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2011.2 Revision of the Evaluated Nuclear Data Library (ENDL2011.2)

B. Beck, M. A. Descalles, C. Mattoon, E. Jurgenson, I. Thompson

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Disclaimer

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2011.2 Revision of the Evaluated Nuclear Data Library (ENDL2011.2)

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(Dated: February 6, 2016)

LLNL's Computational Nuclear Physics Group and Nuclear Theory and Modeling Group have collaborated to create the 2011.2 revised release of the Evaluated Nuclear Data Library (ENDL2011.2). ENDL2011.2 is designed to support LLNL's current and future nuclear data needs and will be employed in nuclear reactor, nuclear security and stockpile stewardship simulations with ASC codes. This database is currently the most complete nuclear database for Monte Carlo and deterministic transport of neutrons and charged particles. This library was assembled with strong support from the ASC PEM and Attribution programs, leveraged with support from Campaign 4 and the DOE/Office of Science's US Nuclear Data Program. This document lists the revisions made in ENDL2011.2 compared with the data existing in the original ENDL2011.0 release and the ENDL2011.1-rc4 release candidate of April 2015. These changes are made in parallel with some similar revisions for ENDL2009.2.

Contents

I. INTRODUCTION

LLNL's Computational Nuclear Physics Group and Nuclear Theory and Modeling Group have collaborated to produce the next iteration of LLNL's evaluated nuclear database ENDL2011. ENDL2011 is the second in a series of major ENDL library releases designed to support LLNL's current and future nuclear data needs. This library contains many new evaluations for radiochemical diagnostics (part of a Campaign 4 L2 milestone), structural materials (part of an ASC Attribution L2 milestone), and thermonuclear reactions (to support NIF diagnostics). In addition, we have striven to keep ENDL2011 at the leading edge of nuclear data library development by reviewing and incorporating new evaluations as they are made available to the nuclear data community. This release is our most highly tested release as we have strengthened our already rigorous testing regime by adding tests against LANL Activation Ratio Measurements and many more new critical assemblies. Our testing is now being incorporated into our development process and is serving to guide library improvements.

The new library can be found on LLNL's Open & Secure Computing facilities. In addition, the data will soon be made available in the Nuclear and Atomic Data System (NADS) data viewer at `http://nuclear.llnl.gov/NADS`.

II. MODIFICATIONS FOR ENDL2011.1, RC4

These are listed according to the ND keys used on the JIRA database at `https://lc.llnl.gov/jira/browse/ND/fixforversion/10807`.

1. ND-3: Temperature dependent data errors

A bug was found in ndfgen which caused arrays going out of bounds when processing entire library. This was not an issue with unheated data as they were built one isotope at a time and then merged together.

2. ND-4: too many data points in some deuteron cross sections

The cross section data for reactions d(d,n)h, d(d,p)t, d(t,n) and d(t,γnα) may have too many points. Using the fudge thinning routine, the number of points in these data sets can be reduced from over 5000 to just over 100, while keeping within a specified accuracy of 0.1%.

Repository revisions 867, 868.

3. ND-6: n+^{1}H elastic and capture cross section do not sum to total cross section

At low energies below 10 keV, the sum of capture and elastic n+^{1}H cross sections differed by more than 0.1% from the total cross section given in the evaluation. This problem was found to occur when using `prepro` (SIGMA1) to heat the cross sections to room temperature. When the heating was performed using FUDGE, the sum of the partial cross sections matched the total cross sections. We therefore reimported the ENDF evaluation into `GND` using FUDGE, heated the cross sections to room temperature, and used these cross sections to replaced the `prepro` generated cross sections.

The three yo=I=s=0 files for C=1, 10 and 46 have been updated.

Repository revisions 920, 921, 924, 925.

4. ND-11: t(d,n)α angular distribution has a spike a single energy and angle

The t(d,n)α angular distribution, in file `yi03/za001003/yo01c11i001s000`, for an incident energy of 0.85 MeV there is a spike at outgoing angle $\mu = \cos\theta = 0.96111$ that erroneously increased the angular probability distribution by 0.2 at that one angle. We have replaced that angle's value with mean value of points either side of the spike.

Repository revision 901.

5. ND-15: ascii data in release does not match processed data

In the `endl_official/endl2009.0` directory containing the official relase of ENDL2009.0, it was discovered that the `ascii` data did not match the process data found in the `ndf` and `mcf` files. This was evident in the fact that we were unable to process the `ascii` data without crashing the `ndfgen` and `mcfgen` . During the build process, changes must have occured to the `ascii` data in order to process it, which were not checked into the svn repository, and did not make it into the `endl_official` release directory. Care was taken in this new ENDL2009.1 release to keep the `ascii` data in sync with what was processed and released into the `endl_official` directory.

6. ND-17: Unresolved Resonance Region (URR) data removed

For this release the URR I=20 data were removed. Due to changes in `NJOY` formatting, these data could not be processed and was therefore removed from the release to keep the `ascii` data in sync with what was processed.

Repository revision 813.

7. ND-18: `endep` changes to gamma C55 files not in released ascii data

When ENDL2008.2 was processed, `endepC++` (the code that calculates the average energy deposition from the distribution data) did not worry about energy balance. When ENDL2009.0 was processed, `endepC++` (via the `-rescale_c5x_cs` option which is true by default) attempted to balance energy by rescaling the C55 data. That is, if there is too much (little) outgoing energy, the C55 gamma multiplicity is effectively lowered (raised). Changes to C55 data were not checked into svn repository and therefore C55 ascii data did not match processed data.

The reason the rescaled C55 data was not checked into the repo, is that the ENDLBUILDER scripts processed the data in a tmp directory, and as part of the build process it ran `endep` . The data were rescaled in the tmp directory, but not in the original ascii directory, and therefore this change was lost. We modified the ENDLBUILDER scripts to run `endep` manually first on the ascii data (with the rescaling option) and then process the data afterwards, giving the flag to skip the `endep` stage as it is already done. This way the rescaling happens in the ascii directory and the changes can be saved.

Repository revision 822.

8. ND-22: He3(t,t) reaction unphysical at low energies

The ENDL2011.0 cross section for He3(t,t) was seen to be very large at low energies compared to ENDL2009.0. Investigation showed that the ENDL2009.0 evaluation was obtained from t(^{3}He,^{3}He) using inverse kinematics, whereas the ENDL2011.0 evaluation was from G. Hale evaluation obtained during R-Matrix fit of ^{6}Li. Unfortunately, the G. Hale result was unphysical at low energies. Since this was not a main focus of his R-Matrix evaluation but only a by-product, we therefore disregard this cross section. Hence we replaced the t(^{3}He,^{3}He) cross section in ENDL2011.1 with that from ENDL2009.0.

Repository revision 866.

9. ND-26: Some distributions are missing I=3 data

Whenever there are more than 2 bodies possible in the final state, then I=1 angular data has to be supplemented by I=3 or I=4 double-differential cross section data, not least to enable the processing code to determine that such reactions are not two-body reactions, but have energy distributions in the final state.

ENDF has to be only complete for neutrons, while ENDL need outgoing distributions for all tracked particles (n,p,d,t,h,a,g). In the earlier making of ENDL2011.1, missing distributions not found in ENDF with distributions found from other evaluations were swapped in, or we made them ourselves from TALYS. It appears this was done incorrectly in some cases, as only the I=1 data was included, not the double-differential data.

Our remedy is to find the needed double-differential data from either the original source, or some other plausible evaluation. This affects many targets, principally Ag07, Ar38, Ar40, Au97, Ba30, Ba32, Ba34, Ba35, Ba36, Ba37, Ba38, Ba40, Br79, Br81, Cd06, Cd08, Cd10, Cd11, Cd12, Cd13, Cd14, Cd16, Ce40, Ce41, Ce42, Ce44, Cr50, Cs34, Cs35, Cs36, Cs37, Cu63, Cu65, Er62, Er64, Er66, Er67, Er68, Er70, Eu51, Eu52, Eu53, Eu54, Eu55, Eu56, F19, Fe54, Fe56, Ga69, Ga71, Gd52, Gd53, Gd55, Gd57, Hg00, Hg01, Hg02, Hg04, Hg96, Hg98, Hg99, I29, I31, I35, In13, In15, K39, K40, K41, Kr80, Kr82, Kr83, Kr84, Kr86, La38, La39, Lu75, Lu76, Mg24, Mg25, Mg26, Mn55, Mo00, Mo92, Mo94, Mo95, Mo96, Mo97, Mo98, Mo99, Na22, Nb93, Nb94, Nb95, Nd43, Nd45, Ni58, Ni59, Ni60, Ni62, Ni64, P31, Pd02, Pd07, Pm47, Pm48, Pm49, Pr43, Rb85, Rb87, Rh05, Ru00, Ru02, Ru03, Ru04, Ru05, Ru06, Ru96, Ru98, Ru99, S32, S33, S34, S36, Sb21, Sb23, Sb24, Sb25, Se74, Se76, Se77, Se78, Se79, Se80, Se82, Si28, Sm47, Sm49, Sn12, Sn14, Sn15, Sn16, Sn17, Sn18, Sn19, Sn20, Sn22n+Sn23, Sn24, Sn26, Sr86, Sr87, Sr88, Sr89, Sr90, Tb59, Te20, Te22, Te23, Te24, Te25, Te26, Te28, Te30, Ti46, Ti47, Ti48, Ti49, Ti50, Xe26, Xe28, Xe29, Xe30, Xe32, Xe33, Xe34, Xe35, Xe36, Y91, Yb74, Zr91, Zr92, Zr93, Zr94, Zr95 and Zr96 (where only the modulo 100 A numbers are shown).

Repository revisions 888–895, 914, 934–936, 938.

10. ND-29: U239(n,γ) has poor resonance region

The resonance region for U239(n,γ) does not go down to low enough energy. Dave Brown worked on the resonance region after the ENDL2011.0 release, for the ENDF-B/VII.1 release. We have further updated the evaluation, to the ENDF-B/VII.2 version, for the ENDL2011.1 release.

Repository revisions 870, 930.

11. ND-30: ^{10}Be evaluation missing

The ENDL2011.0 evaluation included a new ^{11}Be evaluation, but missed ^{10}Be. Some ^{10}Be evaluated data was found for ROSFOND (for activation only), and for TENDL. We therefore created a new merged evaluation using estimates from ROSFOND along with the TALYS results in TENDL2013.

Repository revisions 875, 907, 984, 991.

12. ND-31: wrong ^{27}Al evaluation

The wrong evaluation was used for ENDL2011.0. This evaluations should have been the same as ENDL2009.0, namely the ENDF/B-VII.0 evaluation. Somehow it got

changed to that from the TALYS calculations of Thompson and Summers, but this was rejected for use in ENDL2009.0. The poor ^{27}Al (n,α) cross section for ENDL2011 is the main problem with those calculations. So for ENDL2011.1 we used again the entire evaluation from ENDL2009.0.

Repository revisions 858, 862, 864.

13. ND-33: errors in gamma multiplicities.

The gamma multiplicities (yo=7, I=9 data) have changed for many files between ENDL2009.0 and ENDL011.0, but the source ENDF evaluation has not changed. This appears to be a problem with the `fete`translation from ENDF to ENDL format, as all the I=9 files has only unit multiplicities. For ENDL2011.1, we therefore retranslated these files using revision 2220 of `fete`, instead of the more recent revision 2461 used first for ENDL2011.0.

Repository revisions 869, 871, 876.

14. ND-36: move all C=21 files to C=20 when C=20 does not exist

ENDL has both C=20 and C=21, to describe the (n,np) and (n,pn) channels respectively, but ENDF only has the sum of both of these channels. Most Hauser-Feshbach codes only calculate the sum. When we have the sum both channels, sometimes this has been put in C=20 and sometimes in C=21. We now decide put the sum in C=20 for uniformity across our databases.

Repository revision 827.

15. ND-37: separate ^{241}Am(n,γ) cross section to ground and isomer state in ^{242}Am

In translating n+^{241}Am evaluation from ENDF/B-VII.0, the (n,γ) C=46 cross section was given as the sum of the cross sections to the ground and isomer states in ^{242}Am. The branching to the ground and isomer states was given elsewhere (MT8), and this was not translated by `fete`.

ENDL format has support for cross sections to final isomer states, so a fix was applied by hand to put in two levels in C=46 file, corresponding to ground and isomer final states of ^{242}Am respectively. The sum of these two cross sections is what was in ENDL2009.0 and ENDL2011.0. The branching ratio was obtained from ENDF/B-VII.0. The spectra and multiplicities, also from ENDF/B-VII.0,, were assumed the same for both levels.

Repository revision 969.

16. ND-38: separate ^{45}Sc(n,γ) cross section to ground and isomer state in ^{46}Sc

In translating n+^{45}Sc evaluation from ENDF/B-VII.0, the (n,γ) C=46 cross section was given as the sum of the cross sections to the ground and isomer states in ^{46}Sc. The branching to the ground and isomer states was given elsewhere (MT8), and this was not translated by `fete`.

ENDL format has support for cross sections to final isomer states, so a fix was applied by hand to put in two levels in C=46 file, corresponding to ground and isomer final states of ^{46}Sc respectively. The sum of these two cross sections is what was in ENDL2009.0 and ENDL2011.0. The branching ratio was obtained from JEFF 3.1. The spectra and multiplicities, also from JEFF 3.1, were assumed the same for both levels.

Repository revision 969.

17. ND-39: EGDL fluorescence data missing

The nuclear fluorescence data from EGDL, which resides in the I=30,32 files for incident gammas, was present in ENDL2008.2 release, but was erroneously not in the ENDL2011.0 release. This data has been included in the ENDL2011.1 release.

Repository revision 817, 948, 951.

18. ND-40: Maxwellian averaged cross section I=80,81,84,89,90,91,92 for charged particle libraries

These files have been removed from the library as they are redundant.

Repository revision 945.

19. ND-41: thresholds for some I=0 files higher than other I values

`mcfgen` gives errors for the following reactions in ENDL2011, where the thresholds for some$I$=0 files higher than other I values. Our remedy was to increase first I=4,9 energy points to that of I=0 file, in the problematic nuclides.

Repository version 879–884.

20. ND-42: no distributions for the α particles after the decay of ^{8}Be

For the reactions n+^{10}Be $\rightarrow$ 3n + ^{8}Be and n+^{11}Be $\rightarrow$ 4n + ^{8}Be, the ^{8}Be residual would not normally be tracked. In `mcfgen` however, the ^{8}Be (since it is unstable) is replaced with 2 α particles. Since the α is a tracked particle, if there is no distribution given for the alpha particle, it would returns a null pointer and crash mercury. We therefore included an α distribution

for the ^{8}Be residual, along the lines which exist already for the n+^{9}Be $\rightarrow$ 2n + ^{8}Be. The energy thresholds and Q-values were changed, as based on the assumption of a pure compound nucleus decay mechanism. We produced both yo=6 and yo=16 for the 'direct' and 'recoil' α particles respectively.

Repository versions 896, 897, 906 for ^{10}Be, and 932, 933 for ^{11}Be.

21. ND-43: Missing I=3,4 files for yo$\geq$2 and C=40-45

We discovered that many I=3,4 files, for incident neutrons and charged-particle products, namely the reactions C=40–45. These are the files with the double-differential angle and energy distributions, which do not exist for charged particles in ENDF evaluations.

We therefore copied these, where available, from JEFF-3.1.1 or TENDL-2013. Not all the needed files were found, however, but the files are definitely needed in ENDL to distinguish these from purely two-body exit channels. The number of missing files was significantly reduced when we excluded 103 exit reactions with cross sections less than 10 micobarns even at their highest energy of 20 MeV. Some light-ion channels were recognized to be two-body reactions after all, and were relabeled correctly as s=1 data in ENDL.

Repository versions 888–895, 914, 934–936, 938.

22. ND-46: missing reaction ^{7}Be(n,p)^{7}Li* to the $1/2^{-}$ excited state

In the ENDL2009.0 n+Be-7 evaluation was added a cross section for outgoing proton and gamma for (n,p) reaction going to 1st excited state of ^{7}Li (0.47761 MeV). The file yo00c40i000s001 in ENDL2009.0 contains a second level, but this is missing in ENDL2011.0. The reaction also needs the distribution in yo02c40i001s000, and the file yo07c40i004,9 for the angular distributions and multiplity of the eventual γ decay of this excited state. This addition was lost in ENDL2011.0 evaluation, so we reinserted it in ENDL2011.1. Note that this increases the 'maximum available energy' (emac) calculated by the processing codes, since no other cross sections were reduced.

Repository revision 902.

23. ND-50: t(n,2n)d cross section reduced significantly in the ENDF-B/VII.1 evaluation

The LLNL report LLNL-TR-637152, from Rob Hoffman, examined the status of three nuclear data evaluations for the (n,2n) reaction proceeding on ^{3}H, namely t(n,2n)d, The most recent update to this reaction, based upon a new evaluation by G. Hale, suggests a much lower peak cross section than the previous two evaluations. The t(n,2n)d cross section should therefor be reduced by a factor of about 5. Previous evaluations had ENDL2011.0 = ENDL2009.0 = ENDF-B/VII.0. The ENDF-B/VII.1 reverted t(n,2n) back to ENDF-B/VI.8. Therefore ENDL2011.1 has been updated to the data of the ENDF-B/VII.1 evaluation.

Repository revision 992.

24. ND-52: missing particle angular distributions in ^{19}F

The evaluation for the ^{19}F target from ENDF/B-VII had (n,d) and (n,t) reactions which do not have I=4 exit angular distributions. The I=4 data from ENDL99 was used for this data.

Repository revision 1008.

25. ND-60: too much energy in d $\rightarrow$ n+p breakup on protons and α-particles

The I=4 files describing the d $\rightarrow$ n+p breakup on protons and α-particles were giving too much energy deposition. This error resulted from an erroneous translation of the previous data in ECPL for the inverse reactions of protons and α-particles on deuterons: the incident energies were scaled as if the breakup distributions depended only on the incident energy in the c.m. frame. However, the I=4 files describe data in the laboratory frame, so they should *not* have been changed. This is fixed for ENDL2011.1.

Note that all the described double-differential cross sections are purely phase-space distributions, and await an actual model calculation of breakup.

Repository revisions 985, 987.

26. ND-61: wrong normalization of elastic distributions for charged-particle scattering

The elastic distributions in ENDL are supposed to be normalized to unity for scattering between 20° and above. For some reason, these were normalized instead to 0.522131. This is now fixed for all yi=2–6.

Repository revision 990.

27. ND-62: need consistent $S_{\alpha\beta}$ nuclear data

The $S_{\alpha\beta}$ data are used to make evaluations with A$\geq$800 to represent thermal scattering data, as described in the LLNL report UCRL-ID-153656 written in 2003 by D.E. Cullen. These evaluations are based on normal nuclear scattering data, but are changed below some cutoff energy that is between 1 and 4 eV. Previous $S_{\alpha\beta}$ data was based on ENDL99, so we made a new set of A$\geq$800

datasets starting with our latest ENDL2011.1 data for the needed targets: ^{1}H, ^{2}H, ^{9}Be, ^{12}C and ^{16}O. These new sets do not have xml uncertainty files.

Repository revisions 964, 975, 977.

28. ND-63: missing recoil α particles from ^{8}Be decay

The reactions ^{10}C(n,τ) and ^{11}C(n,α) produce ^{8}Be, which immediately decays into two α-particles. The yo = 6 and 16 distributions (I=3 or 4) are missing for these α particles.

The ^{10}C(n,τ) reaction was fixed as for ND-42, by shifting the incident energies to the correct threshold.
Repository revision 1000.

The ^{11}C(n,α) reaction was fixed by calculating (for each incident energy and each compound state in ^{12}C) the average energy deposition to ^{8}Be. An isotropic I=4 file was made to describe distributions with delta-function energy distributions at this mean energy. Strictly speaking, these distributions should have multiplicity 2.0 since 2 alpha particles are being produced, but a suggested I=9 file made was later omitted as it was not handled correctly by the processing codes (but made the processed results worse).

Repository revisions 1000, 1003 and 1007.

III. MODIFICATIONS FOR ENDL2011.2

This release includes a re-translation of gamma output channels by Bret Beck's code FETEPY.PY, using the ENDF source files wherever they are available. This results in modified yo=7 files, for cross sections (I=4), angles (I=4) and multiplicities (I=9), along with c=55 gamma files.

We process with the new-style endep rescaling of all c55 files (including fission Q values). Furthermore, when ndf files were heated for the files, endep was not run again.

These changes completely replace the changes listed above for ND-33.

IV. OUTLOOK

This new library can be found on LLNL's Open and Secure Computing facilities. In addition, the data may be viewed in the Nuclear and Atomic Data System data viewer at `http://nuclear.llnl.gov/NADS`.

Acknowledgements

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Appendix A: Known Issues

1. ND-47: the ^{7}Be evaluation ends at 8.1 MeV

Our evaluation is from ENDF/B-VII (December 2006). Issue of a low energy limit is being addressed at CSEWG by LANL. See `https://ndclx4.bnl.gov/gf/project/endf/tracker/?action=TrackerItemEdit&tracker_item_id=196&start=0`. We will update our evaluation with LANL's fixes when they become available.

2. ND-63b: multiplicity of recoil α particles from ^{8}Be decay

The reaction ^{11}C(n,α) produce ^{8}Be, which immediately decays into two α-particles.

Strictly speaking, these α yo16 distributions should have multiplicity 2.0 since 2 alpha particles are being produced, but a suggested I=9 file would not be handled correctly by the processing codes.

In the future the processing codes should have this reaction specifically recognized, just as the other reactions which produce ^{8}Be.

3. ND-65: `endep` should not generate files for decays of isomer states

The isomer states produced by neutron reactions on the 43 nuclides listed below should *not* have extra files generated by `endep` for their decay. Those stubs presently give fudge-check warnings of missing I=1 and I=9 files. For these, `endep` should NOT produce I=10,11,13 files, by implementing properly its input control make_inelastic_endep_if_gamma_- data_missing.

The discrete excited states are at energies given by the X1 values:

```
ZA = 11023, yo07c11i???s001, X1 = 5.955000e+00
ZA = 11023, yo07c11i???s001, X1 = 6.078500e+00
ZA = 11023, yo07c11i???s001, X1 = 6.270000e+00
ZA = 11023, yo07c11i???s001, X1 = 7.110000e+00
ZA = 11023, yo07c11i???s001, X1 = 7.790000e+00
ZA = 20044, yo07c11i???s001, X1 = 3.865000e+00
ZA = 20044, yo07c11i???s001, X1 = 3.922600e+00
ZA = 20044, yo07c11i???s001, X1 = 4.169000e+00
ZA = 20044, yo07c11i???s001, X1 = 4.564900e+00
ZA = 20044, yo07c11i???s001, X1 = 4.584100e+00
ZA = 20044, yo07c11i???s001, X1 = 4.604000e+00
ZA = 20044, yo07c11i???s001, X1 = 4.803700e+00
ZA = 20044, yo07c45i???s001, X1 = 1.635000e+00
ZA = 20044, yo07c45i???s001, X1 = 1.985000e+00
ZA = 20044, yo07c45i???s001, X1 = 2.321000e+00
ZA = 20044, yo07c45i???s001, X1 = 2.569000e+00
ZA = 20044, yo07c45i???s001, X1 = 2.695000e+00
ZA = 20044, yo07c45i???s001, X1 = 2.890000e+00
ZA = 20044, yo07c45i???s001, X1 = 3.122000e+00
ZA = 20044, yo07c45i???s001, X1 = 3.285000e+00
```

```
ZA = 20044, yo07c45i???s001, X1 = 3.386000e+00
ZA = 20044, yo07c45i???s001, X1 = 3.430000e+00
ZA = 20044, yo07c45i???s001, X1 = 3.485000e+00
ZA = 20044, yo07c45i???s001, X1 = 3.568000e+00
ZA = 20044, yo07c45i???s001, X1 = 3.592000e+00
ZA = 20044, yo07c45i???s001, X1 = 3.697000e+00
ZA = 20044, yo07c45i???s001, X1 = 3.732000e+00
ZA = 20044, yo07c45i???s001, X1 = 3.773000e+00
ZA = 20044, yo07c45i???s001, X1 = 3.799000e+00
ZA = 20044, yo07c45i???s001, X1 = 3.838000e+00
ZA = 20044, yo07c45i???s001, X1 = 3.889000e+00
ZA = 20048, yo07c11i???s001, X1 = 5.314000e+00
ZA = 20048, yo07c11i???s001, X1 = 5.461000e+00
ZA = 27059, yo07c11i???s001, X1 = 2.584000e+00
ZA = 27059, yo07c11i???s001, X1 = 3.999990e+00
ZA = 50117, yo07c11i???s001, X1 = 3.145800e-01
ZA = 50119, yo07c11i???s001, X1 = 8.953100e-02
ZA = 82207, yo07c40i???s001, X1 = 1.348100e+00
ZA = 93236, yo07c11i???s001, X1 = 6.000000e-02
ZA = 93237, yo07c11i???s001, X1 = 9.840000e-01
ZA = 93237, yo07c11i???s001, X1 = 1.013000e+00
ZA = 97248, yo07c11i???s001, X1 = 5.000000e-02
```

4. ND-66 Erroneous cross section for ^{7}Li(t,n)^{9}Be(gs) reaction

For the reaction ^{7}Li(t,n)^{9}Be, the data on ENDL says it comes from the paper Brune et al PRC 43 (1991)875. The cross section should be taken from Fig. 7 in the paper, however, it appears that the cross section in ENDL is from Fig. 9 or similar source, and is too large. Most of the extra cross sections should probably be moved to the ^{7}Li(t,n)[^{9}Be$^{*} \rightarrow$ n, 2α] channel.

This error dates back at least to ENDL94.

ENDL2011.2-rc2
Comparison to ENDL2011.0
and
ENDL2009.2-rc2

3/19/16

M.-A. Descalle

A little bit of history

Official release: ENDL2011.0

Development release:

- ENDL2011.1-rc4 ->new: Al evaluation from ENDL2009.1

Comparison to ENDL2011.0 and ENDL2009.1-rc8

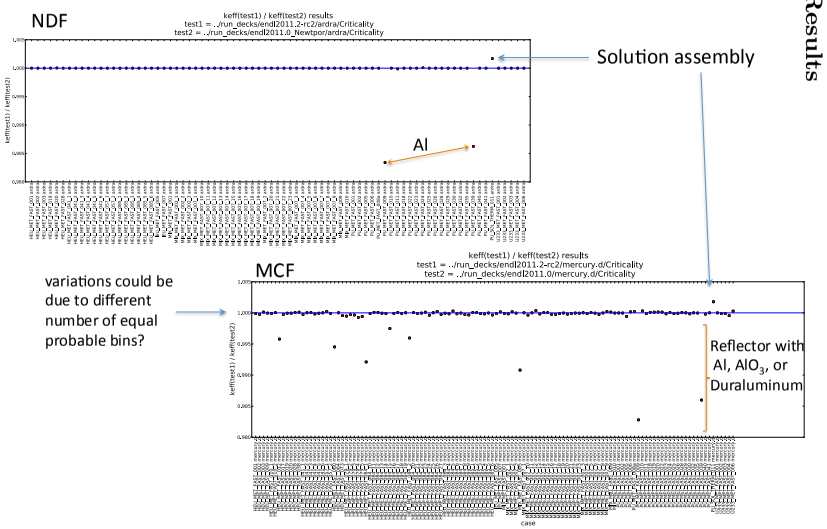
- ENDL2011.2-rc1 (skipped)
- ENDL2011.2-rc2 -> Endep & gamma production

Comparison to ENDL2011.0 and ENDL2009.2-rc2

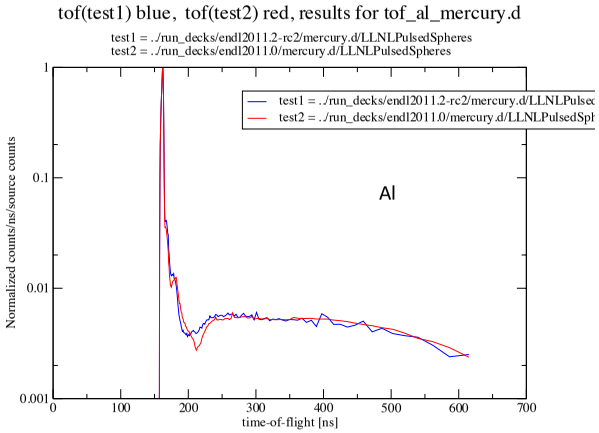
XS libraries comparison
ENDL2011.0 & ENDL2011.2-rc2

MCF	ENDl2011.0	ENDL2011.2-rc2	Comments/differences
Criticality	✔	✔	Large diff. for Al reflected cases Small diff.->number of epb?
Reaction rate ratios	✔	✔	Al (n,p), (n,a) (n,2n) Co59, Y89, Au197, Tm169
TOF: LLNL pulsed spheres	✔	✔	Al, Small differences: Pb, Au, N_2
gamma production 15 cases	✔	✔	Significant differences for most materials, except Al (4%), and Au, C, Ti (see slide 4)
NDF	**ENDl2011.0**	**ENDL2011.2-rc2**	**Comments/differences**
Criticality	✔	✔	Large diff. for Al reflected cases
Reaction rate ratios	✔	✔	(n,g) Br81,Nb93, I127, Au197, Tl205, Bi209 ; (n,2n)Co59, Au197, Tm169
gamma production 15 cases	✔	✔	Significant differences for most materials, except Al (3%), and Au, C, Ti (see slide 4)

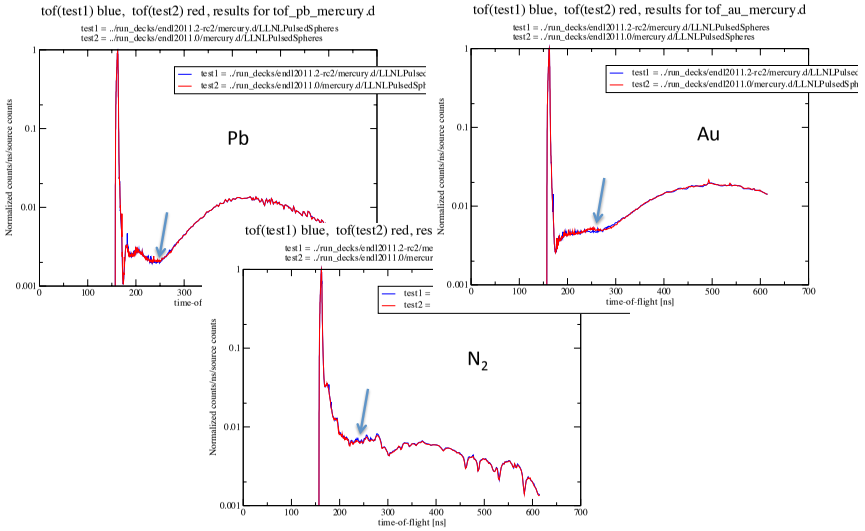
Criticality



Time of flight



Time of flight



Gamma production ENDL2011.0& 11.2-rc2

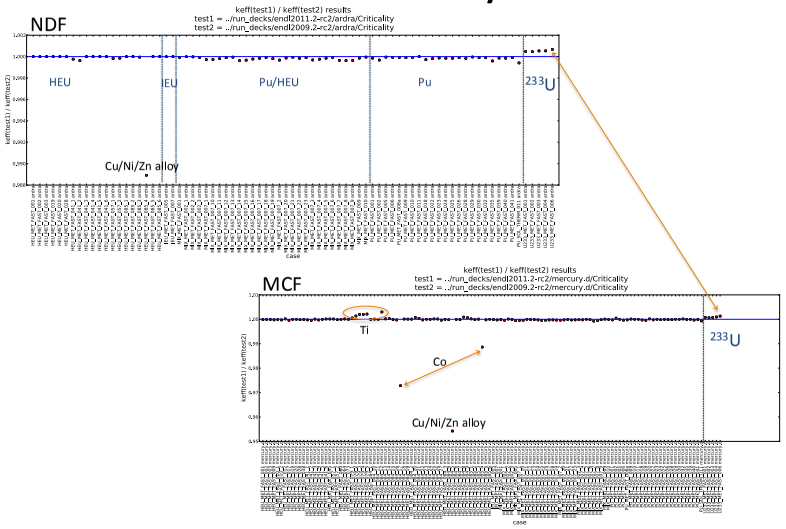
Cumulative Gamma Energy Leaked Ratio ENDL2011.2-rc2 /ENDL2011.0		
Element	Ardra	Mercury
Al	103%	104%
Au	99%	100%
C	101%	100%
C_2F_4	48%	42%
Cu	266%	265%
Fe	247%	248%
H_2O	149%	190%
N_2	234%	232%
Pb	84%	85%
Si	162%	161%
Ta	42%	42%
Th-232	234%	235%
Ti	100%	100%
U-238	130%	189%
W	286%	287%

- Test: 14MeV point source in a 1 mfp thick sphere
- Tally: total particle gamma energy leaked out of the sphere
- For a given element and code , we calculate the ratio
  R= $Tally_{XSlib1}/Tally_{XSlib2}$
- Differences from ENDL2011.0 to ENDL2011.2-rc2
  - Decrease: C_2F_4, Ta, Pb
  - Al, Au, C, Ti
  - Increase: W, Cu, Fe,Th_{232},N_2, Si, H_2O, U_{238}
  - NDF < MCF: U_{238}, H_2O

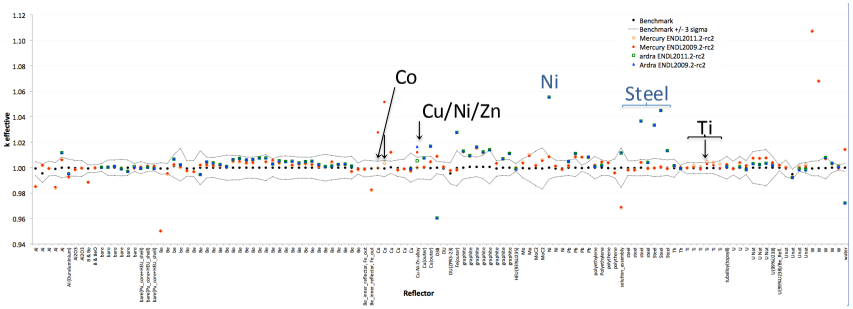
XS libraries comparison ENDL2011.2-rc2/ENDL2009.2-rc2

MCF	ENDl2009.2-rc2	ENDL2011.2-rc2	Comments/differences
Criticality	✔	✔	Ti, Co, Cu/Ni/Zn ENDL2011.2: larger k_{eff} for U233
Reaction rate ratios	✔	✔	(n,g) :Br81, Co59, Nb93, Y89, Zr94-96, I127, Tl205, Bi209, Np237; (n,a):Co59, Nb93,Mo92; (n,p)Ti48, Co59, Mo92; (n,2n) Co59, Y89, , Nb93, Tm169
TOF: LLNL pulsed spheres	✔	✔	N_2, Pb – no difference for Ti
gamma production 15 cases	✔	✔	N_2 (x2.8), Ti (x100)
NDF	**ENDl2009.2-rc2**	**ENDL2011.2-rc2**	**Comments/differences**
Criticality	✔	✔	Be; ENDL2011.2-rc2: larger k_{eff} for U233 and overall smaller k_{eff} for Pu cases
Reaction rate ratios	✔	✔	(n,g) Nb93, Br81, I127, Tl205, Bi209; (n,2n) Co59, Tm169
gamma production 15 cases	✔	✔	N_2 (x2.8), Ti (>x100) C_2F_4(+20%)

Criticality



Criticality Benchmarks vs ENDL2009.2 and 2011.2 (ndf & mcf)



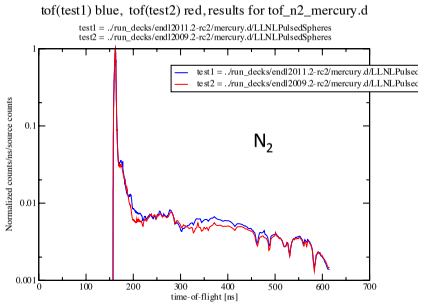
For the 2 XS libraries, most simulations result in similar $k_{effective}$.

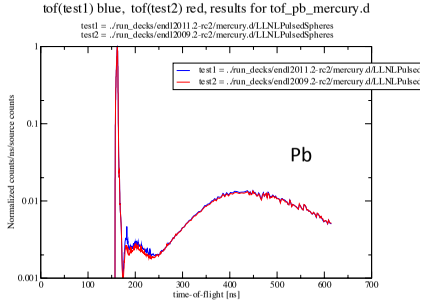
Better agreement with benchmarks was shown for

- ENDL2011.2-rc2: Co, Ni/Cu/Zn
- ENDL2009.2-rc2: Ti

Large discrepancies between multigroup and continuous energy XS for cases with steel and Ni reflectors

Time of flight





Gamma production ENDL2011.2-rc2 & ENDL2009.2-rc2

Cumulative Gamma Energy Leaked Ratio ENDL2011.2-rc2 /ENDL2009.2-rc2		
Element	Ardra	Mercury
Al	100%	100%
Au	100%	100%
C	100%	100%
C_2F_4	120%	100%
Cu	100%	100%
Fe	100%	100%
H_2O	100%	100%
N_2	280%	280%
Pb	99%	99%
Si	99%	99%
Ta	100%	100%
Th-232	100%	100%
Ti	**11394%**	**11114%**
U-238	100%	100%
W	100%	100%

- Test: 14MeV point source in a 1 mfp thick sphere
- Tally: total particle gamma energy leaked out of the sphere
- For a given element and code , we calculate the ratio

  $R = Tally_{XSlib1}/Tally_{XSlib2}$
- Differences ENDL2011.2-rc2 and ENDL2009.2-rc2
  - $C2F_4$: x1.2 for NDF
  - N_2: x2.8
  - Ti : >x100

Appendix C: Release Checklist

Here we reproduce the release checklist that accompanies this release.

ENDL2011.2 Data Release Checklist

Basic Tests

Check/Test	Success	Failure	Comments
python checker on ascii data		1	Known issues described in Appendix A of the revision-release document: Emax only 8.1 MeV for ^{7}Be.
Check the processing errors/ warning messages	✓		
ndf checker	✓		
mcapm checker	✓		

Amtran Tests (ndf)

Check/Test	Success	Failure	Comments
za-loop	✓		
k_{eff}	✓		
Activation foils	✓		

Mercury Tests (mcf)

Check/Test	Success	Failure	Comments
za-loop	✓		
k_{eff}	✓		
LLNL pulsed spheres	✓		
Oktavian spheres	✓		

Other Release Tasks

	Complete	Comments
Add correct bdfls file	OCF: ✓ SCF: ✓	
Add/Edit README.txt	✓	
Check directory layout	OCF: ✓ SCF: ✓	
Check file permissions	OCF: ✓ SCF:	
Post on NADS	Not yet	
Tag release in svn repo	x	endl/branches/endl2011.2, #1051
Release documentation	✓	endl2011.2_release.pdf

Release Features

	Present?	Comments
Momentum deposition	✓	
Energy deposition	✓	
Energy-dependent Q-values for (n,f)	✓	
Multi-temperature data	✓	In mcf files
Large-Angle Coulomb Scattering (LACS) data	✓	Not present in ndf files
Thermal scattering ($S_{\alpha\beta}$) data	✓	For p,d,^{4}He, ^{12}C, and ^{16}O
Unresolved Resonance (URR) data (probability tables)	x	Removed since codes can't currently use it, but will be possible in the future
Uncertainty/Covariance data	About half	
Isomers	9, 1 processed	ASCII files have 9 isomer targets: ^{58m}Co, ^{110m}Ag, ^{115m}Cd, ^{127m,129m}Te, ^{148m}Pm, ^{166m}Ho, ^{242m,244m}Am. However, only ^{242m}Am is processed: it replaces the ground state

Available Formats

	Present?	Comments
mcf	✓	mcf1.pdb.175 mcf1.pdb.175.32epb mcf1.pdb.230 mcf1.pdb.616 mcf2.pdb mcf3.pdb mcf4.pdb mcf5.pdb mcf6.pdb mcf7.pdb
ndf	✓	ndf1.230 ndf2.063 ndf3.063 ndf4.063 ndf5.063 ndf6.063 ndf7.040
tdf	✓	17 reactions
ENDF/B	some	
gnd	x	
other	x	

Appendix D: The README file

Here we reproduce the README file that accompanies the release.

```
          2011.2 Release of the Evaluated Nuclear Data Library (ENDL2011.2)

        B. Beck, M.-A. Descalle, E. Jurgensen, C. Mattoon, and I. J. Thompson
                             (S&T/NACS/NDTG)

                                April 2016

LLNL's Computational Nuclear Physics Group and Nuclear Theory and Modeling Group have
collaborated to create the 2011.2 revised release of the Evaluated Nuclear Data
Library (ENDL2011.2). ENDL2011.2 is designed to support LLNL's current and future nuclear
data needs and will be employed in nuclear reactor, nuclear security and stockpile
stewardship simulations with ASC codes. This database is currently the most complete
nuclear database for Monte Carlo and deterministic transport of neutrons and charged
particles. This library was assembled with strong support from the ASC PEM and Attribution
programs, leveraged with support from Campaign 4 and the DOE/Office of Science's US Nuclear
Data Program. This document lists the revisions made in ENDL2011.2 compared with the data
existing in the original ENDL2011.0 release. These changes are made in conjunction with
the revisions for ENDL2009.2, so that both the .2 releases are as free as possible
of known defects.

The new libraries can be found on LC in:
    /usr/gapps/data/nuclear/endl_official/endl2011.2/ascii for the ENDL ASCII formatted data,
    /usr/gapps/data/nuclear/endl_official/endl2011.2/ndf for deterministic data and
    /usr/gapps/data/nuclear/endl_official/endl2011.2/mcf for Monte-Carlo data.
    /usr/gapps/data/nuclear/endl_official/endl2011.2/tdf for thermonuclear data.

In addition, the data may be viewed in the Nuclear and Atomic Data System data viewer
at http://nuclear.llnl.gov/NADS.



                                Release Notes
                                -------------

10/10/2008 Release ENDL2008.0:

    The new files are posted on the in /usr/gapps/data/nuclear/endl_official/endl2008/.
    The ascii, mcf and ndf files are present in subdirectories, using the new directory
    layout.



2/17/2009 Release ENDL2008.1:

    The new files are posted on the in /usr/gapps/data/nuclear/endl_official/endl2008.1/.
    The ascii, mcf and ndf files are present in subdirectories, using the new directory
    layout.


    Resolved Issues:

        1. The extra files in the d(n,2n) evaluation which produced a
           factor of 2 change in the cross-section have been removed.

        2. The 232Th nubar has been set to the correct value.

        3. The 233Pa nubar has been set to the correct value.

        4. The missing energy dependent Q-values for fission was forgotten in the
           previous release and is now added back into the evaluations for all
           actinides.

        5. A mistake in the 48Ti(n,g) outgoing gamma spectrum (taken from the
           ENDF/B-VII.0 evaluation) produced several *hundred* MeV worth of
           outgoing gammas.  We replaced this unphysical spectrum with one
           from Hauser-Feshbach model calculations.



5/15/2009 Release ENDL2008.2:

    The new files have been posted in /usr/gapps/data/nuclear/endl_official/endl2008.2.
    The ascii, mcf and ndf files are present in subdirectories, using the new directory
```

layout.

New Features:

1. Expected value momentum deposition added

2. Large angle Coulomb scattering for yi=2-6 added

Resolved Issues:

1. Addition of the resonance region for 240Am and 73As

2. Fixed unphysical gamma multiplicities in 41Sc, 103Rh, 125Sn amd 240Am

3. Fixed angular grid miss-match issue in 103Rh and 27Al

4. I = 3 data added to natV, natOs, natTl

5. Added missing triton distributions for 70Zn, 71Zn, 63Ni, 72Ga, 66Cu, 61Co

6. Removed extra I=4 files from 9Be, 11Be

7. Other minor issues in t, 7Be

9/30/2009 Release ENDL2009.0:

The new files have been posted in /usr/gapps/data/nuclear/endl_official/endl2009.0.
The ascii, mcf, ndf and tdf files are present in subdirectories, using the new
directory layout.

New Features:

1. Unresolved resonance probability tables added to ascii data tables

2. TDF data now produced directly from ascii endl files

3. New structural material evaluations for Al, Ta, W, Re, Pt, Pb

4. New radiochemical diagnostic evaluations for Ar, Kr, Xe, Au

5. New evaluations for Cl, K, Mn, Y, Mo, Bi, Po

6. New actinide evaluations for 240Am, 240Pu, 239U

7. Most evaluations also available in ENDF/B format in endf subdirectory

8. Add uncertainty & covariance data to many evaluations

9. Large-angle Coulomb scattering data added for all targets in charged-particle sublibraries

Resolved Issues:

1. Added resonances to Co evaluations

2. Charged particle data available in forward and inverse kinematics for particles p, d, t, 3He, a

3. 6Li files renamed to get correct two-body kinematics using mcapm

2/2012 Release ENDL2011.0:

The new files have been posted in /usr/gapps/data/nuclear/endl_official/endl2011.0.
The ascii, mcf, ndf and tdf files are present in subdirectories, using the new
directory layout.

New Features:

1. Contains every stable isotope, every isotope in the gaps between stable isotopes
   and 2 isotopes on either side of the stable isotopes.

2. 918 neutron evaluations

3. Energy dependent Q(E) values for fission in I=12 files

4. New set of light-ion charged-particle evaluations, with TDF processing

5. Using TENDL-2009 global TALYS data sets for missing nuclides.

6. Fission neutrons from empirical model FREYA, and with expanded covariances.

4/2015 Release ENDL2011.1:

The new files have been posted in /usr/gapps/data/nuclear/endl_official/endl2011.1.
The ascii, mcf, ndf and tdf files are present in subdirectories as for ENDL2011.0

New Features labeled by JIRA record number:

1. ND-3: Fixed Temperature dependent data errors
2. ND-4: Fixed too many data points in some deuteron cross sections
3. ND-6: Fixed that n+1H elastic and capture cross section do not sum to total cross section
4. ND-11: Fixed t(d,n)alpha angular distribution spike at a single energy and angle
5. ND-15: Ensured that ascii data in release does not match processed data
6. ND-17: Unresolved Resonance Region (URR) data removed
7. ND-18: Ensured that endep changes to gamma C55 files in released ascii data
8. ND-22: Fixed He3(t,t) reaction unphysicality at low energies
9. ND-26: Fixed distributions missing I=3 data
10. ND-29: Improved U239(n,gamma) poor resonance region
11. ND-30: Included a 10Be evaluation
12. ND-31: Fixed wrong 27Al evaluation
13. ND-33: Fixed errors in gamma multiplicities.
14. ND-36: Moved all C=21 files to C=20 when C=20 does not exist
15. ND-37: Made separate 241Am(n,gamma) cross section to ground and isomer state in 242Am
16. ND-38: Made separate 45Sc(n,gamma) cross section to ground and isomer state in 46Sc
17. ND-39: EGDL fluorescence data included
18. ND-40: Redundant Maxwellian averaged cross section I=80,81,84,89,90,91,92 for charged particle libraries removed
19. ND-41: Fixed thresholds for some I=0 files higher than other I values
20. ND-42: Made distributions for the alpha particles after the decay of 8Be
21. ND-43: Missing I=3,4 files for yo >= 2 and C=40-45
22. ND-46: Inserted missing reaction 7Be(n,p)7Li* to the 1/2- excited state
23. ND-50: Inserted the t(n,2n)d cross section reduced significantly in the ENDF-B/VII.1 evaluation
24. ND-52: Inserted missing particle angular distributions in 19 F
25. ND-60: Fixed too much energy in d to n+p breakup on protons and alpha-particles
26. ND-61: Fixed wrong normalization of elastic distributions for charged-particle scattering
27. ND-62: Inserted consistent S_(alpha beta) nuclear data
28. ND-63: Fixed missing recoil alpha particles from 8Be decay

4/2016 Release ENDL2011.2:

The new files have been posted in /usr/gapps/data/nuclear/endl_official/endl2011.2.
The ascii, mcf, ndf and tdf files are present in subdirectories as for ENDL2011.0

This release includes a re-translation of gamma output channels by Bret Beck's code fetePy.py,
using the ENDF source files wherever they are available. This results in modified yo=7 files,
for cross sections (I=4), angles (I=4) and multiplicities (I=9), along with c=55 gamma files.

We process with the new-style endep rescaling of all c55 files (including fission Q values).

```
Furthermore, when ndf files were heated for the  files, endep was not run again.
```

Appendix E: Changes between ENDL2009.2 and ENDL2011.2 for incident neutrons

Here we list, for each nuclide in the ENDL2009.2 target list for neutrons, whether the data has changed in ENDL2011.2. In this list we ignore nuclides which appear for the first time only in ENDL2011. Those with two asterisks (**) were calculated with FETE v.2404 that gives different I=1 angular distributions.

TABLE I: Source of incident neutron evaluations in ENDL2011.2.

Symbol	ZA	(%)	ENDL2009.2	ENDL2011.2
Helium				
^{3}He	za002003	0.000137	ENDF/B-VII	JENDL-4
^{4}He	za002004	99.999	JENDL-3.3	ENDF/B-VII.1b
Lithium				
^{6}Li	za003006	7.59	ENDL99	ENDF/B-VII.0 (mod)
^{7}Li	za003007	92.41	ENDL99	ENDF/B-VII.0 (mod)
Boron				
^{10}B	za005010	19.8	ENDL99	ENDF/B-VII.0
Carbon				
^{13}C	za006013	1.11	ENDL99	ROSFOND (mod)
Nitrogen				
^{14}N	za007014	99.634	ENDL99	JENDL-4
^{15}N	za007015	0.366	ENDL99	ROSFOND
Oxygen				
^{16}O	za008016	99.762	ENDF/B-VII	ROSFOND
Sodium				
^{23}Na	za011023	100.0	JENDL-3.3	ROSFOND
Magnesium				
^{25}Mg	za012025		ENDF/B-VII	TENDL-2009
Aluminium				
^{28}Al	za013028		LLNL2009	TENDL-2009
^{29}Al	za013029		LLNL2009	TENDL-2009
Silicon				
^{29}Si	za014029	4.683	ENDF/B-VII	JENDL-4
^{30}Si	za014030	3.087	ENDF/B-VII	JENDL-4
Phosphorus				
^{31}P	za015031	100.0	ENDF/B-VII	JENDL-4
Sulphur				
^{34}S	za016034	4.25	ENDF/B-VII	TENDL-2009
Chlorine				
^{35}Cl	za017035	75.77	ENDF/B-VII **	ENDF/B-VII
^{37}Cl	za017037	24.23	ENDF/B-VII **	ENDF/B-VII
Argon				
^{26}Ar	za018036	0.3365	LLNL2009 **	LLNL2009
Potassium				
^{41}K	za019041	6.7302	ENDF/B-VII	TENDL2009
Calcium				
^{44}Ca	za020044	2.09	ENDF/B-VII	JENDL-4
^{47}Ca	za020047		LLNL2005	TENDL2009
^{48}Ca	za020048	0.187	ENDF/B-VII	JENDL-4
Titanium				
^{46}Ti	za022046	8.25	ENDF/A-7.2009	ENDF/B-VII
^{47}Ti	za022047	7.44	ENDF/A-7.2009	ENDF/B-VII

TABLE I: Source of incident neutron evaluations in ENDL2011.2.

Symbol	ZA	(%)	ENDL2009.2	ENDL2011.2
^{48}Ti	za022048	7.44	ENDF/A-7.2009	ENDF/B-VII
^{49}Ti	za022049	5.41	ENDF/A-7.2009	ENDF/B-VII
^{50}Ti	za022050	5.18	ENDF/A-7.2009	ENDF/B-VII
Vanadium				
^{47}V	za023047		LLNL2005	TENDL2009
^{48}V	za023048		LLNL2005	TENDL2009
^{49}V	za023049		LLNL2005	TENDL2009
^{50}V	za023050	0.25	RACS-1.0	JENDL-4
^{52}V	za023052		LLNL2005	TENDL2009
^{53}V	za023053		LLNL2005	TENDL2009
Chromium				
^{48}Cr	za024048		LLNL2005	TENDL2009
^{49}Cr	za024049		LLNL2005	TENDL2009
^{51}Cr	za024051		LLNL2005	TENDL2009
^{54}Cr	za024054	2.365	ENDF/B-VII	JENDL-4
Manganese				
^{51}Mn	za025051		LLNL2005	TENDL2009
^{52}Mn	za025052		LLNL2005	TENDL2009
Iron				
^{52}Fe	za026052		LLNL2005	TENDL2009
^{53}Fe	za026053		LLNL2005	TENDL2009
^{55}Fe	za026055		LLNL2005	TENDL2009
^{59}Fe	za026059		LLNL2005	LLNL2010
Cobalt				
^{58}Co	za027058		LLNL2009	TENDL2009
^{59}Co	za027059	100.0	LLNL2009	JENDL-4
^{60}Co	za027060		LLNL2009	TENDL2009
^{61}Co	za027061		LLNL2009	TENDL2009
Nickel				
^{56}Ni	za028056		END99	TENDL2009
^{57}Ni	za028057		END99	TENDL2009
^{63}Ni	za028063		END99	TENDL2009
^{65}Ni	za028065		END99	TENDL2009
^{67}Ni	za028067		END99	TENDL2009
Copper				
^{62}Cu	za029062		END99	TENDL2009
^{64}Cu	za029064		LLNL2008	JENDL-4
^{66}Cu	za029066		END99	TENDL2009
^{67}Cu	za029067		END99	TENDL2009
^{68}Cu	za029068		END99	TENDL2009
Zinc				
^{62}Zn	za030062		END99	TENDL2009
^{63}Zn	za030063		END99	TENDL2009
^{64}Zn	za030064	48.63	LLNL2008	JENDL-4
^{65}Zn	za030065		LLNL2008	JENDL-4
^{66}Zn	za030066	27.9	LLNL2008	JENDL-4
^{67}Zn	za030067	4.1	LLNL2008	JENDL-4
^{68}Zn	za030068	18.75	LLNL2008	JENDL-4
^{69}Zn	za030069		END99	TENDL2009
^{70}Zn	za030070	0.62	LLNL2008	TENDL-2009
^{71}Zn	za030071		END99	TENDL2009
^{72}Zn	za030072		END99	TENDL2009
^{73}Zn	za030073		END99	TENDL2009

TABLE I: Source of incident neutron evaluations in ENDL2011.2.

Symbol	ZA	(%)	ENDL2009.2	ENDL2011.2
Gallium				
^{68}Ga	za031068		END99	TENDL2009
^{69}Ga	za031069		END99	TENDL2009
^{70}Ga	za031070		END99	TENDL2009
^{71}Ga	za031071	39.892	ENDF/B-VII	JENDL-4
^{72}Ga	za031072		END99	TENDL2009
Germanium				
^{72}Ge	za032071		ENDF/B-VII	TENDL2009
Arsenic				
Selenium				
^{76}Se	za034076	9.37	ENDF/B-VII	JENDL-4
^{78}Se	za034078	23.77	ENDF/B-VII	TENDL2009
^{79}Se	za034079		ENDF/B-VII	TENDL2009
^{80}Se	za034080		ENDF/B-VII	TENDL2009
^{81}Se	za034081		LLNL2005	TENDL2009
^{82}Se	za034082	8.73	ENDF/B-VII	JENDL-4
Bromine				
^{75}Br	za035075		LLNL2005	TENDL2009
^{76}Br	za035076		LLNL2005	TENDL2009
^{78}Br	za035078		LLNL2005	TENDL2009
^{80}Br	za035080		LLNL2005	TENDL2009
^{81}Br	za035081	49.31	ENDF/B-VII	LLNL2010
^{82}Br	za035082		LLNL2005	TENDL2009
Krypton				
^{78}Kr	za036078	0.35	LLNL-2009	JENDL-4
^{79}Kr	za036079		LLNL2005	TENDL2009
^{80}Kr	za036080		ENDF/B-VII	TENDL2009
^{81}Kr	za036081		LLNL2005	TENDL2009
^{82}Kr	za036082	11.593	ENDF/B-VII	TENDL2009
^{83}Kr	za036083	11.49	ENDF/B-VII	ROSFOND (mod)
^{85}Kr	za036085		ENDF/B-VII	TENDL2009
Rubidium				
^{77}Rb	za037077		LLNL2005	TENDL2009
^{78}Rb	za037078		LLNL2005	TENDL2009
^{79}Rb	za037079		LLNL2005	TENDL2009
^{80}Rb	za037080		LLNL2005	TENDL2009
^{82}Rb	za037082		LLNL2005	TENDL2009
^{83}Rb	za037083		LLNL2005	TENDL2009
^{84}Rb	za037084		LLNL2005	TENDL2009
Strontium				
^{86}Sr	za038086	9.86	ENDF/B-VII	TENDL2009
^{87}Sr	za038087	7.00	ENDF/B-VII	TENDL2009
^{88}Sr	za038088	82.58	ENDF/B-VII	TENDL2009
^{89}Sr	za038089		ENDF/B-VII	TENDL2009
^{90}Sr	za038090		ENDF/B-VII	TENDL2009
Yttrium				
^{88}Y	za039088		ENDL99	RACS-1.0 (mod)
^{90}Y	za039090		ENDF/B-VII	TENDL2009
^{91}Y	za039091		ENDF/B-VII	TENDL2009
Zirconium				
^{91}Zr	za040091	11.22	ENDF/B-VII	LLNL2010
^{93}Zr	za040093		ENDF/B-VII	JENDL-4
^{94}Zr	za040094	17.38	ENDF/B-VII	LLNL2010
^{95}Zr	za040095		ENDF/B-VII	LLNL2010
^{96}Zr	za040096	2.8	ENDF/B-VII	LLNL2010
Niobium				

TABLE I: Source of incident neutron evaluations in ENDL2011.2.

Symbol	ZA	(%)	ENDL2009.2	ENDL2011.2
^{93}Nb	za041093	100.0	ENDF/B-VII	CENDL-3.1
^{94}Nb	za041094		ENDF/B-VII	TENDL-2009
^{95}Nb	za041095		ENDF/B-VII	TENDL-2009
Molybdenum				
^{92}Mo	za042092	14.84	ENDF/B-VII	ROSFOND
^{96}Mo	za042096	16.68	ENDF/B-VII	JENDL-4
^{99}Mo	za042099		ENDF/B-VII	TENDL2009
^{100}Mo	za042100	9.63	ENDF/B-VII	JENDL-4
Technetium				
^{99}Tc	za043099		JEFF-3.1.1	JENDL-4
Ruthenium				
^{98}Ru	za044098	1.87	ENDF/B-VII	TENDL2009
^{99}Ru	za044099	12.76	ENDF/B-VII	TENDL2009
^{100}Ru	za044100	12.60	ENDF/B-VII	TENDL2009
^{101}Ru	za044101	17.06	ENDF/B-VII	TENDL2009
^{102}Ru	za044102	31.55	ENDF/B-VII	TENDL2009
^{103}Ru	za044103		ENDF/B-VII	TENDL2009
^{104}Ru	za044104	18.62	ENDF/B-VII	CENDL-3.1
^{105}Ru	za044105		ENDF/B-VII	TENDL2009
^{106}Ru	za044106		ENDF/B-VII	TENDL2009
Rhodium				
^{103}Pd	za045103	100.0	JEFF-3.1	TENDL2009
^{105}Pd	za045105		ENDF/B-VII	TENDL2009
Palladium				
^{102}Pd	za046102	1.02	JENDL-3.2	TENDL2009
^{103}Pd	za046103		JENDL-3.2	TENDL2009
^{105}Pd	za046105	22.33	ENDF/B-VII	TENDL2009
^{106}Pd	za046106	27.33	ENDF/B-VII	TENDL2009
^{107}Pd	za046107		ENDF/B-VII	TENDL2009
^{108}Pd	za046108	26.46	ENDF/B-VII	TENDL2009
^{110}Pd	za046110	11.72	ENDF/B-VII	TENDL2009
Cadmium				
^{110}Cd	za048110	12.49	JENDL-3.3	JENDL-4
^{111}Cd	za048111	12.8	ENDF/B-VII	JENDL-4
^{112}Cd	za048112	24.13	ENDF/B-VII	JENDL-4
^{113}Cd	za048113	12.22	ENDF/B-VII	JENDL-4
Tin				
^{112}Sn	za050112	0.97	ENDF/B-VII	JENDL-4
^{114}Sn	za050114	0.66	ENDF/B-VII	JENDL-4
^{115}Sn	za050115	0.34	ENDF/B-VII	JENDL-4
^{116}Sn	za050116	14.54	ENDF/B-VII	JENDL-4
^{117}Sn	za050117	7.68	ENDF/B-VII	JENDL-4
^{118}Sn	za050118	24.22	ENDF/B-VII	JENDL-4
^{119}Sn	za050119	8.59	ENDF/B-VII	JENDL-4
^{120}Sn	za050120	32.58	ENDF/B-VII	JENDL-4
^{122}Sn	za050122	4.63	ENDF/B-VII	JENDL-4
^{123}Sn	za050123		ENDF/B-VII	TENDL2009
^{124}Sn	za050124	5.79	ENDF/B-VII	JENDL-4
^{126}Sn	za050126		ENDF/B-VII	TENDL2009
Antimony				
^{124}Sb	za051124		ENDF/B-VII	TENDL2009
^{125}Sb	za051125		ENDF/B-VII	TENDL2009
Iodine				
^{124}I	za053124		LLNL2005	TENDL2009
^{125}I	za053125		LLNL2005	TENDL2009
^{126}I	za053126		LLNL2005	TENDL2009

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Symbol	ZA	(%)	ENDL2009.2	ENDL2011.2
^{127}I	za053127	100.0	ENDF/B-VII	JENDL-4
Xenon				
^{132}Xe	za054132	26.909	ENDF/B-VII	ROSFOND (mod)
^{133}Xe	za054133		ENDF/B-VII	TENDL-2009 (mod)
^{134}Xe	za054134	10.435	ENDF/B-VII	TENDL-2009 (mod)
^{136}Xe	za054136	8.857	ENDF/B-VII	TENDL-2009 (mod)
Cesium				
^{136}Cs	za055136		ENDF/B-VII	TENDL-2009
^{137}Cs	za055137		ENDF/B-VII	TENDL-2009
Barium				
^{130}Ba	za056130	0.106	ENDF/B-VII	CENDL-3.1
^{133}Ba	za056133		ENDF/B-VII	TENDL-2009
^{134}Ba	za056134	2.417	ENDF/B-VII	TENDL-2009
^{135}Ba	za056135	6.592	ENDF/B-VII	TENDL-2009
^{136}Ba	za056136	7.854	ENDF/B-VII	TENDL-2009
^{137}Ba	za056137	11.232	ENDF/B-VII	TENDL-2009
^{140}Ba	za056140		JENDL-3.3	TENDL-2009
Cerium				
^{138}Ce	za058138	0.251	ENDF/B-VII	CENDL-3.1
^{140}Ce	za058140	88.45	ENDF/B-VII	CENDL-3.1
^{144}Ce	za058140		ENDF/B-VII	TENDL-2009
Praseodymium				
^{141}Pr	za059141	100.0	ENDF/B-VII	CENDL-3.1
^{143}Pr	za059143		ENDF/B-VII	JENDL-4
Europium				
^{151}Eu	za063151	47.81	ENDF/B-VII	LLNL-2010
^{155}Eu	za063155		ENDF/B-VII	TENDL-2009
^{156}Eu	za063156		ENDF/B-VII	TENDL-2009
^{157}Eu	za063157		ENDF/B-VII	TENDL-2009
Gadolinium				
^{152}Gd	za064152	0.2	ENDF/B-VII	JENDL-4
^{153}Gd	za064153		ENDF/B-VII	LLNL2010
^{154}Gd	za064154	2.18	ENDF/B-VII	LLNL2010
Thulium				
^{169}Tm	za069169	100.0	TENDL2008	LLNL-2010
^{171}Tm	za069171		TENDL2008	TENDL-2009
Ytterbium				
^{168}Yb	za070168	0.123	TENDL2008	JENDL-4
^{169}Yb	za070169		TENDL2008	TENDL-2009
^{170}Yb	za070170	2.982	TENDL2008	JENDL-4
^{171}Yb	za070171	14.28	TENDL2008	JENDL-4
^{172}Yb	za070172	21.68	TENDL2008	JENDL-4
^{173}Yb	za070173	16.103	TENDL2008	JENDL-4
^{174}Yb	za070174	32.026	TENDL2008	JENDL-4
^{176}Yb	za070176	12.996	TENDL2008	JENDL-4
Lutetium				
^{175}Lu	za071175		ENDF/B-VII	TENDL-2009
^{176}Lu	za071176	2.599	ENDF/B-VII	TENDL-2009
Hafnium				
^{176}Hf	za072176	5.26	JEFF-3.1	TENDL-2009
^{177}Hf	za072177	18.60	ENDF/B-III	TENDL-2009
^{178}Hf	za072178	27.28	JEFF-3.1	TENDL-2009
^{179}Hf	za072179	13.62	ENDF/B-III	TENDL-2009
^{180}Hf	za072180	35.08	JEFF-3.1	TENDL-2009
Osmium				
^{184}Os	za076184	0.02	TENDL-2008	TENDL-2009

TABLE I: Source of incident neutron evaluations in ENDL2011.2.

Symbol	ZA	(%)	ENDL2009.2	ENDL2011.2
^{187}Os	za076187	1.96	TENDL-2008	TENDL-2009
^{188}Os	za076188	13.24	TENDL-2008	TENDL-2009
^{189}Os	za076189	16.15	TENDL-2008	TENDL-2009
^{190}Os	za076190	26.26	TENDL-2008	TENDL-2009
^{191}Os	za076191		TENDL-2008	TENDL-2009
^{192}Os	za076192	40.93	TENDL2008	JENDL-4
^{193}Os	za076193		TENDL-2008	TENDL-2009
Platinum				
^{190}Pt	za078190	0.012	TENDL-2008	TENDL-2009
^{192}Pt	za078192	0.782	TENDL-2008	TENDL-2009
^{194}Pt	za078194	32.86	TENDL-2008	TENDL-2009
^{195}Pt	za078195	33.78	TENDL-2008	TENDL-2009
^{198}Pt	za078198	7.36	TENDL-2008	TENDL-2009
Gold				
^{197}Au	za079197	100.0	ENDF/B-VII	ENDF/B-VII.1β0
Mercury				
^{196}Hg	za080196	0.15	ENDF/B-VII	TENDL-2009
^{198}Hg	za080198	9.97	ENDF/B-VII	TENDL-2009
^{199}Hg	za080199	16.87	ENDF/B-VII	TENDL-2009
^{200}Hg	za080200	23.10	ENDF/B-VII	TENDL-2009
^{201}Hg	za080201	13.18	ENDF/B-VII	TENDL-2009
^{202}Hg	za080202	29.86	ENDF/B-VII	TENDL-2009
^{204}Hg	za080204	6.87	ENDF/B-VII	TENDL-2009
Thallium				
^{205}Tl	za081205	70.476	TENDL2008	TENDL-2009
Lead				
^{204}Pb	za082204	1.4	ENDL2009	JENDL-4
^{202}Pb	za082202		LLNL2009	TENDL-2009
^{203}Pb	za082203		LLNL2009	TENDL-2009
^{205}Pb	za082205		LLNL2009	TENDL-2009
^{206}Pb	za082206	24.1	LLNL2009	JEFF-3.2
^{207}Pb	za082207	22.1	LLNL2009	JEFF-3.2
^{209}Pb	za082209		LLNL2009	TENDL-2009
^{210}Pb	za082210		LLNL2009	TENDL-2009
Bismuth				
^{209}Bi	za083209	100.0	JEFF-3.1	TENDL-2009
Polonium				
^{209}Ra	za084209		TENDL-2008	TENDL-2009
Radium				
^{223}Ra	za088223		ENDF/B-VII	TENDL-2009
^{224}Ra	za088224		ENDF/B-VII	TENDL-2009
^{225}Ra	za088225		ENDF/B-VII	TENDL-2009
^{226}Ra	za088226		ENDF/B-VII	TENDL-2009
Actinium				
^{225}Ac	za089225		JENDL/AC-2008	JENDL-4
^{226}Ac	za089226		JENDL/AC-2008	JENDL-4
^{227}Ac	za089227		JENDL/AC-2008	JENDL-4
Thorium				
^{227}Th	za090227		JENDL/AC-2008	JENDL-4
^{228}Th	za090228		JENDL/AC-2008	JENDL-4
^{229}Th	za090229		JENDL/AC-2008	JENDL-4
^{230}Th	za090230		JENDL/AC-2008	JENDL-4
^{231}Th	za090231		JENDL/AC-2008	JENDL-4
^{233}Th	za090233		ENDF/B-VII	JENDL-4
^{234}Th	za090234		JENDL/AC-2008	JENDL-4
Protactinium				

TABLE I: Source of incident neutron evaluations in ENDL2011.2.

Symbol	ZA	(%)	ENDL2009.2	ENDL2011.2
^{229}Pa	za091229		JENDL/AC-2008	JENDL-4
^{230}Pa	za091230		JENDL/AC-2008	JENDL-4
^{231}Pa	za091231		JENDL/AC-2008	ENDF/B-VII.1β0
^{232}Pa	za091232		JENDL/AC-2008	JENDL-4
^{233}Pa	za091233		ENDF/B-VII	ENDF/B-VII.1β0
Uranium				
^{230}U	za092230		JENDL/AC-2008	JENDL-4
^{231}U	za092231		JENDL/AC-2008	JENDL-4
^{236}U	za092236		ENDF/B-VII **	ENDF/B-VII
^{239}U	za092239		ENDF/B-VII	ENDF/B-VII.1
Neptunium				
^{234}Np	za093234		JENDL/AC-2008	JENDL-4
^{235}Np	za093235		JENDL/AC-2008	JENDL-4
^{236}Np	za093236		JENDL/AC-2008	JENDL-4
^{237}Np	za093237		JENDL/AC-2008	ENDF/B-VII.1β0
^{238}Np	za093238		JENDL/AC-2008	JENDL-4
^{239}Np	za093239		JENDL/AC-2008	JENDL-4
Plutonium				
^{236}Pu	za094236		JENDL/AC-2008	JENDL-4
^{237}Pu	za094237		JENDL/AC-2008	JENDL-4
^{240}Pu	za094240		ENDF/B-VII.1 **	ENDF/B-VII.1
^{241}Pu	za094241		JENDL/AC-2008	JENDL-4
^{242}Pu	za094242		JENDL/AC-2008	JENDL-4
^{243}Pu	za094243		ENDL99	CENDL-3.1
^{244}Pu	za094244		JENDL/AC-2008	JENDL-4
^{245}Pu	za094245		JENDL/AC-2008	CENDL-3.1
^{246}Pu	za094246		JENDL/AC-2008	JENDL-4
Americium				
^{240}Am	za095240		LLNL2009	JENDL-4
^{244}Am	za095244m		ENDF/B-VII	JENDL-4
Curium				
^{240}Cm	za096240		JENDL/AC-2008	JENDL-4
^{241}Cm	za096241		JENDL/AC-2008	JENDL-4
^{242}Cm	za096242		JENDL/AC-2008	JENDL-4
^{243}Cm	za096243		JENDL/AC-2008	JENDL-4
^{244}Cm	za096244		JENDL/AC-2008	JENDL-4
^{245}Cm	za096245		JENDL/AC-2008	JENDL-4
^{246}Cm	za096246		JENDL/AC-2008	JENDL-4
^{247}Cm	za096247		JENDL/AC-2008	JENDL-4
^{248}Cm	za096248		JENDL/AC-2008	JENDL-4
^{249}Cm	za096249		JENDL/AC-2008	JENDL-4
^{250}Cm	za096250		JENDL/AC-2008	JENDL-4
Berkelium				
^{245}Bk	za097245		JENDL/AC-2008	JENDL-4
^{246}Bk	za097246		JENDL/AC-2008	JENDL-4
^{247}Bk	za097247		JENDL/AC-2008	JENDL-4
^{248}Bk	za097248		JENDL/AC-2008	JENDL-4
^{249}Bk	za097249		JENDL/AC-2008	JENDL-4
^{250}Bk	za097250		JENDL/AC-2008	JENDL-4
Californium				
^{249}Cf	za098249		JENDL/AC-2008	JENDL-4
^{250}Cf	za098250		JENDL/AC-2008	JENDL-4
^{252}Cf	za098252		JENDL/AC-2008	JENDL-4
^{253}Cf	za098253		JENDL/AC-2008	JENDL-4
^{254}Cf	za098254		JENDL/AC-2008	JENDL-4