	8.154	hours	1.6E+04	Yes	X	Yes	X	N/A	N/A	
Ta-183	73	5.1	days	1.1E+03	Yes	X	Yes	X	N/A	N/A	
Ta-184	73	8.7	hours	1.5E+04	Yes	X	Yes	X	N/A	N/A	
Ta-186	73	10.5	minutes	7.5E+05	Yes	X	Yes	X	N/A	N/A	
Tb-150	65	3.48	hours	3.8E+04	Yes	X	No		No	N/A	
Tb-154	65	21.5	hours	6.1E+03	Yes	X	Yes	X	N/A	N/A	
Tb-155	65	5.32	days	1.0E+03	Yes	X	Yes	X	N/A	N/A	
Tb-156	65	5.35	days	1.0E+03	Yes	X	Yes	X	N/A	N/A	
Tb-156m	65	24.4	hours	5.4E+03	Yes	X	No		Yes	Yes	X
Tb-156n	65	5.3	hours	2.5E+04	Yes	X	Yes	X	N/A	N/A	
Tb-161	65	6.906	days	793	Yes	X	Yes	X	N/A	N/A	
Tc-101	43	14.22	minutes	5.5E+05	Yes	X	Yes	X	N/A	N/A	
Tc-104	43	18.3	minutes	4.3E+05	Yes	X	Yes	X	N/A	N/A	
Tc-94	43	293	minutes	2.7E+04	Yes	X	Yes	X	N/A	N/A	
Tc-94m	43	52.0	minutes	1.5E+05	Yes	X	Yes	X	N/A	N/A	
Tc-95	43	20.0	hours	6.6E+03	Yes	X	Yes	X	N/A	N/A	
Tc-96	43	4.28	days	1.3E+03	Yes	X	Yes	X	N/A	N/A	
Tc-96m	43	51.5	minutes	1.5E+05	Yes	X	No		Yes	Yes	X
Te-116	52	2.49	hours	5.3E+04	Yes	X	No		Yes	Yes	X
Te-127	52	9.35	hours	1.4E+04	Yes	X	Yes	X	N/A	N/A	
Te-129	52	69.6	minutes	1.1E+05	Yes	X	No		Yes	No	
Te-132	52	3.204	days	1.7E+03	Yes	X	No		Yes	Yes	X
Te-133	52	12.5	minutes	6.3E+05	Yes	X	No		No	N/A	
Te-133m	52	55.4	minutes	1.4E+05	Yes	X	No		No	N/A	
Te-134	52	41.8	minutes	1.9E+05	Yes	X	No		Yes	Yes	X
Ti-45	22	184.8	minutes	4.3E+04	Yes	X	Yes	X	N/A	N/A	
Ti-197	81	2.84	hours	4.6E+04	Yes	X	No		Yes	Yes	X
Ti-198	81	5.3	hours	2.5E+04	Yes	X	Yes	X	N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Tl-198m	81	1.87	hours	7.0E+04	Yes	X	No		Yes	Yes	X
Tl-199	81	7.42	hours	1.8E+04	Yes	X	Yes	X	N/A	N/A	
Tl-200	81	26.1	hours	5.0E+03	Yes	X	Yes	X	N/A	N/A	
Tl-201	81	72.912	hours	1.8E+03	Yes	X	Yes	X	N/A	N/A	
Tl-206	81	4.200	minutes	1.9E+06	Yes		N/A		N/A	N/A	
Tm-162	69	21.70	minutes	3.6E+05	Yes	X	Yes	X	N/A	N/A	
Tm-166	69	7.70	hours	1.7E+04	Yes	X	Yes	X	N/A	N/A	
Tm-172	69	63.6	hours	2.1E+03	Yes	X	Yes	X	N/A	N/A	
Tm-173	69	8.24	hours	1.6E+04	Yes	X	Yes	X	N/A	N/A	
Tm-175	69	15.2	minutes	5.2E+05	Yes	X	No		Yes	Yes	X
V-47	23	32.6	minutes	2.4E+05	Yes	X	Yes	X	N/A	N/A	
W-176	74	2.5	hours	5.3E+04	Yes	X	No		Yes	Yes	X
W-177	74	132	minutes	6.0E+04	Yes	X	No		Yes	Yes	X
W-187	74	23.72	hours	5.5E+03	Yes	X	No		Yes	No	
Xe-120	54	40	minutes	2.0E+05	Yes	X	No		Yes	Yes	X
Xe-122	54	20.1	hours	6.5E+03	Yes	X	No		Yes	Yes	X
Xe-129m	54	8.88	days	617	Yes	X	Yes	X	N/A	N/A	
Xe-131m	54	11.934	days	459	Yes	X	Yes	X	N/A	N/A	
Xe-133	54	5.243	days	1.0E+03	Yes	X	Yes	X	N/A	N/A	
Xe-133m	54	2.19	days	2.5E+03	Yes	X	No		Yes	Yes	X
Xe-135m	54	15.29	minutes	5.2E+05	Yes	X	No		No	N/A	
Xe-138	54	14.08	minutes	5.6E+05	Yes	X	No		Yes	Yes	X
Y-86	39	14.74	hours	8.9E+03	Yes	X	Yes	X	N/A	N/A	
Y-86m	39	48	minutes	1.6E+05	Yes	X	No		Yes	Yes	X
Y-87	39	79.8	hours	1.6E+03	Yes	X	Yes	X	N/A	N/A	
Y-90m	39	3.19	hours	4.1E+04	Yes	X	No		Yes	Yes	X
Y-92	39	3.54	hours	3.7E+04	Yes	X	Yes	X	N/A	N/A	
Y-94	39	18.7	minutes	4.2E+05	Yes	X	Yes	X	N/A	N/A	
Yb-162	70	18.87	minutes	4.2E+05	Yes	X	No		Yes	Yes	X
Yb-166	70	56.7	hours	2.3E+03	Yes	X	No		Yes	Yes	X
Yb-175	70	4.185	days	1.3E+03	Yes	X	Yes	X	N/A	N/A	
Yb-177	70	1.911	hours	6.9E+04	Yes	X	No		Yes	Yes	X

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Yb-178	70	74	minutes	1.1E+05	Yes	X	No		Yes	Yes	X
Zn-62	30	9.186	hours	1.4E+04	Yes	X	No		Yes	Yes	X
Zn-63	30	38.47	minutes	2.1E+05	Yes	X	Yes	X	N/A	N/A	
Zn-69	30	56.4	minutes	1.4E+05	Yes	X	Yes	X	N/A	N/A	
Zn-69m	30	13.76	hours	9.6E+03	Yes	X	No		Yes	Yes	X
Zn-71m	30	3.96	hours	3.3E+04	Yes	X	Yes	X	N/A	N/A	
Zn-72	30	46.5	hours	2.8E+03	Yes	X	No		Yes	Yes	X
Zr-86	40	16.5	hours	8.0E+03	Yes	X	No		Yes	Yes	X
Zr-89	40	78.41	hours	1.7E+03	Yes	X	Yes	X	N/A	N/A	
Zr-97	40	16.744	hours	7.9E+03	Yes	X	No		No	N/A	
Ag-103	47	65.7	minutes	1.2E+05	Yes	X	No		Yes	Yes	X
Ag-106m	47	8.28	days	662	Yes	X	Yes	X	N/A	N/A	
Ag-111	47	7.45	days	735	Yes	X	Yes	X	N/A	N/A	
Ag-115	47	20.0	minutes	3.9E+05	Yes	X	No		No	N/A	
Am-237	95	73.0	minutes	1.1E+05	Yes	X	No		No	N/A	
As-71	33	65.28	hours	2.0E+03	Yes	X	No		Yes	Yes	X
As-74	33	17.77	days	308	Yes	X	Yes	X	N/A	N/A	
Ba-131	56	11.50	days	476	Yes	X	No		Yes	Yes	X
Ba-131m	56	14.6	minutes	5.4E+05	Yes	X	No		No	N/A	
Ba-140	56	12.752	days	430	Yes	X	No		Yes	Yes	X
Ba-141	56	18.27	minutes	4.3E+05	Yes	X	No		No	N/A	
Bi-205	83	15.31	days	358	Yes	X	No		Yes	No	
Cd-117	48	2.49	hours	5.3E+04	Yes	X	No		Yes	Yes	X
Cd-117m	48	3.36	hours	3.9E+04	Yes	X	No		Yes	Yes	X
Ce-141	58	32.508	days	169	Yes	X	Yes	X	N/A	N/A	
Ce-143	58	33.039	hours	4.0E+03	Yes	X	No		Yes	Yes	X
Cr-48	24	21.56	hours	6.1E+03	Yes	X	No		Yes	Yes	X
Cr-51	24	27.7025	days	198	Yes	X	Yes	X	N/A	N/A	
Cs-127	55	6.25	hours	2.1E+04	Yes	X	No		Yes	Yes	X
Cs-131	55	9.689	days	565	Yes	X	Yes	X	N/A	N/A	
Cs-136	55	13.04	days	420	Yes	X	Yes	X	N/A	N/A	
Er-169	68	9.392	days	583	Yes	X	Yes	X	N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Eu-147	63	24.1	days	227	Yes	X	No		Yes	No	
Eu-156	63	15.19	days	361	Yes	X	Yes	X	N/A	N/A	
Gd-147	64	38.06	hours	3.5E+03	Yes	X	No		No	N/A	
Ge-71	32	11.43	days	479	Yes	X	Yes	X	N/A	N/A	
Hf-179m	72	25.05	days	219	Yes	X	Yes	X	N/A	N/A	
I-121	53	2.12	hours	6.2E+04	Yes	X	No		Yes	Yes	X
I-126	53	12.93	days	424	Yes	X	Yes	X	N/A	N/A	
I-131	53	8.02070	days	683	Yes	X	Yes	X	N/A	N/A	
In-117	49	43.2	minutes	1.8E+05	Yes	X	Yes	X	N/A	N/A	
In-117m	49	116.2	minutes	6.8E+04	Yes	X	No		Yes	Yes	X
In-119	49	2.4	minutes	3.3E+06	Yes	X	Yes	X	N/A	N/A	
In-119m	49	18.0	minutes	4.4E+05	Yes	X	No		Yes	Yes	X
Ir-189	77	13.2	days	415	Yes	X	Yes	X	N/A	N/A	
Ir-190	77	11.78	days	465	Yes	X	Yes	X	N/A	N/A	
Ir-190m	77	1.120	hours	1.2E+05	Yes	X	No		Yes	Yes	X
Ir-190n	77	3.087	hours	4.3E+04	Yes	X	No		Yes	Yes	X
La-131	57	59	minutes	1.3E+05	Yes	X	No		No	N/A	
La-141	57	3.92	hours	3.4E+04	Yes	X	No		Yes	Yes	X
La-143	57	14.2	minutes	5.6E+05	Yes	X	No		No	N/A	
Lu-171	71	8.24	days	665	Yes	X	Yes	X	N/A	N/A	
Mn-51	25	46.2	minutes	1.7E+05	Yes	X	No		Yes	Yes	X
Nb-95	41	34.991	days	157	Yes	X	Yes	X	N/A	N/A	
Nb-95m	41	3.61	days	1.5E+03	Yes	X	No		Yes	Yes	X
Nd-151	60	12.44	minutes	6.3E+05	Yes	X	No		Yes	Yes	X
Os-191	76	15.4	days	356	Yes	X	Yes	X	N/A	N/A	
Os-191m	76	13.10	hours	1.0E+04	Yes	X	No		Yes	Yes	X
P-32	15	14.262	days	384	Yes		N/A		N/A	N/A	
P-33	15	25.34	days	216	Yes	X	Yes	X	N/A	N/A	
Pa-227	91	38.3	minutes	2.1E+05	Yes	X	No		No	N/A	
Pd-103	46	16.991	days	322	Yes	X	No		Yes	Yes	X
Po-205	84	1.74	hours	7.6E+04	Yes	X	No		No	N/A	
Pr-137	59	1.28	hours	1.0E+05	Yes	X	No		No	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Pr-143	59	13.57	days	404	Yes	X	Yes	X	N/A	N/A	
Pt-188	78	10.2	days	537	Yes	X	No		Yes	Yes	X
Pt-189	78	10.87	hours	1.2E+04	Yes	X	No		Yes	Yes	X
Rb-81	37	4.570	hours	2.9E+04	Yes	X	No		Yes	No	
Rb-86	37	18.642	days	294	Yes	X	Yes	X	N/A	N/A	
Rb-89	37	15.15	minutes	5.2E+05	Yes	X	No		Yes	Yes	X
Re-178	75	13.2	minutes	6.0E+05	Yes	X	No		No	N/A	
Rh-99	45	16.1	days	340	Yes	X	Yes	X	N/A	N/A	
Sb-129	51	4.40	hours	3.0E+04	Yes	X	No		No	N/A	
Sb-131	51	23.03	minutes	3.4E+05	Yes	X	No		No	N/A	
Se-73m	34	39.8	minutes	2.0E+05	Yes	X	No		No	N/A	
Sm-156	62	9.4	hours	1.4E+04	Yes	X	No		Yes	Yes	X
Sn-117m	50	13.76	days	398	Yes	X	Yes	X	N/A	N/A	
Sr-82	38	25.55	days	214	Yes	X	No		Yes	Yes	X
Tb-147	65	1.7	hours	7.7E+04	Yes	X	No		No	N/A	
Te-121	52	19.16	days	286	Yes	X	Yes	X	N/A	N/A	
Te-131	52	25.0	minutes	3.2E+05	Yes	X	No		Yes	Yes	X
Te-131m	52	30	hours	4.4E+03	Yes	X	No		No	N/A	
Tl-202	81	12.23	days	448	Yes		N/A		N/A	N/A	
Tm-167	69	9.25	days	592	Yes	X	Yes	X	N/A	N/A	
V-48	23	15.9735	days	343	Yes	X	Yes	X	N/A	N/A	
W-178	74	21.6	days	254	Yes	X	No		Yes	Yes	X
Xe-121	54	40.1	minutes	2.0E+05	Yes	X	No		No		
Xe-127	54	36.4	days	151	Yes	X	Yes	X	N/A	N/A	
Y-91m	39	49.71	minutes	1.6E+05	Yes	X	No		Yes	Yes	X
Y-93	39	10.18	hours	1.3E+04	Yes	X	No		No	N/A	
Y-95	39	10.3	minutes	7.7E+05	Yes	X	No		No	N/A	
Yb-167	70	17.5	minutes	4.5E+05	Yes	X	No		Yes	Yes	X
Cd-113	48	7.7E+15	years	0	No		N/A		N/A	N/A	
Gd-152	64	1.08E+14	years	0	No		No		N/A	N/A	
In-115	49	4.41E+14	years	0	No		Yes		N/A	N/A	
Re-187	75	4.12E+10	years	0	No		Yes		N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Ta-180m	73	1.2E+15	years	0	No		Yes		N/A	N/A	
Te-123	52	9.2E+16	years	0	No		Yes		N/A	N/A	
Kr-81	36	2.29E+05	years	0	No		Yes		N/A	N/A	
Kr-85	36	3916.8	days	1	No		Yes		N/A	N/A	
Kr-85m	36	4.480	hours	2.9E+04	Yes	X	No		Yes	No	
Xe-123	54	2.08	hours	6.3E+04	Yes	X	No		No	N/A	
Xe-125	54	16.9	hours	7.8E+03	Yes	X	No		Yes	Yes	X
Xe-135	54	9.14	hours	1.4E+04	Yes	X	No		Yes	No	
Ag-105	47	41.29	days	133	Yes	X	Yes	X	N/A	N/A	
As-73	33	80.30	days	68	Yes	X	Yes	X	N/A	N/A	
Au-195	79	186.098	days	29	Yes	X	Yes	X	N/A	N/A	
Au-195m	79	30.5	seconds	1.6E+07	Yes	X	Yes	X	N/A	N/A	
Be-7	4	53.22	days	103	Yes	X	Yes	X	N/A	N/A	
Ca-45	20	162.61	days	34	Yes	X	Yes	X	N/A	N/A	
Cd-109	48	461.4	days	12	Yes	X	Yes	X	N/A	N/A	
Ce-139	58	137.641	days	40	Yes	X	Yes	X	N/A	N/A	
Co-56	27	77.233	days	71	Yes	X	Yes	X	N/A	N/A	
Co-57	27	271.74	days	20	Yes	X	Yes	X	N/A	N/A	
Co-58	27	70.86	days	77	Yes	X	Yes	X	N/A	N/A	
Dy-159	66	144.4	days	38	Yes	X	Yes	X	N/A	N/A	
Eu-149	63	93.1	days	59	Yes	X	Yes	X	N/A	N/A	
Fe-59	26	44.495	days	123	Yes	X	Yes	X	N/A	N/A	
Gd-151	64	124	days	44	Yes	X	Yes	X	N/A	N/A	
Gd-153	64	240.4	days	23	Yes	X	Yes	X	N/A	N/A	
Hf-175	72	70	days	78	Yes	X	Yes	X	N/A	N/A	
Hf-181	72	42.39	days	129	Yes	X	Yes	X	N/A	N/A	
Hg-203	80	46.595	days	118	Yes	X	Yes	X	N/A	N/A	
I-125	53	59.400	days	92	Yes	X	Yes	X	N/A	N/A	
Ir-194m	77	171	days	32	Yes	X	Yes	X	N/A	N/A	
Lu-173	71	1.37	years	11	Yes	X	Yes	X	N/A	N/A	
Mn-54	25	312.12	days	18	Yes	X	Yes	X	N/A	N/A	
Os-185	76	93.6	days	59	Yes	X	Yes	X	N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Pm-143	61	265	days	21	Yes	X	Yes	X	N/A	N/A	
Rb-84	37	33.1	days	166	Yes	X	Yes	X	N/A	N/A	
Re-184	75	38.0	days	144	Yes	X	Yes	X	N/A	N/A	
S-35	16	87.51	days	63	Yes	X	Yes	X	N/A	N/A	
Sb-124	51	60.11	days	91	Yes	X	Yes	X	N/A	N/A	
Sc-46	21	83.79	days	65	Yes	X	Yes	X	N/A	N/A	
Se-75	34	119.779	days	46	Yes	X	Yes	X	N/A	N/A	
Sn-113	50	115.09	days	48	Yes	X	Yes	X	N/A	N/A	
Sn-119m	50	293.1	days	19	Yes	X	Yes	X	N/A	N/A	
Sn-123	50	129.2	days	42	Yes	X	Yes	X	N/A	N/A	
Sr-85	38	64.84	days	84	Yes	X	Yes	X	N/A	N/A	
Sr-89	38	50.57	days	108	Yes	X	Yes	X	N/A	N/A	
Ta-179	73	1.82	years	8	Yes	X	Yes	X	N/A	N/A	
Tb-160	65	72.3	days	76	Yes	X	Yes	X	N/A	N/A	
Tm-170	69	128.6	days	43	Yes	X	Yes	X	N/A	N/A	
Tm-171	69	1.92	years	8	Yes	X	Yes	X	N/A	N/A	
V-49	23	329	days	17	Yes	X	Yes	X	N/A	N/A	
W-181	74	121.20	days	4.5E+01	Yes	X	Yes	X	N/A	N/A	
W-185	74	75.1	days	73	Yes	X	Yes	X	N/A	N/A	
Y-88	39	106.616	days	51	Yes	X	Yes	X	N/A	N/A	
Y-91	39	58.51	days	94	Yes	X	Yes	X	N/A	N/A	
Yb-169	70	32.018	days	171	Yes	X	Yes	X	N/A	N/A	
Zn-65	30	243.66	days	22	Yes	X	Yes	X	N/A	N/A	
Ag-110m	47	249.76	days	22	Yes	X	No		Yes	Yes	X
Br-75	35	96.7	minutes	8.2E+04	Yes	X	No		Yes	Yes	X
Co-58m	27	9.04	hours	1.5E+04	Yes	X	No		Yes	Yes	X
Cr-49	24	42.3	minutes	1.9E+05	Yes	X	No		Yes	Yes	X
Ga-65	31	15.2	minutes	5.2E+05	Yes	X	No		Yes	Yes	X
Gd-149	64	9.28	days	590	Yes	X	No		Yes	Yes	X
Ge-68	32	270.95	days	20	Yes	X	No		Yes	Yes	X
Hf-172	72	1.87	years	8	Yes	X	No		Yes	Yes	X
Hg-195	80	10.53	hours	1.2E+04	Yes	X	No		Yes	Yes	X

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Ho-159	67	33.05	minutes	2.4E+05	Yes	X	No		Yes	Yes	X
In-114m	49	49.51	days	111	Yes	X	No		Yes	Yes	X
Ir-185	77	14.4	hours	9.1E+03	Yes	X	No		Yes	Yes	X
K-45	19	17.3	minutes	4.6E+05	Yes	X	No		Yes	Yes	X
Lu-169	71	34.06	hours	3.9E+03	Yes	X	No		Yes	Yes	X
Lu-177m	71	160.44	days	34	Yes	X	No		Yes	Yes	X
Ni-56	28	6.075	days	902	Yes	X	No		Yes	Yes	X
Ni-57	28	35.60	hours	3.7E+03	Yes	X	No		Yes	Yes	X
Pr-139	59	4.41	hours	3.0E+04	Yes	X	No		Yes	Yes	X
Rb-83	37	86.2	days	64	Yes	X	No		Yes	Yes	X
Re-181	75	19.9	hours	6.6E+03	Yes	X	No		Yes	Yes	X
Re-184m	75	169	days	32	Yes	X	No		Yes	Yes	X
Ru-103	44	39.26	days	140	Yes	X	No		Yes	Yes	X
Sb-124m	51	93	seconds	5.1E+06	Yes	X	No		Yes	Yes	X
Sb-124n	51	20.2	minutes	3.9E+05	Yes	X	No		Yes	Yes	X
Se-73	34	7.15	hours	1.8E+04	Yes	X	No		Yes	Yes	X
Sr-83	38	32.41	hours	4.1E+03	Yes	X	No		Yes	Yes	X
Sr-85m	38	67.63	minutes	1.2E+05	Yes	X	No		Yes	Yes	X
Sr-91	38	9.63	hours	1.4E+04	Yes	X	No		Yes	Yes	X
Ta-175	73	10.5	hours	1.3E+04	Yes	X	No		Yes	Yes	X
Ta-182m	73	15.84	minutes	5.0E+05	Yes	X	No		Yes	Yes	X
Ta-185	73	49.4	minutes	1.6E+05	Yes	X	No		Yes	Yes	X
Tb-151	65	17.609	hours	7.5E+03	Yes	X	No		Yes	Yes	X
Tb-153	65	2.34	days	2.3E+03	Yes	X	No		Yes	Yes	X
Tc-95m	43	61	days	90	Yes	X	No		Yes	Yes	X
Te-121m	52	154	days	36	Yes	X	No		Yes	Yes	X
Te-127m	52	109	days	50	Yes	X	No		Yes	Yes	X
W-188	74	69.78	days	79	Yes	X	No		Yes	Yes	X
Zr-88	40	83.4	days	66	Yes	X	No		Yes	Yes	X
Zr-95	40	64.032	days	86	Yes	X	No		Yes	Yes	X
Cs-125	55	46.7	minutes	1.7E+05	Yes	X	No		No	N/A	
Hf-173	72	23.6	hours	5.6E+03	Yes	X	No		Yes	No	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Hg-195m	80	41.6	hours	3.2E+03	Yes	X	No		No	N/A	
Nb-88	41	14.55	minutes	5.4E+05	Yes	X	No		No	N/A	
Nd-139	60	29.7	minutes	2.7E+05	Yes	X	No		No	N/A	
Nd-139m	60	5.50	hours	2.4E+04	Yes	X	No		No	N/A	
Os-181	76	105	minutes	7.5E+04	Yes	X	No		No	N/A	
Pa-228	91	22	hours	6.0E+03	Yes	X	No		No	N/A	
Pb-195m	82	15.0	minutes	5.3E+05	Yes	X	No		No	N/A	
Sb-127	51	3.85	days	1.4E+03	Yes	X	No		No	N/A	
Sn-127	50	2.10	hours	6.3E+04	Yes	X	No		No	N/A	
Tb-149	65	4.118	hours	3.2E+04	Yes	X	No		No	N/A	
Tl-195	81	1.16	hours	1.1E+05	Yes	X	No		No	N/A	
Ac-226	89	29.37	hours	4.5E+03	Yes	X	No		No	N/A	
Am-238	95	98	minutes	8.1E+04	Yes	X	No		No	N/A	
Am-239	95	11.9	hours	1.1E+04	Yes	X	No		No	N/A	
Am-240	95	50.8	hours	2.6E+03	Yes	X	No		No	N/A	
Am-244	95	10.1	hours	1.3E+04	Yes	X	No		No	N/A	
Am-244m	95	26	minutes	3.0E+05	Yes	X	No		No	N/A	
Am-245	95	2.05	hours	6.4E+04	Yes	X	No		No	N/A	
Am-246m	95	25.0	minutes	3.2E+05	Yes	X	No		No	N/A	
At-207	85	1.80	hours	7.3E+04	Yes	X	No		No	N/A	
At-211	85	7.214	hours	1.8E+04	Yes	X	No		Yes	No	
Au-193	79	17.65	hours	7.4E+03	Yes	X	No		Yes	No	
Ba-133m	56	38.9	hours	3.4E+03	Yes	X	No		Yes	No	
Bi-202	83	1.72	hours	7.6E+04	Yes	X	No		No	N/A	
Bk-245	97	4.94	days	1.1E+03	Yes	X	No		No	N/A	
Bk-246	97	1.80	days	3.0E+03	Yes	X	No		No	N/A	
Cd-115m	48	44.56	days	123	Yes	X	No		Yes	No	
Ce-137	58	9.0	hours	1.5E+04	Yes	X	No		Yes	No	
Ce-137m	58	34.4	hours	3.8E+03	Yes	X	No		No	N/A	
Cf-244	98	19.4	minutes	4.1E+05	Yes	X	No		No	N/A	
Cf-246	98	35.7	hours	3.7E+03	Yes	X	No		No	N/A	
Cf-248	98	333.5	days	16	Yes	X	No		No	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Cf-253	98	17.81	days	308	Yes	X	No		No	N/A	
Cf-254	98	60.5	days	91	Yes	X	No		No	N/A	
Cm-238	96	2.4	hours	5.5E+04	Yes	X	No		No	N/A	
Cm-240	96	27	days	203	Yes	X	No		No	N/A	
Cm-241	96	32.8	days	167	Yes	X	No		No	N/A	
Cm-249	96	64.15	minutes	1.2E+05	Yes	X	No		No	N/A	
Co-55	27	17.53	hours	7.5E+03	Yes	X	No		Yes	No	
Cs-134m	55	2.912	hours	4.5E+04	Yes	X	No		Yes	No	
Dy-157	66	8.14	hours	1.6E+04	Yes	X	No		Yes	No	
Er-171	68	7.516	hours	1.7E+04	Yes	X	No		Yes	No	
Es-250m	99	2	hours	5.9E+04	Yes	X	No		No	N/A	
Es-251	99	33	hours	4.0E+03	Yes	X	No		No	N/A	
Es-253	99	20.47	days	268	Yes	X	No		No	N/A	
Es-254	99	275.7	days	20	Yes	X	No		No	N/A	
Es-254m	99	39.3	hours	3.3E+03	Yes	X	No		No	N/A	
Eu-145	63	5.93	days	924	Yes	X	No		No	N/A	
Eu-148	63	54.5	days	101	Yes	X	No		No	N/A	
Fm-252	100	25.39	hours	5.2E+03	Yes	X	No		No	N/A	
Fm-253	100	3.00	days	1.8E+03	Yes	X	No		No	N/A	
Fm-254	100	3.240	hours	4.1E+04	Yes	X	No		No	N/A	
Fm-255	100	20.07	hours	6.6E+03	Yes	X	No		No	N/A	
Fm-257	100	100.5	days	55	Yes	X	No		No	N/A	
Fr-222	87	14.2	minutes	5.6E+05	Yes	X	No		No	N/A	
Gd-145	64	23.0	minutes	3.4E+05	Yes	X	No		No	N/A	
Gd-146	64	48.27	days	114	Yes	X	No		No	N/A	
Hf-182m	72	61.5	minutes	1.3E+05	Yes	X	No		No	N/A	
Hg-193	80	3.80	hours	3.5E+04	Yes	X	No		No	N/A	
Hg-193m	80	11.8	hours	1.1E+04	Yes	X	No		No	N/A	
Ho-157	67	12.6	minutes	6.3E+05	Yes	X	No		No	N/A	
I-123	53	13.232	hours	9.9E+03	Yes	X	No		Yes	No	
In-109	49	4.2	hours	3.1E+04	Yes	X	No		Yes	No	
Lu-174m	71	142	days	39	Yes	X	No		Yes	No	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Md-258	101	51.5	days	106	Yes	X	No		No	N/A	
Mo-93m	42	6.85	hours	1.9E+04	Yes	X	No		Yes	No	
Mo-99	42	2.7489	days	2.0E+03	Yes	X	No		No	N/A	
Nd-147	60	10.98	days	499	Yes	X	No		No	N/A	
Np-232	93	14.7	minutes	5.4E+05	Yes	X	No		No	N/A	
Np-233	93	36.2	minutes	2.2E+05	Yes	X	No		No	N/A	
Np-234	93	4.4	days	1.2E+03	Yes	X	No		No	N/A	
Np-235	93	396.1	days	14	Yes	X	No		No	N/A	
Np-236m	93	22.5	hours	5.8E+03	Yes	X	No		No	N/A	
Np-238	93	2.117	days	2.6E+03	Yes	X	No		No	N/A	
Np-240m	93	7.22	minutes	1.1E+06	Yes	X	No		No	N/A	
Pa-230	91	17.4	days	315	Yes	X	No		No	N/A	
Pa-232	91	1.31	days	4.2E+03	Yes	X	No		No	N/A	
Pb-202m	82	3.53	hours	3.7E+04	Yes	X	No		No	N/A	
Pd-101	46	8.47	hours	1.6E+04	Yes	X	No		Yes	No	
Pm-144	61	363	days	15	Yes	X	No		Yes	No	
Pm-148m	61	41.29	days	133	Yes	X	No		No	N/A	
Pm-151	61	28.40	hours	4.6E+03	Yes	X	No		Yes	No	
Po-207	84	5.80	hours	2.3E+04	Yes	X	No		Yes	No	
Pr-147	59	13.4	minutes	5.9E+05	Yes	X	No		No	N/A	
Pt-193m	78	4.33	days	1.3E+03	Yes	X	No		Yes	No	
Pu-234	94	8.8	hours	1.5E+04	Yes	X	No		No	N/A	
Pu-235	94	25.3	minutes	3.1E+05	Yes	X	No		No	N/A	
Pu-237	94	45.2	days	121	Yes	X	No		No	N/A	
Pu-245	94	10.5	hours	1.3E+04	Yes	X	No		No	N/A	
Ra-222	88	38.0	seconds	1.2E+07	Yes	X	No		No	N/A	
Ra-227	88	42.2	minutes	1.9E+05	Yes	X	No		No	N/A	
Rh-101m	45	4.34	days	1.3E+03	Yes	X	No		Yes	No	
Ru-97	44	2.791	days	2.0E+03	Yes	X	No		Yes	No	
Sm-145	62	340	days	16	Yes	X	No		Yes	No	
Sm-155	62	22.3	minutes	3.5E+05	Yes	X	No		Yes	No	
Sn-125	50	9.64	days	568	Yes	X	No		No	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Ta-172	73	36.8	minutes	2.1E+05	Yes	X	No		No	N/A	
Ta-173	73	3.14	hours	4.2E+04	Yes	X	No		No	N/A	
Tc-93	43	2.75	hours	4.8E+04	Yes	X	No		Yes	No	
Tc-93m	43	43.5	minutes	1.8E+05	Yes	X	No		No	N/A	
Tc-97m	43	91.4	days	60	Yes	X	No		Yes	No	
Tc-99m	43	6.0058	hours	2.2E+04	Yes	X	No		Yes	No	
Te-123m	52	119.2	days	46	Yes	X	No		Yes	No	
Te-129m	52	33.6	days	163	Yes	X	No		No	N/A	
Th-226	90	30.57	minutes	2.6E+05	Yes	X	No		No	N/A	
Tl-194	81	33.0	minutes	2.4E+05	Yes	X	No		No	N/A	
Tl-194m	81	32.8	minutes	2.4E+05	Yes	X	No		No	N/A	
U-230	92	20.8	days	263	Yes	X	No		No	N/A	
U-231	92	4.2	days	1.3E+03	Yes	X	No		No	N/A	
U-237	92	6.75	days	812	Yes	X	No		No	N/A	
U-239	92	23.45	minutes	3.4E+05	Yes	X	No		No	N/A	
W-179	74	37.05	minutes	2.1E+05	Yes	X	No		Yes	No	
Ba-133	56	3,841	days	1	No		Yes		N/A	N/A	
Fe-55	26	2,737	years	5	No		Yes		N/A	N/A	
Lu-174	71	3.31	years	5	No		Yes		N/A	N/A	
Os-194	76	6.0	years	3	No		No		N/A	N/A	
Rh-101	45	3.3	years	5	No		Yes		N/A	N/A	
Rh-102	45	208	days	26	Yes		N/A		N/A	N/A	
Rh-102m	45	2.9	years	5	No		No		N/A	N/A	
Tl-204	81	3.78	years	4	No		Yes		N/A	N/A	
Cd-113m	48	14.1	years	1	No		No		N/A	N/A	
Pm-146	61	5.53	years	3	No		No		N/A	N/A	
Ag-108m	47	438	years	0	No		No		N/A	N/A	
Am-242	95	16.02	hours	8.2E+03	Yes		N/A		No	N/A	
Am-246	95	39	minutes	2.0E+05	Yes		N/A		No	N/A	
Be-10	4	1.51E+06	years	0	No		Yes		N/A	N/A	
Bi-207	83	32.9	years	0	No		Yes		N/A	N/A	
Bi-210m	83	3.04E+06	years	0	No		No		N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	No. of Half-lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half-lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Bk-247	97	1,380	years	0	No		No		N/A	N/A	
Bk-250	97	3,212	hours	4.1E+04	Yes		N/A		No	N/A	
Ca-41	20	1.02E+05	years	0	No		Yes		N/A	N/A	
Cf-250	98	13.08	years	1	No		N/A		N/A	N/A	
Cl-36	17	3.01E+05	years	0	No		Yes		N/A	N/A	
Cm-246	96	4,760	years	0	No		N/A		N/A	N/A	
Cm-250	96	8.3E+03	years	0	No		No		N/A	N/A	
Co-60m	27	10.467	minutes	7.5E+05	Yes		N/A		N/A	No	
Eu-150	63	36.9	years	0	No		Yes		N/A	N/A	
Fe-60	26	1.50E+06	years	0	No		No		N/A	N/A	
Gd-148	64	70.9	years	0	No		Yes		N/A	N/A	
Hf-178m	72	31	years	0	No		Yes		N/A	N/A	
Hf-182	72	8.9E+06	years	0	No		No		N/A	N/A	
Hg-194	80	444	years	0	No		No		N/A	N/A	
Ho-166m	67	1.20E+03	years	0	No		Yes		N/A	N/A	
Ir-192	77	73.827	days	74	Yes		N/A		N/A	N/A	
Ir-192m	77	241	years	0	No		No		N/A	N/A	
K-40	19	1.248E+09	years	0	No		Yes		N/A	N/A	
La-137	57	6E+04	years	0	No		Yes		N/A	N/A	
La-138	57	1.02E+11	years	0	No		Yes		N/A	N/A	
Lu-176	71	3.76E+10	years	0	No		Yes		N/A	N/A	
Mn-53	25	3.74E+06	years	0	No		Yes		N/A	N/A	
Mo-93	42	4.0E+03	years	0	No		No		N/A	N/A	
Nb-93m	41	16.13	years	1	No		N/A		N/A	N/A	
Np-236	93	1.54E+05	years	0	No		No		N/A	N/A	
Np-239	93	2,356	days	2.3E+03	Yes		N/A		No	N/A	
Np-240	93	61.9	minutes	1.3E+05	Yes		N/A		No	N/A	
Pb-202	82	5.25E+04	years	0	No		No		N/A	N/A	
Pb-205	82	1.73E+07	years	0	No		N/A		N/A	N/A	
Pd-107	46	6.5E+06	years	0	No		Yes		N/A	N/A	
Pm-145	61	17.7	years	1	No		Yes		N/A	N/A	
Pt-193	78	50	years	0	No		Yes		N/A	N/A	

Table A6. Screening Process Application (Steps 8 through 9)

Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	No. of Half- lives in 15 years	More than 7 Half lives?	99% Decayed and No Ongoing source (653 isotopes)	First Generation Stable (and not in a series)	Step 8 (Exclusion) Age of Waste (No Ongoing source, Half- lives>7 and First daughter is stable) (288 Isotopes)	Two generations to stable	Second generation half life less than 1 year	Step 9 (Exclusion) Age of Waste (No Ongoing source, Half- lives>7 and First daughter half-life less than 1 year) (169 Isotopes)
Pu-236	94	2.858	years	5	No		N/A		N/A	N/A	
Pu-243	94	4.956	hours	2.7E+04	Yes		N/A		No	N/A	
Pu-246	94	10.84	days	505	Yes		N/A		No	N/A	
Rb-87	37	4.97E+10	years	0	No		Yes		N/A	N/A	
Re-186m	75	2.0E+05	years	0	No		No		N/A	N/A	
Si-32	14	132	years	0	No		No		N/A	N/A	
Sm-146	62	1.03E+08	years	0	No		N/A		N/A	N/A	
Sm-147	62	1.06E+11	years	0	No		N/A		N/A	N/A	
Sn-121m	50	43.9	years	0	No		No		N/A	N/A	
Ta-182	73	114.43	days	48	Yes		N/A		N/A	N/A	
Tb-157	65	71	years	0	No		Yes		N/A	N/A	
Tb-158	65	180	years	0	No		Yes		N/A	N/A	
Tc-97	43	4.21E+06	years	0	No		Yes		N/A	N/A	
Tc-98	43	4.2E+06	years	0	No		Yes		N/A	N/A	
Ti-44	22	60.0	years	0	No		No		N/A	N/A	
U-240	92	14.1	hours	9.3E+03	Yes		N/A		No	N/A	
Zr-93	40	1.53E+06	years	0	No		No		N/A	N/A	

Table A7. Screening Process Application (Steps 10 through 14)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Individual Analysis Note To support Criteria 10 to 13 Assessment	Step 10 (Exclusion)	Step 11 (Exclusion)	Step 12 (Exclusion)	Step 13 (Exclusion)	Step 14 (Inclusion)
					Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope During 100y period of Institutional control (8 isotopes)	Will Decay to Longer-Lived Isotope During 100y period of Institutional Control (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Cs-125	55	46.7	minutes	Short lived activation product that decays to stable isotope in multiple short steps	X				
Hf-173	72	23.6	hours		X				
Hg-195m	80	41.6	hours	Short lived activation product that decays to stable isotope in multiple short steps	X				
Nb-88	41	14.55	minutes		X				
Nd-139	60	29.7	minutes		X				
Nd-139m	60	5.50	hours	Short lived activation product that decays to stable isotope in multiple short steps	X				
Os-181	76	105	minutes	Short lived activation product that decays to stable isotope in multiple short steps	X				
Pa-228	91	22	hours	Short lived activation product that decays to longer lived isotope that is addressed separately	X				
Pb-195m	82	15.0	minutes		X				
Sb-127	51	3.85	days		X				
Sn-127	50	2.10	hours		X				
Tb-149	65	4.118	hours	Short lived activation product that decays to stable isotope in multiple short steps	X				
Tl-195	81	1.16	hours		X				
Ac-226	89	29.37	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Am-238	95	98	minutes			X			
Am-239	95	11.9	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Am-240	95	50.8	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Am-244	95	10.1	hours			X			
Am-244m	95	26	minutes			X			
Am-245	95	2.05	hours			X			
Am-246m	95	25.0	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			

Table A7. Screening Process Application (Steps 10 through 14)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Individual Analysis Note To support Criteria 10 to 13 Assessment	Step 10 (Exclusion)	Step 11 (Exclusion)	Step 12 (Exclusion)	Step 13 (Exclusion)	Step 14 (Inclusion)
					Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope During 100y period of Institutional control (8 isotopes)	Will Decay to Longer-Lived Isotope During 100y period of Institutional Control (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
At-207	85	1.80	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
At-211	85	7.214	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Au-193	79	17.65	hours			X			
Ba-133m	56	38.9	hours			X			
Bi-202	83	1.72	hours			X			
Bk-245	97	4.94	days	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Bk-246	97	1.80	days			X			
Cd-115m	48	44.56	days			X			
Ce-137	58	9.0	hours			X			
Ce-137m	58	34.4	hours			X			
Cf-244	98	19.4	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Cf-246	98	35.7	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Cf-248	98	333.5	days			X			
Cf-253	98	17.81	days			X			
Cf-254	98	60.5	days			X			
Cm-238	96	2.4	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Cm-240	96	27	days			X			
Cm-241	96	32.8	days	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Cm-249	96	64.15	minutes			X			
Co-55	27	17.53	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Cs-134m	55	2.912	hours			X			
Dy-157	66	8.14	hours			X			
Er-171	68	7.516	hours			X			
Es-250m	99	2	hours			X			

Table A7. Screening Process Application (Steps 10 through 14)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Individual Analysis Note To support Criteria 10 to 13 Assessment	Step 10 (Exclusion)	Step 11 (Exclusion)	Step 12 (Exclusion)	Step 13 (Exclusion)	Step 14 (Inclusion)
					Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope During 100y period of Institutional control (8 isotopes)	Will Decay to Longer-Lived Isotope During 100y period of Institutional Control (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Es-251	99	33	hours			X			
Es-253	99	20.47	days			X			
Es-254	99	275.7	days			X			
Es-254m	99	39.3	hours			X			
Eu-145	63	5.93	days			X			
Eu-148	63	54.5	days	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Fm-252	100	25.39	hours			X			
Fm-253	100	3.00	days			X			
Fm-254	100	3.240	hours			X			
Fm-255	100	20.07	hours			X			
Fm-257	100	100.5	days			X			
Fr-222	87	14.2	minutes			X			
Gd-145	64	23.0	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Gd-146	64	48.27	days	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Hf-182m	72	61.5	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Hg-193	80	3.80	hours			X			
Hg-193m	80	11.8	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Ho-157	67	12.6	minutes			X			
I-123	53	13.232	hours			X			
In-109	49	4.2	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Lu-174m	71	142	days	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Md-258	101	51.5	days			X			
Mo-93m	42	6.85	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Mo-99	42	2.7489	days			X			

Table A7. Screening Process Application (Steps 10 through 14)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Individual Analysis Note To support Criteria 10 to 13 Assessment	Step 10 (Exclusion)	Step 11 (Exclusion)	Step 12 (Exclusion)	Step 13 (Exclusion)	Step 14 (Inclusion)
					Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope During 100y period of Institutional control (8 isotopes)	Will Decay to Longer-Lived Isotope During 100y period of Institutional Control (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Nd-147	60	10.98	days			X			
Np-232	93	14.7	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Np-233	93	36.2	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Np-234	93	4.4	days			X			
Np-235	93	396.1	days			X			
Np-236m	93	22.5	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Np-238	93	2.117	days			X			
Np-240m	93	7.22	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Pa-230	91	17.4	days	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Pa-232	91	1.31	days			X			
Pb-202m	82	3.53	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Pd-101	46	8.47	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Pm-144	61	363	days	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Pm-148m	61	41.29	days			X			
Pm-151	61	28.40	hours			X			
Po-207	84	5.80	hours			X			
Pr-147	59	13.4	minutes			X			
Pt-193m	78	4.33	days			X			
Pu-234	94	8.8	hours			X			
Pu-235	94	25.3	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Pu-237	94	45.2	days			X			
Pu-245	94	10.5	hours			X			
Ra-222	88	38.0	seconds			X			

Table A7. Screening Process Application (Steps 10 through 14)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Individual Analysis Note To support Criteria 10 to 13 Assessment	Step 10 (Exclusion)	Step 11 (Exclusion)	Step 12 (Exclusion)	Step 13 (Exclusion)	Step 14 (Inclusion)
					Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope During 100y period of Institutional control (8 isotopes)	Will Decay to Longer-Lived Isotope During 100y period of Institutional Control (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Ra-227	88	42.2	minutes			X			
Rh-101m	45	4.34	days	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Ru-97	44	2.791	days			X			
Sm-145	62	340	days			X			
Sm-155	62	22.3	minutes			X			
Sn-125	50	9.64	days			X			
Ta-172	73	36.8	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Ta-173	73	3.14	hours	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Tc-93	43	2.75	hours			X			
Tc-93m	43	43.5	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Tc-97m	43	91.4	days			X			
Tc-99m	43	6.0058	hours			X			
Te-123m	52	119.2	days			X			
Te-129m	52	33.6	days			X			
Th-226	90	30.57	minutes			X			
Tl-194	81	33.0	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Tl-194m	81	32.8	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
U-230	92	20.8	days			X			
U-231	92	4.2	days	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
U-237	92	6.75	days			X			
U-239	92	23.45	minutes			X			
W-179	74	37.05	minutes	Short lived activation product that decays to longer lived isotope that is addressed separately		X			
Ba-133	56	3,841	days				X		
Fe-55	26	2.737	years				X		

Table A7. Screening Process Application (Steps 10 through 14)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Individual Analysis Note To support Criteria 10 to 13 Assessment	Step 10 (Exclusion)	Step 11 (Exclusion)	Step 12 (Exclusion)	Step 13 (Exclusion)	Step 14 (Inclusion)
					Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope During 100y period of Institutional control (8 isotopes)	Will Decay to Longer-Lived Isotope During 100y period of Institutional Control (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Lu-174	71	3.31	years				X		
Os-194	76	6.0	years				X		
Rh-101	45	3.3	years				X		
Rh-102	45	208	days				X		
Rh-102m	45	2.9	years	Short lived activation product that decays to longer lived isotope that is addressed separately			X		
Tl-204	81	3.78	years				X		
Cd-113m	48	14.1	years					X	
Pm-146	61	5.53	years					X	
Ag-108m	47	438	years	Characterization needed.					X
Am-242	95	16.02	hours	Ongoing supply from Am-242m (141y, AP) which is known to be in waste. Reaches secular equilibrium in about 5 days. Characterization needed.					X
Am-246	95	39	minutes	If there is Cm-250 or Pu-246 in waste, then this isotope will be in secular equilibrium. Characterization needed.					X
Be-10	4	1.51E+06	years	Characterization needed.					X
Bi-207	83	32.9	years	Characterization needed.					X
Bi-210m	83	3.04E+06	years	Characterization needed.					X
Bk-247	97	1,380	years	Characterization needed.					X
Bk-250	97	3.212	hours	If there is Cm-250 in waste, then this isotope will be in secular equilibrium. Characterization needed.					X
Ca-41	20	1.02E+05	years	Characterization needed.					X
Cf-250	98	13.08	years	Characterization needed.					X
Cl-36	17	3.01E+05	years	Characterization needed.					X
Cm-246	96	4,760	years	Cm-246 has been detected in DWPF feed. Characterization needed.					X
Cm-250	96	8.3E+03	years	Characterization needed.					X
Co-60m	27	10.467	minutes	This isotope would be in secular equilibrium with Fe-60 (1.5E6y, AP) which is an activation product that is probably not in the waste. Characterization needed.					X

Table A7. Screening Process Application (Steps 10 through 14)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Individual Analysis Note To support Criteria 10 to 13 Assessment	Step 10 (Exclusion)	Step 11 (Exclusion)	Step 12 (Exclusion)	Step 13 (Exclusion)	Step 14 (Inclusion)
					Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope During 100y period of Institutional control (8 isotopes)	Will Decay to Longer-Lived Isotope During 100y period of Institutional Control (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Eu-150	63	36.9	years	Characterization needed.					X
Fe-60	26	1.50E+06	years	Characterization needed.					X
Gd-148	64	70.9	years	Characterization needed.					X
Hf-178m	72	31	years	Characterization needed.					X
Hf-182	72	8.9E+06	years	Characterization needed.					X
Hg-194	80	444	years	Characterization needed.					X
Ho-166m	67	1.20E+03	years	Characterization needed.					X
Ir-192	77	73.827	days	Ir-192m (241y, AP) is an activation product that could be in waste if stable Ir-191 was present during reactor irradiation. Ir-192 would be in secular equilibrium. Needs characterization.					X
Ir-192m	77	241	years	Characterization needed.					X
K-40	19	1.248E+09	years	Characterization needed.					X
La-137	57	6E+04	years	Characterization needed.					X
La-138	57	1.02E+11	years	Characterization needed.					X
Lu-176	71	3.76E+10	years	Characterization needed.					X
Mn-53	25	3.74E+06	years	Characterization needed.					X
Mo-93	42	4.0E+03	years	Characterization needed.					X
Nb-93m	41	16.13	years	If there is Zr-93 (1.5E6y) in the waste, then this isotope will be in secular equilibrium. Zr-93m has been detected in DWPF feed. Characterization needed.					X
Np-236	93	1.54E+05	years	Characterization needed.					X
Np-239	93	2.356	days	If there is Bk-247, Am-243, Cf-251 or Cm-247 in waste, then this isotope will be in secular equilibrium. Am-243, Cf-251 and Cm-247 have been detected in DWPF feed. Characterization needed					X
Np-240	93	61.9	minutes	If there is Cf-252, Cm-248, or Pu-244 in waste, then this isotope will be in secular equilibrium. Cm-248 has been detected in DWPF feed. Characterization needed					X
Pb-202	82	5.25E+04	years	Characterization needed.					X

Table A7. Screening Process Application (Steps 10 through 14)

Isotope	Atomic No.	Half-life (Wallet Card 7 th Edition)	Half-life Units (Wallet Card 7 th Edition)	Individual Analysis Note To support Criteria 10 to 13 Assessment	Step 10 (Exclusion)	Step 11 (Exclusion)	Step 12 (Exclusion)	Step 13 (Exclusion)	Step 14 (Inclusion)
					Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope During 100y period of Institutional control (8 isotopes)	Will Decay to Longer-Lived Isotope During 100y period of Institutional Control (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Pb-205	82	1.73E+07	years	Pb-205 (1.7E7y) is an activation product which may be present in the waste in small amounts. Characterization needed.					X
Pd-107	46	6.5E+06	years	Pd-107 is a fission product that has been detected in DWPF waste. Characterization needed.					X
Pm-145	61	17.7	years	Characterization needed.					X
Pt-193	78	50	years	Characterization needed.					X
Pu-236	94	2.858	years	Characterization needed.					X
Pu-243	94	4.956	hours	If there is Cf-251 or Cm-247 in waste, then this isotope will be in secular equilibrium. Cf-251 has been detected in DWPF feed. Characterization needed					X
Pu-246	94	10.84	days	If there is Cm-250 in waste, then this isotope will be in secular equilibrium. Characterization needed.					X
Rb-87	37	4.97E+10	years	Characterization needed.					X
Re-186m	75	2.0E+05	years	Characterization needed.					X
Si-32	14	132	years	Characterization needed.					X
Sm-146	62	1.03E+08	years	Characterization needed.					X
Sm-147	62	1.06E+11	years	Pm-147 and Sm-147 have been detected in the DWPF feed. Characterization needed.					X
Sn-121m	50	43.9	years	Characterization needed.					X
Ta-182	73	114.43	days	Ta-182 (114d) is a decay product that would be in secular equilibrium with Hf-182 (8.9E6y) if it is present in the waste. Characterization needed.					X
Tb-157	65	71	years	Characterization needed.					X
Tb-158	65	180	years	Characterization needed.					X
Tc-97	43	4.21E+06	years	Characterization needed.					X
Tc-98	43	4.2E+06	years	Characterization needed.					X
Ti-44	22	60.0	years	Characterization needed.					X

Table A7. Screening Process Application (Steps 10 through 14)

					Step 10 (Exclusion)	Step 11 (Exclusion)	Step 12 (Exclusion)	Step 13 (Exclusion)	Step 14 (Inclusion)
Isotope	Atomic No.	Half-life (Wallet Card 7'th Edition)	Half-life Units (Wallet Card 7'th Edition)	Individual Analysis Note To support Criteria 10 to 13 Assessment	Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope During 100y period of Institutional control (8 isotopes)	Will Decay to Longer-Lived Isotope During 100y period of Institutional Control (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
U-240	92	14.1	hours	If there is Cf-252, Cm-248, or Pu-244 in waste, then this isotope will be in secular equilibrium. Cm-248 has been detected in DWPF feed. Characterization needed					X
Zr-93	40	1.53E+06	years	Zr-93 is a fission product that has been detected in DWPF waste. Characterization needed.					X

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
Isotope	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Physical Properties-Gas (no new formation) (30 Isotopes)	Age of Waste Evaluation (Decay to stable) (288 Isotopes)	Age of Waste Evaluation (Decay to Short-lived) (169 Isotopes)	Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope within 100y (8 isotopes)	Will Decay to Longer-Lived Isotope within 100y (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Ac-225	X				X	X								
Ac-227	X	X												
Ac-228	X													
Am-241	X	X												
At-217	X			X										
At-218	X													
Bi-210	X													
Bi-211	X			X										
Bi-212	X			X										
Bi-213	X			X										
Bi-214	X													
Fr-221	X			X										
Fr-223	X				X	X								
Np-237	X	X												
Pa-231	X	X												
Pa-233	X													
Pa-234	X													
Pb-209	X			X										
Pb-210	X													
Pb-211	X			X										
Pb-212	X			X										
Pb-214	X													
Po-210	X													
Po-211	X			X										
Po-212	X			X										
Po-213	X			X										
Po-214	X			X										
Po-215	X			X										
Po-216	X			X										
Po-218	X													
Pu-241	X	X												
Ra-223	X				X	X								
Ra-224	X			X										

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
Isotope	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Physical Properties-Gas (no new formation) (30 Isotopes)	Age of Waste Evaluation (Decay to stable) (288 Isotopes)	Age of Waste Evaluation (Decay to Short-lived) (169 Isotopes)	Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope within 100y (8 isotopes)	Will Decay to Longer-Lived Isotope within 100y (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Ra-225	X				X	X								
Ra-226	X	X												
Ra-228	X	X												
Rn-219	X			X										
Rn-220	X			X										
Rn-222	X													
Th-227	X				X	X								
Th-228	X													
Th-229	X	X												
Th-230	X	X												
Th-231	X													
Th-232	X	X												
Th-234	X													
Tl-207	X			X										
Tl-208	X			X										
Tl-209	X			X										
Tl-210	X		X											
U-233	X	X												
U-234	X	X												
U-235	X	X												
U-238	X	X												
Al-26		X												
Am-242m		X												
Am-243		X												
Ba-137m		X		X										
Bk-249		X												
C-14		X												
Ce-144		X												
Cf-249		X												
Cf-251		X												
Cf-252		X												
Cm-242		X												
Cm-243		X												

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
Isotope	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Physical Properties-Gas (no new formation) (30 Isotopes)	Age of Waste Evaluation (Decay to stable) (288 Isotopes)	Age of Waste Evaluation (Decay to Short-lived) (169 Isotopes)	Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope within 100y (8 isotopes)	Will Decay to Longer-Lived Isotope within 100y (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Cm-244		X												
Cm-245		X												
Cm-247		X												
Cm-248		X												
Co-60		X												
Cs-134		X						X						
Cs-135		X												
Cs-137		X												
Eu-152		X												
Eu-154		X												
Eu-155		X												
H-3		X												
I-129		X												
Na-22		X												
Nb-94		X												
Ni-59		X												
Ni-63		X												
Pm-147		X												
Pr-144		X		X										
Pu-238		X												
Pu-239		X												
Pu-240		X												
Pu-242		X												
Pu-244		X												
Rh-106		X		X				X						
Ru-106		X							X					
Sb-125		X												
Sb-126		X			X	X								
Sb-126m		X			X	X								
Se-79		X												
Sm-151		X												
Sn-126		X												
Sr-90		X												

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
Isotope	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Physical Properties-Gas (no new formation) (30 Isotopes)	Age of Waste Evaluation (Decay to stable) (288 Isotopes)	Age of Waste Evaluation (Decay to Short-lived) (169 Isotopes)	Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope within 100y (8 isotopes)	Will Decay to Longer-Lived Isotope within 100y (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Tc-99		X												
Te-125m		X												
U-232		X												
U-236		X												
Y-90		X		X										
Ar-42			X				X							
As-79			X											
Bi-208			X											
Ce-142			X											
Cf-247			X											
Es-255			X											
Fe-52m			X											
Ga-74			X					X						
Gd-150			X											
Nb-92			X											
Nd-144			X											
Os-186			X											
Pb-204			X											
Po-209			X											
Po-212m			X					X						
Rh-105m			X						X					
Se-79m			X											
Sm-148			X											
Sm-149			X											
Te-118			X						X					
V-50			X											
Yb-165			X											
Ac-223				X										
Ac-224				X										
Ag-102				X				X						
Ag-104				X				X						
Ag-104m				X				X						
Ag-106				X				X						

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
Isotope	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Physical Properties-Gas (no new formation) (30 Isotopes)	Age of Waste Evaluation (Decay to stable) (288 Isotopes)	Age of Waste Evaluation (Decay to Short-lived) (169 Isotopes)	Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope within 100y (8 isotopes)	Will Decay to Longer-Lived Isotope within 100y (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Ag-108				X										
Ag-109m				X				X						
Ag-110				X				X						
Ag-112				X				X						
Al-28				X				X						
Ar-37				X			X	X						
Ar-39				X			X							
Ar-41				X			X							
As-69				X					X					
As-70				X				X						
As-72				X				X						
As-76				X				X						
As-77				X				X						
As-78				X				X						
At-215				X										
At-216				X										
Au-194				X										
Au-198				X				X						
Au-198m				X					X					
Au-199				X				X						
Au-200				X				X						
Au-200m				X					X					
Au-201				X				X						
Ba-126				X					X					
Ba-128				X					X					
Ba-135m				X				X						
Ba-139				X				X						
Ba-142				X					X					
Bi-200				X										
Bi-201				X										
Bi-203				X					X					
Bi-206				X				X						
Br-74				X				X						

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
Isotope	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Physical Properties-Gas (no new formation) (30 Isotopes)	Age of Waste Evaluation (Decay to stable) (288 Isotopes)	Age of Waste Evaluation (Decay to Short-lived) (169 Isotopes)	Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope within 100y (8 isotopes)	Will Decay to Longer-Lived Isotope within 100y (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Br-74m				X				X						
Br-76				X				X						
Br-77				X				X						
Br-80				X				X						
Br-80m				X					X					
Br-82				X				X						
Br-83				X				X						
Br-84				X				X						
C-11				X				X						
Ca-47				X					X					
Ca-49				X					X					
Cd-104				X					X					
Cd-107				X				X						
Cd-115				X										
Ce-134				X					X					
Ce-135				X					X					
Cl-38				X				X						
Cl-39				X										
Co-61				X				X						
Co-62m				X				X						
Cs-126				X				X						
Cs-128				X				X						
Cs-129				X				X						
Cs-130				X				X						
Cs-132				X				X						
Cs-135m				X										
Cs-138				X				X						
Cu-60				X				X						
Cu-61				X				X						
Cu-62				X				X						
Cu-64				X				X						
Cu-66				X				X						
Cu-67				X				X						

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
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Dy-155				X					X					
Dy-165				X				X						
Dy-166				X					X					
Er-161				X					X					
Er-165				X				X						
Er-172				X					X					
Eu-146				X										
Eu-150m				X										
Eu-152m				X				X						
Eu-157				X				X						
Eu-158				X				X						
F-18				X				X						
Fe-52				X					X					
Fr-219				X										
Fr-220				X										
Ga-66				X				X						
Ga-67				X				X						
Ga-68				X				X						
Ga-70				X				X						
Ga-72				X				X						
Ga-73				X				X						
Gd-159				X				X						
Ge-66				X					X					
Ge-67				X					X					
Ge-69				X				X						
Ge-75				X				X						
Ge-77				X					X					
Ge-78				X					X					
Hf-170				X					X					
Hf-174				X										
Hf-177m				X				X						
Hf-180m				X										
Hf-183				X					X					

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
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Hf-184				X					X					
Hg-197				X				X						
Hg-197m				X					X					
Hg-199m				X				X						
Ho-155				X										
Ho-161				X				X						
Ho-162				X				X						
Ho-162m				X					X					
Ho-164				X				X						
Ho-164m				X					X					
Ho-166				X				X						
Ho-167				X				X						
I-120				X				X						
I-120m				X				X						
I-122				X				X						
I-124				X				X						
I-128				X				X						
I-130				X				X						
I-132				X				X						
I-132m				X					X					
I-133				X					X					
I-134				X				X						
I-135				X										
In-110				X				X						
In-110m				X				X						
In-111				X				X						
In-112				X				X						
In-113m				X				X						
In-114				X				X						
In-115m				X										
In-116m				X				X						
Ir-182				X										
Ir-184				X				X						

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
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Ir-186				X										
Ir-186m				X										
Ir-187				X				X						
Ir-188				X				X						
Ir-191m				X				X						
Ir-194				X										
Ir-195				X				X						
Ir-195m				X					X					
K-38				X				X						
K-42				X				X						
K-43				X				X						
K-44				X				X						
Kr-74				X			X		X					
Kr-76				X			X		X					
Kr-77				X			X		X					
Kr-79				X			X	X						
Kr-81m				X			X							
Kr-83m				X			X	X						
Kr-87				X			X							
Kr-88				X			X		X					
La-132				X				X						
La-134				X				X						
La-135				X				X						
La-140				X				X						
La-142				X										
Lu-170				X				X						
Lu-172				X										
Lu-176m				X				X						
Lu-177				X				X						
Lu-178				X				X						
Lu-178m				X				X						
Lu-179				X				X						
Md-257				X										

Table A8. Screening Process Application (Summary)

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Mg-28				X					X					
Mn-52				X				X						
Mn-52m				X					X					
Mn-56				X				X						
Mo-101				X					X					
Mo-90				X					X					
N-13				X				X						
Na-24				X				X						
Nb-89a				X					X					
Nb-89b				X					X					
Nb-90				X				X						
Nb-96				X				X						
Nb-97				X				X						
Nb-97m				X					X					
Nb-98				X				X						
Nd-136				X					X					
Nd-138				X					X					
Nd-141				X				X						
Nd-141m				X					X					
Nd-149				X					X					
Ne-19				X			X	X						
Ni-65				X				X						
Ni-66				X					X					
O-15				X				X						
Os-180				X					X					
Os-182				X					X					
Os-189m				X				X						
Os-190m				X				X						
Os-193				X				X						
P-30				X				X						
Pa-234m				X										
Pb-198				X					X					
Pb-199				X					X					

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Pb-200				X					X					
Pb-201				X					X					
Pb-203				X				X						
Pd-100				X					X					
Pd-109				X					X					
Pm-141				X					X					
Pm-142				X				X						
Pm-148				X										
Pm-149				X										
Pm-150				X				X						
Po-203				X										
Pr-136				X				X						
Pr-138				X				X						
Pr-138m				X				X						
Pr-142				X				X						
Pr-142m				X					X					
Pr-144m				X										
Pr-145				X				X						
Pt-186				X										
Pt-191				X				X						
Pt-195m				X				X						
Pt-197				X				X						
Pt-197m				X					X					
Pt-199				X					X					
Pt-200				X					X					
Rb-79				X					X					
Rb-80				X				X						
Rb-81m				X										
Rb-82				X				X						
Rb-82m				X				X						
Rb-88				X				X						
Re-177				X										
Re-180				X				X						

Table A8. Screening Process Application (Summary)

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Re-182				X				X						
Re-182m				X				X						
Re-186				X										
Re-188				X				X						
Re-188m				X					X					
Re-189				X				X						
Rh-100				X				X						
Rh-103m				X				X						
Rh-105				X				X						
Rh-106m				X				X						
Rh-107				X										
Rh-99m				X					X					
Rn-218				X			X							
Ru-105				X										
Ru-94				X					X					
Sb-115				X				X						
Sb-116				X				X						
Sb-116m				X				X						
Sb-117				X				X						
Sb-118m				X				X						
Sb-119				X				X						
Sb-120				X				X						
Sb-120m				X				X						
Sb-122				X				X						
Sb-128				X				X						
Sb-128m				X					X					
Sb-130				X				X						
Sc-43				X				X						
Sc-44				X										
Sc-44m				X					X					
Sc-47				X				X						
Sc-48				X				X						
Sc-49				X				X						

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	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
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Se-70				X					X					
Se-77m				X				X						
Se-81				X				X						
Se-81m				X					X					
Se-83				X										
Si-31				X				X						
Sm-141				X										
Sm-141m				X										
Sm-142				X					X					
Sm-153				X				X						
Sn-110				X					X					
Sn-111				X					X					
Sn-121				X										
Sn-123m				X				X						
Sn-128				X										
Sr-80				X					X					
Sr-81				X										
Sr-87m				X										
Sr-92				X					X					
Ta-174				X				X						
Ta-176				X				X						
Ta-177				X				X						
Ta-178				X				X						
Ta-178m				X				X						
Ta-180				X				X						
Ta-183				X				X						
Ta-184				X				X						
Ta-186				X				X						
Tb-150				X										
Tb-154				X				X						
Tb-155				X				X						
Tb-156				X				X						
Tb-156m				X					X					

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Tb-156n				X				X						
Tb-161				X				X						
Tc-101				X				X						
Tc-104				X				X						
Tc-94				X				X						
Tc-94m				X				X						
Tc-95				X				X						
Tc-96				X				X						
Tc-96m				X					X					
Te-116				X					X					
Te-127				X				X						
Te-129				X										
Te-132				X					X					
Te-133				X										
Te-133m				X										
Te-134				X					X					
Ti-45				X				X						
Tl-197				X					X					
Tl-198				X				X						
Tl-198m				X					X					
Tl-199				X				X						
Tl-200				X				X						
Tl-201				X				X						
Tl-206				X										
Tm-162				X				X						
Tm-166				X				X						
Tm-172				X				X						
Tm-173				X				X						
Tm-175				X					X					
V-47				X				X						
W-176				X					X					
W-177				X					X					
W-187				X										

Table A8. Screening Process Application (Summary)

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Xe-120				X			X		X					
Xe-122				X			X		X					
Xe-129m				X			X	X						
Xe-131m				X			X	X						
Xe-133				X			X	X						
Xe-133m				X			X		X					
Xe-135m				X			X							
Xe-138				X			X		X					
Y-86				X				X						
Y-86m				X					X					
Y-87				X				X						
Y-90m				X					X					
Y-92				X				X						
Y-94				X				X						
Yb-162				X					X					
Yb-166				X					X					
Yb-175				X				X						
Yb-177				X					X					
Yb-178				X					X					
Zn-62				X					X					
Zn-63				X				X						
Zn-69				X				X						
Zn-69m				X					X					
Zn-71m				X				X						
Zn-72				X					X					
Zr-86				X					X					
Zr-89				X				X						
Zr-97				X										
Ag-103					X	X			X					
Ag-106m					X	X		X						
Ag-111					X	X		X						
Ag-115					X									
Am-237					X									

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
Isotope	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Physical Properties-Gas (no new formation) (30 Isotopes)	Age of Waste Evaluation (Decay to stable) (288 Isotopes)	Age of Waste Evaluation (Decay to Short-lived) (169 Isotopes)	Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope within 100y (8 isotopes)	Will Decay to Longer-Lived Isotope within 100y (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
As-71					X	X			X					
As-74					X	X		X						
Ba-131					X	X			X					
Ba-131m					X	X								
Ba-140					X	X			X					
Ba-141					X									
Bi-205					X									
Cd-117					X	X			X					
Cd-117m					X	X			X					
Ce-141					X			X						
Ce-143					X	X			X					
Cr-48					X	X			X					
Cr-51					X			X						
Cs-127					X	X			X					
Cs-131					X	X		X						
Cs-136					X	X		X						
Er-169					X	X		X						
Eu-147					X									
Eu-156					X	X		X						
Gd-147					X									
Ge-71					X	X		X						
Hf-179m					X			X						
I-121					X	X			X					
I-126					X	X		X						
I-131					X	X		X						
In-117					X	X		X						
In-117m					X	X			X					
In-119					X			X						
In-119m					X				X					
Ir-189					X	X		X						
Ir-190					X	X		X						
Ir-190m					X	X			X					
Ir-190n					X	X			X					

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
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La-131					X	X								
La-141					X				X					
La-143					X	X								
Lu-171					X	X		X						
Mn-51					X				X					
Nb-95					X			X						
Nb-95m					X				X					
Nd-151					X				X					
Os-191					X	X		X						
Os-191m					X	X			X					
P-32					X	X								
P-33					X			X						
Pa-227					X	X								
Pd-103					X	X			X					
Po-205					X	X								
Pr-137					X									
Pr-143					X	X		X						
Pt-188					X	X			X					
Pt-189					X	X			X					
Rb-81					X									
Rb-86					X	X		X						
Rb-89					X				X					
Re-178					X									
Rh-99					X	X		X						
Sb-129					X									
Sb-131					X	X								
Se-73m					X									
Sm-156					X	X			X					
Sn-117m					X	X		X						
Sr-82					X				X					
Tb-147					X									
Te-121					X	X		X						
Te-131					X	X			X					

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	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
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Te-131m					X	X								
Tl-202					X	X								
Tm-167					X	X		X						
V-48					X	X		X						
W-178					X	X			X					
Xe-121					X	X	X							
Xe-127					X	X	X	X						
Y-91m					X				X					
Y-93					X									
Y-95					X									
Yb-167					X	X			X					
Cd-113						X								
Gd-152						X								
In-115						X								
Re-187						X								
Ta-180m						X								
Te-123						X								
Kr-81							X							
Kr-85							X							
Kr-85m							X							
Xe-123							X							
Xe-125							X		X					
Xe-135							X							
Ag-105								X						
As-73								X						
Au-195								X						
Au-195m								X						
Be-7								X						
Ca-45								X						
Cd-109								X						
Ce-139								X						
Co-56								X						
Co-57								X						

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
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Co-58								X						
Dy-159								X						
Eu-149								X						
Fe-59								X						
Gd-151								X						
Gd-153								X						
Hf-175								X						
Hf-181								X						
Hg-203								X						
I-125								X						
Ir-194m								X						
Lu-173								X						
Mn-54								X						
Os-185								X						
Pm-143								X						
Rb-84								X						
Re-184								X						
S-35								X						
Sb-124								X						
Sc-46								X						
Se-75								X						
Sn-113								X						
Sn-119m								X						
Sn-123								X						
Sr-85								X						
Sr-89								X						
Ta-179								X						
Tb-160								X						
Tm-170								X						
Tm-171								X						
V-49								X						
W-181								X						
W-185								X						

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
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Y-88								X						
Y-91								X						
Yb-169								X						
Zn-65								X						
Ag-110m									X					
Br-75									X					
Co-58m									X					
Cr-49									X					
Ga-65									X					
Gd-149									X					
Ge-68									X					
Hf-172									X					
Hg-195									X					
Ho-159									X					
In-114m									X					
Ir-185									X					
K-45									X					
Lu-169									X					
Lu-177m									X					
Ni-56									X					
Ni-57									X					
Pr-139									X					
Rb-83									X					
Re-181									X					
Re-184m									X					
Ru-103									X					
Sb-124m									X					
Sb-124n									X					
Se-73									X					
Sr-83									X					
Sr-85m									X					
Sr-91									X					
Ta-175									X					

Table A8. Screening Process Application (Summary)

	Step 1 Inclusion	Step 2 Inclusion	Step 3 Exclusion	Step 4 Exclusion	Step 5 Exclusion	Step 6 Exclusion	Step 7 Exclusion	Step 8 Exclusion	Step 9 Exclusion	Step 10 Exclusion	Step 11 Exclusion	Step 12 Exclusion	Step 13 Exclusion	Step 14 Inclusion
Isotope	Member of U, Ac, Th, Np Decay Series (54 isotopes)	Residual Radionuclide Inventory Isotope (64 isotopes)	Not on Table (23 Isotopes)	NCRP Screened (388 isotopes)	Does not exceed 4 mrem/yr in 1E6 Ci (89 isotopes)	Does not exceed 4 mrem/yr in 1000 lbs (67 isotopes)	Physical Properties-Gas (no new formation) (30 Isotopes)	Age of Waste Evaluation (Decay to stable) (288 Isotopes)	Age of Waste Evaluation (Decay to Short-lived) (169 Isotopes)	Decayed to Stable Isotope In Multiple Steps (13 isotopes)	Decayed to Longer Lived Isotope (101 isotopes)	Will Decay to Stable Isotope within 100y (8 isotopes)	Will Decay to Longer-Lived Isotope within 100y (2 Isotopes)	Further Evaluation Needed (55 Isotopes)
Ta-182m									X					
Ta-185									X					
Tb-151									X					
Tb-153									X					
Tc-95m									X					
Te-121m									X					
Te-127m									X					
W-188									X					
Zr-88									X					
Zr-95									X					
Cs-125										X				
Hf-173										X				
Hg-195m										X				
Nb-88										X				
Nd-139										X				
Nd-139m										X				
Os-181										X				
Pa-228										X				
Pb-195m										X				
Sb-127										X				
Sn-127										X				
Tb-149										X				
Tl-195										X				
Ac-226											X			
Am-238											X			
Am-239											X			
Am-240											X			
Am-244											X			
Am-244m											X			
Am-245											X			
Am-246m											X			
At-207											X			
At-211											X			

Table A8. Screening Process Application (Summary)

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Au-193											X			
Ba-133m											X			
Bi-202											X			
Bk-245											X			
Bk-246											X			
Cd-115m											X			
Ce-137											X			
Ce-137m											X			
Cf-244											X			
Cf-246											X			
Cf-248											X			
Cf-253											X			
Cf-254											X			
Cm-238											X			
Cm-240											X			
Cm-241											X			
Cm-249											X			
Co-55											X			
Cs-134m											X			
Dy-157											X			
Er-171											X			
Es-250m											X			
Es-251											X			
Es-253											X			
Es-254											X			
Es-254m											X			
Eu-145											X			
Eu-148											X			
Fm-252											X			
Fm-253											X			
Fm-254											X			
Fm-255											X			
Fm-257											X			

Table A8. Screening Process Application (Summary)

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Fr-222											X			
Gd-145											X			
Gd-146											X			
Hf-182m											X			
Hg-193											X			
Hg-193m											X			
Ho-157											X			
I-123											X			
In-109											X			
Lu-174m											X			
Md-258											X			
Mo-93m											X			
Mo-99											X			
Nd-147											X			
Np-232											X			
Np-233											X			
Np-234											X			
Np-235											X			
Np-236m											X			
Np-238											X			
Np-240m											X			
Pa-230											X			
Pa-232											X			
Pb-202m											X			
Pd-101											X			
Pm-144											X			
Pm-148m											X			
Pm-151											X			
Po-207											X			
Pr-147											X			
Pt-193m											X			
Pu-234											X			
Pu-235											X			

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Pu-237											X			
Pu-245											X			
Ra-222											X			
Ra-227											X			
Rh-101m											X			
Ru-97											X			
Sm-145											X			
Sm-155											X			
Sn-125											X			
Ta-172											X			
Ta-173											X			
Tc-93											X			
Tc-93m											X			
Tc-97m											X			
Tc-99m											X			
Te-123m											X			
Te-129m											X			
Th-226											X			
Tl-194											X			
Tl-194m											X			
U-230											X			
U-231											X			
U-237											X			
U-239											X			
W-179											X			
Ba-133												X		
Fe-55												X		
Lu-174												X		
Os-194												X		
Rh-101												X		
Rh-102												X		
Rh-102m												X		
Tl-204												X		

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Cd-113m													X	
Pm-146													X	
Ag-108m														X
Am-242														X
Am-246														X
Be-10														X
Bi-207														X
Bi-210m														X
Bk-247														X
Bk-250														X
Ca-41														X
Cf-250														X
Cl-36														X
Cm-246														X
Cm-250														X
Co-60m														X
Eu-150														X
Fe-60														X
Gd-148														X
Hf-178m														X
Hf-182														X
Hg-194														X
Ho-166m														X
Ir-192														X
Ir-192m														X
K-40														X
La-137														X
La-138														X
Lu-176														X
Mn-53														X
Mo-93														X
Nb-93m														X
Np-236														X

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Np-239														X
Np-240														X
Pb-202														X
Pb-205														X
Pd-107														X
Pm-145														X
Pt-193														X
Pu-236														X
Pu-243														X
Pu-246														X
Rb-87														X
Re-186m														X
Si-32														X
Sm-146														X
Sm-147														X
Sn-121m														X
Ta-182														X
Tb-157														X
Tb-158														X
Tc-97														X
Tc-98														X
Ti-44														X
U-240														X
Zr-93														X