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A Database for Transmutation of Nuclear Materials on Internet

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A database system on Internet for nuclear material design and selection used in various reactors are developed in NRIM site of "Data-Free-Way". In order to retrieve and maintain the database, the user interface for the data retrieval was developed where special knowledge on handling of the database or the machine structure is not required for end-user. It is indicated that using the database, the possibility of nuclides and radioactivity in a material can be easily retrieved though the evaluation is qualitatively.

1. Introduction

In the data system for nuclear material design and selection used in various reactors, huge material databases and several kinds of tools for data analysis or simulation code of the phenomena under irradiation are required. Thus, a database on transmutation for nuclear materials had constructed on PC [1]. The database converted to a system used on Internet. As a database for nuclear material design and selection used in various reactors are developed in NRIM site of "Data-Free-Way"[2.3]. A database storing the data on nuclear reaction needs to calculate of the simulation. Using the database, we can retrieve the data of nuclear reaction for material design on the Internet and understand qualitatively the behavior of nuclear reaction such as the transmutation or decay. The database is required for the friend user-interface for the retrieval of necessary data. In the paper, features and functions of the developed system are described and especially, examples of the easy accessible search of nuclear reactions are introduced.

2. Outline of the database on transmutation for nuclear materials

2.1 Database system

In the database of transmutation for nuclear materials, the data of nuclear reaction for material design is stored and we can understand qualitatively the behavior of nuclear reaction such as the transmutation or decay. The database is managed by ORACLE where RDBMS (relational database management system) is supported on work station with unix OS.
As the RDBMS and WWW were connected, user are able to retrieve necessary data using Netscape or Explorer as a user-interface through the Internet.

Fig. 1 shows the home page in the WWW of NRIM site on "Data-Free-Way". Users are accessed the database by selecting the term of "transmutation of material" in the home page. Then. the opening screen of the database as shown Fig. 2 is appeared. Users are able to select various interface for retrieval and obtain the necessary data.

2.2 Data structure

The database consists of five main tables and three supplemental tables, as shown Fig. 3. Main tables are element, isotope, spontaneous decay, transmutation and cross section table. The element table has the data such as element name, atomic weight and etc. These data are input values obtained from ordinary periodic table. The data in the isotope table consist of the natural abundance ratio, half-life data, gamma-ray or beta-ray energy and maximum permissible concentration in air (MPC), which are taken from isotope table. The spontaneous decay table has the data of decay mode and branching ratio. The transmutation table has the data of transmutation process, produced nuclide and etc.. The neutron cross-section table stores the data with 42-energy group covering from thermal neutron energy to 15MeV. Fig. 4 is shown a example of ^{180}W drown by the data in this table. It is defined that high neutron energy is more than 0.1MeV and low one is less than 0.1MeV.

The supplemental tables are three kinds of spontaneous decay, decay mode, gamma energy

Fig. 1 WWW of NRIM's home page in "Data-Free-Way" system.

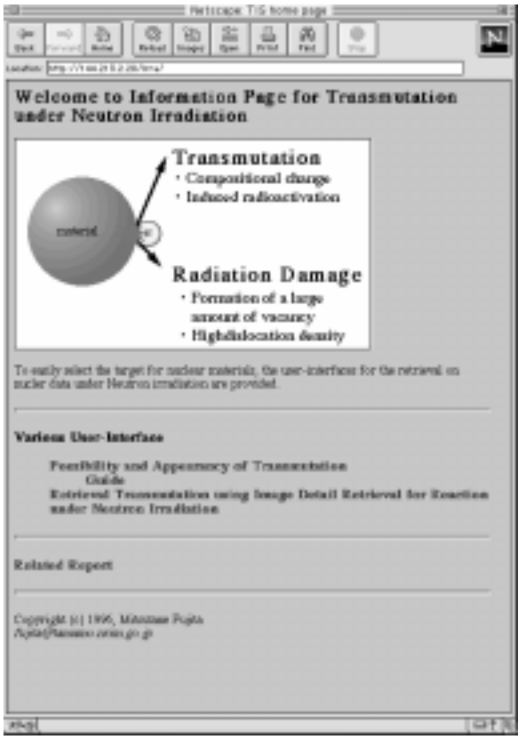

Fig. 2 Opening screen of the for transmutation under neutron irradiation.

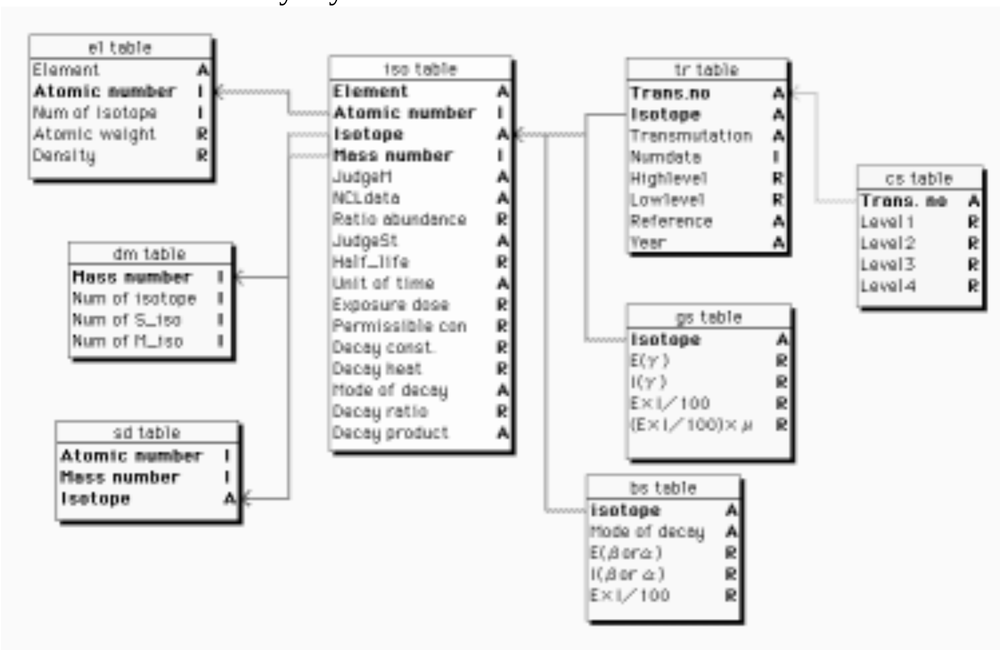

Fig. 3 The data structures of the database on transmutation for nuclear materials.

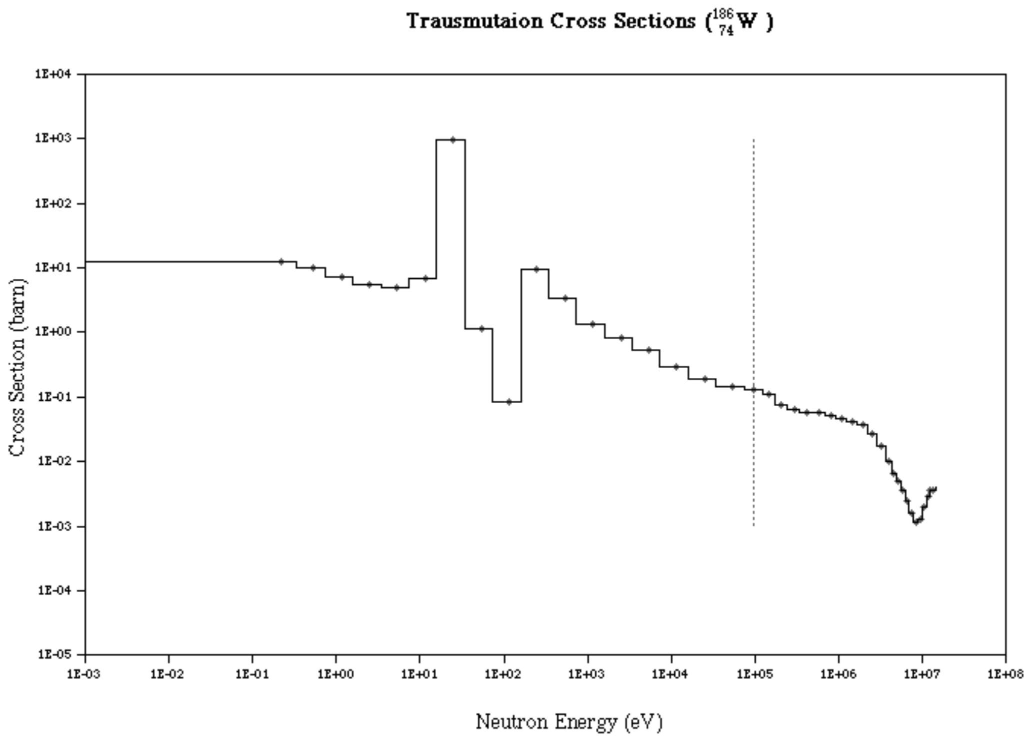

Fig. 4 Relation between cross section of nuclear reaction and neutron spectrum.

and beta or alpha. These tables play the roles due to aid the retrieval and the calculation of heat. Both tables are related by a certain unique key mutually.

2.3 Stored data

Various data, which are required for simulation on nuclear reaction, have been collected and stored in the database from reports as follows.

I. Nuclear data such as neutron cross-section are collected from JAERI's CRROSLIB, ENDF/B-6, JENDL-3 and FENDL 1.1. The number of element stored in the database is 54 at present, however, this will increase to be 89 in near future.

II. The data on element and isotope are collected from
  a. "Table of Radioactive Isotopes" E. Browne and R. B. Firestone, 1986, LBLU of C, John Wiley & Sons,
  b. "Chart of the Nuclides" compiled by Y. Yoshizaw and T. Horiguchi and M. Yamada, 1980, JNDC and NDC in JAERI.

In the near future, the system will be used through the Internet and the improvement will be being done to consider step reaction including many unstable nuclides.

3. Functions and user-interface

3.1 Functions

Fig. 2 shows opening main menu screen of the database. This database has four retrieval functions of nuclear reaction process, properties of radioactive isotope, spontaneous decay of each isotope and decay of produced nuclides after nuclear reaction. We can understand qualitatively the behavior of nuclear reaction such as the transmutation or decay.

3.2 User-interface for retrieval data

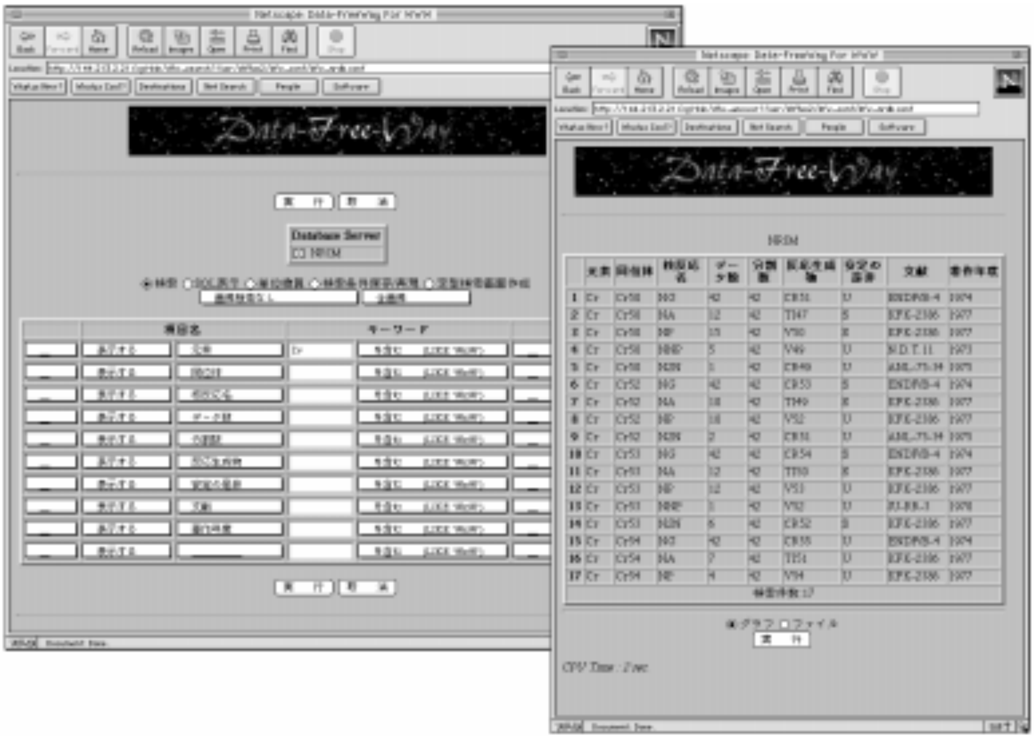

Fig. 5 Screen to retrieve data on nuclear transmutation and the results of Cr atomic element.

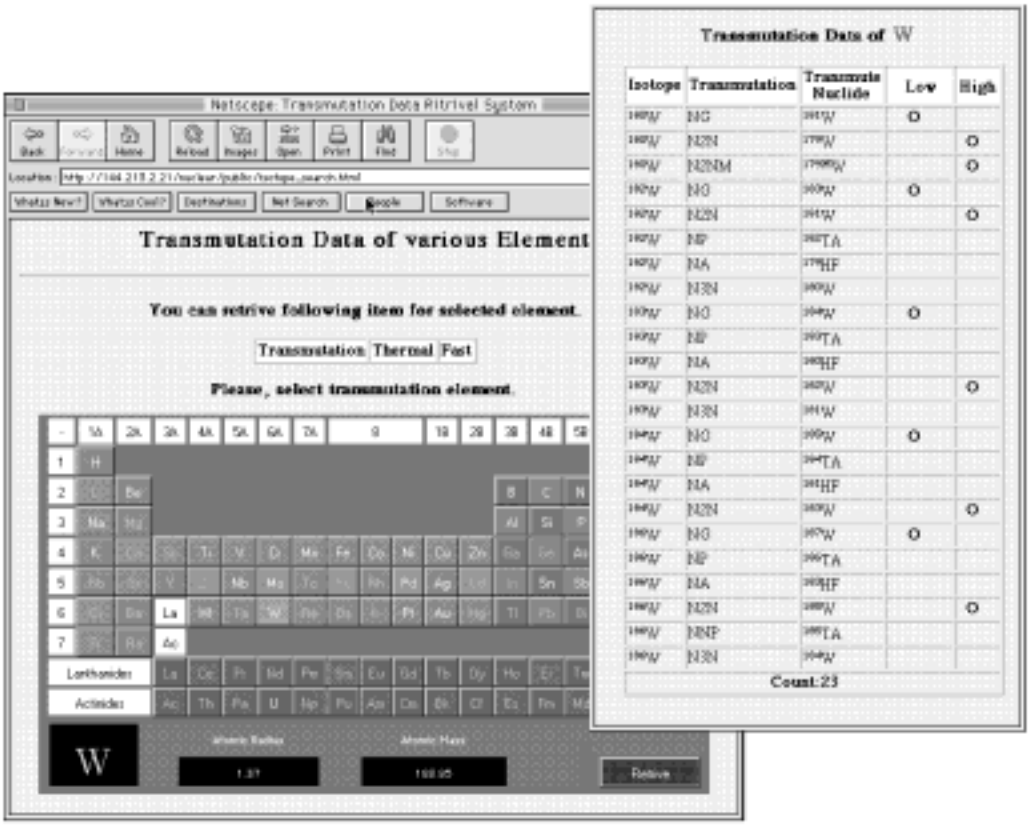

Fig. 6 Screen to retrieve data on nuclear transmutation using periodic table and the results of ^{186}W .

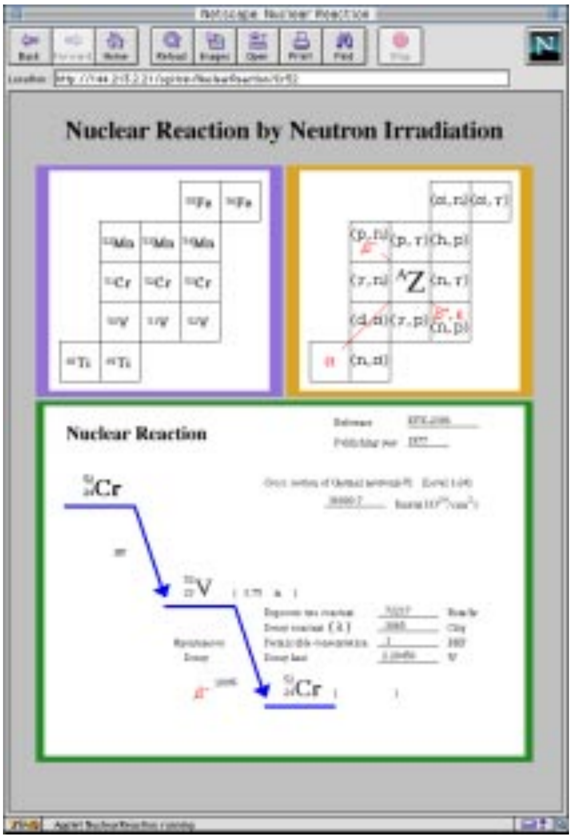

Fig. 7 Screen to retrieve data on nuclear transmutation and decay process and the results.

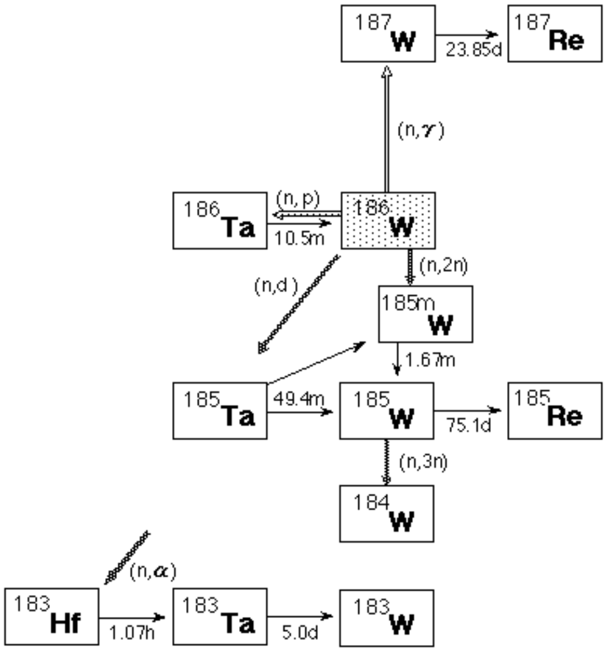

Fig. 8 Nuclear reaction for first step of ^{186}W.

After choosing one of four functions on opening screen, various screens corresponding to the function appear as shown Fig. 5,6,7. Fig 5 shows a screen to retrieve data related all item in main five tables. Retrieved results indicates nuclear reaction, transmuted nuclides and stability of the nuclide in stable isotope of Cr. Fig. 6 shows either the nuclide is easily formed by neutron energy in each nuclear transmutation of ^{180}W or not. Fig. 7 shows screen that by selecting the desired nuclear reaction in right folder, it is possible to know records on a given transmutation and spontaneous decay in the reaction process as shown ordinary in Fig. 8 in under folder. Fig. 8 shows nuclear reaction for first step of ^{186}W.

The user-interface (i.e. folder) of the database performs an important role either useful system or not. Using this user-interface, end-user can easily obtain the necessary information by the easy operation for retrieving, because a screen provided with pop-up and pull down menu, is employed to be mainly operated by micro-mouse in addition to keyboard.

4 Example of system operation

Type 316 stainless steel is used as the structural material of the fuel sub-assemblies in the sodium cooled fast breeder reactors. This steel is regarded as a candidate material for blanket structures of the fusion reactors. However it is required that materials should have a high resistance against swelling and low radioactivation under the high-energy neutron irradiation environment such as in fusion reactors. Ferritic 9Cr1WVTa steel is also being considered as an alternate candidate structural material to type 316 stainless steel [3]. An amount of He formation and radioactivity under neutron irradiation of both steels will be evaluated as an example of application of the present simulation system.

Using the nuclide database, the possibility of large amount of He formation and radioactivity

Table 1 Results of retrieval for long half-life on the products of nuclear reaction of the first step caused by neutron irradiation to both type 316 stainless and ferritic steel.

(a) type 316 stainless steel
(Fe,Cr,Ni,Mo,Ti,Cu,C,Mn,Si,S,P,O,N,B)

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Isotope	Transmutaion	Transmute Nuclide	Half-life	Unit	Decay heat	Fast	Thermal
B10	NP	Be10	2.0000e+6	y	1.8500e-1		
C13	NG	C14	5.7300e+3	y	5.2300e-1		
C13	NA	Be10	2.0000e+6	y	1.8500e-1	○	
N14	NP	C14	5.7300e+3	y	5.2300e-1		○
O17	NA	C14	5.7300e+3	y	5.2300e-1		
Fe54	NG	Fe55	2.7000e+0	y			○
Fe54	NNP	Mn53	4.0000e+6	y			
Fe56	N2N	Fe55	2.7000e+0	y			
Ni58	NG	Ni59	7.5000e+4	y	3.5600e-1		○
Ni58	NA	Fe55	2.7000e+0	y			
Ni60	NP	Co60	5.2690e+0	y	2.6200e+0		
Ni60	N2N	Ni59	7.5000e+4	y	3.5600e-1		
Ni61	NNP	Co60	5.2690e+0	y	2.6200e+0		
Ni62	NG	Ni63	1.0000e+2	y	2.2000e-1		○
Ni64	N2N	Ni63	1.0000e+2	y	2.2000e-1	○	
Cu63	NA	Co60	5.2690e+0	y	2.6200e+0		
Cu63	NP	Ni63	1.0000e+2	y	2.2000e-1		
Mo92	NG	Mo93	3.5000e+3	y			
Mo92	NP	Nb92	3.0000e+7	y	1.5000e+0		
Mo92	NNP	Nb91	6.8000e+2	y			
Mo94	NP	Nb94	2.0000e+4	y	1.7400e+0		
Mo94	N2N	Mo93	3.5000e+3	y		○	
Mo95	NNP	Nb94	2.0000e+4	y	1.7400e+0		
Mo96	NA	Zr93	2.0000e+6	y	2.5000e-1		

(b) ferritic 9Cr-1WVTa steel
(Fe,Cr,W,V,Ta,C,Mn,Si,S,P,O,N,B)

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Isotope	Transmutaion	Transmute Nuclide	Half-life	Unit	Decay heat	Fast	Thermal
B10	NNP	Be9					
B10	NP	Be10	2.0000e+6	y	1.8500e-1		
B11	NP	Be11	1.3800e+1	s	4.7400e+0		
V51	NP	Ti51	5.7600e+0	m	1.6300e+0		
Cr50	NP	V50				○	
Cr50	NNP	V49	3.3000e+2	d			
Cr52	NP	V52	3.7500e+0	m	2.2800e+0	○	
Cr53	NP	V53	1.6100e+0	m	1.8300e+0		
Cr53	NNP	V52	3.7500e+0	m	2.2800e+0		
Cr54	NP	V54	4.9800e+1	s	3.4100e+0		
Fe54	NP	Mn54	3.1221e+2	d	8.3500e-1	○	
Fe54	NNP	Mn53	4.0000e+6	y			
Fe56	NP	Mn56	2.5790e+0	h	2.2700e+0		
Fe56	NNP	Mn55					
Fe57	NP	Mn57	1.6100e+0	m	9.4400e-1		
Fe57	NNP	Mn56	2.5790e+0	h	2.2700e+0		
Fe58	NP	Mn58	6.5300e+1	s	3.2400e+0		
Ta181	NP	Hf181	4.2400e+1	d	6.6500e-1		
W182	NP	Ta182	1.1500e+2	d	1.2800e+0		
W183	NP	Ta183	5.1000e+0	d	4.1900e-1		
W184	NP	Ta184	8.7000e+0	h	1.8800e+0		
W186	NP	Ta186	1.0500e+1	m	1.7300e+0		
W186	NNP	Ta185	4.9000e+1	m	6.2600e-1		

in the candidate materials can be easily evaluated qualitatively. The possibility of He formation is known by retrieving cross section size of (n, alpha;) reaction on compositional atoms of materials. The radioactivity is known by retrieving half-life of transmuted products of compositional atoms of material. Table 1 shows transmuted products with half-life of more than one year in type 316 and ferritic steel. These result suggest that type 316 stainless steel has more radioactive nuclides and is radioactivated more easily than ferritic 9Cr-1WVTa steel under neutron irradiation. It is found that this system will be frequently used by nuclear material scientists as a material information tool, if this system is jointed to networking system such as "Data-Free-Way"[2]~[3].

5. Summary

1) A database on transmutation for nuclear materials with user friendly interface was constructed in WWW server on the Internet. (http://inaba.nrim.go.jp//Irra/)
2) The database consists of mainly four tables stored the information of atomic element , isotope, transmutation and cross section for 42 neutron energy group.
3) The compositional change and radioactivity in materials can be easily evaluated qualitatively.
4) The radioactivity is known by retrieving half-life of transmuted products of compositional atoms of material. Transmuted products with half-life of longer than one year in type 316 and ferritic steel. These result suggest that type 316 stainless steel has more radioactive nuclides and radioactivated more easily than ferritic 9Cr-1WVTa steel for reduced activationunder neutron irradiation .

References

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[3] Ueno F., Kano S., Iwata S.,Fujita M., Kurihara Y., Nakajima H., Yokoyama N. and Iwata S., J. Nucl. Sci. Technol, vol.31 (1994) p.1314-1334.