

Calculation of Survival Rates and Effective  
Inactivation Cross Sections of Targets for  
Heavy Charged Particles Based on Microdose  
Concept

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August 1969

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# Calculation of survival rates and effective inactivation cross sections of targets for heavy charged particles based on microdose concept

## Abstract

According to the microdose concept, survival rates and effective inactivation cross sections of the targets are studied for heavy charged particles of energies  $4 \sim 12 \text{ MeV}/\text{amu}$  and of charges  $1 \sim 18$ . Calculation was performed using an IBM-7044 computer. The survival rates were calculated for one-, two-, and three-events models with different combinations of the following parameters: effective charges of ions,  $Z_{\text{eff}}$ , incident energies of ions,  $E_p$ , cut-off energies of  $\delta$ -rays,  $\eta$ , target thicknesses,  $l$ . As an input quantity,  $Z$  (primary energy transfer per target) was used. The effective inactivation cross sections were derived from the survival rates for the one-event model.

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## 微視的線量概念にもとづいた重荷電粒子に対する 標的の不活性化有効断面積と生存率の計算

### 要　　旨

微視的線量概念にもとづいて、エネルギーが  $4 \sim 12 \text{ MeV}/\text{amu}$ 、電荷が  $1 \sim 18$  の重荷電粒子に対する標的不活性化有効断面積と生存率を IBM-7044 を用いて計算した。生存率は one-, two- および three-events model の標的について、重荷電粒子の有効電荷  $Z_{\text{eff}}$ 、入射エネルギー  $E_p$ 、 $\delta$  線の cut-off エネルギー  $\eta$ 、標的厚み  $l$  をパラメータとして、それぞれ異なる組み合せをした場合について求めた。Input としては  $Z$ (標的当たりの附与エネルギー) を用いた。不活性化有効断面積は one-event model の場合についてのみ、生存率から求めた。

1969 年 3 月

日本原子力研究所東海研究所

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## 文 献

## 1. Introduction

One of the most striking features representing the action of ionizing radiations on the various systems (physical, chemical and especially biological systems) is that only a minute amount of energy is sufficient to produce a remarkable effect. These specific characteristics are principally due to the following two aspects of the primary energy transfer by ionizing particles, that is, the quantum theoretical discontinuity of the interaction of ionizing particles with matter, and the high degrees of the concentration of activation events around the track of ionizing particles and also of the intercorrelation of the activation events on the same track as well as among the neighboring tracks. The energy deposition by the ionizing particles, therefore, may be stated to be of the higher-ordered. With the definition of absorbed energy in the rad unit<sup>1)</sup> (macroscopic dose concept), these features are completely disregarded. The absorbed dose in the unit of rad,  $D$ , is defined by the following equation :

$$D = \frac{\Delta E}{\Delta m}, \quad (1)$$

where  $\Delta E$  is the energy (in the unit of 100 ergs) actually deposited in a volume element of mass  $\Delta m$  (in the unit of gram) in question by ionizing particles. This expression may be a sort of the local dose (or the differential dose) and has been usually recognized to be a quantity measurable with an extrapolation chamber. However, in this definition, specific characteristics of primary energy transfer by ionizing particles are not included and serious objections have been proposed theoretically<sup>2)3)</sup> and experimentally<sup>4)~7)</sup> to the measurability of the differential dose.

Consequently, the description of radiation effects in terms of survival curves (or rates), which has been usually regarded as the most fundamental one of the dose-effect(input-output) relation, can not explain the effect of the radiation quality, as long as it is based on the macroscopic dose. Therefore, new concept was for a long time wanted for to represent the input quantity relevant to the dose-effect relations in the radiation biology. For this purpose, a new concept of microdose was introduced to reflect the specific statistical characteristics of primary energy transfer by charged particles, and theoretical as well as experimental studies have been developed since 1959<sup>8)~11)</sup>.

In this paper, the survival rates of biological targets for several kinds of heavy charged particles were evaluated with the use of  $Z$  which is one of the input quantities introduced on the basis of the microdose concept. The survival rates were calculated for one-, two-, and three-events models with different combination of the following parameters; the effective charge of ions,  $Z_{\text{eff}}$ , the incident energy of ions,  $E_p$ , the cut-off energy of  $\delta$ -rays,  $\eta$ , and the target thickness,  $l$ .

The numerical values for the physical quantities necessary for performing the present calculation, such as  $Z^2_{\text{eff}}$ ,  $L_l(E, \eta)$ ,  $L_t(E, \eta)$ ,  $\phi_\delta(E)$ ,  $P(E, j)$  and  $f_j$ , were already given in the previous paper<sup>12)</sup>. Tables of survival rates in the case of  $T$ -input were also given there in the form of  $S_{\text{eff}}/S_0$  from which survival rates can be readily derived.

## 2. Method of calculation

### 2.1 Formulation of target theory based on $Z$ -distribution

In this paper, a fundamental quantity  $Z$  is made use of as the input quantity for the microscopic description of the primary energy transfer into the target volume.<sup>12)</sup>

$Z$ : the transferred energy in a target by all tracks traversing a target per target.

$Z$  is dependent of the dose, on the contrary to another input quantity  $T$  used in the preceding paper.<sup>12)</sup>

In order to get the  $Z$ -distribution simply, one would be better introduce the generating function which is usually used in the probability theory. One can refer to Ref.(11) as for the mathematical derivation of the  $Z$ -distribution<sup>11)</sup>. In the following, for simplicity, the total number of ions produced by primary energy transfer per target,  $J$ , is used as the input quantity instead of  $Z$ . The relation between  $J$  and  $Z$  is expressed as follows:

$$Z = JW, \quad (2)$$

where  $W$  is an average energy necessary to produce an ion pair. A random variable  $X_k$  is defined as a variable for the number of primary ionizations due to  $k$ -th hit where hit means the traversal of charged particles through a target. A distribution function for  $X_k$  is introduced by

$$P(X_k=j) = f_j, \quad (3)$$

where  $j$  is the number of ions produced by the primary energy transfer per track per target.

A random variable for the total number of ionizations due to  $N$  hits,  $S_N$ , is introduced as follows:

$$S_N = X_1 + X_2 + \dots + X_N, \quad (4)$$

where  $N$  is a random number for the number of hits and independent of  $X_i$ . A distribution function for  $N$  is defined by

$$P(N=m) = g_m. \quad (5)$$

Then, a distribution function for the total number of ionizations  $S_N$  is given as follows:

$$P(S_N=J) = h_J. \quad (6)$$

Since eq.(3) means that the probability of occurrence of  $j$  ionizations by the  $k$ -th hit is  $f_j$  and eq.(5) means that the probability of occurrence of  $m$  hits is  $g_m$ , then eq.(6) can be derived as a convolution of the two distribution functions, given by eqs.(3) and (5), as follows:

$$P(S_N=J) = h_J = \sum_{m=0}^{\infty} P(N=m) P(S_m=J). \quad (7)$$

The explicit form of  $h_J$  can be readily derived with the use of generating function for  $f_j$ ,  $g_m$  and  $h_J$  which are denoted by  $f(s)$ ,  $g(s)$ , and  $h(s)$ , respectively. Since a random distribution function for  $N$ ,  $g_m$  is, in principle, given by a Poisson distribution, we have the following equation:

$$g(s) = \exp - \bar{m}(1-s), \quad (8)$$

where  $\bar{m}$  is a mean hit number and has the following relation with total flux of charged particles,  $\bar{\phi}_t$ , and the mean geometrical cross section of target,  $S_0$ ,

$$\bar{m} = \bar{\phi}_t S_0, \quad (9)$$

$$\bar{\phi}_t = \int \phi_t(E) dE. \quad (10)$$

Here, let us define the probability  $P(E, j)$  that a particle with energy  $E$  delivers  $j$  ions in a target. Then  $f_j$  is given as follows:

$$f_j = \frac{\int \phi_t(E) P(E, j) dE}{\int \phi_t(E) dE}. \quad (11)$$

With the use of eq. (11) and the recursion formula for  $h_J$ , an explicit expression for  $h_J$  can be readily derived and given as follows:

$$h_0 = \exp - \bar{m}(1-f_0) = \exp - \bar{\phi}_t S_0 (1-f_0) \quad J=0, \quad (12)$$

$$h_J = \frac{\bar{m}^{J-1}}{J} \sum_{i=0}^{J-1} (J-i) f_{J-i} h_i \quad J \geq 1. \quad (13)$$

Survival rates of the biological targets can be readily calculated with the use of eqs. (12) or (13). Practical applications will be described in Section 3.

## 2.2 Calculation on distribution of primary energy transfer for heavy charged particles

The probability distribution function based on  $Z$ -distribution can be regarded as a secondary quantity derivable from the parameters concerning the primary energy transfer of heavy charged particles such as  $\bar{\phi}_t$ ,  $f_j$  and  $S_0$ . Since the practical method of calculations and numerical values of  $\bar{\phi}_t$  and  $f_j$  were already described and tabulated in Ref. (12), only the outline of them will be here recapitulated.

First, the effective charges of the heavy ions,  $Z_{\text{eff}}$ , were estimated according to the empirical formula introduced by Northcliffe<sup>13)</sup>. The primary energy transfer of ionizing particles is divided into three parts: the local energy transfer, the  $\delta$ -ray production, and the radiative energy transfer. Accordingly, the total  $LET$  is divided into three parts as follows:<sup>14)15)</sup>

$$\begin{aligned} [\text{total } LET] &= [\text{local } LET] + (\text{energy imparted to } \delta\text{-rays}) \\ &\quad + (\text{radiative energy transfer}), \\ L_t(E) &= L_l(E) + L_{cl}(E) + L_{rad}(E). \end{aligned} \quad (14)$$

The local *LET* corresponds to the energy transfer delivered in the vicinity of the track, which mainly comes from the glancing collisions and can be calculated by the formula given by Bethe.<sup>16)</sup> The energy imparted to  $\delta$ -ray ( $L_{el}(E)$ ) gives rise to the newly produced ionizing radiation flux ( $\delta$ -rays) whose energy is consumed in the region far from the primary track.  $L_{el}(E)$  is the energy loss which comes from the knock-on collisions and can be calculated with the use of the Møller cross section formula<sup>17)</sup> for electrons.  $L_{rad}(E)$  is the radiative energy loss and was calculated by the formula derived by Racah<sup>18)</sup>.

Corresponding to the decomposition of the total *LET* mentioned above, the total flux of the radiation fields consists of the two components; that is, the primary flux and the  $\delta$ -ray flux:

$$\phi_t(E) = \phi_p(E) + \phi_\delta(E), \quad (15)$$

where  $\phi_p(E)$  and  $\phi_\delta(E)$  are the differential flux for heavy ions and for  $\delta$ -rays, respectively. We assumed that the energy loss of heavy ions in the target medium is so small that the energy of the incident heavy ions is constant through the medium of interest. It is also assumed that  $\delta$ -rays are produced from heavy ion tracks following the Rutherford formula<sup>19)</sup> and are degraded in the medium following the modified continuous slowing-down model.<sup>14)15)</sup>

Then we get the following relation between  $\bar{\phi}_p$  and  $\phi_\delta$

$$\bar{\phi}_\delta = \bar{\phi}_p a Z_{\text{eff}}^2, \quad (16)$$

where

$$\bar{\phi}_\delta = \int \phi_\delta(E) dE, \quad (17)$$

$$\bar{\phi}_p = \int \phi_p(E) dE, \quad (18)$$

and "a" is a numerical factor which is the total energy flux of  $\delta$ -rays produced by heavy ion of 1 particle/cm<sup>2</sup> and of  $Z_{\text{eff}}=1$ . Therefore eq. (15) can be rewritten using eq. (16) as follows:

$$\bar{\phi}_t = \bar{\phi}_p (1 + a Z_{\text{eff}}^2). \quad (19)$$

### 3. Results

The parameters used to get the actual results are given in Table 1. The biological system is here represented by the water medium as an approximation, so that *LET* of heavy ions and of electrons and  $\phi_\delta(E)$  were calculated with the values for the water medium tabulated in Table 1. The exact form of  $P(E, j)$  in the expression of  $f_j$  in eq. (11) would be of the much complicated one. However, if the mean diameter of the target is sufficiently small that the energy loss of the particle passing through the target is negligibly small compared with the particle energy, each ionization event along the same track may be regarded to be stochastically independent of each other. Therefore, the Poisson distribution was here assumed for  $P(E, j)$  as a considerably good approximation.

$$P(E, j) = \frac{[(l/W)L_i(E)]^j}{j!} \exp^{-(l/W)L_i(E)}, \quad (20)$$

where  $l$  is the average diameter of the target.

In the following, the survival rates of the biological systems were evaluated with the use of

**Table 1** Input parameters

Kind of heavy ion, $Z$ : ${}^1\text{H}$ , ${}^2\text{He}$ , ${}^3\text{Li}$ , ${}^5\text{B}$ , ${}^6\text{C}$ , ${}^7\text{N}$ , ${}^8\text{O}$ , ${}^9\text{F}$ , ${}^{10}\text{Ne}$ , ${}^{18}\text{A}$ .
Incident energy of heavy ion, $E_p(\text{MeV}/\text{amu})$ : 4, 6, 8, 10, 12.
Cut-off energy, $\eta(\text{eV})$ : 125, 250, 500, 1000.
Number of primary ionization per track per target, $j$ : 0, 1, 2.
Number of primary ionization per target, $J$ : 0, 1, 2
Target size, $l/W(100 \text{ \AA}/\text{eV})$ : 1/1000, 1/300, 1/100, 1/30, 1/10.
Average diameter of target: $l(\text{\AA})$ .
Average energy required to produce one primary ionization: $W(\text{eV})$ .
Input data for water medium
$N_e = 3.33698 \times 10^{23} \text{ els/cm}^3$
$Z = 10$
$A = 18.0153$
$\rho = 0.9982$
$I = 74.1 \text{ eV}$ .

$Z$ -distribution. One can refer to the Ref. (11) on the difference of the meanings of between  $T$  and  $Z$  when used as an input quantity.

When the multi-targets model is taken, survival rates can be readily derived with appropriate combinations of  $h_j$  corresponding to the properties of the target system of interest. Hereafter, for convenience and simplicity, calculations are performed on the one target model.

In the case in which the threshold energy,  $E_{\text{th}}$ , for the inactivation of target is equal to  $W$ , which is usually so called one target one event model, the survival rates are calculated by the following equation:

$$h_0 = \exp -\bar{\phi}_p S_0 (1 + aZ_{\text{eff}}^2)(1 - f_0), \quad (21)$$

where  $\bar{\phi}_p S_0$  plays a role corresponding to the macroscopic dose,  $D$ . The expression of eq.(21) is the same as that for  $T$ -input and the survival curves are an exponential type, as long as the number of targets in the system is one. In this case, the effective inactivation cross section,  $S_{\text{eff}}$ , of a target is given as

$$S_{\text{eff}} = S_0 (1 + aZ_{\text{eff}}^2)(1 - f_0). \quad (22)$$

On the other hand, survivals for  $E_{\text{th}} = mW$ , where  $m$  is integer and called as the number of the threshold events, are given as follows:

$$h_0 + h_1 + \dots + h_{m-1}, \quad (23)$$

and, for an example, the survival rate for  $m=2$  is given with eq.(13) as

$$h_0 + h_1 = [1 + \bar{\phi}_p S_0 (1 + aZ_{\text{eff}}^2)f_1] h_0. \quad (24)$$

As is readily seen from an example with  $m=2$ , the survival curves are generally not of the exponential shape except for a case with  $m=1$ , even in the one target model. Actual calculations were carried out for  $m=1, 2$  and  $3$  with different combination of five kinds of  $E_p$ , ten kinds of ions, and four kinds of  $l/W$ . The results are tabulated in Table 2. The data are so massive that the data are printed in microfiche. Discussion about these results from the point of view of physics, biology and radiation dosimetry will be published elsewhere together with the results obtained from  $T$ -distribution, including the actual application of  $T$ - and  $Z$ -distribution for the biological system.

**Table 2** Survival rate

Calculated values of survival rates as function of primary energy of incident ions,  $E_p$ , kind of heavy ions, target size,  $l/W$ , cut-off energy,  $\eta$ , for three kinds of models,  $h_0$ ,  $h_0+h_1$  and  $h_0+h_1+h_2$ . Because of typographical limitations, symbols of parameters used in text are indicated as follows:

$\phi_p S_0$ (ions/target)	: FPSO (IONS/TAGT)
$E_p$	: EP
$\eta$	: ETA
$l/W$	: L/W
$h_0$	: H0
$h_0+h_1$	: H0+H1
$h_0+h_1+h_2$	: H0+H1+H2

Powers of ten are indicated by symbol E: thus 8.37678 E-01 means  $8.37678 \times 10^{-1}$ .

**Table** is divided into five parts according to  $E_p$ , thus,

**Table 2-1** :  $E_p=4$  MeV/amu

**Table 2-2** :  $E_p=6$  MeV/amu

**Table 2-3** :  $E_p=8$  MeV/amu

**Table 2-4** :  $E_p=10$  MeV/amu

**Table 2-5** :  $E_p=12$  MeV/amu

The data are so massive that are printed in microfiche. Among them, five samples of the data are shown in the following. The microfiche will be obtained if you request to the authors or to the Division of Technical Information, Japan Atomic Energy Research Institute, Tokaimura, Naka-gun, Ibaraki-ken, Japan.

**Table 2.1**  $E_p=4$  MeV/amu  
 $H_0 + H_1$ ,  $H_0+H_1+H_2$

EP = 4.0 (MEV/AMU)		ETA = 0.125 (KEV)		L/W = 1.000E-06 (CM/KEV)		HYDROGEN	
FPSO (IONS/TAGT)	HO	HO+H1	HO+H1+H2	FPSO (IONS/TAGT)	HO	HO+H1	HO+H1+H2
0.	1.00000E 00	1.00000E 00	1.00000E 00	4.48257E 01	2.89427E -02	1.26859E -01	2.96862E -01
2.24128E 00	8.37678E -01	9.79375E -01	9.97688E -01	4.70670E 01	2.42446E -02	1.410368E -01	2.67180E -01
4.48257E 00	7.01704E -01	9.3098E -01	9.8985E -01	4.93083E 01	2.03092E -02	9.58882E -01	2.39894E -01
6.72385E 00	5.87802E -01	8.86691E -01	9.75088E -01	5.15496E 01	1.70125E -02	8.32012E -02	2.14913E -01
8.96514E 00	4.22548E -01	8.25549E -01	9.53139E -01	5.37908E 01	1.42510E -02	7.21064E -02	1.92129E -01
1.12064E 01	4.12463E -01	7.61514E -01	9.24418E -01	5.60321E 01	1.19378E -02	6.24213E -02	1.71420E -01
1.34477E 01	3.45511E -01	6.96181E -01	8.89794E -01	5.82734E 01	1.00000E 01	5.39805E -02	1.52658E -01
1.56889E 01	2.89427E -01	6.31344E -01	8.50355E -01	6.05147E 01	8.37678E -03	4.66352E -02	1.35711E -01
1.79303E 01	2.42446E -01	5.70535E -01	8.01717E -01	6.27560E 01	7.01704E -03	4.02522E -02	1.20443E -01
2.01716E 01	2.03092E -01	5.12279E -01	7.61439E -01	6.49973E 01	5.87802E -03	3.47127E -02	1.06725E -01
2.24128E 01	1.70125E -01	4.57902E -01	7.14148E -01	6.72385E 01	4.92388E -03	2.99110E -02	9.44273E -02
2.46541E 01	1.42510E -01	4.07681E -01	6.66225E -01	6.94798E 01	4.12463E -03	2.57534E -02	8.34281E -02
2.68954E 01	1.19378E -01	3.61698E -01	6.18459E -01	7.17211E 01	3.45511E -03	2.21575E -02	7.36106E -02
2.91367E 01	1.00000E -01	3.19902E -01	5.71507E -01	7.39624E 01	2.89427E -03	1.90000E -02	6.48649E -02
3.13780E 01	8.37678E -02	2.82124E -01	5.25899E -01	7.62037E 01	2.42446E -03	1.63683E -02	5.70883E -02
3.36193E 01	7.01704E -02	2.48216E -01	4.82047E -01	7.84450E 01	2.03092E -03	1.40549E -02	5.01853E -02
3.58606E 01	5.87802E -02	2.17868E -01	4.40257E -01	8.06663E 01	1.70126E -03	1.20612E -02	4.40679E -02
3.81018E 01	4.92388E -02	1.90332E -01	4.00741E -01	8.29275E 01	1.42510E -03	1.03445E -02	3.86549E -02
4.03431E 01	4.12463E -02	1.66833E -01	3.63634E -01	8.51688E 01	1.19378E -03	8.86727E -03	3.38722E -02
4.25844E 01	3.45511E -02	1.45597E -01	3.29003E -01	8.74101E 01	1.00000E -03	7.59707E -03	2.96523E -02
0.	1.00000E 00	1.00000E 00	1.00000E 00	1.17766E 01	2.89427E -02	1.21857E -01	2.79935E -01
5.88829E -01	8.37678E -01	9.72136E -01	9.95863E -01	1.23654E 01	2.42446E -02	1.05968E -01	2.51567E -01
1.17766E 00	7.01704E -01	9.26970E -01	9.84800E -01	1.29542E 01	2.03092E -02	9.20270E -02	2.25555E -01
1.76649E 00	5.87802E -01	8.70552E -01	9.66234E -01	1.35431E 01	1.70125E -02	8.91917E -02	2.01798E -01
2.35532E 00	4.92388E -01	8.08529E -01	9.40433E -01	1.41319E 01	1.42510E -02	6.91507E -02	1.80178E -01
2.94415E 00	4.12463E -01	7.43492E -01	9.08176E -01	1.47207E 01	1.19378E -02	5.98422E -02	1.60567E -01
3.53298E 00	3.45511E -01	6.78266F -01	8.70514E -01	1.53096E 01	1.00000E -02	5.17336E -02	1.42833E -01
4.12180E 00	2.89427E -01	6.14625E -01	8.28607E -01	1.58984E 01	8.37678E -03	4.46807E -02	1.26841E -01
4.71063E 00	2.42446E -01	5.53774E -01	7.83615E -01	1.64872E 01	7.01704E -03	3.85543E -02	1.12459E -01
5.29946E 00	2.03092E -01	4.96483E -01	7.36629E -01	1.70760E 01	5.87802E -03	3.32396E -02	9.95546E -02
5.88829E 00	1.70125E -01	4.43200E -01	6.88633E -01	1.76649E 01	4.92389E -03	2.86344E -02	8.80035E -02
6.47712E 00	1.42510E -01	3.94134E -01	6.40481E -01	1.82537E 01	4.12463E -03	2.46485E -02	7.76855E -02
7.06595E 00	1.19378E -01	3.49319E -01	5.92892E -01	1.88425E 01	3.45511E -03	2.12021E -02	6.84875E -02
7.65478E 00	1.00000E -01	3.08668E -01	5.46454E -01	1.94314E 01	2.89427E -03	1.82251E -02	6.03032E -02
8.24361E 00	8.37678E -02	2.72010E -01	5.01628E -01	2.00202E 01	2.42446E -03	1.56559E -02	5.30339E -02
8.83244E 00	7.01704E -02	2.39120E -01	4.58764E -01	2.06090E 01	2.03092E -03	1.34406E -02	4.65879E -02
9.42127E 00	5.87802E -02	2.09741E -01	4.18113E -01	2.11978E 01	1.70126E -03	1.08810E -02	4.08810E -02
1.00101E 01	4.92388E -02	1.83598E -01	3.79840E -01	2.17867E 01	1.42510E -03	9.88881E -03	3.58361E -02
1.05989E 01	4.12463E -02	1.60417E -01	3.44039E -01	2.23755E 01	1.19378E -03	8.47525E -02	3.13825E -02
1.11878E 01	3.45511E -02	1.39924E -01	3.10741E -01	2.29643E 01	1.00000E -03	7.26004E -03	2.74563E -02

Table 2.2  $E_p=6$  MeV/amu  
 $H_0 + H_0 + H_1 + H_2$

EP = 6.0 (MEV/AMU)		ETA = 0.125 (KEV)		L/W = 1.000E-06 (CM/KEV)		HYDROGEN	
FPS0 (IONS/TAGT)	H0	H0+H1	H0+H1+H2	FPS0 (IONS/TAGT)	H0	H0+H1	H0+H1+H2
0.	1.00000E 00	1.00000E 00	1.00000E 00	6.09953E 01	2.89427E-02	1.27470E-01	2.98960E-01
3.04976E 00	8.37678E-01	9.8259E-01	9.97874E-01	6.40450E 01	2.42446E-02	1.10905E-01	2.69117E-01
6.09953E 00	7.01704E-01	9.40579E-01	9.90419E-01	6.70948E 01	2.03092E-02	9.63597E-02	2.41673E-01
9.14929E 00	5.81892E-01	8.76121E-01	9.54635E-01	1.70146E 01	1.70146E 01	8.36141E-02	2.16541E-01
1.21991E 01	4.92388E-01	8.27298E-01	9.54635E-01	7.311943E 01	1.42510E-02	7.24673E-02	1.92613E-01
1.52488E 01	4.12463E-01	7.63911E-01	9.26354E-01	7.62441E 01	1.19378E-02	6.27362E-02	1.72769E-01
1.82986E 01	3.45511E-01	6.98369E-01	8.92211E-01	7.92939E 01	1.00000E-02	5.42548E-02	1.53880E-01
2.13483E 01	2.89427E-01	6.34221E-01	8.52966E-01	8.23436E 01	8.37678E-03	4.68394E-02	1.36614E-01
2.43901E 01	2.24462E-01	5.72582E-01	8.10041E-01	8.53934E 01	7.01704E-03	4.04596E-02	1.21427E-01
2.74479E 01	2.03092E-01	5.14208E-01	7.64464E-01	8.84431E 01	5.87802E-03	3.48926E-02	1.01617E-01
3.04976E 01	1.70125E-01	4.59697E-01	7.17264E-01	9.14929E 01	4.92388E-03	3.00668E-02	9.52272E-02
3.35474E 01	1.45510E-01	4.09335E-01	6.69380E-01	9.45427E 01	4.12463E-03	2.58884E-02	8.4134E-02
3.65972E 01	1.19378E-01	3.63210E-01	6.21598E-01	9.75924E 01	3.45511E-03	2.27442F-02	7.42389E-02
3.96469E 01	1.00000E-01	3.22747E-01	5.74583E-01	1.00642E 02	2.89427E-03	1.91512E-02	6.54334E-02
4.26967E 01	8.37678E-02	2.83382E-01	5.28890E-01	1.03692E 02	2.42446E-03	1.64552F-02	5.75933E-02
4.57465E 01	7.01704E-02	2.49324E-01	4.84942E-01	1.06742E 02	2.03092E-03	1.42299E-02	5.06939E-02
4.87962E 01	5.87602E-02	2.18861E-01	4.42992E-01	1.09719E 02	1.70126E-03	1.21258E-02	4.44693E-02
5.18460E 01	4.92388E-02	1.91774E-01	4.03328E-01	1.12841E 02	1.42510E-03	1.04001E-02	3.90062E-02
5.48957E 01	4.12463E-02	1.66761E-01	3.66059E-01	1.15891E 02	1.19378E-03	8.91514E-03	3.41828E-02
5.79455E 01	3.45511E-02	1.46289E-01	3.31265E-01	1.18941E 02	1.00000E-03	7.63823E-03	2.99264E-02
0.	1.00000E 00	1.00000E 00	1.00000E 00	1.58011E 01	2.89427E-02	1.23843E-01	2.86611E-01
7.90054E-01	9.75778E-01	9.75011E-01	9.96664E-01	1.65011E 01	2.42446E-02	1.07705E-01	2.55722E-01
1.58011E 00	7.01704E-01	9.31788E-01	9.86924E-01	1.73812E 01	2.03092E-02	9.35002E-02	2.31200E-01
2.37016E 00	5.87602E-01	8.76903E-01	9.69883E-01	1.8112E 01	1.70125E-02	8.11264E-02	2.06965E-01
3.16022E 00	4.92388E-01	8.15287E-01	9.45606E-01	1.89613E 01	1.42510E-02	7.03243E-02	1.84884E-01
3.9027E 00	4.12463E-01	7.50569E-01	9.14744E-01	1.95014E 01	1.19378E-02	6.08662E-02	1.64840E-01
4.74532E 00	3.45511E-01	6.85377E-01	8.78267E-01	2.05441E 01	1.02000E-02	5.26257E-02	1.46700E-01
5.53038E 00	2.89427E-01	6.21577E-01	8.37312E-01	2.13315E 01	8.31678E-03	4.54567E-02	1.30331E-01
6.32243E 00	2.42446E-01	5.60429E-01	7.93027E-01	2.21215E 01	7.01704E-03	3.92285E-02	1.15600E-01
7.11049E 00	2.03092E-01	5.02755E-01	7.446517E-01	2.29116E 01	5.87802E-03	3.38245F-02	1.02375E-01
7.90054E 00	1.70125E-01	4.49038E-01	6.98783E-01	2.37016E 01	4.92388E-03	2.91413E-02	9.05294E-02
8.69060E 00	1.42510E-01	3.99513E-01	6.50706E-01	2.44917E 01	4.12463E-03	2.50872E-02	7.99431E-02
9.48865E 00	1.19378E-01	3.54234E-01	6.03034E-01	2.52817E 01	3.45511E-03	2.15814E-02	7.05012E-02
1.02707E 01	1.00000E-01	3.13129E-01	5.56382E-01	2.60178E 01	2.89227E-03	1.85558E-02	6.20959E-02
1.10008E 01	8.37618E-02	2.76034E-01	5.11237E-01	2.68818E 01	2.42446E-03	1.59387E-02	5.46270E-02
1.18508E 01	7.01704E-02	2.42732E-01	4.67974E-01	2.76519E 01	2.03092E-03	1.36845E-02	4.80012E-02
1.26408E 01	5.87802E-02	2.12968E-01	4.26866E-01	2.84419E 01	1.70126E-03	1.17421E-02	4.21329E-02
1.34309E 01	4.92388E-02	1.86471E-01	3.88096E-01	2.92202E 01	1.42510E-03	1.00697E-02	3.69432E-02
1.42221E 01	4.12463E-02	1.62964E-01	3.51775E-01	3.00221E 01	1.19378E-03	8.63091E-03	3.23602E-02
1.50110E 01	3.45511E-02	1.42176E-01	3.17947E-01	3.08121E 01	1.00000E-03	7.39386E-03	2.83186E-02

Table 2.3  $E_p=8$  MeV/amu $\text{HO} + \text{H}_2$  $\text{HO} + \text{H}_1 + \text{H}_2$ 

FPSO (IONS/TAGT)	HO	EP = 8.0 (MEV/AMU)	ETA = 0.125 (KEV)	L/W = 1.000E+06 (CM/KEV)		HYDROGEN	
				HO+H1+H2	FPSO (IONS/TAGT)	HO	HO+H1
0.	1.00000E 00	1.00000E 00	1.00000E 00	7.63228E 01	2.89427E-02	1.27810E-01	3.00132E-01
3.81614E 00	8.80751E-01	9.97976E-01	8.01389E 01	2.42446E-02	1.11204E-01	2.70198E-01	
7.63228E 00	7.01704E-01	9.41403E-01	8.39509E 01	9.66220E-02	2.42667E-01		
1.14464E 01	5.67802E-01	8.89888E-01	8.77712E 01	1.70125E-02	8.38438E-02	2.17451E-01	
1.52646E 01	4.92388E-01	8.28784E-01	9.15874E 01	1.42510E-02	7.26682E-02	1.94442E-01	
1.90807E 01	4.12463E-01	7.64702E-01	9.54035E 01	1.19378E-02	6.29114F-02	1.73522E-01	
2.28968E 01	3.45511E-01	6.93401E-01	9.92166E 01	1.00000E-02	5.44075E-02	1.54563E-01	
2.67130E 01	2.89427E-01	6.35461E-01	1.03036E 02	8.37678E-03	4.70067E-02	1.37430E-01	
3.05291E 01	2.42446E-01	5.73721E-01	1.06852E 02	7.01704E-03	4.05749E-02	1.21992E-01	
3.43453E 01	2.03092E-01	5.15281E-01	7.66150E-01	1.10668E 02	5.87802E-03	3.49927E-02	1.08116E-01
3.81614E 01	1.70125E-01	4.60696E-01	7.19008E-01	1.14484E 02	4.92388E-03	3.01536E-02	9.56740E-02
4.19775E 01	1.42510E-01	4.10255E-01	6.71141E-01	1.18300E 02	4.12463E-03	2.59634E-02	8.45430E-02
4.57937E 01	1.19378E-01	3.64051E-01	6.23351E-01	1.22116E 02	3.45511E-03	2.23391E-02	7.46055E-02
4.96098E 01	1.00000E-01	3.22037E-01	5.76309E-01	1.25933E 02	2.89427E-03	1.92073E-02	6.57510E-02
5.34260E 01	8.37678E-01	2.84071E-01	5.30559E-01	1.29749E 02	2.42446E-03	1.65306E-02	5.78611E-02
5.72421E 01	7.01704E-02	2.49494E-01	4.86523E-01	1.33565E 02	2.03092E-03	1.41716E-02	5.08845E-02
6.10582E 01	5.87802E-02	2.19413E-01	4.44519E-01	1.37381E 02	1.70125E-03	1.21618F-02	4.46874E-02
6.48744E 01	4.92388E-02	1.92207E-01	4.04768E-01	1.41197E 02	1.42510E-03	1.04311E-02	3.92029E-02
6.86905E 01	4.12463E-02	1.68052E-01	3.67413E-01	1.45013E 02	1.19378E-03	8.94178E-03	3.43564E-02
7.25067E 01	3.45511E-02	1.46675E-01	3.32528E-01	1.48829E 02	1.00000E-03	7.66112E-03	3.00795E-02
0.	1.00000E 00	1.00000E 00	1.00000E 00	1.96234E 01	2.89427E-02	1.24933E-01	2.90305E-01
9.81168E-01	8.37678E-01	9.76589E-01	9.97065E-01	2.06045E 01	2.42446E-02	1.08674E-01	2.61129E-01
1.96234E 00	7.01704E-01	9.34430E-01	9.88031E-01	2.15857E 01	2.03092E-02	9.44020E-02	2.34334E-01
2.94350E 00	5.87802E-01	8.80226E-01	9.71823E-01	2.25669E 01	1.70125E-02	8.18996F-02	2.09826E-01
3.92467E 00	4.92388E-01	8.18998E-01	9.48383E-01	2.35480E 01	1.42510E-02	7.09687E-02	1.87492E-01
4.90584E 00	4.12463E-01	7.54454E-01	9.18290E-01	2.45922E 01	1.19378E-02	6.14285E-02	1.67208E-01
5.88701E 00	3.45511E-01	6.89285E-01	8.82479E-01	2.55104E 01	1.00000E-02	5.31156E-02	1.48844E-01
6.86817E 00	2.89427E-01	6.25394E-01	8.42057E-01	2.64915E 01	8.37678E-03	4.58829F-02	1.32666E-01
7.84934E 00	2.42446E-01	5.64083E-01	7.98173E-01	2.74727E 01	7.01704E-03	3.95987E-02	1.17342E-01
8.83051E 00	2.03092E-01	5.06199E-01	7.51934E-01	2.84539E 01	5.87802E-03	3.41457E-02	1.03939E-01
9.81168E 00	1.70125E-01	4.52243E-01	7.04354E-01	2.94350E 01	4.92389E-03	2.94196E-02	9.19309E-02
1.07928E 01	1.42510E-01	4.02466E-01	6.56326E-01	3.04162E 01	4.12463E-03	2.53281E-02	8.11960E-02
1.17740E 01	1.19378E-01	3.56933E-01	6.08615E-01	3.13974E 01	3.45511E-03	2.17898E-02	7.16189E-02
1.27552E 01	1.00000E-01	3.15578E-01	5.61850E-01	3.23785E 01	2.89427E-03	1.87328E-02	6.30911E-02
1.37363E 01	8.37678E-02	2.78244E-01	5.16534E-01	3.33597E 01	2.42446E-03	1.60941E-02	5.55115E-02
1.47175E 01	7.01704E-02	2.44715E-01	4.73056E-01	3.43409E 01	2.03092E-03	1.38184E-02	4.87860E-02
1.56987E 01	5.87802E-02	2.14740E-01	4.31699E-01	3.53220E 01	1.70126E-03	1.18575E-02	4.28281E-02
1.66799E 01	4.92388E-02	1.88048E-01	3.92658E-01	3.63032E 01	1.42510E-03	1.01691E-02	3.75581E-02
1.76610E 01	4.12463E-02	1.64363E-01	3.66051E-01	3.72844E 01	1.19378E-03	8.17638E-03	3.29034E-02
1.86422E 01	3.45511E-02	1.43413E-01	3.21932E-01	3.82655E 01	1.00000E-03	7.46735E-03	2.87977E-02

Table 2.4  $E_p = 10 \text{ MeV/amu}$ 

HO + H1 + H2		EP = 10.0 (MEV/AMU)		ETA = 0.125 (KEV)		L/W = 1.000E-06 (CM/KEV)		HYDROGEN	
FPSO (IONS/TAGT)	HO	HO+H1	HO+H2	HO+H1+H2	FPSO (IONS/TAGT)	HO	HO+H1	HO+H1+H2	
0.	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	9.08785E 01	2.89427E 02	1.28032E 01	3.00902E 01	
4.54392E 06	8.37678E -01	9.81074E -01	9.98034E -01	9.54224E 01	2.42446E -02	2.11400E -01	2.70509E -01		
9.08785E 00	7.01704E -01	9.41943E -01	9.90938E -01	9.99663E 01	2.03092E -02	9.67940E -02	2.4320E -01		
1.36318E 01	5.87802E -01	8.89666E -01	9.77061E -01	1.04510E 02	1.70125E -02	8.9944E -02	2.1848E -01		
1.81757E 01	4.93388E -01	8.29545E -01	9.56011E -01	1.09054E 02	1.42510E -02	7.27998E -02	1.94988E -01		
2.27196E 01	4.12463E -01	7.65495E -01	9.28139E -01	1.13598E 02	1.19378E -02	6.0263E -02	1.7418E -01		
2.72635E 01	3.45511E -01	7.00384E -01	8.94248E -01	1.18142E 02	1.00000E -02	5.05076E -02	1.55011E -01		
3.18075E 01	2.89475E -01	6.36241E -01	8.55386E -01	1.22686E 02	8.37678E -03	4.70937E -02	1.3735E -01		
3.63514E 01	2.42446E -01	5.74467E -01	8.12688E -01	1.27230E 02	7.01704E -03	4.06506E -02	1.22557E -01		
4.08953E 01	2.03092E -01	5.15988E -01	7.67257E -01	1.31774E 02	5.87802E -03	3.50583E -02	1.08444E -01		
4.56349E 01	1.70125E -01	4.61351E -01	7.20150E -01	1.36318E 02	4.92388E -03	3.02104E -02	9.59677E -02		
4.99831E 01	1.42510E -01	4.10859E -01	6.72229E -01	1.40862E 02	4.12463E -03	2.60127E -02	8.48856E -02		
5.42711E 01	1.19318E -01	3.64603E -01	6.24502E -01	1.45406E 02	3.55511E -03	2.23817E -02	7.48398E -02		
5.90110E 01	1.00000E -01	3.22538E -01	5.77439E -01	1.49949E 02	2.89427E -03	1.92441E -02	6.59597E -02		
6.36149E 01	8.37678E -02	2.84522E -01	5.31653E -01	1.54493E 02	2.42446E -03	1.65354E -02	5.80616E -02		
6.81588E 01	7.01704E -02	2.50350E -01	4.87057E -01	1.59037E 02	2.03092E -03	1.41990E -02	5.1092E -02		
7.27028E 01	5.18702E -02	2.19775E -01	4.45525E -01	1.3581E 02	1.70125E -03	1.21854E -02	4.48335E -02		
7.72467E 01	4.92338E -02	1.92529E -01	4.05716E -01	1.68125E 02	1.42510E -03	1.04144E -02	3.9332E -02		
8.17906E 01	4.12463E -02	1.68338E -01	3.68303E -01	1.2669E 02	1.19318E -03	8.95244E -03	3.44105E -02		
8.63345E 01	3.45511E -02	1.46928E -01	3.33358E -01	1.77213E 02	1.00000E -03	7.67613E -03	3.01801E -03		
EP = 10.0 (MEV/AMU)		ETA = 0.125 (KEV)		L/W = 1.000E-06 (CM/KEV)		HYDROGEN			
FPSO (IONS/TAGT)	HO	HO+H1	HO+H2	HO+H1+H2	FPSO (IONS/TAGT)	HO	HO+H1	HO+H1+H2	
0.	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	2.32642E 01	2.894427E 02	1.25638E 01	2.92703E 01	
1.16271E 00	8.37678E -01	9.77609E -01	9.97310E -01	2.44619E 01	2.42446E 02	1.09294E 01	2.63341E 01		
2.32542E 00	7.01704E -01	9.36139E -01	9.88723E -01	2.55196E 01	2.03092E 02	9.49461E -02	2.36366E -01		
3.48812E 00	5.87802E -01	8.82373E -01	9.73052E -01	2.67423E 01	1.70126E -02	8.23761E -02	2.11685E -01		
4.65083E 00	4.92338E -01	8.21398E -01	9.50156E -01	2.79040E 01	1.42510E -02	7.19374E -02	1.88186E -01		
5.81354E 00	4.12463E -01	7.56966E -01	9.20564E -01	2.90677E 01	1.19374E -02	6.17792E -02	1.68747E -01		
6.97622E 00	3.45511E -01	6.91810E -01	8.85184E -01	3.02040E 01	1.00000E -02	5.34322E -02	1.50237E -01		
8.13895E 00	2.89427E -01	6.27861E -01	8.45112E -01	3.13931E 01	8.37678E -03	4.61585F -02	1.33524E -01		
9.30166E 00	2.42446E -01	5.66445E -01	8.01491E -01	3.25528E 01	7.01704E -03	3.98379E -02	1.18474E -01		
1.04644E 01	2.03092E -01	5.08424E -01	7.55431E -01	3.37185E 01	5.87802E -03	3.435335E -02	1.04956E -01		
1.16271E 01	1.70125E -01	4.54315E -01	7.07953E -01	3.48812E 01	4.92388E -03	2.95995E -02	9.28422E -02		
1.27898E 01	1.42510E -01	4.04375E -01	6.59961E -01	3.60439E 01	4.12463E -03	2.54838E -02	8.20107E -02		
1.39525E 01	1.19378E -01	3.58678E -01	6.12227E -01	3.72066E 01	3.45511E -03	2.19244E -02	7.23458E -02		
1.51152E 01	1.00000E -01	3.17161E -01	5.65391E -01	3.83694E 01	2.89442E -03	1.88491E -02	6.37385E -02		
1.62779E 01	8.37678E -02	2.79672E -01	5.19966E -01	3.95321E 01	2.42446E -03	1.61944E -02	5.60869E -02		
1.74405E 01	7.01704E -02	2.45997E -01	4.76349E -01	4.06948E 01	2.03092E -03	1.39050E -02	4.92966E -02		
1.86603E 01	5.87802E -02	2.15885E -01	4.34832E -01	4.18575F 01	1.70125E -03	1.1932F -02	4.32804E -02		
1.97660E 01	4.92338E -02	1.89067E -01	3.95616E -01	4.30202E 01	1.42510E -03	1.02339E -02	3.79582E -02		
2.09287E 01	4.12463E -02	3.58825E -01	3.65267E -01	4.41829E 01	1.1937E -03	8.77162E -02	3.32568E -02		
2.20914E 01	3.45511E -02	1.44212E -01	3.24519E -01	4.53456E 01	1.00000E -03	7.51484E -03	2.91094E -02		

Table 2.5  $E_p=12.0$  MeV/amu

$H_0 + H_0 + H_1 + H_2$

		EP = 12.0 (MeV/AMU)		ETA = 0.125 (KEV)	L/W = 1.000E-06 (CM/KEV)	
FPS0	(IONS/TAGT)	$H_0$	$H_0 + H_1$	$H_0 + H_1 + H_2$	FPS0 (IONS/TAGT)	$H_0 + H_1$
0.	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	1.04948E 02	2.89427E-02
5.24741E 00	8.37678E-01	9.81303E-01	9.98089E-01	1.10196E 02	2.42446E-02	1.28191E-01
1.04948E 01	7.01704E-01	9.42327E-01	9.91078E-01	1.15443E 02	2.03092E-02	1.11539E-01
1.57422E 01	5.87802E-01	9.77322E-01	9.20590E 02	1.70251E-02	8.41015E-02	2.43765E-01
2.09896E 01	4.92388E-01	8.30081E-01	9.56938E-01	1.25938E 02	1.70251E-02	2.18474E-01
2.62370E 01	4.12463E-01	7.66060E-01	9.28639E-01	1.31185E 02	1.19378E-02	1.95375E-01
3.14944E 01	3.45511E-01	7.00951E-01	8.94849E-01	1.36633E 02	1.00000E-02	1.74310E-01
3.67318E 01	2.89421E-01	6.36795E-01	8.56069E-01	1.41680E 02	8.37678E-03	1.5530F-01
4.19794E 01	2.42446E-01	5.74948E-01	8.13428E-01	1.69277E 02	7.01704E-03	1.38123E-01
4.72266E 01	2.03092E-01	5.16484E-01	7.68045E-01	1.52175E 02	5.87802E-03	1.22216E-01
5.24741E 01	1.70125E-01	4.61818E-01	7.20963E-01	1.57422E 02	4.92388E-03	1.08677E-01
5.77215E 01	1.42510E-01	4.11288E-01	6.73119E-01	1.62670E 02	4.12463E-03	9.61767E-02
6.29689E 01	1.19378E-01	3.64995E-01	6.25320E-01	1.67917E 02	3.45511E-03	8.49925E-02
6.82163E 01	1.00000E-01	3.22893E-01	5.78243E-01	1.73164E 02	2.89427E-03	7.5067E-02
7.34633E 01	8.37678E-02	2.84843E-01	5.32436E-01	1.78412E 02	2.42446E-03	6.61683E-02
7.88711E 01	7.01704E-02	2.50638E-01	4.88323E-01	1.83659E 02	2.03092E-03	5.1938E-02
8.39559E 01	5.87802E-02	4.66239E-01	4.70070E 02	1.88907E 02	1.70126E-03	4.42184E-02
8.92059E 01	4.92388E-02	1.92759E-01	4.06391E-01	1.94154E 02	1.42510E-03	4.9372E-02
9.44533E 01	4.12463E-02	1.68541E-01	3.68936E-01	1.99401E 02	1.19378E-03	3.9440E-02
9.97067E 01	3.45511E-02	1.47107E-01	3.33946E-01	2.04649E 02	1.00000E-03	3.45217E-02

		EP = 12.0 (MeV/AMU)		ETA = 0.125 (KEV)	L/W = 1.000E-06 (CM/KEV)	
FPS0	(IONS/TAGT)	$H_0$	$H_0 + H_1$	$H_0 + H_1 + H_2$	FPS0 (IONS/TAGT)	$H_0 + H_1$
0.	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	2.67658E 01	2.89427E-02
1.33929E 00	8.37678E-01	9.77322E-01	9.97444E-01	2.81041E 01	2.42446E-02	1.09728E-01
2.67559E 00	7.01704E-01	9.37335E-01	9.89201E-01	2.94424E 01	2.03092E-02	2.64895E-01
4.01487E 00	5.87802E-01	8.88766E-01	9.73902E-01	3.07807E 01	1.70125E-02	2.37794E-01
5.35315E 00	4.92388E-01	8.23075E-01	9.51286E-01	3.21189E 01	1.42510E-02	2.12991E-01
6.69445E 00	4.12463E-01	7.58723E-01	9.22447E-01	3.34572E 01	1.19378E-02	1.90376E-01
8.02974E 00	3.45511E-01	6.92577E-01	8.87072E-01	3.47955E 01	1.00000E-02	6.20463E-02
9.36803E 00	2.89421E-01	6.29588E-01	8.47246E-01	3.61338E 01	8.37678E-03	5.36538E-02
1.07063E 01	2.24463E-01	5.68998E-01	8.09310E-01	3.74721E 01	7.01704E-03	4.63511E-02
1.203446E 01	2.03092E-01	5.09982E-01	7.57877E-01	3.88104E 01	5.87802E-03	4.44985E-02
1.33829E 01	1.70125E-01	4.55765E-01	7.10473E-01	4.01487E 01	4.92388E-03	2.97254E-02
1.47212E 01	1.42510E-01	4.05711E-01	6.62507E-01	4.14870E 01	4.12463E-03	2.55928E-02
1.60595E 01	1.19378E-01	3.59899E-01	6.14758E-01	4.28253E 01	3.45511E-03	2.0186F-02
1.73978E 01	1.00000E-01	3.18269E-01	5.67873E-01	4.41635E 01	2.89427E-03	1.89305E-02
1.87361E 01	8.37678E-01	2.80671E-01	5.2373E-01	4.55018E 01	2.42446E-03	1.62647E-02
2.00743E 01	7.01704E-02	2.46894E-01	4.78660E-01	4.68401E 01	2.03092E-03	1.39656E-02
2.14126E 01	5.87802E-02	2.16686E-01	4.37031E-01	4.81784E 01	1.70126E-03	1.19843E-02
2.27509E 01	4.92388E-02	1.89781E-01	3.97693E-01	4.95167E 01	1.42510E-03	1.02782E-02
2.40892E 01	4.12463E-02	1.65900E-01	3.60773E-01	5.08550E 01	1.19378E-03	8.1028E-03
2.54275E 01	3.45511E-02	1.44772E-01	3.26334E-01	5.21933E 01	1.00000E-03	7.54807E-03

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