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Standard Practice for Characterizing Neutron Energy Fluence Spectra in Terms of an Equivalent Monoenergetic Neutron Fluence for Radiation-Hardness Testing of Electronics¹

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This standard has been approved for use by agencies of the Department of Defense.

ε¹ Note—Table A1.1 and A2.1 were corrected editorially in February 2005. ε²Note—An = sign was added in Eq 1 in April 2007.

—Editorial changes were made throughout in October 2009.

1. Scope

- 1.1 This practice covers procedures for characterizing a-neutron fluence from a source in terms of an equivalent monoenergetic neutron fluence. It is applicable to neutron effects testing, to the development of test specifications, and to the characterization of neutron test environments. The sources may have a broad neutron-energy spectrum,range, or may be mono-energetic neutron sources with energies up to 20 MeV. This practice is not applicable in cases where the predominant source of displacement damage is from neutrons of energy less than 10 keV. The relevant equivalence is in terms of a specified effect on certain physical properties of materials upon which the source spectrum is incident. In order to achieve this, knowledge of the effects of neutrons as a function of energy on the specific property of the material of interest is required. Sharp variations in the effects with neutron energy may limit the usefulness of this practice in the case of mono-energetic sources.
- 1.2 This practice is presented in a manner to be of general application to a variety of materials and sources. Correlation between displacements (1-3)² caused by different particles (electrons, neutrons, protons, and heavy ions) is beyond the scope of this practice. In radiation-hardness testing of electronic semiconductor devices, specific materials of interest include silicon and gallium arsenide, and the neutron sources generally are test and research reactors and californium-252 irradiators.
- 1.3 The technique involved relies on the following factors: (1) a detailed determination of the energyfluence spectrum of the neutron source, and (2) a knowledge of the degradation (damage) effects of neutrons as a function of energy on specific material properties.
- 1.4 The detailed determination of the neutron <u>energyfluence</u> spectrum referred to in 1.3 need not be performed afresh for each test exposure, provided the exposure conditions are repeatable. When the spectrum determination is not repeated, a neutron fluence monitor shall be used for each test exposure.

1.5

- 1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.
- 1.6 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards:³

E170 Terminology Relating to Radiation Measurements and Dosimetry

E265 Test Method for Measuring Reaction Rates and Fast-Neutron Fluences by Radioactivation of Sulfur-32

E693 Practice for Characterizing Neutron Exposures in Iron and Low Alloy Steels in Terms of Displacements Per Atom (DPA), E 706(ID)

¹ This practice is under the jurisdiction of ASTM Committee E10 on Nuclear Technology and Applications and is the direct responsibility of Subcommittee E10.07 on Radiation Dosimetry for Radiation Effects on Materials and Devices.

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² The boldface numbers in parentheses refer to a list of references at the end of this practice.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.



- E720 Guide for Selection and Use of Neutron Sensors for Determining Neutron Spectra Employed in Radiation-Hardness Testing of Electronics
- E721 Guide for Determining Neutron Energy Spectra from Neutron Sensors for Radiation-Hardness Testing of Electronics
- E844 Guide for Sensor Set Design and Irradiation for Reactor Surveillance, E 706(IIC)
- E944 Guide for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance, E 706 (IIA)
- 2.2 International Commission on Radiation Units and Measurements (ICRU) Reports:
- ICRU Report 13—Neutron Fluence, Neutron Spectra, and Kerma⁴
- ICRU Report 26—Neutron Dosimetry for Biology and Medicine⁴ ICRU Report 33—RadiationQuantities and Units⁴
- ICRU Report 33—Radiation Quantities and Units⁴

3. Terminology

- 3.1 Definitions of Terms Specific to This Standard:
- 3.1.1 displacement damage function—(F_(F) an energydependent parameter proportional to the quotient of the observable displacement damage per target atom and the neutron fluence.) an energy-dependent parameter proportional to the quotient of the observable displacement damage per target atom and the neutron fluence. Different displacement-related damage functions may exist, so the damage mode of interest and the observation procedure shall be identified when the specific damage function is defined. See, for example, Annexes A1.2.2 and A2.2.2.
- 3.1.1.1 Discussion—Observable changes in a material's properties attributable to the atomic displacement process are useful indices of displacement damage in that material. In cases where the observed displacement damage is not in linear proportion to the applied fluence, the displacement damage function represents the quotient $F_{D,mat}$ (E)/d Φ , in the limiting case of zero fluence. Examples of suitable representations of displacement damage functions are given in the annexes. In the case of silicon, it has been shown that the displacement damage function may be successfully equated with the displacement kerma factor. This question is discussed further in the annexes. (E)/d Φ in the limiting case of zero fluence. Examples of suitable representations of displacement damage functions are given in the annexes. In the case of silicon, damage mode of interest is the change in minority-carrier recombination lifetime in the bulk semiconductor material. While several procedures exist to directly measure the minority carrier lifetime in bulk material, since this lifetime is related to the gain of a bipolar junction transistor (BJT), one observable damage metric is the BJT gain degradation. For this damage mode, it has been shown that the displacement damage function may be successfully equated with the microscopic displacement kerma factor. This question is discussed further in the annexes.
- 3.1.2 displacement kerma factor—(K_{microscopic displacement kerma factor—(K_{D,mat} (E)) the energy dependent quotient of the displacement kerma per target atom and the neutron fluence. (E)) the energy-dependent quotient of the displacement kerma per target atom} and the neutron fluence. $\kappa_{D,mat}$ (E) is proportional to $K_{D,mat}\bar{A}/\Phi$, where $K_{D,mat}$ is the displacement kerma, \bar{A} is the mean atomic mass of the material and Φ is the neutron fluence from a monoenergetic source of energy E.
- 3.1.2.1 Discussion—This quantity may be calculated from the microscopic neutron interaction cross sections, the kinematic relations for each reaction and from a suitable partition function which divides the total kerma into ionization and displacement kerma.—This quantity may be calculated from the microscopic neutron interaction cross sections, the kinematic relations for each reaction and from a suitable partition function which divides the total kerma into ionization and displacement kerma. The use of the term *microscopic* kerma factor in this standard is to indicate that energy times area per atom is used, instead of per unit mass, as in the term kerma factor defined in E170.
- 3.1.3 energy-spectrum hardness parameter—($H_{\underline{\text{fluence spectrum hardness parameter}}$ —($H_{\underline{\text{mut}}} = \Phi_{eq,Eref,mat}/\Phi$) this parameter is defined as the ratio of the equivalent monoenergetic neutron fluence to the true-total fluence, $\Phi_{eq,Eref,mat}/\Phi$. The numerical value of the hardness parameter is also equal to the fluence of monoenergetic neutrons at the specific energy, Eref, required to produce the same displacement damage in the specified material, mat, per unit fluence of neutrons of spectral distribution neutron spectrum $\Phi(E)$.
- 3.1.3.1 Discussion—For damage correlation, a convenient method of characterizing the shape of an incident neutron energy-fluence fluence spectrum $\Phi(E)$, is in terms of an energy fluence spectrum hardness parameter (4) parameter. The hardness parameter in a particular neutron field depends on the displacement damage function used to compute the damage (see annexes) and is therefore different for different semiconductor materials.
- 3.1.4 equivalent monoenergetic neutron fluence— $(\Phi_{eq,Eref,mat})$ an equivalent monoenergetic neutron fluence, $\Phi_{eq,Eref,mat}$, characterizes an incident energy-fluence fluence spectrum, $\Phi(E)$, in terms of the fluence of monoenergetic neutrons at a specific energy Eref required to produce the same displacement damage in a specified irradiated material, mat, as $\Phi(E)$.
- 3.1.4.1 Discussion—Note that $\Phi_{eq,Eref,mat}$ is equivalent to $\Phi(E)$ if, and only if, the specific device effect (for example, current gain degradation in silicon) being correlated is described by the displacement damage function used in the calculation.
- 3.1.5 kerma—(K_{fluence and fluence spectrum—see neutron fluence and neutron fluence spectrum.}
 3.1.6 kerma factor—(K_{mat} (E)) the sum of the initial kinetic energies of all the charged particles liberated by indirectly ionizing particles (for example, neutrons) in a volume element containing a unit mass of the specified material (see ICRU reports 13 and 33).

⁴ Available from International Commission on Radiation Units and Measurements, 7910 Woodmont Ave., Avenue Suite 400 Bethesda, MD 20814:20841-3095, http://www.icru.org/



- 3.1.5.1(E)) the **kerma** per unit fluence of particles of energy E present in a specified material, mat. See Terminology E170 for the definition of **kerma**, and a formula for calculating the kerma factor.
- <u>3.1.6.1</u> *Discussion*—When a material is irradiated by a neutron field, the energy imparted to <u>charged particles in</u> the material may be described by the quantity kerma. The total kerma may be divided into two parts, ionization kerma and displacement kerma. See 3.1.2.1 for the distinction between kerma factor and microscopic kerma factor. Calculations of ionization and <u>microscopic</u> displacement kerma in silicon and gallium arsenide as a result of irradiation by neutrons with energies up to 20 MeV are described in Refs **5-8** and in the annexes.
- 3.1.7 neutron fluence and neutron fluence spectrum are used in this standard, and are special cases of **particle fluence** and **particle fluence spectrum** as defined in E170.
- 3.1.7.1 *Discussion*—In cases where the context makes clear that neutrons are referred to, the terms *fluence* and *fluence spectrum* are sometimes used.

4. Summary of Practice

4.1 The equivalent monoenergetic neutron fluence,

 $\Phi_{\text{eq.Eref.mat}}$, is given as follows:

(1) Φ eq,Eref,mat = $0 \times \Phi(E)FD$,mat(E)dEFD,Eref,mat

(1) Φ eq,Eref,mat = $0 \approx \Phi(E)FD$,mat(E)dEFD,Eref,mat

where:

 $\Phi(E)$ = incident neutron energy-fluence spectral distribution,

Fincident neutron fluence spectrum,

 $\underline{F}_{D,mat}$ = neutron displacement damage function for the irradiated material (displacement damage per unit fluence) as a

function of energy, and

 $F_{D,Eref,mat}$ = displacement damage reference value designated for the irradiated material and for the specified equivalent energy, Eref, as given in the annexes.

The energy limits on the integral are determined in practice by the <u>incident-energy-incident neutron fluence</u> spectrum and by the material being irradiated.

4.2 The neutron energy-spectrum hardness parameter, H_{mat} , is given as follows:

$$H_{\text{mat}} = \frac{\int_{0}^{\infty} \Phi(E) F_{\text{D,mat}}(E) dE}{F_{\text{D,Eref,mat}} \int_{0}^{\infty} \Phi(E) dE}$$
(2)

https://standards.iteh.ai/catalog/standards/sist/1b90 $\int_0^\infty \Phi(E) F_{D,mat}(E) dE$ b2-9045-1020075a251a/astm-e722-09e1 $H_{mat} = \frac{10}{F_{D,Eref,mat}} \int_0^\infty \Phi(E) dE$ (2)

4.3 Once the neutron energy-fluence spectrum has been determined (for example, in accordance with Test Method E 721E721) and the equivalent monoenergetic fluence calculated, then a monitor (such as an activation foil) can be used in subsequent irradiations at the same location to determine the fluence; that is, the neutron fluence is then described in terms of the equivalent monoenergetic neutron fluence per unit monitor response, $\Phi_{eq,Eref,mat}$ /M_{/M_r}. Use of a monitor foil to predict $\Phi_{eq,Eref,mat}$ is valid only if the energyneutron spectrum remains constant.

5. Significance and Use

- 5.1 This practice is important in characterizing the radiation hardness of electronic devices irradiated by neutrons. This characterization makes it feasible to predict some changes in operational properties of irradiated semiconductor devices or electronic systems. To facilitate uniformity of the interpretation and evaluation of results of irradiations by sources of different energyfluence spectra, it is convenient to reduce the incident neutron fluence from a source to a single parameter—an equivalent monoenergetic neutron fluence—applicable to a particular semiconductor material.
- 5.2 In order to determine an equivalent monoenergetic neutron fluence, it is necessary to evaluate the displacement damage of the particular semiconductor material. Ideally, this quantity is correlated to the degradation of a specific functional performance parameter (such as current gain) of the semiconductor device or system being tested. However, this correlation has not been established unequivocally for all device types and performance parameters since, in many instances, other effects also can be important. Ionization effects produced by the incident neutron fluence or by gamma rays in a mixed neutron fluence, short-term and long-term annealing, and other factors can contribute to observed performance degradation (damage). Thus, caution should be exercised in making a correlation between calculated displacement damage and performance degradation of a given electronic device. The types of devices for which this correlation is applicable, and numerical evaluation of displacement damage are discussed in the annexes.



5.3 The concept of 1-MeV equivalent fluence is widely used in the radiation-hardness testing community. It has merits and disadvantages that have been debated widely (9-12). For these reasons, specifics of a standard application of the 1-MeV equivalent fluence are presented in the annexes.

6. Procedure for Calculating $\Phi_{eq,Eref,mat}$

- 6.1 To evaluate Eq 1 and 2, determine the energy limits E_{\min} and E_{\max} to be used in place of zero and infinity in the integrals of (Eq 1) and (Eq 2) and the values of the displacement damage function $F_{D,\max}$ (E) for the irradiated material and perform the indicated integrations.
- 6.1.1 Choose the upper limit E_{max} to be at an energy above which the integral damage falls to an insignificant level. For Godiva-or TRIGA-type spectra, this limit is about 12 MeV.
- 6.1.2 Choose the lower-energy limit E_{\min} to be at an energy below which the integral damage falls to an insignificant level. For silicon irradiated by Godiva-type spectra, this energy has been historically chosen to be about 0.01 MeV. More highly moderated spectra may require lower thresholds or specialized filtering requirements such as a boron shield, or both.
- 6.1.3 The values of the neutron displacement damage function used in Eq 1 and 2 obviously depend on the material and the equivalent energy chosen. For silicon, resonance effects cause large variations (by a factor of 20 or more) in the displacement damage function as a function of energy over the range from about 0.1 to 8 MeV (4, 5). Therefore, monoenergetic neutron sources with these energies may not be useful for effects testing. Also, for a selected equivalent energy, the value of $F_{D,Eref,mat}$ at that specific energy may not be representative of the displacement damage function at nearby energies. In such cases, a method of averaging the damage function over a range of energies around the chosen equivalent energy can be used. Such averaging is discussed in the annexes. Because the $F_{D,mat}$ (E) term is normalized by dividing by $F_{D,Eref,mat}$ in Eq 1 and 2, only the shape of the $F_{D,mat}$ (E) function versus energy is of primary importance. In such a case, precise knowledge of the absolute values of $F_{D,mat}$ (E) is not required in evaluating $\Phi_{eq,Eref,mat}$ and H_{mat} .

7. Determining $\Phi_{eq, Eref, mat}$ with a Monitor Foil

- 7.1 At the same time that the energyfluence spectrum, $\Phi(E)$, of the source is determined (for example, with an activation foil set in accordance with Guides E 720 or E 844E720 or E844, or both, and Test Method E 721E721 or Practice E 944or Practice E944, or both, place a fast-neutron monitor foil in the neutron field at an appropriate location. After $\Phi_{eq,Eref,mat}$ is determined and the monitor foil counted, calculate the ratio of the equivalent monoenergetic fluence to the unit monitor response, $\Phi_{eq,Eref,mat}/M_r$.
- 7.2 Use the response of the fast-neutron monitor foil, M_r , to predict $\Phi_{\text{eq,Eref,mat}}$ in subsequent routine device test irradiations. For this method to be valid, it is important to keep the source-foil geometry essentially identical to that used for calibrating the monitor foil. Moderate changes in source-to-foil distance are allowable. In addition, make sure the source location (of a Godiva-type reactor) with respect to scattering materials (walls, floor, etc.) is the same. Do not change or move nearby scattering materials or moderators.
- 7.3 Precautions in maintaining original calibration conditions are necessary to avoid altering the neutron energyfluence spectrum significantly in subsequent irradiations. An appreciable change in the spectrum will invalidate the calibration of the monitor foil and, therefore, would necessitate a new measurement of $\Phi(E)$ and recalibration of the monitor foil. Whenever the neutron source configuration is changed, as for example, if the core fuel elements are replaced or rearranged in a nuclear reactor, the activation foil spectrum measurements and all quantities derived from them may need to be remeasured.
 - 7.4 The choice of a monitor foil material depends on several factors:
- 7.4.1 The activation threshold should be high enough so as to make it insensitive to neutrons below the E_{min} value used in Eq 1 and 2. However, the threshold energy should be low enough to sample a significant fraction of the total fluence.
 - 7.4.2 The monitor foil should have a high neutron sensitivity and a convenient half-life.
- 7.4.3 The detector system available for counting the monitor foil may dictate the choice of foil material. A germanium gamma-ray detector system can be used, and ⁵⁴Fe or ⁵⁸Ni foils utilized as monitors. However, if a beta particle detector system is available, then ³²S foils are suitable. Details of the use of sulfur foils are given in Test Method E 265E265.

8. Report

- 8.1 In the report of the results of radiation-hardness tests in which an equivalent monoenergetic neutron fluence is calculated, the report should include at least the following information:
- 8.1.1 Semiconductor material and device performance parameter (for example, current gain in silicon bipolar transistors) degradation being correlated to displacement damage should be specified.
 - 8.1.2 Neutron source as to type and mode of operation during tests (fast-pulse or steady state).
- 8.1.3 Neutron energy-fluence fluence spectrum and how it was determined.
- 8.1.4 Monitor foil employed and the detector system used for counting the foil. If an effective fission cross section for the monitor foil is used, its value should be stated.
- 8.1.5 The neutron displacement damage function should be given, or referenced. The specific material (for example, silicon) whose applicable damage function was used must be specified. The values cited in Annex A1 and Annex A2 shall be used for silicon and GaAs, respectively.
 - 8.1.6 Methods used for determining the average value of $F_{D,Eref,mat}$ and the value of Eref selected. The values cited in Annex



A1 and Annex A2 shall be used for silicon and GaAs, respectively.

- 8.1.7 Method used for evaluating the integrals of Eq 1 and 2 (for example, the energy bin width and number of bins in a numerical integration).
 - 8.1.8 Values of $\Phi_{\text{eq,Eref,mat}}$, H_{mat} , and $\Phi_{\text{eq,Eref,mat}} / M_{/M_r}$.

9. Precision and Bias

- 9.1 The precision in calculating $\Phi_{\text{eq,Eref,mat}}$ and H_{mat} will depend on the method of evaluation of the integrals in Eq 1 and 2 (for example, the width of the energy bins used in a numerical integration).
- 9.2 The uncertainty of the calculated results depends on (1) knowledge of the neutron source energy-fluence fluence spectrum, (2) knowledge of the displacement damage functions over that energy spectrum, and (3) knowledge of the value of the average displacement damage function at the specified equivalent energy.
- 9.3 A specific example of the uncertainty associated with the calculation of a 1-MeV equivalent fluence for silicon is given in Annex A1.

10. Keywords

10.1 displacement damage; electronic hardness; gallium arsenide; hardness parameter; silicon; silicon damage; silicon equivalent damage (SED); 1–MeV equivalent fluence

ANNEXES

(Mandatory Information)

A1. CALCULATION OF 1-MeV EQUIVALENT NEUTRON FLUENCE FOR SILICON

A1.1 Background

- A1.1.1The choice of the specific energy for determining an equivalent fluence has been the subject of some controversy within the electronics hardness-testing community
- A1.1.1 The observable damage metric of interest in this annex is the change in gain of a silicon bipolar junction transistor (BJT) due to bulk displacement damage effects. The damage mechanism is the change in minority-carrier recombination lifetime in the bulk semiconductor material. While a BJT gain may also be degraded by oxide traps and interface states introduced by the ionizing dose to the oxide, this is a surface effect and is not within the scope of this standard. In interpreting measurements of this 1-MeV(Si) damage, efforts must be made to eliminate any interference from ionization-related surface effects.
- A1.1.2 The choice of the specific energy for determining an equivalent fluence has been the subject of some controversy within the electronics hardness-testing community (9). Some workers (10) have proposed that 1 MeV be used while others (H-11, 12) have suggested 14 MeV to be more appropriate. The concept of 1-MeV equivalent fluence has gained broad acceptance in practice, and procedures for applying it to silicon are described in this annex in some detail.
- A1.1.2AnA1.1.3 An important basis of the practice is the correlation of radiation damage effects in a semiconductor device with the displacement kerma produced in bulk silicon by neutron irradiation. This correlation assumes that volume (versus surface) effects are the dominant radiation damage mechanism. Experimental evidence indicates that displacement kerma is a valid measure of device performance degradation (for example, reduction in current gain) in bipolar transistors whose operation basically depends on volume mechanisms (13, 14). However, for device types governed by surface phenomena (such as MOSFET devices), it is clear that this correlation is not valid. Surface-effect devices are more sensitive than are volume-effect devices to ionization radiation effects produced either by a neutron field or a mixed neutron-gamma field. Therefore, the basic mechanism associated with device performance and the effect being correlated (for example, gain degradation) should be kept in mind before applying this practice at any equivalent energy.

A1.2 Calculation of $\Phi_{eq,1MeV,Si}$

- A1.2.1A 1-MeV equivalent fluence in a given material can be defined for an irradiation by neutrons of any neutron spectrum. The neutron energy fluence, $\Phi(E)$, may be that determined from a neutron transport calculation, that determined from measurements, or that given in an environment specification document.
- A1.2.2The neutron energy-fluence spectrum, $\Phi(E)$, may be determined experimentally by measuring a set of activation foils and then by application of a spectral adjustment computer code (see Guide E 720
- A1.2.1 The displacement damage function, $F_{D,mat}$ (E), defined for silicon in this annex is the silicon microscopic displacement kerma factor, as tabulated in Table A1.1.
- A1.2.2 A 1-MeV equivalent fluence in silicon is defined for an irradiation by neutrons of any neutron spectrum for which the predominant source of displacement damage is from neutrons of energy between 10 keV and 20 MeV. The neutron fluence spectrum, $\Phi(E)$, may be that determined from a neutron transport calculation, that determined from measurements, or that given in an environment specification document.
 - A1.2.3 The neutron fluence spectrum, $\Phi(E)$, may be determined experimentally by measuring a set of activation foils and then



TABLE	Continued
Bin Mid-Point Energ	<u>Displacement Damage Function</u>
<u># (MeV)</u>	(MeV·mbarn)
$\frac{1}{2}$ $\frac{19.9500}{19.8500}$	182.8700 183.0000
<u>3</u> <u>19.8300</u> <u>19.7500</u>	183.1200
$\frac{4}{5}$ $\frac{19.6500}{19.5500}$	183.2500 183.3800
6 19.3300	183.5100
7 19.3500	183.6300
8 19.2500 9 19.1500	183.7500 183.8800
10 19.0500	184.000
1 19.9500 2 19.8500 3 19.7500 4 19.6500 5 19.5500 6 19.4500 7 19.3500 8 19.2500 9 19.1500 10 19.0500 11 18.9500 12 18.8500 13 18.7500 14 18.6500	184.1100 184.2000
13 18.7500	184.2800
14 18.6500 15 18.5500	184.3700 184.4500
16 18.4500	184.3100
<u>17</u> <u>18.3500</u> <u>18.2500</u>	183.9700 183.6200
19 18.1500	183.2800
20 <u>18.0500</u> 21 <u>17.9500</u>	182.9400 182.5900
22 17.8500	182.2400
23 17.7500 24 17.6500 25 17.5500	181.9100 181.5800
25 17.5500	181.2400
26 27 17.4500 17.3500	180.6700 179.8800
28 17.2500	$\frac{179.0800}{178.2800}$
30 17.0500	178.2800 177.4900
31 32 16.9500 16.8500	$\frac{177.2400}{177.5000}$
33 - 16.7500	177.7600
34 35 16.6500 16.5500	178.0100 178.2700
36 16.4500	178.3200
37 38 16.3500 16.2500	178.1800 178.0300
39 16.1500	E722-09e1 <u>177.8900</u>
catalo 40 tandards/six 16.0500 15.9500	$\frac{177.7400}{176.3000}$ 5-1020
42 15.8500	173.6300
43 15.7500 44 15.6500 45 15.5500	171.3200 170.8600
	170.7200
<u>46</u> <u>15.4500</u> <u>15.3500</u>	170.5600 170.4000
48 15.2500	170.2500
<u>49</u> <u>15.1500</u> <u>50</u> <u>15.0500</u>	170.0900 169.9300
51 14.9500	169.7900
52 53 14.8500 14.7500	169.6600 169.5200
54 14.6500	169.3700
55 56 14.5500 14.4500	169.2100 168.7300
57 58 14.3500 14.2500	167.9400 167.1400
59 14.1500	166.3400
60 61 13.9500	165.5400 165.4000
62 13.8500	165.8600
63 13.7500 64 13.6500	166.2900 166.7300
65 13.5500	167.1600
66 13.4500 67 13.3500	167.5300 167.8300
68 13.2500	168.1100
69 70 13.1500 13.0500	168.3900 168.6600
71 12.9500	168.6200
72 12.8500	168.2800



TABLE Continued

		IADEL	<u>Oritinaca</u>
•	Bin	Mid-Point Energy	Displacement Damage Function
	<u>#</u>	(MeV)	(MeV-mbarn)
•	73 74	12.7500	167.9400
	74	12.6500	167.6000 167.3700
	75 76 77 78 79	<u>12.5500</u> 12.4500	167.2700 167.2200
	77	12.3500	167.4700
	78	12.2500	167.7100
	80	12.1500 12.0500	<u>167.9500</u> 168.1700
	81	11.9500	165.6600
	82	11.8500	165.4600
	83 84	11.7500 11.6500	166.6200 165.7900
	85	11.5500	168.6200
	86	11.4500	165.3800
	<u>87</u> 88	11.3500 11.2500	166.0300 159.5200
	89	11.1500	155.6100
	90	11.0500	158.7500
	91	10.9500	160.0500
	<u>92</u> 93	10.8500 10.7500	162.9100 159.0000
	94	10.6500	155.5100
	95	10.5500	154.6000
	96 97	10.4500 10.3500	154.7600 164.6700
	98	10.2500	163.3600
	_99	10.1500	168.6300
	100 101	10.0500	$\frac{166.2100}{164.4900}$
	101	9.8500	164.0600
	103	9.7500 9.6500	161.9600
	104	9.6500	156.1000
	105 106	9.5500 9.4500	164.4100 169.8200
	107	9.3500	166.2100
	108	9.2500	150.6900
	109 110	<u>9.1500</u> <u>9.0500</u>	153.8800 174.5800
	<u>111</u>	A 8.9500 E 7 2	2-()9e1 <u>177.5700</u>
	112	8.8500	160.2200
	113 no	dards/sist/8.7500 d9c- 8.6500	163.8600 10200 103.8600
	115	8.5500	165.8300
	116	8.4500	166.6100
	117 118	8.3500 8.2500	162.0200 158.4200
	118	8.2500 8.1500	158.4200 154.4300
	120	8.0500	165.0000
	121	7.9500	186.4000
	<u>122</u> 123	7.8500 7.7500	175.3400 174.8000
	124	7.6500	170.3100
	125	7.5500	162.9100
	<u>126</u> 127	7.4500 7.3500	167.0500 168.4300
	128	7.2500	169.2700
	129	7.1500	139.1600
	130 131	7.0500 6.9500	<u>161.1000</u> 141.7700
	132	6.8500	146.8900
	133	6.7500	162.2500
	134	6.6500 6.5500	150.9200 110.2700
	135 136	6.5500 6.4500	119.2700 139.2700
	137	6.3500	150.0900
	138	6.2500	175.3800
	139 140	6.1500 6.0500	127.7100 153.0000
	141	5.9500	137.1000
	142	5.8500	164.7000
	<u>143</u> 144	5.7500 5.6500	180.0500 152.0700
	144	<u>5.6500</u>	152.0700



	IABLE C	onunueu	_
Bin	Mid-Point Energy	Displacement Damage Func-	
<u>=</u>	<u> 2</u>	<u>tion</u>	-
<u>#</u>	(MeV)	(MeV⋅mbarn)	_
<u>145</u>	5.5500	145.6000	
146	<u>5.4500</u>	116.9800 120.1500	
147 148	<u>5.3500</u> 5.2500	<u>120.1500</u> 145.7000	
149	5.1500	170.3100	
150	5.0500	149.1600	
151 152	4.9500 4.8500	145.5000 160.6700	
152	4.7500	185.6100	
153 154	4.6500	158.6400	
<u>155</u>	4.5500	138.3800	
156 157	4.4500 4.3500	140.9200 134.8600	
158	4.2500	164.4100	
<u>159</u>	4.1500	108.7100	
160 161	4.0500 3.9500	131.6400	
162	3.8500	134.3400 108.8400	
163	3.7500	115.1300	
164	3.6500	69.52400	
165 166	3.5500 3.4500	111.2700 119.0600	
167	3.3500	113.8700	
168	3.2500	118.0200	
169	3.1500	131.5000	
170 171	3.0500 2.9500	120.2000 98.84500	
172	2.8500	135.0400	
173	2.7500	106.9100	
174 175	<u>2.6500</u> <u>2.5500</u>	115.6700 131.1900	
176	2.4500	118.9200	
177	2.3500	102.8200	
178 179	2.2500 2.1500	105.4900	
180	2.0500	95.21800	
181	1.9500	129.4000	
182	1.8500	72.2.00 - 1 72.24200	
183 184	1.7500 M E	722-09e1 <u>78.34200</u> 163.0200	
catalo 185 stan	dards/sis 1.5500 Ubd9	c-cdUe-450 <u>105.9800</u> 5-1020	
186	1.4500	98.97900	
187 188	1.3500 1.2500	88.76000 88.99400	
189	1.1500	62.67300	
190	1.0500	75.69200	
191 192	0.98000 0.94000	111.7900	
193	0.90000	<u>111.4900</u> 87.78100	
<u>194</u>	0.86000	78.33600	
195	0.82000	136.8000	
196 197	0.78000 0.74000	87.94400 64.57500	
198	0.70500	59.30200	
199	0.67500	56.76700	
200 201	0.64500	55.29000 53.61800	
201 202	<u>0.61500</u> 0.58750	52.61800 58.33400	
203	0.56250	124.5500	
204	0.53750	77.95800	
<u>205</u> 206	0.51250 0.48750	57.41600 55.40500	
206 207	0.46250	53.50800	
208	0.43750	52.65400	
209	0.41250	51.89700	
210	0.39000 0.37000	<u>52.10700</u> 49.72200	
<u>211</u> 212	0.37000	<u>49.72200</u> 50.09500	
213	0.33000	49.28000	
214	0.31000	50.23700	
<u>215</u> 216	<u>0.29000</u> 0.27500	<u>51.32600</u> <u>52.55800</u>	
210	0.27000	<u>52.55600</u>	-



	IABLE OU	minaca
Bin	Mid-Point Energy	Displacement Damage Function
#_	(MeV)	(MeV·mbarn)
217	0.26250	54.95900
218	0.24750	58.46000
<u>219</u> 220	<u>0.23500</u> 0.22500	64.07300 69.75000
<u>220</u> 221	0.21500	69.75000 78.66700
222	0.20500	91.83600
223	0.19500	111.2800
224	0.18500	114.1000
225 226	<u>0.17500</u> 0.16500	<u>64.49300</u> 19.04800
227	0.15500	4.323200
228	0.14625	1.350900
229	0.13875	1.870700
<u>230</u> 231	<u>0.13125</u> 0.12375	<u>2.552600</u> 3.352800
232	0.11750	3.982800
233	0.11250	4.431900
234	0.10750	4.876000
235 236	0.10250 0.0000E 01	5.197800 5.417300
237	0.98000E-01 0.94000E-01	<u>5.417300</u> 5.611900
238	0.90000E-01	5.844300
239	0.86000E-01	6.040100
240	0.82000E-01	6.185300
241 242	0.78000E-01 0.74000E-01	6.310600 6.595600
243	0.70500E-01	6.831900
244	0.67500E-01	7.178200
245	0.64500E-01	6.972900
246 247	0.61500E-01 0.58750E-01	7.992000 11.45300
248	0.56250E-01	47.95000
249	0.53750E-01	1.498700
250	0.51250E-01	1.847000
251 252	0.48750E-01 0.46250E-01	2.470200 2.820300
<u>252</u> <u>253</u>	0.43750E-01	3.026800
254	0.41250E-01	3.234200
<u>255</u>	0.39000E-01	3.697700
talo 2 256 257 mdar	0.37000E-01 0.35000E-01	$d0 = 4bb2 \frac{2.995800}{2.949100} \cdot 10200$
<u>258</u>	0.33000E-01	2.823100
259	0.31000E-01	2.689600
<u>260</u>	0.29000E-01	<u>2.556800</u>
<u>261</u> 262	0.27500E-01 0.26250E-01	2.452700 2.363100
263	0.24750E-01	2.261300
264	0.23500E-01	2.180800
<u>265</u>	0.22500E-01	<u>2.116100</u>
<u>266</u> 267	0.21500E-01 0.20500E-01	2.050100 1.979200
268	0.19500E-01	1.900700
269	0.18500E-01	1.820900
270	0.17500E-01	1.738500
<u>271</u> 272	0.16500E-01 0.15500E-01	1.655100 1.565500
272 273	0.14625E-01	1.485300
274	0.13875E-01	1.414100
275	0.13125E-01	1.342200
<u>276</u> 277	0.12375E-01 0.11750E-01	1.270100 1.210800
277 278	0.11250E-01	1.165800
279	0.10750E-01	1.121000
280	0.10250E-01	1.076200
281	0.98000E-02	1.036000 0.0080800
<u>282</u> 283	0.94000E-02 0.90000E-02	<u>0.9989800</u> 0.9611300
284	0.86000E-02	0.9232700
285	0.82000E-02	0.8854100
286	0.78000E-02	0.8475500
287 288	0.74000E-02 0.70500E-02	0.8096600 0.7753600
<u>288</u>	0.70500E-02	0.7753600



	IABLE COI	<u>ılınueu</u>	
D:-	Mid Deint Co	Displacement Damage Func-	
<u>Bin</u>	Mid-Point Energy	tion	
#	(MeV)	 (MeV⋅mbarn)	
<u>289</u>	0.67500E-02	0.7451400	
<u>290</u>	0.64500E-02	0.7149200	
<u>291</u>	0.61500E-02	0.6847000	
<u>292</u>	0.58750E-02	0.6570400	
<u>293</u>	0.56250E-02	<u>0.6318600</u>	
<u>294</u>	0.53700E-02	0.6066800	
<u>295</u>	0.51250E-02	<u>0.5821900</u>	
<u>296</u>	0.48750E-02	<u>0.6085100</u>	
<u>297</u>	0.46250E-02	<u>0.5211400</u>	
<u>298</u>	0.43750E-02	0.4872300	
<u>299</u>	0.41250E-02	0.4598900	
<u>300</u>	0.39000E-02	<u>0.4361800</u>	
<u>301</u>	0.37000E-02	<u>0.4151300</u>	
<u>302</u>	0.35000E-02	0.3939900	
303	0.33000E-02	0.3727900	
304	0.31000E-02	0.3514300	
305	0.29000E-02	0.3298500	
306	0.27500E-02	<u>0.3137700</u>	
<u>307</u>	0.26250E-02	0.3002000	
308	0.24750E-02	0.2834300	
<u>309</u>	0.23500E-02	0.2693700	
310	0.22500E-02	0.2580800	
<u>311</u>	0.21500E-02	0.2467900	
312	0.20500E-02	0.2355000	
313	0.19500E-02	0.2243300	
<u>314</u>	0.18500E-02	0.2132400	
<u>315</u>	0.17500E-02	0.2021500	
316	0.16500E-02	0.1910600	
317	0.15500E-02	0.1799600	
318	0.14625E-02	0.1697200	
319	0.13875E-02	0.1606400	
320	0.13125E-02	0.1515600	
321	0.12375E-02	0.1424900	
322	0.11750E-02	0.1349500	
323	0.11250E-02	0.1289000	
324	0.10750E-02	0.1228500	
325	0.10250E-02	0.1168000	
<u>326</u>	0.98000E-03	0.1115900	
<u>327</u>	0.94000E-03	<u>2-09e1</u> <u>0.1071900</u>	
328	0.90000E-03	0.1028000	
catal(329 standar		<u></u>	
330	0.82000E-03	0.94013E-01	
<u>331</u>	0.78000E-03	0.89045E-01	
332	0.74000E-03	0.83513E-01	
333	0.70500E-03	0.78736E-01	
334	0.67500E-03	0.75315E-01	
335	0.64500E-03	0.72097E-01	
336	0.61500E-03	0.68880E-01	
337	0.58750E-03	0.65583E-01	
338	0.56250E-03	0.62205E-01	
339	0.53750E-03	0.58827E-01	
340	0.51250E-03	0.55449E-01	
341	0.48750E-03	0.51682E-01	
342	0.46250E-03	0.47534E-01	
343	0.43750E-03	0.43386E-01	
344	0.41250E-03	0.39238E-01	
345	0.39000E-03	0.36301E-01	
346	0.37000E-03	0.34546E-01	
347	0.35000E-03	0.32464E-01	
348	0.33000E-03	0.28456E-01	
349	0.31000E-03	0.24134E-01	
350	0.29000E-03	0.20712E-01	
351	0.27500E-03	0.18816E-01	
352	0.26250E-03	0.17222E-01	
353	0.24750E-03	0.14956E-01	
<u>354</u>	0.23500E-03	0.12137E-01	
355	0.22500E-03	0.98052E-02	
356	0.21500E-03	0.74733E-02	
357	0.20500E-03	0.51414E-02	
358	0.19500E-03	0.34199E-02	
359	0.18500E-03	0.22979E-02	
360	0.17500E-03	0.13235E-02	



Bin Mid-Point Energy Displacement Damage Function	IAB	LE C	Continued
# (MeV) (MeV-mbarn) 361	Rin Mid-Point F	neray	
361	<u> </u>	<u>o.gy</u>	<u>tion</u>
362	<u>#</u> (MeV)	(MeV·mbarn)
362		 E-03	0.12182E-02
963 364 0.1875E-03 365 0.1312E-03 366 0.1375E-03 367 0.11750E-03 367 0.11750E-03 368 0.11250E-03 368 0.11250E-03 369 0.10750E-03 370 0.10250E-03 371 0.9800E-04 0.15839E-02 373 0.9400E-04 0.16182E-02 374 0.8600E-04 0.16182E-02 375 0.8200E-04 0.16182E-02 376 0.78000E-04 0.16182E-02 377 0.74000E-04 0.16182E-02 377 0.74000E-04 0.16182E-02 377 0.74000E-04 0.16182E-02 377 0.74000E-04 0.16182E-02 378 0.7500E-04 0.18750E-02 380 0.64500E-04 0.1915E-02 381 0.6550E-04 0.1915E-02 383 0.6450E-04 0.1915E-02 383 0.56250E-04 0.2003SE-02 383 0.56250E-04 0.2003SE-02 384 0.53750E-04 0.21432E-02 385 0.51250E-04 0.22454E-02 386 0.43750E-04 0.22454E-02 387 0.48250E-04 0.22958E-02 388 0.43750E-04 0.22958E-02 389 0.41250E-04 0.22958E-02 389 0.43750E-04 0.22958E-02 389 0.43750E-04 0.23938E-02 393 0.33000E-04 0.225734E-02 393 0.33000E-04 0.225734E-02 394 0.33000E-04 0.225734E-02 395 0.33000E-04 0.225734E-02 396 0.3300E-04 0.23938E-02 0.3300E-04 0.23938E-02 0.3393E-02 0.3390E-04 0.23938E-02 0.3393E-02 0.3393E			
9666 0.13125E-03 0.13666E-02 367 0.11750E-03 0.14670E-02 368 0.12375E-03 0.1484E-02 368 0.11250E-03 0.1482E-02 370 0.10250E-03 0.1569BE-02 371 0.98000E-04 0.15839E-02 372 0.94000E-04 0.16182E-02 373 0.9000E-04 0.16182E-02 374 0.8600E-04 0.16182E-02 375 0.82000E-04 0.16395E-02 376 0.78000E-04 0.16395E-02 377 0.74000E-04 0.16395E-02 378 0.79500E-04 0.16395E-02 379 0.75000E-04 0.18242E-02 379 0.75000E-04 0.1827E-02 379 0.7500E-04 0.1827E-02 380 0.64500E-04 0.1915E-02 381 0.7550E-04 0.1915E-02 381 0.61500E-04 0.2030E-02 382 0.58750E-04 0.2030E-02 383 0.56250E-04 0.2030E-02 384 0.53750E-04 0.21392E-02 385 0.51250E-04 0.21392E-02 386 0.44750E-04 0.2236E-02 387 0.46250E-04 0.2236E-02 388 0.44750E-04 0.2236E-02 389 0.33000E-04 0.22368E-02 380 0.33000E-04 0.23398E-02 380 0.33000E-04 0.22368E-02 380 0.33000E-04 0.23398E-02 381 0.33000E-04 0.23398E-02 382498E-02 3839 0.33000E-04 0.33338E-02 384 0.3100E-04 0.33038E-02 385 0.3100E-04 0.33038E-02 386 0.41750E-04 0.4399E-02 387 0.46250E-04 0.33038E-02 388 0.44750E-04 0.33038E-02 389 0.33000E-04 0.33038E-02			0.12918E-02
366		E-03	0.13292E-02
967 0.11750E-03 0.14484E-02 368 0.11250E-03 0.15161E-02 370 0.10250E-03 0.15489E-02 371 0.98000E-04 0.16182E-02 372 0.94000E-04 0.16182E-02 373 0.9000E-04 0.16825E-02 374 0.98000E-04 0.16825E-02 375 0.82000E-04 0.17301E-02 376 0.78000E-04 0.17750E-02 377 0.74000E-04 0.17750E-02 378 0.770500E-04 0.180242E-02 378 0.70500E-04 0.180242E-02 0.180242E-02 378 0.70500E-04 0.19115E-02 380 0.64500E-04 0.19115E-02 381 0.61500E-04 0.19115E-02 383 0.6650E-04 0.2003E-02 383 0.56250E-04 0.2003E-02 384 0.53750E-04 0.2003E-02 385 0.51250E-04 0.21432E-02 386 0.48750E-04 0.22454E-02 387 0.47500E-04 0.23088E-02 388 0.43750E-04 0.23088E-02 389 0.43750E-04 0.23088E-02 389 0.43750E-04 0.23088E-02 389 0.43750E-04 0.23088E-02 389 0.43750E-04 0.23088E-02 399 0.35000E-04 0.25026E-02 0.24355E-02 0.24355E-02 0.24355E-02 0.24355E-02 0.25026E-02 0.25026E-02 0.25026E-02 0.25026E-02 0.25026E-02 0.25026E-02 0.36439E-02 0.36449E-02 0.36439E-02 0.36439E-02 0.36439E-02 0.36439E-02 0.36439E-02 0.36539E-02 0.36509E-04 0.4469FE-02 0.56500E-04 0.66500E-04 0.66500			
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<u>0.58750E-05</u> <u>0.64441E-02</u>			
428 0.56250E-05 0.65942E-02			
429 0.53750E-05 0.67442E-02	429 0.53750E		0.67442E-02
<u>0.51250E-05</u> <u>0.68942E-02</u>			
<u>0.48750E-05</u> <u>0.70711E-02</u>			
<u>432</u> <u>0.46250E-05</u> <u>0.72741E-02</u>	<u>432</u> <u>0.46250</u>	<u>-05</u>	<u>0.72741E-02</u>



474 0.53750E-06 0.21425E-01 475 0.51250E-06 0.21927E-01 476 0.48750E-06 0.22476E-01 477 0.46250E-06 0.23071E-01 478 0.43750E-06 0.23710E-01 479 0.41250E-06 0.24392E-01 480 0.39000E-06 0.25056E-01 481 0.37000E-06 0.25732E-01 482 0.35000E-06 0.27350E-01 483 0.33000E-06 0.27350E-01 485 0.29000E-06 0.29186E-01 486 0.27500E-06 0.29964E-01 487 0.26250E-06 0.30690E-01 488 0.24750E-06 0.31600E-01 489 0.23500E-06 0.33135E-01 490 0.22500E-06 0.33919E-01 492 0.20500E-06 0.35582E-01 493 0.19500E-06 0.35582E-01 493 0.19500E-06 0.36547E-01 495 0.17500E-06 0.36547E-01 496 0.16500E-06 0.38700E-01 </th <th><u> </u></th> <th>IABLE Continued</th> <th></th> <th></th>	<u> </u>	IABLE Continued		
### (MeV)	Bin Mid-Poi	int Energy <u>Displa</u>		
1833	<u>#</u> (N	MeV)		_
434 0.41250E-05 0.7890SE-02 435 0.39000E-05 0.81233E-02 437 0.35000E-05 0.8358E-02 438 0.37000E-05 0.8358E-02 439 0.31000E-05 0.8251E-02 440 0.29000E-05 0.8251E-02 441 0.27500E-05 0.8251E-02 444 0.22500E-05 0.9891E-02 444 0.22500E-05 0.9891E-02 444 0.22500E-05 0.9891E-02 444 0.22500E-05 0.9891E-02 444 0.24500E-05 0.9891E-02 445 0.22500E-05 0.9891E-02 446 0.21500E-05 0.9891E-02 447 0.20500E-05 0.9991E-02 448 0.18500E-05 0.9991E-02 449 0.18500E-05 0.9991E-02 449 0.18500E-05 0.9991E-02 449 0.18500E-05 0.9991E-02 450 0.17500E-05 0.9991E-02 451 0.16500E-05 0.9991E-02 452 0.15500E-05 0.9991E-02 453 0.14625E-05 0.9991E-02 454 0.13875E-05 0.9991E-02 455 0.1313E-01 456 0.12375E-05 0.9991E-02 457 0.11750E-05 0.1331SE-01 458 0.1123E-05 0.1331SE-01 459 0.10750E-05 0.14808E-01 459 0.10750E-05 0.14808E-01 459 0.10750E-05 0.14808E-01 459 0.10750E-05 0.15808E-01 459 0.10750E-05 0.15808E-01 459 0.10750E-05 0.15808E-01 459 0.10750E-05 0.15808E-01 450 0.12375E-05 0.14808E-01 451 0.98000E-06 0.16247E-01 452 0.15500E-06 0.14808E-01 453 0.14608E-01 454 0.18750E-06 0.14808E-01 456 0.12375E-05 0.14808E-01 457 0.11750E-05 0.15878E-01 458 0.11250E-05 0.15858E-01 459 0.10750E-05 0.15858E-01 460 0.10250E-06 0.16247E-01 461 0.98000E-06 0.16247E-01 462 0.94000E-06 0.16247E-01 463 0.7500E-06 0.16268E-01 464 0.98000E-06 0.16247E-01 465 0.88000E-06 0.16247E-01 466 0.7500E-06 0.16268E-01 467 0.7400E-06 0.16268E-01 468 0.7500E-06 0.22478E-01 470 0.46500E-06 0.22478E-01 471 0.46500E-06 0.22478E-01 472 0.46500E-06 0.22478E-01 473 0.46500E-06 0.22478E-01 474 0.53750E-06 0.22478E-01 475 0.41250E-06 0.22478E-01 477 0.46200E-06 0.22478E-01 488 0.23500E-06 0.22478E-01 489 0.2550E-06 0.22478E-01 489 0.2550E-06 0.22478E-01 489 0.2550E-06 0.22478E-01 489 0.13875E-06 0.22478E-01 489 0.13875E-06 0.22478E-01				_
436 0.37000E-05 0.81323E-02 437 0.35000E-05 0.88381E-02 438 0.33000E-05 0.88381E-02 439 0.31000E-05 0.88381E-02 440 0.29000E-05 0.98370E-02 441 0.27500E-05 0.94350E-02 4441 0.23500E-05 0.94350E-02 4442 0.26250E-05 0.9916E-02 4443 0.24750E-05 0.9916E-02 4444 0.23500E-05 0.10278E-01 445 0.22500E-05 0.10278E-01 446 0.21500E-05 0.10278E-01 447 0.20500E-05 0.1050E-01 448 0.18500E-05 0.1123500E-01 449 0.18500E-05 0.1123500E-01 449 0.18500E-05 0.1123500E-01 449 0.18500E-05 0.1123500E-01 451 0.16500E-05 0.1123500E-01 452 0.15500E-05 0.12566E-01 453 0.14628E-05 0.12338E-01 454 0.13378E-05 0.13313E-01 455 0.133128E-05 0.13388E-01 456 0.12378E-05 0.13388E-01 457 0.11750E-05 0.14508E-01 458 0.11250E-05 0.14508E-01 459 0.10750E-05 0.14508E-01 460 0.10250E-05 0.14508E-01 461 0.98000E-06 0.16247E-01 462 0.94000E-06 0.16247E-01 463 0.9000E-06 0.16247E-01 464 0.8600E-06 0.16247E-01 465 0.8200E-06 0.17350E-01 466 0.8200E-06 0.16247E-01 467 0.8600E-06 0.16247E-01 468 0.7500E-06 0.16247E-01 469 0.8600E-06 0.16247E-01 460 0.10250E-06 0.16258E-01 461 0.98000E-06 0.16258E-01 462 0.94000E-06 0.16258E-01 463 0.9500DE-06 0.16258E-01 464 0.8600E-06 0.16258E-01 465 0.8200E-06 0.16258E-01 466 0.9800DE-06 0.16258E-01 467 0.9400E-06 0.16258E-01 468 0.7500E-06 0.16258E-01 469 0.9200E-06 0.16258E-01 470 0.6450C-06 0.16258E-01 471 0.1650C-06 0.16258E-01 472 0.9400E-06 0.16258E-01 473 0.9400E-06 0.16258E-01 474 0.95750C-06 0.223710E-01 475 0.9150C-06 0.223710E-01 476 0.94750E-06 0.223710E-01 477 0.1550C-06 0.223710E-01 478 0.94750E-06 0.223710E-01 479 0.9450C-06 0.223710E-01 480 0.3750C-06 0.223710E-01 480 0.3750C-06 0.223710E-01 481 0.3750C-06 0.233710E-01 482 0.3500C-06 0.233710E-01 483 0.33300E-06 0.22476E-01 477 0.1550C-06 0.233710E-01 478 0.94750E-06 0.233710E-01 479 0.9450C-06 0.233710E-01 470 0.9450C-06 0.233710E-01 471 0.9450C-06 0.233710E-01 472 0.9450C-06 0.233710E-01 473 0.9450C-06 0.233710E-01 474 0.9550C-06 0.3338E-01 475 0.913750E-06 0.233710E-01 477 0.9450C-06 0.233710E-01 478 0.94750E-06 0.233710E-01 479 0.9450C-06 0.3338E-01 489	434 0.412	250E-05	0.76803E-02	
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