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## Displacement Kerma Cross Sections for Neutron Interactions in Molybdenum

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Modifications to the displacement kerma cross section methods employed in the NJOY99 nuclear data processing code are described. Calculations were performed with the modified code for molybdenum using ENDF-6 neutron interaction data.

Results are presented for a range of plausible  $E_d$  values.

**KEYWORDS:** *dpa, radiation damage, NJOY, displacement threshold energy,  $E_d$*

### 1. Introduction

Atomic displacements are accepted as the principal underlying radiation damage mechanism for energetic neutron radiation in many materials. It is believed that accumulated displacements at the microscopic level (i.e., radiation damage) form the basis for the changes in material properties at the macroscopic level (i.e., radiation effects). Therefore, it is important to quantify the amount of displacements caused to such materials in the radiation field corresponding to their intended use. Such a characterization is seldom possible and it is common practice to conduct accelerated irradiation tests in which a comparable, albeit preferably much stronger, irradiation field is used. Theory is then used to correlate the observable experimental effects to the expected behavior in the actual intended operational field. If it is accepted that the total number of accumulated displacements determines the effect in the material, then displacements per atom (dpa) would provide a means for correlating damage in a given experimental testing field to damage in the expected operational field. It follows that a reliable method for ascertaining the number of displacements is highly desirable for all possible irradiation fields. Dpa is a commonly accepted measure for radiation damage at the macroscopic level. The rational calculation of dpa requires the availability of displacement kerma cross sections for the materials of interest. The displacement kerma cross section has been a useful tool in calculating dpa because it allows the integration of the energy-dependent response of the material to the neutron radiation environment. This paper presents estimates for displacement kerma cross sections for molybdenum, which is a material of potential interest for advanced reactor concepts.

Previous work [1-5] in this area has largely concentrated on monatomic metals and semiconductors, as reflected in several ASTM standards. [6-8] Thompson and Wright [5] investigated damage in graphite, and derived a formulation for the damage function from first principles. In a more common approach, [1,2] others performed calculations of displacement kerma cross sections based on the NJOY89 code [9] for iron, silicon, and gallium arsenide. Griffin, et al., [3] also used calculations based on NJOY89 and calculated the displacement damage function for gallium arsenide and silicon, but included comparisons to experiments in semiconductor devices. Both teams included the effects of primary recoils and emitted charged particles for single particle emission reactions and (n,n' particle) interactions with single charged

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particle emissions. Heinisch, et al., [4] calculated dpa in silicon carbide for several reactor spectra based on the method of the SPECOMP code. [10]

The present work updates the modifications made in References 1 and 2 to the NJOY99 code, [11] adds generalized particle emission and incorporates other modifications to model non-monatomic solids more accurately. As in References 1 and 2, this work incorporates the modified Kinchin-Pease [12] (or Norgett-Robinson-Torrens) model in the calculation of the displacement kerma cross section. These displacement kerma cross sections, recently generated as part of a research effort at INEEL to improve methods for dpa calculation in monatomic and polyatomic solids, have important applications, especially in the design and analysis of the new fourth-generation (Gen-IV) nuclear power reactors.

## 2. Theory

The NJOY99 code [11] is widely used for nuclear data processing. It operates on evaluated cross section data and transforms them into pointwise or groupwise cross sections suitable for use in other nuclear analysis codes. Functionality is available to reconstruct and Doppler-broaden resonances, construct kerma data, and produce a variety of output formats. The HEATR module within NJOY provides the facility for computing displacement kerma cross sections. The displacement kerma cross section is the product of the reaction cross section and the damage energy, or the energy transferred to lattice atoms that can result in displacements resulting from said reaction summed over all reactions.

The damage energy is calculated by determining the emitted particles from the reaction, calculating the kinetic energy carried away for each emitted particle, and then computing the fraction of this energy available to cause displacements in the lattice. This latter computation uses the Robinson version [13] of the Lindhard partition function [14] for each emitted particle. The Lindhard partition function is essentially a damage efficiency, describing the fraction of the particle energy available to cause atomic displacement damage in the lattice. It accounts for the effects of the differences in recoil particle and lattice atom electronic charges and masses on the damage energy. Conservation of energy is maintained for each reaction by assuring that the sum of the energies of the primary knock-on atom (PKA) and all emitted particles is equal to the sum of the incident neutron energy and the energy released by the reaction.

The partition of the reaction energy between the PKA and emitted particles is determined by the kinematics of the particle emission. For single particle emission, or charged particle emission following emission of one or more neutrons, the kinematics equations are easily solved. However, for multiple charged particle emissions, the equations are underdetermined, and a closed form solution is not possible without additional information. To provide an approximate treatment for this situation, a two-stage process was used. First, the PKA energy was calculated by solving the kinematics equations for the emission of a “lump” consisting of all the emitted charged particles:

$$E_R = A(B \cdot E_p + Q) + C \cdot D \cdot E_p - 2\mu_s \sqrt{A(B \cdot E_p + Q)(C \cdot D \cdot E_p)} \quad (1)$$

The “lump” energy is given by:

$$E_b = C(B \cdot E_p + Q) + A \cdot D \cdot E_p - 2\mu_s \sqrt{C(B \cdot E_p + Q)(A \cdot D \cdot E_p)} \quad (2)$$

where the following are defined for Equations (1) and (2):

$$A = \frac{m_b}{m_b + m_R}, \quad B = \frac{m_T}{m_T + m_p}, \quad C = \frac{m_R}{m_b + m_R}, \quad D = \frac{m_p}{m_T + m_p}$$

with p, T, R, and b denoting the incident particle, target nucleus, PKA recoil, and “lump”, respectively, and m, E, Q, and  $\mu_s$  having their usual meanings. The “lump” energy is then divided amongst the N emitted particles in inverse proportion to the particle masses, while maintaining the fundamental kinematic ratios:

$$E_j = \frac{m_j^{\max}}{m_j \sum_{i=1}^N \frac{m_i^{\max}}{m_i}} E_b \quad (3)$$

Thus, a particle of mass two will carry away twice as much kinetic energy as a particle of mass four. Numerical bracketing experiments have shown that this approximation will introduce errors of no more than 1-2% in the damage energy calculation, which is well within the uncertainty of the displacement kerma cross section calculation.

The modified Kinchin-Pease model of displacement damage, also referred to as the NRT model, [12] is a widely accepted method for calculating damage in materials, especially metals. The model was originally formulated as a way to provide an expression for the number of displacements caused by a particle with damage energy E; however, it may be easily recast to provide an expression for the damage energy. When conforming to the NRT model, the equation for the damage energy is given by:

$$E = \begin{cases} 0, & E < E_d \\ 2.5E_d, & E_d < E < 2.5E_d \\ E, & E \geq 2.5E_d \end{cases} \quad (4)$$

where  $E_d$  is the average threshold energy for displacement. It is this form that is implemented in the modified NJOY99, and applied to each PKA and emitted particle from all reactions.

### 3. Implementation

The HEATR module of NJOY99 was modified to incorporate both the modified Kinchin-Pease (NRT) model of displacement damage and the partition of energy between emitted charged particles and recoil nucleus. This energy partition model is applied only to reactions that do not have a detailed energy-angle description of particle emission (File 6) in the ENDF neutron reaction data. All allowed ENDF reaction types emitting secondary charged particles (MT numbers in the ranges 11-45 and 102-117) were modeled by this modified method. An

additional option flag was added to the HEATR user input to allow the user to either bypass or invoke the NRT model. Also, two other new input parameters allow the user to make the distinction between recoiling and lattice nuclei in the Lindhard partition function, thus more accurately modeling damage in non-monatomic solids.

The cross section data used for the NJOY calculations were obtained from ENDF/B-VI whenever possible. For verification of the modified code, comparisons against published results for Fe, Si and GaAs were carried out. Calculations for the iron isotopes used the most recent revisions of the ENDF data. Elemental gallium data were obtained from ENDF/B-V, as no new evaluation has been performed for gallium for ENDF/B-VI. The elemental arsenic data available in ENDF/B-V and ENDF/B-VI are incomplete and unsuitable for the displacement kerma cross section computations; therefore, data for this element were obtained from the LENDL-V data library. Values for the displacement threshold energy,  $E_d$ , were obtained from the literature. Elemental values were used for iron. [15] Values for gallium and arsenic in gallium arsenide were obtained from Griffin. [3]

The threshold displacement energy  $E_d$  for molybdenum was calculated by molecular dynamics simulations using the “embedded atom method” code DYN85 (obtained from Sandia-Livermore), with semi-empirical potentials for Mo taken from the literature. [16] While these potential functions were not intended to describe interactions between atoms at very small separations as occur during high-energy collisions, they nonetheless produce values for the self-interstitial formation energies that are in reasonable agreement with experimental values, and so are believed to be adequate for these calculations of  $E_d$ . The latter calculations were accomplished by giving a single Mo atom, initially at a lattice site in a periodic cell of 4000 Mo atoms at temperature 0 K, an initial velocity sufficient to produce a Frenkel pair; the kinetic energy to which that minimum velocity corresponds is then  $E_d$ . For collisions in the  $\langle 100 \rangle$ ,  $\langle 110 \rangle$ ,  $\langle 111 \rangle$ , and  $\langle 210 \rangle$  crystallographic directions, the calculated values of  $E_d$  were 27.5 eV, 38.9 eV, 46.3 eV, and 66.4 eV, respectively. Collisions in the  $\langle 100 \rangle$  direction is expected to produce the minimum  $E_d$  values. These calculated values are very similar to those reported in the literature. [17] However, there is significant uncertainty in the displacement threshold energy value for Mo. To account for this uncertainty, a range of plausible  $E_d$  values (40-80 eV) that bracketed the range of accepted values (60-70 eV) from the literature was used for the displacement kerma cross section calculations.

#### 4. Results

Verification of the code modifications was performed by comparison to existing ASTM standards for iron, silicon, and gallium arsenide. The iron ASTM standards data were reproduced exactly. The new silicon and gallium arsenide results reflect improvements made to the NJOY cross section processing modules between 1991 and the present. This was verified by introducing the same changes into an older version of NJOY (NJOY89). The older code thus modified reproduced the results of the standards and the literature.

Displacement kerma cross sections were calculated for molybdenum using the modified version of NJOY99 described above. Calculations were performed at the mean value of  $E_d$  (65 eV), and for a range of plausible values bracketing this mean. Data for the mean value of  $E_d$  are

shown in Table 1. The results for molybdenum are presented in Figure 1 for the range of plausible  $E_d$  values discussed above, with the data shown in tabular form in Table 2.

The effects of the displacement threshold energy variations, as shown in Figure 1, are most obvious in two energy ranges – 1-10 keV and below 10 eV. Differences between the displacement kerma cross sections for the extreme values of  $E_d$  in the thermal range are approximately 20%. The steep discontinuity at the low keV range denotes the neutron energy above which the recoils from elastic scattering exceed the displacement threshold energy for Mo, and thus are able to cause displacements. Appropriate interpolation between the curves allows selection of any  $E_d$  value in the range, and confidence bands for the resulting displacement kerma cross sections may be estimated from the other values. This method allows improved displacement kerma cross section calculations to be made as future work refines knowledge of the  $E_d$  value for Mo.

## 5. Discussion

When the  $E_d$  value used to derive the table has a low uncertainty, then the application is straightforward. The computation of dpa consists of folding the neutron spectrum with the displacement kerma cross section, and multiplication of the resulting value by the total neutron fluence. For multigroup (discrete) neutron spectrum calculations, energy interpolation of the spectrum may be required to unify the energy grids of the spectrum and the displacement kerma cross section. For continuous energy (stochastic) neutron spectrum calculations, the folding process may be performed directly in the tally by using the displacement kerma cross section as an energy-dependent response function.

Table 2 shows values for the displacement kerma cross section for Mo assuming a range of plausible values of  $E_d$ . The table includes data only for the energy region that is strongly sensitive to changes in  $E_d$ , as seen on Figure 1. If a more precise knowledge of  $E_d$  cannot be obtained, the table can be used to estimate the uncertainty in the dpa calculation. This may be accomplished by calculating the dpa with the average value of  $E_d$  and using the extreme values from the table to ascertain the error band on the dpa estimate. If a trusted value of  $E_d$  is available, then the modified NJOY99 run can be repeated to produce a better estimate for the displacement kerma cross section. An alternative is to interpolate between the tabulated values to calculate an estimated displacement kerma cross section for the more precise  $E_d$  value. In all cases, discrepancies between the estimated values and the unknown real values of the resulting dpa values should be small. An exception would be the extreme case(s) where the neutron spectrum would have an extremely large component in the energy region where the sensitivity of the displacement kerma cross section with respect to  $E_d$  is large (below 10 keV for Mo).

## 6. Conclusions

Displacement kerma cross sections for the characterization of radiation testing fields at or near room temperature have been developed and presented graphically and in tabular forms suitable for the direct computation of dpa estimates for Mo. The proper method of applying these data was also presented. In particular, the correct use of the data for low-confidence values of the displacement threshold energy was shown.

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**Table 1** ENDF/B-VI based displacement kerma cross sections (eV-barns) for molybdenum (T=300K,  $E_d = 65\text{eV}$  in the SAND-IIA 640-group energy structure.

Lower Energy (eV)	Upper Energy (eV)	Mo	Lower Energy (eV)	Upper Energy (eV)	Mo	Lower Energy (eV)	Upper Energy (eV)	Mo	Lower Energy (eV)	Upper Energy (eV)	Mo
1.000E-4	1.050E-4	5.330E+3	4.000E-3	4.250E-3	8.402E+2	1.425E-1	1.500E-1	1.411E+2	5.750E+0	6.000E+0	2.291E+1
1.050E-4	1.100E-4	5.204E+3	4.250E-3	4.500E-3	8.158E+2	1.500E-1	1.600E-1	1.371E+2	6.000E+0	6.300E+0	2.235E+1
1.100E-4	1.150E-4	5.087E+3	4.500E-3	4.750E-3	7.935E+2	1.600E-1	1.700E-1	1.329E+2	6.300E+0	6.600E+0	2.181E+1
1.150E-4	1.200E-4	4.978E+3	4.750E-3	5.000E-3	7.729E+2	1.700E-1	1.800E-1	1.290E+2	6.600E+0	6.900E+0	2.129E+1
1.200E-4	1.275E-4	4.850E+3	5.000E-3	5.250E-3	7.538E+2	1.800E-1	1.900E-1	1.255E+2	6.900E+0	7.200E+0	2.081E+1
1.275E-4	1.350E-4	4.710E+3	5.250E-3	5.500E-3	7.360E+2	1.900E-1	2.000E-1	1.222E+2	7.200E+0	7.600E+0	2.032E+1
1.350E-4	1.425E-4	4.581E+3	5.500E-3	5.750E-3	7.195E+2	2.000E-1	2.100E-1	1.192E+2	7.600E+0	8.000E+0	1.985E+1
1.425E-4	1.500E-4	4.462E+3	5.750E-3	6.000E-3	7.040E+2	2.100E-1	2.200E-1	1.164E+2	8.000E+0	8.400E+0	1.931E+1
1.500E-4	1.600E-4	4.334E+3	6.000E-3	6.300E-3	6.881E+2	2.200E-1	2.300E-1	1.138E+2	8.400E+0	8.800E+0	1.876E+1
1.600E-4	1.700E-4	4.201E+3	6.300E-3	6.600E-3	6.719E+2	2.300E-1	2.400E-1	1.113E+2	8.800E+0	9.200E+0	1.850E+1
1.700E-4	1.800E-4	4.079E+3	6.600E-3	6.900E-3	6.568E+2	2.400E-1	2.500E-1	1.085E+2	9.200E+0	9.600E+0	1.874E+1
1.800E-4	1.900E-4	3.967E+3	6.900E-3	7.200E-3	6.427E+2	2.500E-1	2.700E-1	1.053E+2	9.600E+0	1.000E+1	1.979E+1
1.900E-4	2.000E-4	3.864E+3	7.200E-3	7.600E-3	6.273E+2	2.700E-1	2.800E-1	1.029E+2	1.000E+1	1.050E+1	2.364E+1
2.000E-4	2.100E-4	3.769E+3	7.600E-3	8.000E-3	6.110E+2	2.800E-1	3.000E-1	1.002E+2	1.050E+1	1.100E+1	3.491E+1
2.100E-4	2.200E-4	3.680E+3	8.000E-3	8.400E-3	5.959E+2	3.000E-1	3.200E-1	9.695E+1	1.100E+1	1.150E+1	7.532E+1
2.200E-4	2.300E-4	3.597E+3	8.400E-3	8.800E-3	5.819E+2	3.200E-1	3.400E-1	9.396E+1	1.150E+1	1.200E+1	6.422E+2
2.300E-4	2.400E-4	3.520E+3	8.800E-3	9.200E-3	5.688E+2	3.400E-1	3.600E-1	9.123E+1	1.200E+1	1.275E+1	1.211E+3
2.400E-4	2.550E-4	3.430E+3	9.200E-3	9.600E-3	5.566E+2	3.600E-1	3.800E-1	8.873E+1	1.275E+1	1.350E+1	6.196E+1
2.550E-4	2.700E-4	3.330E+3	9.600E-3	1.000E-2	5.451E+2	3.800E-1	4.000E-1	8.642E+1	1.350E+1	1.425E+1	2.772E+1
2.700E-4	2.800E-4	3.254E+3	1.000E-2	1.050E-2	5.330E+2	4.000E-1	4.250E-1	8.405E+1	1.425E+1	1.500E+1	2.023E+1
2.800E-4	3.000E-4	3.169E+3	1.050E-2	1.100E-2	5.204E+2	4.250E-1	4.500E-1	8.161E+1	1.500E+1	1.600E+1	1.747E+1
3.000E-4	3.200E-4	3.065E+3	1.100E-2	1.150E-2	5.088E+2	4.500E-1	4.750E-1	7.938E+1	1.600E+1	1.700E+1	1.959E+1
3.200E-4	3.400E-4	2.970E+3	1.150E-2	1.200E-2	4.978E+2	4.750E-1	5.000E-1	7.733E+1	1.700E+1	1.800E+1	1.567E+1
3.400E-4	3.600E-4	2.884E+3	1.200E-2	1.275E-2	4.851E+2	5.000E-1	5.250E-1	7.541E+1	1.800E+1	1.900E+1	1.568E+1
3.600E-4	3.800E-4	2.805E+3	1.275E-2	1.350E-2	4.710E+2	5.250E-1	5.500E-1	7.364E+1	1.900E+1	2.000E+1	1.600E+1
3.800E-4	4.000E-4	2.732E+3	1.350E-2	1.425E-2	4.581E+2	5.500E-1	5.750E-1	7.198E+1	2.000E+1	2.100E+1	1.654E+1
4.000E-4	4.250E-4	2.657E+3	1.425E-2	1.500E-2	4.462E+2	5.750E-1	6.000E-1	7.043E+1	2.100E+1	2.200E+1	1.724E+1
4.250E-4	4.500E-4	2.580E+3	1.500E-2	1.600E-2	4.335E+2	6.000E-1	6.300E-1	6.884E+1	2.200E+1	2.300E+1	1.811E+1
4.500E-4	4.750E-4	2.509E+3	1.600E-2	1.700E-2	4.201E+2	6.300E-1	6.600E-1	6.725E+1	2.300E+1	2.400E+1	1.917E+1
4.750E-4	5.000E-4	2.444E+3	1.700E-2	1.800E-2	4.079E+2	6.600E-1	6.900E-1	6.572E+1	2.400E+1	2.550E+1	2.078E+1
5.000E-4	5.250E-4	2.384E+3	1.800E-2	1.900E-2	3.968E+2	6.900E-1	7.200E-1	6.431E+1	2.550E+1	2.700E+1	2.318E+1
5.250E-4	5.500E-4	2.327E+3	1.900E-2	2.000E-2	3.864E+2	7.200E-1	7.600E-1	6.277E+1	2.700E+1	2.800E+1	2.571E+1
5.500E-4	5.750E-4	2.275E+3	2.000E-2	2.100E-2	3.769E+2	7.600E-1	8.000E-1	6.114E+1	2.800E+1	3.000E+1	2.965E+1
5.750E-4	6.000E-4	2.226E+3	2.100E-2	2.200E-2	3.680E+2	8.000E-1	8.400E-1	5.962E+1	3.000E+1	3.200E+1	3.697E+1
6.000E-4	6.300E-4	2.176E+3	2.200E-2	2.300E-2	3.598E+2	8.400E-1	8.800E-1	5.822E+1	3.200E+1	3.400E+1	4.825E+1
6.300E-4	6.600E-4	2.125E+3	2.300E-2	2.400E-2	3.520E+2	8.800E-1	9.200E-1	5.692E+1	3.400E+1	3.600E+1	6.691E+1
6.600E-4	6.900E-4	2.077E+3	2.400E-2	2.550E-2	3.430E+2	9.200E-1	9.600E-1	5.568E+1	3.600E+1	3.800E+1	1.013E+2
6.900E-4	7.200E-4	2.032E+3	2.550E-2	2.700E-2	3.331E+2	9.600E-1	1.000E+0	5.454E+1	3.800E+1	4.000E+1	1.761E+2
7.200E-4	7.600E-4	1.984E+3	2.700E-2	2.800E-2	3.254E+2	1.000E+0	1.050E+0	5.333E+1	4.000E+1	4.250E+1	4.747E+2
7.600E-4	8.000E-4	1.932E+3	2.800E-2	3.000E-2	3.169E+2	1.050E+0	1.100E+0	5.207E+1	4.250E+1	4.500E+1	1.866E+4
8.000E-4	8.400E-4	1.884E+3	3.000E-2	3.200E-2	3.065E+2	1.100E+0	1.150E+0	5.090E+1	4.500E+1	4.750E+1	1.924E+4
8.400E-4	8.800E-4	1.840E+3	3.200E-2	3.400E-2	2.971E+2	1.150E+0	1.200E+0	4.980E+1	4.750E+1	5.000E+1	4.456E+2
8.800E-4	9.200E-4	1.799E+3	3.400E-2	3.600E-2	2.885E+2	1.200E+0	1.275E+0	4.853E+1	5.000E+1	5.250E+1	1.456E+2
9.200E-4	9.600E-4	1.760E+3	3.600E-2	3.800E-2	2.806E+2	1.275E+0	1.350E+0	4.715E+1	5.250E+1	5.500E+1	7.278E+1
9.600E-4	1.000E-3	1.724E+3	3.800E-2	4.000E-2	2.733E+2	1.350E+0	1.425E+0	4.584E+1	5.500E+1	5.750E+1	4.957E+1
1.000E-3	1.050E-3	1.685E+3	4.000E-2	4.250E-2	2.657E+2	1.425E+0	1.500E+0	4.465E+1	5.750E+1	6.000E+1	3.002E+1
1.050E-3	1.100E-3	1.646E+3	4.250E-2	4.500E-2	2.581E+2	1.500E+0	1.600E+0	4.337E+1	6.000E+1	6.300E+1	2.245E+1
1.100E-3	1.150E-3	1.609E+3	4.500E-2	4.750E-2	2.510E+2	1.600E+0	1.700E+0	4.203E+1	6.300E+1	6.600E+1	1.981E+1
1.150E-3	1.200E-3	1.574E+3	4.750E-2	5.000E-2	2.444E+2	1.700E+0	1.800E+0	4.081E+1	6.600E+1	6.900E+1	3.212E+1
1.200E-3	1.275E-3	1.534E+3	5.000E-2	5.250E-2	2.384E+2	1.800E+0	1.900E+0	3.970E+1	6.900E+1	7.200E+1	1.722E+3
1.275E-3	1.350E-3	1.489E+3	5.250E-2	5.500E-2	2.328E+2	1.900E+0	2.000E+0	3.867E+1	7.200E+1	7.600E+1	4.455E+1
1.350E-3	1.425E-3	1.449E+3	5.500E-2	5.750E-2	2.276E+2	2.000E+0	2.100E+0	3.771E+1	7.600E+1	8.000E+1	1.367E+1
1.425E-3	1.500E-3	1.411E+3	5.750E-2	6.000E-2	2.227E+2	2.100E+0	2.200E+0	3.682E+1	8.000E+1	8.400E+1	8.652E+0
1.500E-3	1.600E-3	1.371E+3	6.000E-2	6.300E-2	2.176E+2	2.200E+0	2.300E+0	3.599E+1	8.400E+1	8.800E+1	6.929E+0
1.600E-3	1.700E-3	1.328E+3	6.300E-2	6.600E-2	2.125E+2	2.300E+0	2.400E+0	3.521E+1	8.800E+1	9.200E+1	6.840E+0
1.700E-3	1.800E-3	1.290E+3	6.600E-2	6.900E-2	2.077E+2	2.400E+0	2.500E+0	3.431E+1	9.200E+1	9.600E+1	8.207E+0
1.800E-3	1.900E-3	1.255E+3	6.900E-2	7.200E-2	2.033E+2	2.550E+0	2.700E+0	3.332E+1	9.600E+1	1.000E+2	7.484E+0
1.900E-3	2.000E-3	1.222E+3	7.200E-2	7.600E-2	1.984E+2	2.700E+0	2.800E+0	3.255E+1	1.000E+2	1.050E+2	9.754E+0
2.000E-3	2.100E-3	1.192E+3	7.600E-2	8.000E-2	1.933E+2	2.800E+0	3.000E+0	3.172E+1	1.050E+2	1.100E+2	1.847E+1
2.100E-3	2.200E-3	1.164E+3	8.000E-2	8.400E-2	1.885E+2	3.000E+0	3.200E+0	3.067E+1	1.100E+2	1.150E+2	1.840E+2
2.200E-3	2.300E-3	1.138E+3	8.400E-2	8.800E-2	1.841E+2	3.200E+0	3.400E+0	2.972E+1	1.150E+2	1.200E+2	4.477E+1
2.300E-3	2.400E-3	1.113E+3	8.800E-2	9.200E-2	1.799E+2	3.400E+0	3.600E+0	2.886E+1	1.200E+2	1.275E+2	1.254E+2
2.400E-3	2.550E-3	1.085E+3	9.200E-2	9.600E-2	1.761E+2	3.600E+0	3.800E+0	2.807E+1	1.275E+2	1.350E+2	9.658E+2
2.550E-3	2.700E-3	1.053E+3	9.600E-2	1.000E-1	1.724E+2	3.800E+0	4.000E+0	2.740E+1	1.350E+2	1.425E+2	1.355E+3
2.700E-3	2.800E-3	1.029E+3	1.000E-1	1.050E-1	1.686E+2	4.000E+0	4.250E+0	2.722E+1	1.425E+2	1.500E+2	2.635E+1
2.800E-3	3.000E-3	1.002E+3	1.050E-1	1.100E-1	1.646E+2	4.250E+0	4.500E+0	2.656E+1	1.500E+2	1.600E+2	2.882E+2
3.000E-3	3.200E-3	9.691E+2	1.100E-1	1.150E-1	1.609E+2	4.500E+0	4.750E+0	2.589E+1	1.600E+2	1.700E+2	4.074E+1
3.200E-3	3.400E-3	9.393E+2	1.150E-1	1.200E-1	1.574E+2	4.750E+0	5.000E+0	2.524E+1	1.700E+2	1.800E+2	3.541E+0
3.400E-3	3.600E-3	9.121E+2	1.200E-1	1.275E-1	1.534E+2	5.000E+0	5.250E+0	2.462E+1	1.800E+2	1.900E+2	2.346E+0
3.600E-3	3.800E-3	8.871E+2	1.275E-1	1.350E-1	1.490E+2	5.250E+0	5.500E+0	2.403E+1	1.900E+2	2.000E+2	1.801E+0
3.800E-3	4.000E-3	8.640E+2	1.350E-1	1.425E-1	1.449E+2	5.500E+0	5.750E+0	2.346E+1	2.000E+2	2.100E+2	5.648E+0



Lower Energy (eV)	Upper Energy (eV)	Mo	Lower Energy (eV)	Upper Energy (eV)	Mo	Lower Energy (eV)	Upper Energy (eV)	Mo	Lower Energy (eV)	Upper Energy (eV)	Mo
2.100E+2	2.200E+2	2.731E+1	1.000E+4	1.050E+4	1.651E+3	5.250E+5	5.500E+5	5.105E+4	7.200E+6	7.300E+6	1.836E+5
2.200E+2	2.300E+2	2.677E+1	1.050E+4	1.100E+4	1.753E+3	5.500E+5	5.750E+5	5.238E+4	7.300E+6	7.400E+6	1.856E+5
2.300E+2	2.400E+2	1.547E+0	1.100E+4	1.150E+4	1.819E+3	5.750E+5	6.000E+5	5.363E+4	7.400E+6	7.500E+6	1.876E+5
2.400E+2	2.550E+2	2.720E+1	1.150E+4	1.200E+4	1.885E+3	6.000E+5	6.300E+5	5.492E+4	7.500E+6	7.600E+6	1.896E+5
2.550E+2	2.700E+2	1.111E+2	1.200E+4	1.275E+4	1.967E+3	6.300E+5	6.600E+5	5.623E+4	7.600E+6	7.700E+6	1.916E+5
2.700E+2	2.800E+2	5.460E+0	1.275E+4	1.350E+4	2.059E+3	6.600E+5	6.900E+5	5.743E+4	7.700E+6	7.800E+6	1.936E+5
2.800E+2	3.000E+2	1.828E+2	1.350E+4	1.425E+4	2.146E+3	6.900E+5	7.200E+5	5.854E+4	7.800E+6	7.900E+6	1.956E+5
3.000E+2	3.200E+2	4.343E+1	1.425E+4	1.500E+4	2.239E+3	7.200E+5	7.600E+5	5.972E+4	7.900E+6	8.000E+6	1.975E+5
3.200E+2	3.400E+2	2.691E+1	1.500E+4	1.600E+4	2.356E+3	7.600E+5	8.000E+5	6.100E+4	8.000E+6	8.100E+6	1.996E+5
3.400E+2	3.600E+2	8.733E+2	1.600E+4	1.700E+4	2.493E+3	8.000E+5	8.400E+5	6.218E+4	8.100E+6	8.200E+6	2.019E+5
3.600E+2	3.800E+2	1.102E+3	1.700E+4	1.800E+4	2.624E+3	8.400E+5	8.800E+5	6.321E+4	8.200E+6	8.300E+6	2.042E+5
3.800E+2	4.000E+2	1.862E+2	1.800E+4	1.900E+4	2.749E+3	8.800E+5	9.200E+5	6.412E+4	8.300E+6	8.400E+6	2.065E+5
4.000E+2	4.250E+2	1.168E+1	1.900E+4	2.000E+4	2.881E+3	9.200E+5	9.600E+5	6.488E+4	8.400E+6	8.500E+6	2.088E+5
4.250E+2	4.500E+2	6.358E+2	2.000E+4	2.100E+4	3.019E+3	9.600E+5	1.000E+6	6.555E+4	8.500E+6	8.600E+6	2.098E+5
4.500E+2	4.750E+2	1.614E+3	2.100E+4	2.200E+4	3.158E+3	1.000E+6	1.100E+6	6.765E+4	8.600E+6	8.700E+6	2.097E+5
4.750E+2	5.000E+2	3.440E+1	2.200E+4	2.300E+4	3.296E+3	1.100E+6	1.200E+6	7.103E+4	8.700E+6	8.800E+6	2.095E+5
5.000E+2	5.250E+2	8.186E+1	2.300E+4	2.400E+4	3.429E+3	1.200E+6	1.300E+6	7.413E+4	8.800E+6	8.900E+6	2.093E+5
5.250E+2	5.500E+2	6.890E+0	2.400E+4	2.550E+4	3.594E+3	1.300E+6	1.400E+6	7.733E+4	8.900E+6	9.000E+6	2.090E+5
5.500E+2	5.750E+2	4.556E+2	2.550E+4	2.700E+4	3.799E+3	1.400E+6	1.500E+6	8.114E+4	9.000E+6	9.100E+6	2.096E+5
5.750E+2	6.000E+2	2.786E+0	2.700E+4	2.800E+4	3.971E+3	1.500E+6	1.600E+6	8.494E+4	9.100E+6	9.200E+6	2.110E+5
6.000E+2	6.300E+2	2.306E+2	2.800E+4	3.000E+4	4.168E+3	1.600E+6	1.700E+6	8.790E+4	9.200E+6	9.300E+6	2.125E+5
6.300E+2	6.600E+2	2.316E+1	3.000E+4	3.200E+4	4.441E+3	1.700E+6	1.800E+6	9.058E+4	9.300E+6	9.400E+6	2.139E+5
6.600E+2	6.900E+2	5.884E+2	3.200E+4	3.400E+4	4.722E+3	1.800E+6	1.900E+6	9.247E+4	9.400E+6	9.500E+6	2.153E+5
6.900E+2	7.200E+2	6.501E+0	3.400E+4	3.600E+4	4.999E+3	1.900E+6	2.000E+6	9.405E+4	9.500E+6	9.600E+6	2.165E+5
7.200E+2	7.600E+2	2.711E+1	3.600E+4	3.800E+4	5.276E+3	2.000E+6	2.100E+6	9.560E+4	9.600E+6	9.700E+6	2.176E+5
7.600E+2	8.000E+2	1.782E+2	3.800E+4	4.000E+4	5.558E+3	2.100E+6	2.200E+6	9.720E+4	9.700E+6	9.800E+6	2.186E+5
8.000E+2	8.400E+2	3.624E+2	4.000E+4	4.250E+4	5.874E+3	2.200E+6	2.300E+6	9.859E+4	9.800E+6	9.900E+6	2.197E+5
8.400E+2	8.800E+2	2.580E+1	4.250E+4	4.500E+4	6.224E+3	2.300E+6	2.400E+6	9.980E+4	9.900E+6	1.000E+7	2.208E+5
8.800E+2	9.200E+2	1.556E+2	4.500E+4	4.750E+4	6.574E+3	2.400E+6	2.500E+6	1.009E+5	1.000E+7	1.010E+7	2.209E+5
9.200E+2	9.600E+2	1.099E+2	4.750E+4	5.000E+4	6.926E+3	2.500E+6	2.600E+6	1.025E+5	1.010E+7	1.020E+7	2.200E+5
9.600E+2	1.000E+3	1.334E+2	5.000E+4	5.250E+4	7.242E+3	2.600E+6	2.700E+6	1.048E+5	1.020E+7	1.030E+7	2.191E+5
1.000E+3	1.050E+3	1.134E+2	5.250E+4	5.500E+4	7.523E+3	2.700E+6	2.800E+6	1.069E+5	1.030E+7	1.040E+7	2.182E+5
1.050E+3	1.100E+3	1.115E+2	5.500E+4	5.750E+4	7.794E+3	2.800E+6	2.900E+6	1.090E+5	1.040E+7	1.050E+7	2.173E+5
1.100E+3	1.150E+3	1.097E+2	5.750E+4	6.000E+4	8.056E+3	2.900E+6	3.000E+6	1.110E+5	1.050E+7	1.060E+7	2.176E+5
1.150E+3	1.200E+3	1.078E+2	6.000E+4	6.300E+4	8.386E+3	3.000E+6	3.100E+6	1.128E+5	1.060E+7	1.070E+7	2.194E+5
1.200E+3	1.275E+3	1.055E+2	6.300E+4	6.600E+4	8.788E+3	3.100E+6	3.200E+6	1.144E+5	1.070E+7	1.080E+7	2.211E+5
1.275E+3	1.350E+3	1.028E+2	6.600E+4	6.900E+4	9.193E+3	3.200E+6	3.300E+6	1.158E+5	1.080E+7	1.090E+7	2.228E+5
1.350E+3	1.425E+3	1.000E+2	6.900E+4	7.200E+4	9.600E+3	3.300E+6	3.400E+6	1.173E+5	1.090E+7	1.100E+7	2.245E+5
1.425E+3	1.500E+3	9.725E+1	7.200E+4	7.600E+4	1.007E+4	3.400E+6	3.500E+6	1.187E+5	1.100E+7	1.110E+7	2.261E+5
1.500E+3	1.600E+3	9.415E+1	7.600E+4	8.000E+4	1.061E+4	3.500E+6	3.600E+6	1.201E+5	1.110E+7	1.120E+7	2.276E+5
1.600E+3	1.700E+3	9.333E+1	8.000E+4	8.400E+4	1.115E+4	3.600E+6	3.700E+6	1.215E+5	1.120E+7	1.130E+7	2.291E+5
1.700E+3	1.800E+3	1.163E+2	8.400E+4	8.800E+4	1.168E+4	3.700E+6	3.800E+6	1.229E+5	1.130E+7	1.140E+7	2.307E+5
1.800E+3	1.900E+3	1.666E+2	8.800E+4	9.200E+4	1.222E+4	3.800E+6	3.900E+6	1.242E+5	1.140E+7	1.150E+7	2.322E+5
1.900E+3	2.000E+3	2.357E+2	9.200E+4	9.600E+4	1.276E+4	3.900E+6	4.000E+6	1.255E+5	1.150E+7	1.160E+7	2.337E+5
2.000E+3	2.100E+3	3.108E+2	9.600E+4	1.000E+5	1.330E+4	4.000E+6	4.100E+6	1.270E+5	1.160E+7	1.170E+7	2.352E+5
2.100E+3	2.200E+3	3.749E+2	1.000E+5	1.050E+5	1.465E+4	4.100E+6	4.200E+6	1.288E+5	1.170E+7	1.180E+7	2.367E+5
2.200E+3	2.300E+3	4.320E+2	1.050E+5	1.100E+5	1.529E+4	4.200E+6	4.300E+6	1.306E+5	1.180E+7	1.190E+7	2.382E+5
2.300E+3	2.400E+3	4.813E+2	1.100E+5	1.150E+5	1.593E+4	4.300E+6	4.400E+6	1.323E+5	1.190E+7	1.200E+7	2.397E+5
2.400E+3	2.550E+3	5.345E+2	1.150E+5	1.200E+5	1.656E+4	4.400E+6	4.500E+6	1.339E+5	1.200E+7	1.210E+7	2.408E+5
2.550E+3	2.700E+3	5.948E+2	1.200E+5	1.275E+5	1.735E+4	4.500E+6	4.600E+6	1.358E+5	1.210E+7	1.220E+7	2.415E+5
2.700E+3	2.800E+3	6.433E+2	1.275E+5	1.350E+5	1.829E+4	4.600E+6	4.700E+6	1.380E+5	1.220E+7	1.230E+7	2.421E+5
2.800E+3	3.000E+3	6.971E+2	1.350E+5	1.425E+5	1.922E+4	4.700E+6	4.800E+6	1.401E+5	1.230E+7	1.240E+7	2.428E+5
3.000E+3	3.200E+3	7.575E+2	1.425E+5	1.500E+5	2.014E+4	4.800E+6	4.900E+6	1.421E+5	1.240E+7	1.250E+7	2.433E+5
3.200E+3	3.400E+3	8.033E+2	1.500E+5	1.600E+5	2.115E+4	4.900E+6	5.000E+6	1.442E+5	1.250E+7	1.260E+7	2.439E+5
3.400E+3	3.600E+3	8.415E+2	1.600E+5	1.700E+5	2.225E+4	5.000E+6	5.100E+6	1.462E+5	1.260E+7	1.270E+7	2.444E+5
3.600E+3	3.800E+3	8.761E+2	1.700E+5	1.800E+5	2.332E+4	5.100E+6	5.200E+6	1.482E+5	1.270E+7	1.280E+7	2.450E+5
3.800E+3	4.000E+3	9.079E+2	1.800E+5	1.900E+5	2.436E+4	5.200E+6	5.300E+6	1.501E+5	1.280E+7	1.290E+7	2.455E+5
4.000E+3	4.250E+3	9.341E+2	1.900E+5	2.000E+5	2.539E+4	5.300E+6	5.400E+6	1.520E+5	1.290E+7	1.300E+7	2.461E+5
4.250E+3	4.500E+3	9.458E+2	2.000E+5	2.100E+5	2.637E+4	5.400E+6	5.500E+6	1.538E+5	1.300E+7	1.310E+7	2.464E+5
4.500E+3	4.750E+3	9.672E+2	2.100E+5	2.200E+5	2.733E+4	5.500E+6	5.600E+6	1.557E+5	1.310E+7	1.320E+7	2.465E+5
4.750E+3	5.000E+3	9.983E+2	2.200E+5	2.300E+5	2.825E+4	5.600E+6	5.700E+6	1.576E+5	1.320E+7	1.330E+7	2.465E+5
5.000E+3	5.250E+3	1.022E+3	2.300E+5	2.400E+5	2.914E+4	5.700E+6	5.800E+6	1.593E+5	1.330E+7	1.340E+7	2.466E+5
5.250E+3	5.500E+3	1.043E+3	2.400E+5	2.550E+5	3.024E+4	5.800E+6	5.900E+6	1.610E+5	1.340E+7	1.350E+7	2.467E+5
5.500E+3	5.750E+3	1.073E+3	2.550E+5	2.700E+5	3.161E+4	5.900E+6	6.000E+6	1.627E+5	1.350E+7	1.360E+7	2.467E+5
5.750E+3	6.000E+3	1.108E+3	2.700E+5	2.800E+5	3.276E+4	6.000E+6	6.100E+6	1.644E+5	1.360E+7	1.370E+7	2.468E+5
6.000E+3	6.300E+3	1.140E+3	2.800E+5	3.000E+5	3.408E+4	6.100E+6	6.200E+6	1.660E+5	1.370E+7	1.380E+7	2.467E+5
6.300E+3	6.600E+3	1.171E+3	3.000E+5	3.200E+5	3.580E+4	6.200E+6	6.300E+6	1.676E+5	1.380E+7	1.390E+7	2.467E+5
6.600E+3	6.900E+3	1.202E+3	3.200E+5	3.400E+5	3.745E+4	6.300E+6	6.400E+6	1.692E+5	1.390E+7	1.400E+7	2.467E+5
6.900E+3	7.200E+3	1.235E+3	3.400E+5	3.600E+5	3.903E+4	6.400E+6	6.500E+6	1.707E+5	1.400E+7	1.410E+7	2.470E+5
7.200E+3	7.600E+3	1.273E+3	3.600E+5	3.800E+5	4.055E+4	6.500E+6	6.600E+6	1.722E+5	1.410E+7	1.420E+7	2.477E+5
7.600E+3	8.000E+3	1.317E+3	3.800E+5	4.000E+5	4.201E+4	6.600E+6	6.700E+6	1.736E+5	1.420E+7	1.430E+7	2.484E+5
8.000E+3	8.400E+3	1.363E+3	4.000E+5	4.250E+5	4.357E+4	6.700E+6	6.800E+6	1.751E+5	1.430E+7	1.440E+7	2.491E+5
8.400E+3	8.800E+3	1.412E+3	4.250E+5	4.500E+5	4.522E+4	6.800E+6	6.900E+6	1.765E+5	1.440E+7	1.450E+7	2.498E+5
8.800E+3	9.200E+3	1.461E+3	4.500E+5	4.750E+5	4.676E+4	6.900E+6	7.000E+6	1.779E+5	1.450E+7	1.460E+7	2.506E+5
9.200E+3	9.600E+3	1.510E+3	4.750E+5	5.000E+5	4.823E+4	7.000E+6	7.100E+6	1.795E+5	1.460E+7	1.470E+7	2.517E+5
9.600E+3	1.000E+4	1.554E+3	5.000E+5	5.250E+5	4.965E+4	7.100E+6	7.200E+6	1.815E+5	1.470E+7	1.480E	

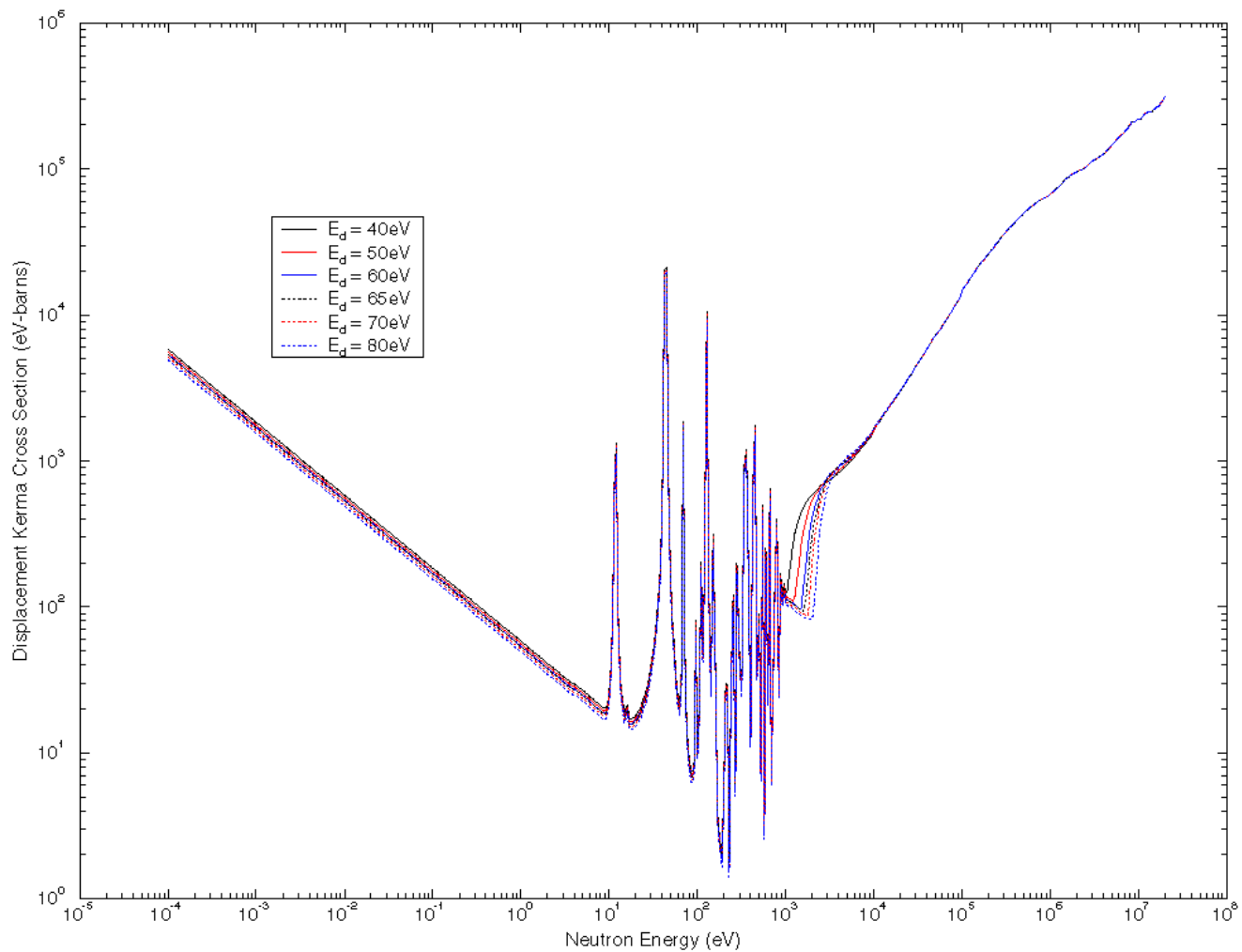
Lower Energy (eV)	Upper Energy (eV)	Mo	Lower Energy (eV)	Upper Energy (eV)	Mo	Lower Energy (eV)	Upper Energy (eV)	Mo	Lower Energy (eV)	Upper Energy (eV)	Mo
1.480E+7	1.490E+7	2.541E+5	1.610E+7	1.620E+7	2.659E+5	1.740E+7	1.750E+7	2.761E+5	1.870E+7	1.880E+7	2.932E+5
1.490E+7	1.500E+7	2.554E+5	1.620E+7	1.630E+7	2.656E+5	1.750E+7	1.760E+7	2.777E+5	1.880E+7	1.890E+7	2.943E+5
1.500E+7	1.510E+7	2.566E+5	1.630E+7	1.640E+7	2.653E+5	1.760E+7	1.770E+7	2.792E+5	1.890E+7	1.900E+7	2.954E+5
1.510E+7	1.520E+7	2.578E+5	1.640E+7	1.650E+7	2.650E+5	1.770E+7	1.780E+7	2.808E+5	1.900E+7	1.910E+7	2.969E+5
1.520E+7	1.530E+7	2.589E+5	1.650E+7	1.660E+7	2.652E+5	1.780E+7	1.790E+7	2.823E+5	1.910E+7	1.920E+7	2.988E+5
1.530E+7	1.540E+7	2.600E+5	1.660E+7	1.670E+7	2.661E+5	1.790E+7	1.800E+7	2.839E+5	1.920E+7	1.930E+7	3.006E+5
1.540E+7	1.550E+7	2.611E+5	1.670E+7	1.680E+7	2.670E+5	1.800E+7	1.810E+7	2.852E+5	1.930E+7	1.940E+7	3.025E+5
1.550E+7	1.560E+7	2.622E+5	1.680E+7	1.690E+7	2.679E+5	1.810E+7	1.820E+7	2.864E+5	1.940E+7	1.950E+7	3.044E+5
1.560E+7	1.570E+7	2.631E+5	1.690E+7	1.700E+7	2.688E+5	1.820E+7	1.830E+7	2.875E+5	1.950E+7	1.960E+7	3.063E+5
1.570E+7	1.580E+7	2.640E+5	1.700E+7	1.710E+7	2.700E+5	1.830E+7	1.840E+7	2.887E+5	1.960E+7	1.970E+7	3.082E+5
1.580E+7	1.590E+7	2.649E+5	1.710E+7	1.720E+7	2.715E+5	1.840E+7	1.850E+7	2.898E+5	1.970E+7	1.980E+7	3.100E+5
1.590E+7	1.600E+7	2.658E+5	1.720E+7	1.730E+7	2.731E+5	1.850E+7	1.860E+7	2.909E+5	1.980E+7	1.990E+7	3.119E+5
1.600E+7	1.610E+7	2.662E+5	1.730E+7	1.740E+7	2.746E+5	1.860E+7	1.870E+7	2.921E+5	1.990E+7	2.000E+7	3.138E+5

**Table 2** ENDF/B-VI based displacement kerma cross sections (eV-barns) for molybdenum (T=300K) in the SAND-IIA 640-group energy structure. Data were calculated for a range of plausible  $E_d$  values, and data are displayed only for groups with significant variation in the displacement kerma cross section. Upper energies are identical to those in Table 1.

Lower Energy (eV)	40 eV	50 eV	60 eV	70 eV	80 eV	Lower Energy (eV)	40 eV	50 eV	60 eV	70 eV	80 eV
1.000E-4	5.814E+3	5.568E+3	5.374E+3	5.124E+3	4.899E+3	1.275E-3	1.625E+3	1.556E+3	1.502E+3	1.432E+3	1.369E+3
1.050E-4	5.678E+3	5.437E+3	5.248E+3	5.003E+3	4.783E+3	1.350E-3	1.580E+3	1.513E+3	1.461E+3	1.393E+3	1.332E+3
1.100E-4	5.550E+3	5.315E+3	5.130E+3	4.891E+3	4.676E+3	1.425E-3	1.539E+3	1.474E+3	1.423E+3	1.357E+3	1.297E+3
1.150E-4	5.431E+3	5.201E+3	5.020E+3	4.786E+3	4.575E+3	1.500E-3	1.495E+3	1.432E+3	1.382E+3	1.318E+3	1.260E+3
1.200E-4	5.292E+3	5.067E+3	4.891E+3	4.663E+3	4.458E+3	1.600E-3	1.449E+3	1.388E+3	1.340E+3	1.277E+3	1.221E+3
1.275E-4	5.138E+3	4.920E+3	4.749E+3	4.528E+3	4.329E+3	1.700E-3	1.407E+3	1.348E+3	1.301E+3	1.240E+3	1.186E+3
1.350E-4	4.998E+3	4.786E+3	4.620E+3	4.404E+3	4.211E+3	1.800E-3	1.369E+3	1.311E+3	1.265E+3	1.206E+3	1.153E+3
1.425E-4	4.868E+3	4.662E+3	4.500E+3	4.290E+3	4.101E+3	1.900E-3	1.333E+3	1.277E+3	1.232E+3	1.175E+3	1.123E+3
1.500E-4	4.728E+3	4.528E+3	4.371E+3	4.167E+3	3.984E+3	2.000E-3	1.300E+3	1.245E+3	1.202E+3	1.146E+3	1.095E+3
1.600E-4	4.583E+3	4.389E+3	4.236E+3	4.039E+3	3.861E+3	2.100E-3	1.270E+3	1.216E+3	1.174E+3	1.119E+3	1.070E+3
1.700E-4	4.450E+3	4.261E+3	4.113E+3	3.922E+3	3.749E+3	2.200E-3	1.241E+3	1.189E+3	1.147E+3	1.094E+3	1.046E+3
1.800E-4	4.328E+3	4.145E+3	4.000E+3	3.814E+3	3.646E+3	2.300E-3	1.214E+3	1.163E+3	1.123E+3	1.070E+3	1.023E+3
1.900E-4	4.216E+3	4.037E+3	3.897E+3	3.715E+3	3.552E+3	2.400E-3	1.183E+3	1.133E+3	1.094E+3	1.043E+3	9.969E+2
2.000E-4	4.112E+3	3.938E+3	3.801E+3	3.623E+3	3.464E+3	2.550E-3	1.149E+3	1.100E+3	1.062E+3	1.013E+3	9.680E+2
2.100E-4	4.015E+3	3.845E+3	3.711E+3	3.538E+3	3.383E+3	2.700E-3	1.123E+3	1.075E+3	1.038E+3	9.893E+2	9.458E+2
2.200E-4	3.925E+3	3.758E+3	3.628E+3	3.459E+3	3.306E+3	2.800E-3	1.093E+3	1.047E+3	1.010E+3	9.633E+2	9.210E+2
2.300E-4	3.840E+3	3.678E+3	3.550E+3	3.384E+3	3.235E+3	3.000E-3	1.057E+3	1.012E+3	9.773E+2	9.317E+2	8.908E+2
2.400E-4	3.742E+3	3.583E+3	3.459E+3	3.298E+3	3.153E+3	3.200E-3	1.025E+3	9.813E+2	9.472E+2	9.030E+2	8.633E+2
2.550E-4	3.633E+3	3.479E+3	3.358E+3	3.202E+3	3.061E+3	3.400E-3	9.950E+2	9.529E+2	9.197E+2	8.769E+2	8.383E+2
2.700E-4	3.550E+3	3.400E+3	3.281E+3	3.128E+3	2.991E+3	3.600E-3	9.678E+2	9.268E+2	8.945E+2	8.528E+2	8.153E+2
2.800E-4	3.457E+3	3.310E+3	3.195E+3	3.046E+3	2.912E+3	3.800E-3	9.426E+2	9.027E+2	8.713E+2	8.307E+2	7.941E+2
3.000E-4	3.343E+3	3.202E+3	3.090E+3	2.946E+3	2.817E+3	4.000E-3	9.166E+2	8.778E+2	8.472E+2	8.078E+2	7.722E+2
3.200E-4	3.240E+3	3.103E+3	2.995E+3	2.856E+3	2.730E+3	4.250E-3	8.900E+2	8.523E+2	8.227E+2	7.843E+2	7.499E+2
3.400E-4	3.146E+3	3.013E+3	2.908E+3	2.773E+3	2.651E+3	4.500E-3	8.657E+2	8.290E+2	8.002E+2	7.629E+2	7.293E+2
3.600E-4	3.060E+3	2.931E+3	2.829E+3	2.697E+3	2.578E+3	4.750E-3	8.432E+2	8.074E+2	7.793E+2	7.430E+2	7.103E+2
3.800E-4	2.981E+3	2.854E+3	2.755E+3	2.627E+3	2.511E+3	5.000E-3	8.223E+2	7.875E+2	7.601E+2	7.247E+2	6.928E+2
4.000E-4	2.899E+3	2.776E+3	2.679E+3	2.554E+3	2.442E+3	5.250E-3	8.030E+2	7.689E+2	7.422E+2	7.076E+2	6.765E+2
4.250E-4	2.814E+3	2.695E+3	2.601E+3	2.480E+3	2.371E+3	5.500E-3	7.849E+2	7.517E+2	7.255E+2	6.917E+2	6.613E+2
4.500E-4	2.737E+3	2.621E+3	2.530E+3	2.412E+3	2.306E+3	5.750E-3	7.680E+2	7.355E+2	7.099E+2	6.768E+2	6.471E+2
4.750E-4	2.666E+3	2.553E+3	2.464E+3	2.350E+3	2.246E+3	6.000E-3	7.507E+2	7.189E+2	6.938E+2	6.615E+2	6.324E+2
5.000E-4	2.600E+3	2.490E+3	2.404E+3	2.292E+3	2.191E+3	6.300E-3	7.330E+2	7.019E+2	6.775E+2	6.459E+2	6.175E+2
5.250E-4	2.539E+3	2.432E+3	2.347E+3	2.238E+3	2.139E+3	6.600E-3	7.165E+2	6.862E+2	6.623E+2	6.314E+2	6.037E+2
5.500E-4	2.482E+3	2.377E+3	2.294E+3	2.187E+3	2.091E+3	6.900E-3	7.012E+2	6.715E+2	6.481E+2	6.179E+2	5.907E+2
5.750E-4	2.429E+3	2.326E+3	2.245E+3	2.140E+3	2.046E+3	7.200E-3	6.844E+2	6.554E+2	6.326E+2	6.031E+2	5.766E+2
6.000E-4	2.374E+3	2.273E+3	2.194E+3	2.092E+3	2.000E+3	7.600E-3	6.666E+2	6.384E+2	6.162E+2	5.874E+2	5.616E+2
6.300E-4	2.318E+3	2.220E+3	2.142E+3	2.043E+3	1.953E+3	8.000E-3	6.501E+2	6.226E+2	6.009E+2	5.729E+2	5.477E+2
6.600E-4	2.266E+3	2.170E+3	2.094E+3	1.997E+3	1.909E+3	8.400E-3	6.348E+2	6.079E+2	5.868E+2	5.594E+2	5.348E+2
6.900E-4	2.217E+3	2.123E+3	2.049E+3	1.954E+3	1.868E+3	8.800E-3	6.206E+2	5.943E+2	5.736E+2	5.469E+2	5.228E+2
7.200E-4	2.164E+3	2.072E+3	2.000E+3	1.907E+3	1.823E+3	9.200E-3	6.072E+2	5.815E+2	5.613E+2	5.351E+2	5.116E+2
7.600E-4	2.108E+3	2.019E+3	1.948E+3	1.858E+3	1.776E+3	9.600E-3	5.947E+2	5.695E+2	5.497E+2	5.241E+2	5.010E+2
8.000E-4	2.056E+3	1.969E+3	1.900E+3	1.812E+3	1.732E+3	1.000E-2	5.815E+2	5.568E+2	5.375E+2	5.124E+2	4.899E+2
8.400E-4	2.007E+3	1.922E+3	1.855E+3	1.769E+3	1.691E+3	1.050E-2	5.678E+2	5.437E+2	5.248E+2	5.004E+2	4.784E+2
8.800E-4	1.962E+3	1.879E+3	1.814E+3	1.729E+3	1.653E+3	1.100E-2	5.550E+2	5.315E+2	5.130E+2	4.891E+2	4.676E+2
9.200E-4	1.920E+3	1.839E+3	1.775E+3	1.692E+3	1.618E+3	1.150E-2	5.431E+2	5.201E+2	5.020E+2	4.786E+2	4.575E+2
9.600E-4	1.880E+3	1.801E+3	1.738E+3	1.657E+3	1.584E+3	1.200E-2	5.292E+2	5.068E+2	4.892E+2	4.662E+2	4.458E+2
1.000E-3	1.839E+3	1.761E+3	1.700E+3	1.620E+3	1.549E+3	1.275E-2	5.139E+2	4.921E+2	4.750E+2	4.528E+2	4.329E+2
1.050E-3	1.795E+3	1.719E+3	1.660E+3	1.582E+3	1.513E+3	1.350E-2	4.998E+2	4.786E+2	4.620E+2	4.405E+2	4.211E+2
1.100E-3	1.755E+3	1.681E+3	1.622E+3	1.547E+3	1.479E+3	1.425E-2	4.868E+2	4.662E+2	4.500E+2	4.290E+2	4.102E+2
1.150E-3	1.717E+3	1.645E+3	1.587E+3	1.513E+3	1.447E+3	1.500E-2	4.729E+2	4.529E+2	4.371E+2	4.167E+2	3.984E+2
1.200E-3	1.673E+3	1.602E+3	1.547E+3	1.475E+3	1.410E+3	1.600E-2	4.583E+2	4.389E+2	4.237E+2	4.039E+2	3.861E+2

Lower Energy (eV)	40 eV	50 eV	60 eV	70 eV	80 eV	Lower Energy (eV)	40 eV	50 eV	60 eV	70 eV	80 eV
1.700E-2	4.451E+2	4.262E+2	4.114E+2	3.922E+2	3.750E+2	8.400E-1	6.351E+1	6.082E+1	5.871E+1	5.597E+1	5.351E+1
1.800E-2	4.328E+2	4.145E+2	4.001E+2	3.814E+2	3.647E+2	8.800E-1	6.209E+1	5.946E+1	5.739E+1	5.472E+1	5.231E+1
1.900E-2	4.216E+2	4.037E+2	3.897E+2	3.715E+2	3.552E+2	9.200E-1	6.075E+1	5.818E+1	5.615E+1	5.353E+1	5.118E+1
2.000E-2	4.112E+2	3.938E+2	3.801E+2	3.624E+2	3.464E+2	9.600E-1	5.950E+1	5.698E+1	5.500E+1	5.243E+1	5.013E+1
2.100E-2	4.015E+2	3.845E+2	3.711E+2	3.538E+2	3.383E+2	1.000E+0	5.818E+1	5.571E+1	5.378E+1	5.127E+1	4.901E+1
2.200E-2	3.925E+2	3.758E+2	3.628E+2	3.459E+2	3.307E+2	1.050E+0	5.680E+1	5.440E+1	5.251E+1	5.006E+1	4.786E+1
2.300E-2	3.840E+2	3.678E+2	3.550E+2	3.384E+2	3.235E+2	1.100E+0	5.552E+1	5.317E+1	5.132E+1	4.893E+1	4.678E+1
2.400E-2	3.742E+2	3.584E+2	3.459E+2	3.298E+2	3.153E+2	1.150E+0	5.433E+1	5.203E+1	5.022E+1	4.788E+1	4.577E+1
2.500E-2	3.634E+2	3.480E+2	3.359E+2	3.202E+2	3.062E+2	1.200E+0	5.295E+1	5.070E+1	4.894E+1	4.666E+1	4.461E+1
2.700E-2	3.550E+2	3.400E+2	3.282E+2	3.129E+2	2.991E+2	1.275E+0	5.144E+1	4.926E+1	4.754E+1	4.533E+1	4.334E+1
2.800E-2	3.458E+2	3.311E+2	3.196E+2	3.047E+2	2.913E+2	1.350E+0	5.001E+1	4.789E+1	4.622E+1	4.407E+1	4.213E+1
3.000E-2	3.344E+2	3.203E+2	3.091E+2	2.947E+2	2.817E+2	1.425E+0	4.871E+1	4.665E+1	4.503E+1	4.293E+1	4.104E+1
3.200E-2	3.241E+2	3.104E+2	2.996E+2	2.856E+2	2.731E+2	1.500E+0	4.732E+1	4.532E+1	4.374E+1	4.170E+1	3.987E+1
3.400E-2	3.147E+2	3.014E+2	2.909E+2	2.773E+2	2.651E+2	1.600E+0	4.586E+1	4.391E+1	4.239E+1	4.041E+1	3.863E+1
3.600E-2	3.061E+2	2.931E+2	2.829E+2	2.697E+2	2.579E+2	1.700E+0	4.453E+1	4.264E+1	4.119E+1	3.924E+1	3.751E+1
3.800E-2	2.981E+2	2.855E+2	2.756E+2	2.627E+2	2.512E+2	1.800E+0	4.331E+1	4.147E+1	4.003E+1	3.816E+1	3.649E+1
4.000E-2	2.899E+2	2.776E+2	2.680E+2	2.555E+2	2.442E+2	1.900E+0	4.218E+1	4.040E+1	3.899E+1	3.717E+1	3.554E+1
4.250E-2	2.815E+2	2.696E+2	2.602E+2	2.481E+2	2.372E+2	2.000E+0	4.114E+1	3.939E+1	3.802E+1	3.625E+1	3.466E+1
4.500E-2	2.738E+2	2.622E+2	2.531E+2	2.413E+2	2.307E+2	2.100E+0	4.017E+1	3.846E+1	3.713E+1	3.540E+1	3.384E+1
4.750E-2	2.667E+2	2.554E+2	2.465E+2	2.350E+2	2.247E+2	2.200E+0	3.926E+1	3.760E+1	3.629E+1	3.460E+1	3.308E+1
5.000E-2	2.601E+2	2.491E+2	2.404E+2	2.292E+2	2.191E+2	2.300E+0	3.842E+1	3.679E+1	3.551E+1	3.385E+1	3.236E+1
5.250E-2	2.540E+2	2.432E+2	2.347E+2	2.238E+2	2.140E+2	2.400E+0	3.743E+1	3.585E+1	3.460E+1	3.299E+1	3.154E+1
5.500E-2	2.482E+2	2.377E+2	2.295E+2	2.188E+2	2.091E+2	2.550E+0	3.635E+1	3.481E+1	3.360E+1	3.203E+1	3.062E+1
5.750E-2	2.429E+2	2.326E+2	2.245E+2	2.141E+2	2.046E+2	2.700E+0	3.551E+1	3.400E+1	3.282E+1	3.129E+1	2.992E+1
6.000E-2	2.374E+2	2.274E+2	2.195E+2	2.092E+2	2.000E+2	2.800E+0	3.460E+1	3.313E+1	3.198E+1	3.049E+1	2.915E+1
6.300E-2	2.318E+2	2.220E+2	2.143E+2	2.043E+2	1.953E+2	3.000E+0	3.346E+1	3.204E+1	3.093E+1	2.949E+1	2.819E+1
6.600E-2	2.266E+2	2.170E+2	2.095E+2	1.997E+2	1.909E+2	3.200E+0	3.243E+1	3.105E+1	2.997E+1	2.857E+1	2.732E+1
6.900E-2	2.218E+2	2.124E+2	2.050E+2	1.954E+2	1.868E+2	3.400E+0	3.148E+1	3.015E+1	2.910E+1	2.774E+1	2.652E+1
7.200E-2	2.165E+2	2.073E+2	2.001E+2	1.908E+2	1.824E+2	3.600E+0	3.062E+1	2.932E+1	2.830E+1	2.698E+1	2.580E+1
7.600E-2	2.109E+2	2.019E+2	1.949E+2	1.858E+2	1.777E+2	3.800E+0	2.989E+1	2.863E+1	2.763E+1	2.634E+1	2.518E+1
8.000E-2	2.057E+2	1.969E+2	1.901E+2	1.812E+2	1.733E+2	4.000E+0	2.969E+1	2.843E+1	2.745E+1	2.617E+1	2.502E+1
8.400E-2	2.008E+2	1.923E+2	1.856E+2	1.770E+2	1.692E+2	4.250E+0	2.898E+1	2.775E+1	2.678E+1	2.554E+1	2.441E+1
8.800E-2	1.963E+2	1.880E+2	1.814E+2	1.730E+2	1.654E+2	4.500E+0	2.825E+1	2.705E+1	2.611E+1	2.489E+1	2.380E+1
9.200E-2	1.921E+2	1.839E+2	1.775E+2	1.693E+2	1.618E+2	4.750E+0	2.754E+1	2.637E+1	2.546E+1	2.427E+1	2.320E+1
9.600E-2	1.881E+2	1.801E+2	1.739E+2	1.658E+2	1.585E+2	5.000E+0	2.686E+1	2.572E+1	2.483E+1	2.367E+1	2.263E+1
1.000E-1	1.839E+2	1.761E+2	1.700E+2	1.621E+2	1.549E+2	5.250E+0	2.622E+1	2.510E+1	2.423E+1	2.310E+1	2.209E+1
1.050E-1	1.796E+2	1.720E+2	1.660E+2	1.582E+2	1.513E+2	5.500E+0	2.559E+1	2.451E+1	2.366E+1	2.255E+1	2.156E+1
1.100E-1	1.755E+2	1.681E+2	1.622E+2	1.547E+2	1.479E+2	5.750E+0	2.500E+1	2.394E+1	2.311E+1	2.203E+1	2.106E+1
1.150E-1	1.718E+2	1.645E+2	1.588E+2	1.514E+2	1.447E+2	6.000E+0	2.439E+1	2.335E+1	2.254E+1	2.149E+1	2.055E+1
1.200E-1	1.674E+2	1.603E+2	1.547E+2	1.475E+2	1.410E+2	6.300E+0	2.380E+1	2.279E+1	2.200E+1	2.097E+1	2.005E+1
1.275E-1	1.625E+2	1.556E+2	1.502E+2	1.432E+2	1.369E+2	6.600E+0	2.323E+1	2.225E+1	2.147E+1	2.047E+1	1.957E+1
1.350E-1	1.581E+2	1.514E+2	1.461E+2	1.393E+2	1.332E+2	6.900E+0	2.270E+1	2.174E+1	2.099E+1	2.001E+1	1.913E+1
1.425E-1	1.540E+2	1.475E+2	1.423E+2	1.357E+2	1.297E+2	7.200E+0	2.217E+1	2.123E+1	2.049E+1	1.954E+1	1.868E+1
1.500E-1	1.496E+2	1.432E+2	1.383E+2	1.318E+2	1.260E+2	7.600E+0	2.165E+1	2.074E+1	2.002E+1	1.908E+1	1.824E+1
1.600E-1	1.450E+2	1.388E+2	1.340E+2	1.278E+2	1.221E+2	8.000E+0	2.106E+1	2.017E+1	1.947E+1	1.856E+1	1.775E+1
1.700E-1	1.408E+2	1.348E+2	1.301E+2	1.240E+2	1.186E+2	8.400E+0	2.047E+1	1.960E+1	1.892E+1	1.804E+1	1.724E+1
1.800E-1	1.369E+2	1.311E+2	1.265E+2	1.206E+2	1.153E+2	8.800E+0	2.018E+1	1.933E+1	1.866E+1	1.779E+1	1.700E+1
1.900E-1	1.333E+2	1.277E+2	1.233E+2	1.175E+2	1.123E+2	9.200E+0	2.044E+1	1.958E+1	1.889E+1	1.801E+1	1.722E+1
2.000E-1	1.301E+2	1.245E+2	1.202E+2	1.146E+2	1.096E+2	9.600E+0	2.159E+1	2.068E+1	1.996E+1	1.903E+1	1.819E+1
2.100E-1	1.270E+2	1.216E+2	1.174E+2	1.119E+2	1.070E+2	1.000E+1	2.259E+1	2.170E+1	2.099E+1	2.001E+1	1.913E+1
2.200E-1	1.241E+2	1.189E+2	1.147E+2	1.094E+2	1.046E+2	1.050E+1	3.809E+1	3.647E+1	3.521E+1	3.357E+1	3.209E+1
2.300E-1	1.215E+2	1.163E+2	1.123E+2	1.070E+2	1.023E+2	1.100E+1	8.217E+1	7.869E+1	7.595E+1	7.241E+1	6.923E+1
2.400E-1	1.184E+2	1.134E+2	1.094E+2	1.043E+2	9.973E+1	1.150E+1	7.006E+2	6.709E+2	6.476E+2	6.174E+2	5.903E+2
2.550E-1	1.149E+2	1.101E+2	1.062E+2	1.013E+2	9.683E+1	1.200E+1	1.321E+3	1.265E+3	1.221E+3	1.164E+3	1.113E+3
2.700E-1	1.123E+2	1.075E+2	1.038E+2	9.894E+1	9.459E+1	1.275E+1	6.759E+1	6.473E+1	6.248E+1	5.956E+1	5.695E+1
2.800E-1	1.094E+2	1.047E+2	1.011E+2	9.637E+1	9.213E+1	1.350E+1	3.024E+1	2.896E+1	2.795E+1	2.665E+1	2.548E+1
3.000E-1	1.058E+2	1.013E+2	9.776E+1	9.320E+1	8.910E+1	1.425E+1	2.207E+1	2.113E+1	2.040E+1	1.945E+1	1.859E+1
3.200E-1	1.025E+2	9.816E+1	9.475E+1	9.033E+1	8.636E+1	1.500E+1	1.906E+1	1.826E+1	1.762E+1	1.680E+1	1.606E+1
3.400E-1	9.953E+1	9.531E+1	9.200E+1	8.771E+1	8.385E+1	1.600E+1	2.137E+1	2.047E+1	1.976E+1	1.884E+1	1.801E+1
3.600E-1	9.680E+1	9.270E+1	8.947E+1	8.530E+1	8.155E+1	1.700E+1	1.709E+1	1.637E+1	1.580E+1	1.506E+1	1.440E+1
3.800E-1	9.428E+1	9.029E+1	8.715E+1	8.308E+1	7.943E+1	1.800E+1	1.711E+1	1.638E+1	1.581E+1	1.508E+1	1.441E+1
4.000E-1	9.169E+1	8.781E+1	8.475E+1	8.080E+1	7.725E+1	1.900E+1	1.746E+1	1.672E+1	1.614E+1	1.538E+1	1.471E+1
4.250E-1	8.903E+1	8.526E+1	8.229E+1	7.846E+1	7.501E+1	2.000E+1	1.804E+1	1.728E+1	1.668E+1	1.590E+1	1.520E+1
4.500E-1	8.660E+1	8.293E+1	8.004E+1	7.631E+1	7.296E+1	2.100E+1	1.881E+1	1.801E+1	1.738E+1	1.657E+1	1.584E+1
4.750E-1	8.437E+1	8.079E+1	7.798E+1	7.435E+1	7.108E+1	2.200E+1	1.976E+1	1.892E+1	1.826E+1	1.741E+1	1.665E+1
5.000E-1	8.227E+1	7.879E+1	7.605E+1	7.250E+1	6.931E+1	2.300E+1	2.091E+1	2.002E+1	1.933E+1	1.843E+1	1.762E+1
5.250E-1	8.033E+1	7.693E+1	7.425E+1	7.079E+1	6.768E+1	2.400E+1	2.267E+1	2.171E+1	2.095E+1	1.998E+1	1.910E+1
5.500E-1	7.852E+1	7.520E+1	7.258E+1	6.920E+1	6.615E+1	2.550E+1	2.529E+1	2.422E+1	2.337E+1	2.229E+1	2.131E+1
5.750E-1	7.683E+1	7.358E+1	7.102E+1	6.771E+1	6.473E+1	2.700E+1	2.804E+1	2.686E+1	2.592E+1	2.471E+1	2.363E+1
6.000E-1	7.510E+1	7.192E+1	6.941E+1	6.618E+1	6.327E+1	2.800E+1	3.235E+1	3.097E+1	2.990E+1	2.850E+1	2.725E+1
6.300E-1	7.336E+1	7.026E+1	6.781E+1	6.465E+1	6.181E+1	3.000E+1	4.033E+1	3.862E+1	3.728E+1	3.554E+1	3.398E+1
6.600E-1	7.170E+1	6.866E+1	6.627E+1	6.319E+1	6.041E+1	3.200E+1	5.264E+1	5.041E+1	4.865E+1	4.639E+1	4.435E+1
6.900E-1	7.016E+1	6.719E+1	6.485E+1	6.183E+1	5.911E+1	3.400E+1	7.299E+1	6.990E+1	6.747E+1	6.432E+1	6.150E+1
7.200E-1	6.848E+1	6.557E+1	6.329E+1	6.034E+1	5.769E+1	3.600E+1	1.105E+2	1.058E+2	1.021E+2	9.737E+1	9.308E+1
7.600E-1	6.670E+1	6.388E+1	6.165E+1	5.878E+1	5.620E+1	3.800E+1	1.921E+2	1.840E+2	1.776E+2	1.693E+2	1.619E+2
8.000E-1	6.504E+1	6.228E+1	6.012E+1	5.732E+1	5.480E+1	4.000E+1	5.179E+2	4.959E+2	4.787E+2		

Lower Energy (eV)	40 eV	50 eV	60 eV	70 eV	80 eV	Lower Energy (eV)	40 eV	50 eV	60 eV	70 eV	80 eV
4.250E+1	2.035E+4	1.949E+4	1.881E+4	1.794E+4	1.715E+4	1.700E+3	5.180E+2	3.898E+2	1.959E+2	8.798E+1	8.411E+1
4.500E+1	2.099E+4	2.010E+4	1.940E+4	1.850E+4	1.768E+4	1.800E+3	5.447E+2	4.499E+2	2.661E+2	8.726E+1	8.321E+1
4.750E+1	4.861E+2	4.655E+2	4.493E+2	4.284E+2	4.096E+2	1.900E+3	5.663E+2	5.001E+2	3.397E+2	1.312E+2	8.231E+1
5.000E+1	1.588E+2	1.521E+2	1.468E+2	1.399E+2	1.338E+2	2.000E+3	5.862E+2	5.413E+2	4.117E+2	2.106E+2	8.239E+1
5.250E+1	7.940E+1	7.604E+1	7.340E+1	6.997E+1	6.690E+1	2.100E+3	6.044E+2	5.711E+2	4.656E+2	2.830E+2	1.054E+2
5.500E+1	5.408E+1	5.179E+1	4.999E+1	4.766E+1	4.556E+1	2.200E+3	6.233E+2	5.959E+2	5.095E+2	3.496E+2	1.454E+2
5.750E+1	3.275E+1	3.136E+1	3.027E+1	2.886E+1	2.759E+1	2.300E+3	6.412E+2	6.191E+2	5.517E+2	4.115E+2	2.063E+2
6.000E+1	2.449E+1	2.345E+1	2.263E+1	2.158E+1	2.063E+1	2.400E+3	6.617E+2	6.463E+2	6.018E+2	4.827E+2	3.007E+2
6.300E+1	2.161E+1	2.070E+1	1.998E+1	1.905E+1	1.821E+1	2.550E+3	6.837E+2	6.761E+2	6.465E+2	5.534E+2	3.964E+2
6.600E+1	3.505E+1	3.356E+1	3.239E+1	3.088E+1	2.953E+1	2.700E+3	7.000E+2	6.992E+2	6.756E+2	6.042E+2	4.641E+2
6.900E+1	1.879E+3	1.799E+3	1.737E+3	1.656E+3	1.583E+3	2.800E+3	7.098E+2	7.236E+2	7.207E+2	6.612E+2	5.453E+2
7.200E+1	4.861E+1	4.655E+1	4.493E+1	4.283E+1	4.095E+1	3.000E+3	7.214E+2	7.548E+2	7.763E+2	7.257E+2	6.436E+2
7.600E+1	1.491E+1	1.428E+1	1.378E+1	1.314E+1	1.256E+1	3.200E+3	7.382E+2	7.832E+2	8.159E+2	7.749E+2	7.235E+2
8.000E+1	9.438E+0	9.039E+0	8.724E+0	8.318E+0	7.952E+0	3.400E+3	7.622E+2	8.017E+2	8.389E+2	8.166E+2	7.831E+2
8.400E+1	7.559E+0	7.239E+0	6.987E+0	6.662E+0	6.369E+0	3.600E+3	7.896E+2	8.158E+2	8.562E+2	8.547E+2	8.270E+2
8.800E+1	7.462E+0	7.146E+0	6.897E+0	6.576E+0	6.287E+0	3.800E+3	8.110E+2	8.388E+2	8.781E+2	8.899E+2	8.681E+2
9.200E+1	8.953E+0	8.574E+0	8.276E+0	7.890E+0	7.543E+0	4.000E+3	8.322E+2	8.648E+2	9.075E+2	9.260E+2	9.107E+2
9.600E+1	8.165E+1	7.819E+1	7.547E+1	7.195E+1	6.879E+1	4.200E+3	8.562E+2	8.842E+2	9.372E+2	9.617E+2	9.536E+2
1.000E+2	1.064E+1	1.019E+1	9.836E+0	9.377E+0	8.965E+0	4.500E+3	8.809E+2	9.118E+2	9.574E+2	9.937E+2	9.927E+2
1.050E+2	2.015E+1	1.930E+1	1.863E+1	1.776E+1	1.698E+1	4.750E+3	9.097E+2	9.480E+2	9.759E+2	1.026E+3	1.033E+3
1.100E+2	2.007E+2	1.922E+2	1.855E+2	1.769E+2	1.691E+2	5.000E+3	9.397E+2	9.783E+2	9.967E+2	1.047E+3	1.071E+3
1.150E+2	4.885E+1	4.678E+1	4.515E+1	4.304E+1	4.115E+1	5.250E+3	9.697E+2	1.005E+3	1.021E+3	1.063E+3	1.103E+3
1.200E+2	1.368E+2	1.310E+2	1.264E+2	1.205E+2	1.152E+2	5.500E+3	9.997E+2	1.032E+3	1.053E+3	1.080E+3	1.124E+3
1.275E+2	1.054E+4	1.009E+4	9.739E+3	9.285E+3	8.877E+3	5.750E+3	1.029E+3	1.059E+3	1.088E+3	1.100E+3	1.138E+3
1.350E+2	1.478E+2	1.415E+2	1.366E+2	1.302E+2	1.245E+2	6.000E+3	1.064E+3	1.090E+3	1.122E+3	1.133E+3	1.167E+3
1.425E+2	2.874E+1	2.753E+1	2.657E+1	2.533E+1	2.422E+1	6.300E+3	1.102E+3	1.126E+3	1.155E+3	1.178E+3	1.210E+3
1.500E+2	3.144E+2	3.011E+2	2.906E+2	2.771E+2	2.649E+2	6.600E+3	1.141E+3	1.163E+3	1.188E+3	1.214E+3	1.242E+3
1.600E+2	4.445E+1	4.256E+1	4.108E+1	3.917E+1	3.745E+1	6.900E+3	1.179E+3	1.199E+3	1.222E+3	1.245E+3	1.269E+3
1.700E+2	3.863E+0	3.699E+0	3.571E+0	3.404E+0	3.255E+0	7.200E+3	1.223E+3	1.241E+3	1.262E+3	1.282E+3	1.301E+3
1.800E+2	2.560E+0	2.451E+0	2.366E+0	2.256E+0	2.157E+0	7.600E+3	1.272E+3	1.290E+3	1.308E+3	1.324E+3	1.341E+3
1.900E+2	1.965E+0	1.882E+0	1.816E+0	1.731E+0	1.655E+0	8.000E+3	1.320E+3	1.339E+3	1.355E+3	1.369E+3	1.392E+3
2.000E+2	6.162E+0	5.901E+0	5.696E+0	5.430E+0	5.192E+0	8.400E+3	1.367E+3	1.390E+3	1.405E+3	1.416E+3	1.452E+3
2.100E+2	2.979E+1	2.853E+1	2.754E+1	2.626E+1	2.510E+1	8.800E+3	1.416E+3	1.437E+3	1.455E+3	1.464E+3	1.504E+3
2.200E+2	2.920E+1	2.796E+1	2.699E+1	2.573E+1	2.460E+1	9.200E+3	1.468E+3	1.480E+3	1.505E+3	1.512E+3	1.550E+3
2.300E+2	1.688E+0	1.616E+0	1.560E+0	1.487E+0	1.422E+0	9.600E+3	1.515E+3	1.522E+3	1.550E+3	1.556E+3	1.591E+3
2.400E+2	2.968E+1	2.842E+1	2.743E+1	2.615E+1	2.500E+1	1.000E+4	1.611E+3	1.620E+3	1.647E+3	1.654E+3	1.688E+3
2.550E+2	1.212E+2	1.161E+2	1.121E+2	1.068E+2	1.021E+2	1.050E+4	1.714E+3	1.724E+3	1.746E+3	1.755E+3	1.787E+3
2.700E+2	5.956E+0	5.704E+0	5.506E+0	5.249E+0	5.018E+0	1.100E+4	1.777E+3	1.791E+3	1.804E+3	1.821E+3	1.851E+3
2.800E+2	1.994E+2	1.909E+2	1.843E+2	1.757E+2	1.680E+2	1.150E+4	1.841E+3	1.859E+3	1.864E+3	1.886E+3	1.914E+3
3.000E+2	4.738E+1	4.537E+1	4.379E+1	4.175E+1	3.992E+1	1.200E+4	1.924E+3	1.924E+3	1.945E+3	1.968E+3	1.994E+3
3.200E+2	2.936E+1	2.812E+1	2.714E+1	2.587E+1	2.474E+1	1.275E+4	2.025E+3	2.038E+3	2.045E+3	2.066E+3	2.089E+3
3.400E+2	9.528E+2	9.124E+2	8.807E+2	8.396E+2	8.027E+2	1.350E+4	2.123E+3	2.130E+3	2.143E+3	2.161E+3	2.183E+3
3.600E+2	1.202E+3	1.152E+3	1.111E+3	1.060E+3	1.013E+3	1.425E+4	2.218E+3	2.225E+3	2.241E+3	2.253E+3	2.269E+3
3.800E+2	2.031E+2	1.945E+2	1.878E+2	1.790E+2	1.711E+2	1.500E+4	2.331E+3	2.341E+3	2.356E+3	2.355E+3	2.370E+3
4.000E+2	1.274E+1	1.220E+1	1.177E+1	1.123E+1	1.073E+1	1.600E+4	2.467E+3	2.471E+3	2.483E+3	2.490E+3	2.503E+3
4.250E+2	6.936E+2	6.642E+2	6.411E+2	6.113E+2	5.844E+2	1.700E+4	2.601E+3	2.603E+3	2.614E+3	2.626E+3	2.639E+3
4.500E+2	1.761E+3	1.686E+3	1.628E+3	1.552E+3	1.483E+3	1.800E+4	2.732E+3	2.739E+3	2.749E+3	2.761E+3	2.773E+3
4.750E+2	3.752E+1	3.593E+1	3.468E+1	3.307E+1	3.161E+1	1.900E+4	2.865E+3	2.875E+3	2.878E+3	2.896E+3	2.908E+3
5.000E+2	8.930E+1	8.552E+1	8.254E+1	7.870E+1	7.523E+1	2.000E+4	3.001E+3	3.010E+3	3.009E+3	3.031E+3	3.041E+3
5.250E+2	7.517E+0	7.199E+0	6.948E+0	6.624E+0	6.333E+0	2.100E+4	3.137E+3	3.145E+3	3.146E+3	3.163E+3	3.173E+3
5.500E+2	4.971E+2	4.760E+2	4.595E+2	4.381E+2	4.188E+2	2.200E+4	3.272E+3	3.279E+3	3.285E+3	3.294E+3	3.301E+3
5.750E+2	3.039E+0	2.910E+0	2.809E+0	2.678E+0	2.560E+0	2.300E+4	3.410E+3	3.417E+3	3.424E+3	3.431E+3	3.438E+3
6.000E+2	2.516E+2	2.409E+2	2.325E+2	2.217E+2	2.119E+2	2.400E+4	3.581E+3	3.588E+3	3.595E+3	3.602E+3	3.609E+3
6.300E+2	2.526E+1	2.419E+1	2.335E+1	2.226E+1	2.128E+1	2.550E+4	3.784E+3	3.790E+3	3.796E+3	3.801E+3	3.806E+3
6.600E+2	6.419E+2	6.148E+2	5.934E+2	5.657E+2	5.408E+2	2.700E+4	3.952E+3	3.957E+3	3.963E+3	3.967E+3	3.970E+3
6.900E+2	7.092E+0	6.791E+0	6.555E+0	6.250E+0	5.975E+0	2.800E+4	4.152E+3	4.156E+3	4.167E+3	4.171E+3	4.174E+3
7.200E+2	2.957E+1	2.832E+1	2.734E+1	2.606E+1	2.492E+1	3.000E+4	4.427E+3	4.430E+3	4.441E+3	4.445E+3	4.453E+3
7.600E+2	1.944E+2	1.861E+2	1.797E+2	1.713E+2	1.638E+2	3.200E+4	4.708E+3	4.711E+3	4.716E+3	4.719E+3	4.735E+3
8.000E+2	3.953E+2	3.786E+2	3.654E+2	3.484E+2	3.331E+2	3.400E+4	4.986E+3	4.989E+3	4.991E+3	5.000E+3	5.010E+3
8.400E+2	2.815E+1	2.695E+1	2.602E+1	2.480E+1	2.371E+1	3.600E+4	5.264E+3	5.268E+3	5.269E+3	5.280E+3	5.286E+3
8.800E+2	1.698E+2	1.626E+2	1.569E+2	1.496E+2	1.430E+2	3.800E+4	5.542E+3	5.549E+3	5.551E+3	5.556E+3	5.568E+3
9.200E+2	1.199E+2	1.148E+2	1.108E+2	1.056E+2	1.010E+2	4.000E+4	5.858E+3	5.865E+3	5.867E+3	5.871E+3	5.883E+3
9.600E+2	1.455E+2	1.394E+2	1.345E+2	1.283E+2	1.226E+2	4.250E+4	6.214E+3	6.217E+3	6.218E+3	6.228E+3	6.230E+3
1.000E+3	1.237E+2	1.184E+2	1.143E+2	1.090E+2	1.042E+2	4.500E+4	6.568E+3	6.569E+3	6.574E+3	6.581E+3	6.579E+3
1.050E+3	1.283E+2	1.165E+2	1.125E+2	1.072E+2	1.025E+2	4.750E+4	6.922E+3	6.922E+3	6.931E+3	6.932E+3	6.937E+3
1.100E+3	1.637E+2	1.146E+2	1.106E+2	1.055E+2	1.008E+2	5.000E+4	7.237E+3	7.239E+3	7.246E+3	7.248E+3	7.258E+3
1.150E+3	2.041E+2	1.127E+2	1.088E+2	1.037E+2	9.912E+1	5.250E+4	7.513E+3	7.518E+3	7.521E+3	7.529E+3	7.531E+3
1.200E+3	2.574E+2	1.103E+2	1.064E+2	1.015E+2	9.701E+1	5.500E+4	7.784E+3	7.789E+3	7.789E+3	7.800E+3	7.798E+3
1.275E+3	3.180E+2	1.178E+2	1.036E+2	9.881E+1	9.447E+1	5.750E+4	8.050E+3	8.052E+3	8.051E+3	8.061E+3	8.058E+3
1.350E+3	3.652E+2	1.547E+2	1.009E+2	9.616E+1	9.193E+1	6.000E+4	8.383E+3	8.383E+3	8.384E+3	8.392E+3	8.391E+3
1.425E+3	4.040E+2	2.015E+2	9.807E+1	9.350E+1	8.939E+1	6.300E+4	8.787E+3	8.786E+3	8.792E+3	8.793E+3	8.800E+3
1.500E+3	4.400E+2	2.660E+2	9.737E+1	9.052E+1	8.654E+1	6.600E+4	9.190E+3	9.191E+3	9.197E+3	9.198E+3	9.205E+3
1.600E+3	4.824E+2	3.295E+2	1.356E+2	8.892E+1	8.501E+1	6.900E+4	9.594E+3	9.598E+3	9.600E+3	9.605E+3	9.607E+3



**Figure 1** Displacement kerma cross sections for molybdenum for several values of the displacement energy threshold,  $E_d$ . Results were computed at  $T=300\text{K}$  and are displayed on the SAND-IIA (640 groups) energy group structure.