

# Input Format Design and Translator Development for NJOY

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## Abstract

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The NJOY Nuclear Data Processing System is a software system used for nuclear data management [1]. In particular, it is used to convert evaluated nuclear data for materials stored in Evaluated Nuclear Data Files (ENDF) [2] into different formats, as well as performing operations on the data.

NJOY is widely used within nuclear data research, and as such, it is important that the system has a user friendly interface. The NJOY input instructions [4] is a non-interactive user interface used for specifying jobs to be run by NJOY. The input instructions are complex and hard to read compared to e.g. a high-level programming language. Working with a large and complex job easily becomes a daunting and error-prone task. Accordingly, there is a need for an improved input format.

In this thesis, a new input format has been designed. In order to make the new input format useable with NJOY, a translator which is able to translate the new input format into the original NJOY input instructions has also been implemented. The results have been verified by a small set of tests.

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# 1 Introduction

## 1.1 Background

Usability of software systems is important. The usability of a software system is determined, among other things, by its user interface. The user interface of a software system should provide means of interaction between the users and the system such that the desired result can be produced in an easy, elegant, and efficient fashion.

The NJOY Nuclear Data Processing System [1] is a software system used for nuclear data management. In particular, it is used to convert evaluated nuclear data for materials stored in Evaluated Nuclear Data Files (ENDF) [2] into different formats, as well as performing operations on the data. ENDF is a file format used for storing nuclear data which has been produced through an evaluation process.

NJOY is widely used within nuclear data research, and as such, it is important that the system has a user friendly interface. NJOY is currently being used within the MACRO project [3] at the Division of Applied Nuclear Physics, at the Department of Physics and Astronomy at Uppsala University. MACRO is a project that aims at linking reactor parameter uncertainties to uncertainties in nuclear cross sections and nuclear model parameters. This will be done using Monte Carlo-methods, and will require nuclear data processing on a large scale. It has been apparent to the researchers within the project that the non-interactive user interface used for specifying NJOY jobs is not as user friendly as one would like.

## 1.2 Problem Description

The NJOY input instructions [1, 4] are used for specifying jobs to be run by NJOY. It is a non-interactive user interface in the sense that the entire job needs to be specified prior to feeding the job to NJOY. No further input will be given when the processing of the job has started.

The NJOY input instructions are complex and hard to read compared to e.g. a high-level programming language. For example, algorithm 1 on the following page is a *short* and *simple* NJOY job which illustrates what the input instructions look like.

---

**Algorithm 1** NJOY Test Problem 14

---

```
1  acer
2  20 21 0 31 32
3  1 0 1/
4  'proton + 7-n-14 apt la150 njoy99 mcnp'/'
5  725 0./
6  /
7  /
8  acer
9  0 31 33 34 35
10 7 1 2/
11 'proton + 7-n-14 apt la150 njoy99 mcnp'/'
12 viewr
13 33 36/
14 stop
```

---

Without consulting the documentation, one might guess that line 4 and 11 are some kind of descriptive titles, which is correct. One might also guess that line 14 terminates the program. However, it is not obvious that line 2 denotes input and output files (each number indicates a specific file) that the system will operate on. It is also hard to deduce that the first number on line 5 denotes the material to be processed, and that the second number denotes the desired temperature in kelvin.

The input instructions can be annotated with descriptive comments, but even then, working with a large and complex job easily becomes a daunting and error-prone task.

### 1.3 Objective

The NJOY input instructions is not an optimal input format. Therefore, the scope of this thesis has been to design and implement a more user friendly, and readable input format. The design of the new input format could be based on some commonly known existing format that is fitting to the task. The basis could for example be a programming language.

In order to make the new input format useable with NJOY, it has to be translated into the original NJOY input instructions. As such, the scope of this work also included developing an accompanying translator for the new input format.



## 2 NJOY Input Instructions

The NJOY input instructions is described in reference [1, 4]. A brief summary of the general structure of the input instructions is provided in section 2.1 as a convenience for the reader.

### 2.1 General Structure

NJOY is composed by a set of modules where each module performs a specific task. Each module has its separate input specification, which defines the expected input instructions for the module.

An NJOY job is an ordered sequence of modules, where the order denotes the execution order. The name of a module is used to denote the start of the corresponding module and its specific input instructions. The input instructions for a module is composed by an ordered sequence of *cards*. A *card* is a line with an ordered sequence of values separated by spaces (or commas). A card may be terminated with a slash character to denote the end of the card, but it is not required. Algorithm 2 illustrates the general structure of an NJOY job.

---

**Algorithm 2** General structure of an NJOY job

---

```
1 module_name
2 value value ... value
3 value value ... value
4 ...
5 value value ... value
6 module_name
7 value value ... value
8 value value/
9 ...
10 value value ... value
11
12 ...
13
14 module_name
15 value value ... value
16 /
17 ...
18 value value ... value
19 stop
```

---

Line 1 denotes the start of the first module and its specific input instructions. Line 2 denotes the first card for the module declared on line 1. Line 3 through 5 denotes input instructions for successive cards that also belongs to the module declared on line 1. Line 6 through 10 denotes the declaration of another module and its corresponding cards. Successive module definitions, lines 11 through 18, may follow. Line 8 and 16 shows cards that have been terminated with the

slash character, denoting that no more values has been defined for the cards. An NJOY job is terminated by the **stop** instruction as indicated by line 19.

The expected cards in a module and the expected values within a card depends on the specific input specification for the module. The expected type of the values also depends on the input specification for the specific card and module. There are three kinds of types that the values in a card may be defined as: floating-point numbers, natural numbers (integers), and character strings. Character strings are generally required to be terminated by a slash character.

A card may have default values. A default value is a value that does not have to be defined in an NJOY job. If the value is not defined, then a default value will be set by NJOY. Values that may be defaulted are always defined at the end of the card. Hence, the values in a card are organized such that values that must be defined are always defined prior to values that may be defaulted. Default values will be used when a card is terminated by a slash character. For example, according to reference [4], card 3 in the **reconr** module is composed by three values. The last two values have default values. Declaring the card as

**value/**

will set the first value to **value** while the last two values will be set to their default values internally by NJOY since no more values were defined in the card.

To conclude, the NJOY input instructions are powerful. It is possible to construct a complex NJOY job by declaring a long chain of modules with their specific input instructions. Or, an NJOY job may be as simple as a single **stop** instruction, which just terminates the job.

## 3 Methodology

### 3.1 Introduction

The NJOY input instructions had to be understood in order to design the new input format. Each module in the NJOY software system, as described in reference [1, 4], was analyzed separately such that a general structure and common language features could be extracted and used for further analysis.

The NJOY modules are listed in table 1. The modules have been prioritized with a number. The number indicates the importance level of the module to the MACRO project [3]. A low number indicates high priority, e.g. a module with a low number had to be implemented before a module with a higher number.

NJOY Module	Priority
acer	1
broadr	1
ccccr	3
covr	1
dtfr	3
errorr	1
gaminr	3
gaspr	3
groupr	1
heatr	1
leapr	3
matxsr	3
mixr	3
moder	1
plotr	2
powr	3
purr	3
reconr	1
resxsr	3
thermr	1
unresr	3
viewr	2
wimsr	3

Table 1: Implementation priority of the NJOY modules

As stated in reference [5], a translator (*compiler*) is a program that can read a program in one language and translate it into an equivalent program in another language. In the following subsections, principles and techniques for constructing a translator presented in reference [5], is described.

## 3.2 Designing the New Input Format

### 3.2.1 Syntax Definition

The syntax definition of the new input format was specified in a notation called context-free grammar [6]. A context-free grammar is a convenient method of specifying the syntax of a programming language. For instance, the assignment (*declaration*) of an identifier can have the form

```
material = 9237
```

which can be expressed in a context-free grammar as the production

```
assignment ::= l_value "=" r_value
```

where `l_value` and `r_value` are other productions expressing the structure of the left and right hand side of the assignment, respectively.

## 3.3 Building the Translator

In reference [5], the translation process is described as a sequence of phases. Each phase inspects and transforms a representation of the source program to another. Phases such as lexical analysis, syntax analysis, and semantic analysis has been used throughout this work and is described in section 4.2 on page 10.

The translator, which is supposed to translate the input format into NJOY input instructions, was partly constructed using a lexical-analyzer generator [7] and a parser generator [8].

The translator was written in the Python programming language [9], in a Unix-like environment.

### 3.3.1 Lexical Analysis

Lexical analysis is the process of dividing the source program into sequences of characters, called tokens [10]. Each token describes a group of characters in the source program as an abstract type.

For example, the identifier `material`, the assignment character, `=`, and the integer `9237` could be represented as tokens of the form

```
<IDENTIFIER, material>,
```

```
<ASSIGNMENT, =>, and
```

```
<INTEGER, 9237>
```

PLY Lex [11] was used to generate a lexical analyzer (*lexer*) for the input format. The method of identifying the tokens was implemented by using the notation of regular expressions [12] in PLY Lex.

### 3.3.2 Syntax Analysis

Syntax analysis is the process of creating a tree-like representation, an abstract syntax tree, composed of the tokens generated by the lexical analyzer [13]. The syntax tree is used to describe the grammatical structure of the source program.

PLY Yacc [11] was used to generate a syntax analyzer (*parser*) for the grammar definition of the input format. The method of building the syntax tree was implemented by using the facilities provided by the PLY tools.

### 3.3.3 Semantic Analysis

Semantic analysis is the process of checking the syntax tree for errors that have to do with the *meaning* of the program [14].

For example, according to reference [4], card 1, 2 and 3 in the `acer` module must always be defined, and they must be defined in sequential order. The translator should report an error if these rules are violated; such as when card 1 has not been defined or when card 3 has been defined prior to card 2.

Type checking is another important part of the semantic analysis where the translator checks that each operator has valid operands.

For example, the identifier `hk`, in card 3 module `acer`, is used to denote a descriptive character string. According to reference [4], `hk` must be declared as a character string and must not exceed 70 characters in length. The translator should report an error if these rules are violated; such as when `hk` has been declared as an integer, or when the character string contains more than 70 characters.

## 3.4 Testing

Testing was carried out continuously during the design and implementation of the input format and the translator. The NJOY test problems<sup>1</sup> [1] was used to test the functionality of both the input format and the translator.

The NJOY test problems was manually translated into equivalent NJOY jobs in the new input format, which were run through the translator. The resulting output was compared with the expected output, to verify that the translator was working appropriately.

The Python unit testing framework [9] was utilized to set up the testing environment.

---

<sup>1</sup>The NJOY Test Problems are test runs which are used to test the functionality of the NJOY software system. See <http://t2.lanl.gov/codes/njoy99/>

## 4 Implementation

### 4.1 NJOY Input Format (NIF)

The new input format, NJOY Input Format (NIF), is basically the original NJOY input instructions which have been annotated with a syntax to make it easier to read and express. NIF has been designed to appear more like a high-level programming language.

#### 4.1.1 Grammar Definition

The proposed NJOY Input Format (NIF) is illustrated as a context-free grammar definition in algorithm 3 on the following page. The structure of the grammar is simple. Just like in reference [4], a NIF program is an ordered sequence of modules. Each module is composed by an ordered sequence of cards. A card is an ordered sequence of value definitions.

In NIF, the start symbol is **program**. The capitalized terminals, such as **MODULE** and **CARD**, are token classes specified by the lexer. Special symbols are denoted within double quotes. **empty** denotes the empty string.

An assignment denotes that a left hand side is assigned to hold the values of a right hand side. A left hand side is an ordered list of elements, where the elements can be an array or identifier. A right hand side is an ordered list of elements, where the elements can be a float, integer, null or a string. As such, a value definition is an array or identifier that has been declared to hold the value of either a floating-point number, natural number, empty string or a character string.

As indicated by the grammar, NIF supports multiple assignment. That is, multiple identifiers can be assigned in the same expression. For example, the expression

```
material, temp = 9237, 300.0;
```

denotes that the identifier **material** holds the integer 9237, and the identifier **temp** holds the float 300.0.

Note that the number of elements on the left hand side of an assignment does not have to be equal to the number of elements on the right hand side. According to the grammar, an assignment such as

```
material = 128, 9237;
```

is allowed even though it does not make sense. This is not allowed. The syntax analysis in the parser enforces that the number of elements on both sides of an assignment are the same.

---

**Algorithm 3** NJOY Input Format (NIF) Grammar Definition

---

```
program ::= module_list

module_list ::= module module_list
             | empty
module      ::= MODULE "{" card_list "}"

card_list  ::= card card_list
             | empty
card       ::= CARD "{" stmt_list "}"

stmt_list  ::= statement stmt_list
             | empty
statement  ::= expression ";"
expression ::= assignment

assignment ::= l_value_list "=" r_value_list

l_value_list ::= l_value
               | l_value "," l_value_list
r_value_list ::= r_value
               | r_value "," r_value_list

l_value ::= array
          | ident
array    ::= IDENTIFIER "[" INTEGER "]"
ident    ::= IDENTIFIER

r_value  ::= FLOAT
          | INTEGER
          | NULL
          | STRING
```

---

## 4.2 NJOY Input Format Translator (**nifty**)

### 4.2.1 Structure of the Translator

The translator, NJOY Input Format Translator (**nifty**), was constructed as a set of modules where each module implements a specific phase in the translation process. Five phases have been implemented as part of the translation process and are shown in figure 1.

The first phase is the lexical analysis which is implemented by the lexer module. The second phase, syntax analysis, is implemented by the parser module.

The third phase, implemented by the organizer module, is a special phase where the order of the statements in a card are analyzed and possible rearranged.

The fourth phase is the semantic analysis which is implemented by the module named analyzer. The fifth, and final, phase of the translator is the emitter module which implements a NJOY input instructions generator.

A basic user manual for the translator is available in appendix A on page 26.

### 4.2.2 Reserved Keywords

An important design choice is that the translator will enforce the use of reserved keywords to specify NIF programs. It will not only consider card and module names as reserved keywords, but also identifier names. As such, it is not possible to use an identifier name until it has been defined as an identifier in the translator. Similarly, it is not possible to use a card or module name which has not been defined in the translator. This restricts the expressiveness of the input format, but allows detailed analysis of the semantics in the organizer and analyzer modules. As a consequence, it also forces the user to write consistent and readable input files – which has been the objective of this work.

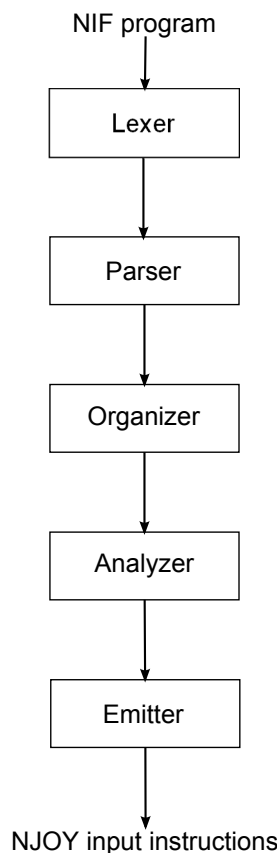


Figure 1: Translation process in **nifty**



### 4.2.3 The Modules

**Lexer** The lexer is responsible for recognizing character patterns and generating the appropriate NIF tokens. As input, the lexer expects a NIF program and will generate a token stream as its output unless the lexer detects a lexical error. If a lexical error is detected, an error message will be reported and the translation process will stop at this phase. The lexer will only recognize card and module names which are specified in reference [4], thus enforcing the use of a specific set of cards and modules as mentioned previously. The lexer also recognizes comments in the input program. The comments will be discarded during the lexical analysis and thus won't be passed on to the next phase in the translation process.

**Parser** The parser is responsible for enforcing the structure of the NIF grammar and constructing the syntax tree. As input, the parser expects a stream of tokens generated by the lexer. The parser will produce a syntax tree as its output, which represents the structure of the NIF program. If the parser detects a syntax error, an error message will be reported and the translation process will stop at this phase.

**Organizer** The organizer analyzes the syntax tree produced by the parser. Its purpose is to rearrange the statements in a card such that they appear in the expected, working order. As such, it should be possible to write a NIF program without having to list the statements in a card in the expected order as indicated by reference [4].

The NJOY modules and the cards within the modules still needs to be given in the correct order though. This is due to the fact that the number of possible NJOY jobs is infinite (all may not be functional in the NJOY software system, though). An infinite number of NJOY jobs can simply be created by just appending another module specification to an existing NJOY job in order to create a new one. Simply stated, the translator can not guess the intention of the job due to the number of possible combinations the modules may be listed in. Hence, the modules must be provided in the expected order by the user. Cards are not arrangeable either, since they also are prone to be repetitive. It is not possible to determine which card should go first from a set of cards (with the same name) which e.g. only contains a descriptive title. The cards must also be provided in the expected order by the user.

Each NJOY module requires its own organizer implementation since each module has its specific set of rules as described in reference [4]. Since the identifier names are hardwired in the translator, the organizer is able to do a detailed analysis of the syntax tree and easily detect if a specific identifier has been defined out of order.

If any statements have been provided out of order in a card, and the organizer is able to arrange the statements, a new syntax tree is returned where the statements have been ordered in the expected sequence. If the organizer

somehow fails, it will return the original syntax tree as produced by the parser and pass it on to the next phase in the translation process.

**Analyzer** The analyzer expects a syntax tree as its input. Like in the organizer phase, the NJOY modules need to be analyzed separately since each module has its specific set of rules. As such, each module also requires its own analyzer implementation.

The analyzer basically visits every node in the order they appear in the syntax tree and checks if it is the expected one. The analysis can be made very detailed since the translator can, to some extent, predict the next card or identifier due to the ordered nature described in reference [4]. Since the cards and the identifiers have reserved names, the analyzer is able to easily determine whether a card or an identifier is the expected one. Using reserved names also makes type checking easy, since a reserved identifier in a specific card may be associated with a specific type, range, size, length, et cetera.

The analyzer does not alter the syntax tree, it just analyzes it. The input syntax tree will be the output of the analyzer if the syntax tree is semantically correct according to the translator. If the analyzer detects a semantic error in the syntax tree, an error message will be reported and the translation process will stop at this phase.

**Emitter** The emitter expects a syntax tree as its input and it is responsible for generating NJOY input instructions from the syntax tree. The emitter simply flattens the tree structure and formats the instructions to their corresponding counterparts in the NJOY input instructions format. The emitter returns a string with the resulting NJOY input instructions. Each card in the resulting output has been annotated with a descriptive comment, indicating which card it is, to make it easier to find errors.

### 4.3 Translation Verification

As previously described in section 3.4 on page 7, the NJOY test problems [1] were manually translated into NIF programs expressing the equivalent NJOY jobs. The resulting NIF programs were used for verifying that the implementation was working appropriately by setting up a test suite using the Python unit testing framework [9]. Each test problem was set up to be run through each individual phase in the translation process, and each run was expected to be successful since the NIF programs should be an equivalent and functional version of the original test problems.

The resulting output, as produced by the emitter, was compared with the expected output. That is, each NIF version of the test problems was compared with its corresponding original NJOY test problem.

Note that modified versions of the original NJOY test problems had to be used as the expected output when comparing the resulting output from the translator. The comments that the emitter appends to every card had to be appended to the expected output such that the comparison could be performed.

## 4.4 Translation Efficiency

A simple Python script was written to check the resulting translation efficiency of the translator. Two different notions of timing were used in the script, namely *process time* and *wall time*.

Process time is the time that the entire task spent executing on the processor, measured by `time.clock()` which should be used for timing algorithms [9]. Wall time is the time that elapsed from when the task was started to when the task finished, measured by checking the difference in time using `time.time()` [9]. The main difference between process time and wall time is that wall time is the time it takes until the system delivers the computed result, whereas process time is the time that it took to compute the result.

## 5 Results

### 5.1 NJOY Input Format (NIF)

The result of the proposed grammar described in section 4.1 on page 8 is best illustrated with examples. Algorithm 4 illustrates NJOY input instructions (slightly modified to make it shorter for illustrational purposes) from NJOY Test Problem 2 [1]. In algorithm 5 on the next page, lines 1 through 9 from algorithm 4 are expressed in NIF.

---

**Algorithm 4** Modified subset of NJOY Test Problem 2

---

```
1  moder
2  20 -21/
3  reconr
4  -21 -22/
5  'pendf tape for pu-238 from endf/b-iv tape 404'/
6  1050 1/
7  0.005/
8  '94-pu-238 from endf/b tape t404'/
9  0/
10 broadr
11 -21 -22 -23/
12 1050 3 0 1/
13 0.005/
14 300.0 900.0 2100.0/
15 0/
16 stop
```

---

---

**Algorithm 5** NIF version of Algorithm 4 on the previous page, lines 1 through 9

---

```

1  moder {
2      card_1 {
3          pendf_input = 20;
4          pendf_output = -21;
5      }
6  }
7
8  reconr {
9      card_1 {
10         nendf = -21;
11         npend = -22;
12     }
13
14     card_2 {
15         tlabel = "pendf tape for pu-238 from endf/b-
16                 iv tape 404";
17     }
18
19     card_3 {
20         mat = 1050;
21         ncards = 1;
22     }
23
24     card_4 {
25         err = 0.005;
26     }
27
28     card_5 {
29         cards = "94-pu-238 from endf/b tape t404";
30     }
31     /* Card 6 not defined since 'ngrid' defaults to 0
32        in first card 3. */
33     card_3 { mat = 0; } // Terminate reconr.
34 }

```

---

Descriptive names for the identifiers on line 3 and 4 have been specified in the translator. The other identifier names has been chosen to reflect the documentation in reference [4] (the identifier names are hardwired in the translator). Line 30 and 31 shows how comments are expressed in NIF. Line 30 illustrates the structure of multiline comments while line 31 illustrates the structure of single line comments.

Algorithm 6 on the following page is a NIF version of the lines 10 through

16 from algorithm 4 on page 14. It shows how arrays are expressed in NIF (lines 24 through 26). The **stop** instruction on line 16 in algorithm 4 on page 14 does not have to be specified in NIF, the translator will automatically append it in the translation process.

When combined, algorithm 5 on the previous page and algorithm 6 forms the complete NJOY job as listed in algorithm 4 on page 14.

---

**Algorithm 6** NIF version of Algorithm 4 on page 14, lines 10 through 16

---

```

1  broadr {
2      card_1
3      {
4          nendf = -21;
5          nin = -22;
6          nout = -23;
7      }
8
9      card_2
10     {
11         mat1 = 1050;
12         ntemp2 = 3;
13         istart = 0;
14         istrap = 1;
15     }
16
17     card_3
18     {
19         errthn = 0.005;
20     }
21
22     card_4
23     {
24         temp2[0] = 300.0;
25         temp2[1] = 900.0;
26         temp2[2] = 2100.0;
27     }
28
29     /* Terminate execution of broadr with mat1 = 0 as
30        usual. */
31     card_5
32     {
33         mat1 = 0;
34     }
35 }
```

---

## 5.2 NJOY Input Format Translator (**nifty**)

Table 2 shows the implementation status for the NJOY modules. Each column entry indicates the completeness of a translator phase for a given NJOY module.

NJOY Module	Lexer	Parser	Organizer	Analyzer	Emitter
acer	100%		100%	90%	100%
broadr			100%	90%	
ccccr			0%		
covr			100%	90%	
dtfr			0%		
errorr			70%	20%	
gaminr			100%	90%	
gaspr			100%	99%	
groupr			100%	90%	
heatr			100%	90%	
leapr			0%		
matxsr					
mixr					
moder			100%	95%	
plotr			100%	90%	
powr			0%		
purr			100%	90%	
reconr			100%	90%	
resxsr			0%		
thermr			100%	90%	
unresr			100%	95%	
viewr			100%	10%	
wimsr			0%		

Table 2: Implementation status for the NJOY modules

The completeness of the implementation has been rated in a grading scale with percentage. The grades has been set with respect to whether the functionality of the phases presented in section 4.2.3 on page 11 (also see section 3.3 on page 6) has been fulfilled or not. 100% indicates that the functionality has been finished. 0% indicates that the implementation of the functionality has not been started. The other percentages are rough approximations of how much functionality that has been implemented.

### 5.3 Translation Verification

The result of the translation verification is summarized in table 3. All test problems listed in Appendix B on page 29 passed all the phases in the translation process. That is, the test problems were successfully translated<sup>2</sup>; no lexical, syntax, nor semantic errors were found. No differences between the expected output and the resulting output were detected for the test problems.

Test Problem	Translator Phases	Output
tp01	Passed	Expected
tp02		
tp03		
tp04		
tp05		
tp06		
tp07		
tp08		
tp10		
tp11		
tp12		
tp13		
tp14		
tp17		

Table 3: Translation verification results for the test problems

---

<sup>2</sup>Note that the organizer’s ability to arrange statements in the correct order has not been tested for the test problems, since the instructions in the test problems have been provided in the expected order.



## 5.4 Translation Efficiency

The efficiency of the translator was tested by running the entire translation process for each test problem, listed in Appendix B on page 29, 10 000 times. Table 4 shows the resulting runtimes, both process time and wall time, in seconds. The resulting runtimes denotes the aggregate of 10 000 repeated runs for a given test problem.

Test Problem	Process Time	Wall Time
tp01	2.87	345.22
tp02	2.87	374.29
tp03	2.81	292.49
tp04	2.79	281.89
tp05	3.10	255.14
tp06	3.05	346.87
tp07	3.07	278.47
tp08	2.75	294.17
tp10	3.05	288.98
tp11	2.84	373.76
tp12	2.72	301.82
tp13	3.19	280.76
tp14	3.25	251.40
tp17	2.95	350.35
<b>Average Time:</b>	2.95	308.26

Table 4: Aggregated runtimes (in seconds) for 10 000 runs

The average wall time for a single run for the test problems is  $308.26/10000 \approx 0.031$  seconds.

The repeated runs were conducted on a multi-user system equipped with three Dual Core AMD Opteron Processor 280 at 2.4GHz each, and a total of 3.6GB RAM. The system was running Linux 2.6.18 and Python 2.4.3.

The Python library functions `time.clock()` and `time.time()` [9] were used to measure the process time and wall time, respectively.

## 6 Discussion

### 6.1 NJOY Input Format (NIF)

The proposed grammar does not differ much from the original NJOY input instructions since it basically is an annotated version of them. The NIF grammar could have been expanded to include more complex programming idioms, such as an `if` expression to allow flow control in a NIF program. Although, the structure of NIF was designed to be simple and to closely resemble the original input instructions such that a user does not need to learn a completely new programming language to specify NJOY jobs. Another intention of this design choice is that the NJOY input instructions documented in reference [4] can be used to specify NJOY jobs in NIF.

As indicated by the examples listed in section 5.1 on page 14, a typical NIF program is vertically long compared to the compact notation of the NJOY input instructions. NIF programs can of course be specified in a compact form as well, e.g. on a single line, but this is not the intended usage of NIF. The purpose of NIF is to make NJOY jobs readable. The readability would be limited if the jobs were expressed on a single line.

### 6.2 NJOY Input Format Translator (`nifty`)

An organizer and analyzer has not been provided for all modules in the NJOY software system due to time constraints of this thesis. As such, the important semantic analysis of the translator is incomplete. However, much of the needed functionality and structure is provided by the existing implementation such that both the organizer and the analyzer should be easy to complete. Even though the organizer and analyzer phase has not been implemented for all NJOY modules in the translator, NIF programs which include these modules can still be translated into functional NJOY input instructions.

The implementation of the analyzer module has been the most time consuming task when designing the translator. It requires detailed analysis of what kind of input the NJOY modules expect and how they operate on it. The documentation in reference [4] was the main resource used while implementing the semantic analysis in the analyzer. It was evident that this was not a sufficient resource for the task at hand. It does not clearly indicate the expected type for all identifiers, nor the expected integer ranges or length of the character strings. In some cases, it has also been hard to deduce which cards that must be supplied by just reading the documentation in reference [4]. To fully check the semantics of a NIF program, the source code for the NJOY software system must be studied in greater detail. The ENDF formats must also be studied in greater detail in order to understand the semantics and what kind of values that the NJOY modules accept.

### 6.3 Translation Verification

The testing that was conducted within this work is not rigorous enough due to time constraints of this thesis. NJOY is a large and complex program<sup>3</sup> with many possible combinations of input within each NJOY module and card. The NJOY test problems [1] which were used to test the translation functionality is a very small set of possible NJOY jobs. Hence, there is a lot of scenarios within each NJOY module that has not been tested.

### 6.4 Translation Efficiency

The efficiency testing of the translator as described in section 5.4 on page 19 was conducted in a simple fashion. The resulting process runtimes revealed that the performance of the translator implementation is not a huge bottleneck, compared to the much greater wall times. The performance appeared to be good enough to fit the purpose of the translator. Therefore, more elaborate testing of the efficiency was not conducted.

---

<sup>3</sup>The source files for the NJOY software system consists of more than 100 000 lines.

## 7 Conclusions

In this thesis, a new input format, NJOY Input Format (NIF), has been designed. A translator which is able to translate NIF into NJOY input instructions has been implemented.

It is possible to specify basic NJOY jobs in NIF. The resulting NIF programs can be translated into NJOY input instructions, which can be run by the NJOY software system. Production use is although not advisable, since it has been challenging to conduct rigorous and complete testing.

It has also been evident that analyzing the NJOY input instructions is not enough to design a new input format for the NJOY software system. Analyzing the ENDF libraries and the source code for the NJOY software system is required in order to build a translator which can conduct a complete semantic analysis for an NJOY job.

## 8 Future Work

Future work includes completing the semantic analysis and the organizer feature for all modules in the NJOY software system. The NJOY Input Format and the translator also needs to be systematically evaluated and verified by a complete software quality assurance process as described in reference [15]. The project may also be expanded to include default scenarios, which uses normal mode of operation per default, such that the user does not have to specify exhaustive NJOY jobs just to convert a library into another.

A spin-off project, that is related to developing a user friendly and readable input format, is to construct a graphical user interface editor which can display and produce NJOY input instructions in a user friendly fashion.

## References

- [1] R. E. MacFarlane, “NJOY99 – code system for producing pointwise and multigroup neutron and photon cross-sections from ENDF/B data”, Los Alamos Nat. Laboratory, Los Alamos, NM, Rep. RSIC PSR-480, 2000.
- [2] M. B. Chadwick *et al.*, “ENDF/B-VII.0: Next Generation Evaluated Nuclear Data Library for Nuclear Science and Technology,” *Nuclear Data Sheets*, vol. 107, no. 12, pp. 2931-3060, Dec. 2006.
- [3] C. Gustavsson *et al.*, “Massive Computation Methodology for Reactor Operation (MACRO),” in *European Nuclear Conference*, 2010 © European Nuclear Society. ISBN: 978-92-95064-09-6
- [4] A. C. Kahler and R. E. MacFarlane. (2010, Mar. 31). *User Input for NJOY99, updated through version 364* [Online]. Available: <http://t2.lanl.gov/codes/njoy99/Userinp.364>
- [5] A. V. Aho *et al.*, *Compilers: Principles, Techniques, & Tools*, Second Edition. Boston: Pearson Educ., 2007.
- [6] A. V. Aho *et al.*, “Syntax Analysis” in *Compilers: Principles, Techniques, & Tools*, Second Edition. Boston: Pearson Educ., 2007, ch. 4, sec. 4.2, pp. 197-206.
- [7] A. V. Aho *et al.*, “Lexical Analysis” in *Compilers: Principles, Techniques, & Tools*, Second Edition. Boston: Pearson Educ., 2007, ch. 3, sec. 3.5, pp. 140-146.
- [8] A. V. Aho *et al.*, “Syntax Analysis” in *Compilers: Principles, Techniques, & Tools*, Second Edition. Boston: Pearson Educ., 2007, ch. 4, sec. 4.9, pp. 287-297.
- [9] F. L. Drake, Jr., *et al.* (2011, Apr. 16) *Python v2.7.1 documentation* [Online]. Available: <http://docs.python.org/>
- [10] A. V. Aho *et al.*, “Lexical Analysis” in *Compilers: Principles, Techniques, & Tools*, Second Edition. Boston: Pearson Educ., 2007, ch. 3, sec. 3.1, pp. 109-114.
- [11] D. M. Beazley. (2011, Apr. 16). *PLY (Python Lex-Yacc)* [Online]. Available: <http://www.dabeaz.com/ply/ply.html>
- [12] A. V. Aho *et al.*, “Lexical Analysis” in *Compilers: Principles, Techniques, & Tools*, Second Edition. Boston: Pearson Educ., 2007, ch. 3, sec. 3.3, pp. 116-124.
- [13] A. V. Aho *et al.*, “Syntax Analysis” in *Compilers: Principles, Techniques, & Tools*, Second Edition. Boston: Pearson Educ., 2007, ch. 4, sec. 4.1, pp. 192-196.

- [14] A. V. Aho *et al.*, “Introduction” in *Compilers: Principles, Techniques, & Tools*, Second Edition. Boston: Pearson Educ., 2007, ch. 1, sec. 1.2, pp. 8-9.
- [15] C. Kaner *et al.*, *Testing Computer Software*, Second Edition. New York: John Wiley and Sons, Inc., 1999.

## A User Manual

### A.1 Structure of **nifty**

The **nifty** directory structure is organized as shown in figure A.1.

```
nifty/  
  bin/  
    analyzer  
    bench  
    emitter  
    lexer  
    nifty  
    organizer  
    parser  
    test  
  data/  
    ...  
    test_problems/  
  nifty/  
    analyzer/  
    emitter/  
    environment/  
    lexer/  
    organizer/  
    parser/  
    settings/  
    tests/  
  [ply/]
```

Figure A.1: Directory Structure of **nifty**

The **nifty/bin/** directory includes all executable Python scripts which are used for running and testing the translator. The **nifty** executable in the **nifty/bin/** directory runs the complete translation process on an input NIF program. The **test** executable runs the test suite. The **bench** executable is a script used for testing the efficiency of the translator. The other executable scripts runs their corresponding named phase in the translation process (and all the successive phases that they depend on).

The test problems are located in the **nifty/data/test\_problems/** directory. The **nifty/nifty/** directory contains the source code for the translator. The optional directory **ply/** indicates where **PLY** can be placed such that the translator is able to locate it.



## A.2 Installation

Python version 2.2 or greater is required to use **nifty**. Python version 2.4.3 and 2.6.1 has been tested with **nifty** and are known to work. **nifty** itself does not require any special installation methods, although PLY [11] is required to run the translator. It is sufficient to download PLY and put the `ply/` directory from PLY in the **nifty/** top directory as indicated by figure A.1 on the preceding page. (Note the non-restrictive license of PLY generously provided by its author.)

## A.3 Running the Translator

The translator has been implemented as a command-line based interface for a Unix-like environment. To run the entire translation process, the **nifty** executable in the **nifty/bin/** directory should be used. Issuing the command

```
bin/nifty -h
```

in the **nifty/** top directory, will print the usage message shown in figure A.2.

```
usage: nifty [options] [input_file] [output_file]
options:
  -h, --help    show this help message and exit
  -a            don't analyze the input
  -o            don't organize the input
```

Figure A.2: bin/nifty usage

The **options** flag(s) are optional. The **input\_file** and **output\_file** are also optional. If no input file is given, standard input (**stdin**) will be used as the input source. If no output file is given, the result will be redirected to standard output (**stdout**).

As an example, the command

```
bin/nifty input.nif output
```

will simply run the translator on a file named **input.nif** and output the resulting NJOY input instructions on a file named **output**. The analyzer and organizer phase can be skipped by giving the **-a** and **-o** flag

```
bin/nifty -a input.nif output, to skip the analyzer phase
```

```
bin/nifty -o input.nif output, to skip the organizer phase
```

To skip both the organizer and analyzer phase, run **nifty** with both flags specified

```
bin/nifty -ao input.nif output
```

## A.4 Settings

The `nifty/nifty/settings/` directory as shown in figure Figure A.1 on page 26 contains module specific settings. Each module has its own settings file. The analyzer and organizer phase utilizes the settings files when processing a syntax tree. The settings describes the expected identifiers and their expected order within the cards in a module.

## B Test Problems

In this section, the test problems that were used for testing the functionality of the translator is listed. Both the NIF versions and the expected NJOY input instructions are provided. The test problems listed in this section are also available in the `nifty/data/test_problems/` directory, as described in section A.1 on page 26.

### B.1 Test Problem 01 (tp01)

#### NIF Version of Test Problem 01

```
1  moder
2  {
3      card_1
4      {
5          nin = 20;
6          nout = -21;
7      }
8  }
9
10 reconr
11 {
12     card_1
13     {
14         nendf = -21;
15         npend = -22;
16     }
17
18     card_2
19     {
20         tlabel = "pendf tape for c-nat from endf/b tape 511";
21     }
22
23     card_3
24     {
25         mat = 1306;
26         ncards = 3;
27     }
28
29     card_4
30     {
31         err = 0.005; // Use C-style floats.
32     }
33
34     card_5
35     {
36         cards = "6-c-nat from tape 511";
37     }
38
39     card_5
40     {
41         cards = "processed by the njoy nuclear data processing system";
42     }
43
44     card_5
45     {
46         cards = "see original endf/b-v tape for details of evaluation";
47     }
48
49     /* Card 6 skipped since ngrid defaults to 0 in first card 3 */
50
51     card_3
52     {
```

```

53         mat = 0;
54     }
55 }
56
57 broadr
58 {
59     card_1
60     {
61         nendf = -21;
62         nin = -22;
63         nout = -23;
64     }
65
66     card_2
67     {
68         mat1 = 1306;
69         ntemp2 = 1;
70     }
71
72     card_3
73     {
74         errthn = 0.005; // Use C-style floats.
75     }
76
77     card_4
78     {
79         temp2[0] = 300.0; // Use C-style floats.
80     }
81
82     card_5
83     {
84         mat1 = 0;
85     }
86 }
87
88 heatr
89 {
90     card_1
91     {
92         nendf = -21;
93         nin = -23;
94         nout = -22;
95     }
96
97     card_2
98     {
99         matd = 1306;
100        npk = 1;
101    }
102
103    card_3
104    {
105        mtk[0] = 444; // Note that mtk has to be defined as an array.
106    }
107
108    /* Card 4, 5, and 5a are skipped since nqa defaults to 0 in card 2. */
109 }
110
111 thermr
112 {
113     card_1
114     {
115         nendf = 0;
116         nin = -22;
117         nout = -24;
118     }
119
120     card_2

```

```

121     {
122         matde = 0;
123         matdp = 1306;
124         nbin = 8;
125         ntemp = 1;
126         iinc = 1;
127         icoh = 0;
128         natom = 1;
129         mtref = 221;
130         iprint = 0;
131     }
132
133     card_3
134     {
135         tempr[0] = 300.0; // Use C-style floats.
136     }
137
138     card_4
139     {
140         tol = 0.05; // Use C-style floats.
141         emax = 1.2;
142     }
143 }
144
145 thermr
146 {
147     card_1
148     {
149         nendf = 26;
150         nin = -24;
151         nout = -23;
152     }
153
154     card_2
155     {
156         matde = 1065;
157         matdp = 1306;
158         nbin = 8;
159         ntemp = 1;
160         iinc = 4;
161         icoh = 1;
162         natom = 1;
163         mtref = 229;
164         iprint = 0;
165     }
166
167     card_3
168     {
169         tempr[0] = 300.0; // Use C-style floats.
170     }
171
172     card_4
173     {
174         tol = 0.05; // Use C-style floats.
175         emax = 1.2;
176     }
177 }
178
179 groupr
180 {
181     card_1
182     {
183         nendf = -21;
184         npend = -23;
185         ngout1 = 0;
186         ngout2 = -24;
187     }
188

```

```

189     card_2
190     {
191         matb = 1306;
192         ign = 3;
193         igg = 3;
194         iwt = 3;
195         lord = 3;
196         ntemp = 1;
197         nsigz = 1;
198         iprint = 1;
199     }
200
201     card_3
202     {
203         title = "carbon in graphite";
204     }
205
206     card_4
207     {
208         temp[0] = 300;
209     }
210
211     card_5
212     {
213         sigz[0] = 1.0e10; // No trailing dots. Use C-style floats.
214     }
215
216     card_9
217     {
218         mfd = 3;
219         mtd = 1;
220         mtname = "total";
221     }
222
223     card_9
224     {
225         mfd = 3;
226         mtd = 2;
227         mtname = "elastic";
228     }
229
230     card_9
231     {
232         mfd = 3;
233         mtd = 4;
234         mtname = "inelastic";
235     }
236
237     card_9
238     {
239         mfd = 3;
240         mtd = 51;
241         mtname = "discrete inelastic";
242     }
243
244     card_9
245     {
246         mfd = 3;
247         mtd = -68;
248         mtname = "continued";
249     }
250
251     card_9
252     {
253         mfd = 3;
254         mtd = 91;
255         mtname = "continuum inelastic";
256     }

```

```

257
258     card_9
259     {
260         mfd = 3;
261         mtd = 102;
262         mtname = "n,g";
263     }
264
265     card_9
266     {
267         mfd = 3;
268         mtd = 103;
269         mtname = "(n,p)";
270     }
271
272     card_9
273     {
274         mfd = 3;
275         mtd = 104;
276         mtname = "(n,d)";
277     }
278
279     card_9
280     {
281         mfd = 3;
282         mtd = 107;
283         mtname = "(n,a)";
284     }
285
286     card_9
287     {
288         mfd = 3;
289         mtd = 221;
290         mtname = "free thermal scattering";
291     }
292
293     card_9
294     {
295         mfd = 3;
296         mtd = 229;
297         mtname = "graphite inelastic thermal scattering";
298     }
299
300     card_9
301     {
302         mfd = 3;
303         mtd = 230;
304         mtname = "graphite elastic thermal scattering";
305     }
306
307     card_9
308     {
309         mfd = 3;
310         mtd = 251;
311         mtname = "mubar";
312     }
313
314     card_9
315     {
316         mfd = 3;
317         mtd = 252;
318         mtname = "xi";
319     }
320
321     card_9
322     {
323         mfd = 3;
324         mtd = 253;

```

```

325         mtname = "gamma";
326     }
327
328     card_9
329     {
330         mfd = 3;
331         mtd = 301;
332         mtname = "total heat production";
333     }
334
335     card_9
336     {
337         mfd = 3;
338         mtd = 444;
339         mtname = "total damage energy production";
340     }
341
342     card_9
343     {
344         mfd = 6;
345         mtd = 2;
346         mtname = "elastic";
347     }
348
349     card_9
350     {
351         mfd = 6;
352         mtd = 51;
353         mtname = "discrete inelastic";
354     }
355
356     card_9
357     {
358         mfd = 6;
359         mtd = -68;
360         mtname = "continued";
361     }
362
363     card_9
364     {
365         mfd = 6;
366         mtd = 91;
367         mtname = "continuum inelastic";
368     }
369
370     card_9
371     {
372         mfd = 6;
373         mtd = 221;
374         mtname = "free thermal scattering";
375     }
376
377     card_9
378     {
379         mfd = 6;
380         mtd = 229;
381         mtname = "graphite inelastic thermal scattering";
382     }
383
384     card_9
385     {
386         mfd = 6;
387         mtd = 230;
388         mtname = "graphite elastic thermal scattering";
389     }
390
391     card_9
392     {

```



```

393         mfd = 17;
394         mtd = 51;
395         mtname = "inelastic gamma production";
396     }
397
398     card_9
399     {
400         mfd = 16;
401         mtd = 102;
402         mtname = "capture gamma production";
403     }
404
405     card_9
406     {
407         mfd = 0;
408     }
409
410     card_10
411     {
412         matd = 0;
413     }
414 }
415
416 moder
417 {
418     card_1
419     {
420         nin = -23;
421         nout = 25;
422     }
423 }

```

### Expected NJOY Input Instructions for Test Problem 01

```

1  moder
2  20 -21/ ### card_1
3  reconr
4  -21 -22/ ### card_1
5  'pendf tape for c-nat from endf/b tape 511'/ ### card_2
6  1306 3/ ### card_3
7  0.005/ ### card_4
8  '6-c-nat from tape 511'/ ### card_5
9  'processed by the njoy nuclear data processing system'/ ### card_5
10 'see original endf/b-v tape for details of evaluation'/ ### card_5
11 0/ ### card_3
12 broadr
13 -21 -22 -23/ ### card_1
14 1306 1/ ### card_2
15 0.005/ ### card_3
16 300.0/ ### card_4
17 0/ ### card_5
18 heatr
19 -21 -23 -22/ ### card_1
20 1306 1/ ### card_2
21 444/ ### card_3
22 thermr
23 0 -22 -24/ ### card_1
24 0 1306 8 1 1 0 1 221 0/ ### card_2
25 300.0/ ### card_3
26 0.05 1.2/ ### card_4
27 thermr
28 26 -24 -23/ ### card_1
29 1065 1306 8 1 4 1 1 229 0/ ### card_2
30 300.0/ ### card_3
31 0.05 1.2/ ### card_4
32 groupr
33 -21 -23 0 -24/ ### card_1

```

```

34 1306 3 3 3 3 1 1 1/ ### card_2
35 'carbon in graphite'/ ### card_3
36 300/ ### card_4
37 1.0e10/ ### card_5
38 3 1 'total'/ ### card_9
39 3 2 'elastic'/ ### card_9
40 3 4 'inelastic'/ ### card_9
41 3 51 'discrete inelastic'/ ### card_9
42 3 -68 'continued'/ ### card_9
43 3 91 'continuum inelastic'/ ### card_9
44 3 102 'n,g'/ ### card_9
45 3 103 '(n,p)'/ ### card_9
46 3 104 '(n,d)'/ ### card_9
47 3 107 '(n,a)'/ ### card_9
48 3 221 'free thermal scattering'/ ### card_9
49 3 229 'graphite inelastic thermal scattering'/ ### card_9
50 3 230 'graphite elastic thermal scattering'/ ### card_9
51 3 251 'mubar'/ ### card_9
52 3 252 'xi'/ ### card_9
53 3 253 'gamma'/ ### card_9
54 3 301 'total heat production'/ ### card_9
55 3 444 'total damage energy production'/ ### card_9
56 6 2 'elastic'/ ### card_9
57 6 51 'discrete inelastic'/ ### card_9
58 6 -68 'continued'/ ### card_9
59 6 91 'continuum inelastic'/ ### card_9
60 6 221 'free thermal scattering'/ ### card_9
61 6 229 'graphite inelastic thermal scattering'/ ### card_9
62 6 230 'graphite elastic thermal scattering'/ ### card_9
63 17 51 'inelastic gamma production'/ ### card_9
64 16 102 'capture gamma production'/ ### card_9
65 0/ ### card_9
66 0/ ### card_10
67 moder
68 -23 25/ ### card_1
69 stop

```

## B.2 Test Problem 02 (tp02)

### NIF Version of Test Problem 02

```

1 moder
2 {
3     card_1
4     {
5         nin = 20;
6         nout = -21;
7     }
8 }
9
10 reconr
11 {
12     card_1
13     {
14         nendf = -21;
15         npend = -22;
16     }
17
18     card_2
19     {
20         tlabel = "pendf tape for pu-238 from endf/b-iv tape 404";
21     }
22
23     card_3
24     {
25         mat = 1050;

```

```

26         ncards = 3;
27     }
28
29     card_4
30     {
31         err = 0.005; // Use C-style floats instead of ".005".
32     }
33
34     card_5
35     {
36         cards = "94-pu-238 from endf/b tape t404";
37     }
38
39     card_5
40     {
41         cards = "processed by the njoy nuclear data processing system";
42     }
43
44     card_5
45     {
46         cards = "see original endf/b-iv tape for details of evaluation";
47     }
48
49     /* Card 6 skipped since ngrid defaults to 0 in first card 3. */
50
51     card_3
52     {
53         mat = 0;
54     }
55 }
56
57 broadr
58 {
59     card_1
60     {
61         nendf = -21;
62         nin = -22;
63         nout = -23;
64     }
65
66     card_2
67     {
68         mat1 = 1050;
69         ntemp2 = 3;
70         istart = 0;
71         istrap = 1;
72         temp1 = 0;
73     }
74
75     card_3
76     {
77         errthn = 0.005; // Use C-style floats instead of ".005".
78     }
79
80     card_4
81     {
82         /* In this example, Each temperature is declared as an element in an
83            array.
84            ntemp2 in card_2 denotes the number of expected temperatures.
85            */
86         temp2[0] = 300.0;
87         temp2[1] = 900.0;
88         temp2[2] = 2100.0;
89     }
90
91     card_5
92     {
93         mat1 = 0;

```

```

94     }
95 }
96
97 moder
98 {
99     card_1
100     {
101         nin = -23;
102         nout = 33;
103     }
104 }
105
106 unresr
107 {
108     card_1
109     {
110         nendf = -21;
111         nin = -23;
112         nout = -24;
113     }
114
115     card_2
116     {
117         matd = 1050;
118         ntemp = 3;
119         nsigz = 7;
120         iprint = 1;
121     }
122
123     card_3
124     {
125         temp[0] = 300;
126         temp[1] = 900;
127         temp[2] = 2100;
128     }
129
130     card_4
131     {
132         sigz[0] = 1.0e10;
133         sigz[1] = 1.0e5;
134         sigz[2] = 1.0e4;
135         sigz[3] = 1000.0;
136         sigz[4] = 100.0;
137         sigz[5] = 10.0;
138         sigz[6] = 1;
139     }
140
141     card_2
142     {
143         matd = 0;
144     }
145 }
146
147 groupr
148 {
149     card_1
150     {
151         nendf = -21;
152         npend = -24;
153         ngout1 = 0;
154         ngout2 = -25;
155     }
156
157     card_2
158     {
159         matb = 1050;
160         ign = 5;
161         igg = 0;

```

```

162         iwt = 4;
163         lord = 3;
164         ntemp = 3;
165         nsigz = 7;
166         iprint = 1;
167     }
168
169     card_3
170     {
171         title = "94-pu-238";
172     }
173
174     card_4
175     {
176         /* ntemp in card_2 denotes the number of expected temperatures. */
177         temp[0] = 300.0;
178         temp[1] = 900.0;
179         temp[2] = 2100.0;
180     }
181
182     card_5
183     {
184         /* nsigz in card_2 denotes the number of expected sigma zeroes. */
185         sigz[0] = 1.0e10;
186         sigz[1] = 1.0e5;
187         sigz[2] = 1.0e4;
188         sigz[3] = 1000.0;
189         sigz[4] = 100.0;
190         sigz[5] = 10.0;
191         sigz[6] = 1;
192     }
193
194     card_8c
195     {
196         eb = 0.1;
197         tb = 0.025;
198         ec = 0.8208e06;
199         tc = 1.4e06;
200     }
201
202     /* Reactions for temperature 300.0. */
203     card_9
204     {
205         mfd = 3;
206         mtd = 1;
207         mtname = "total";
208     }
209
210     card_9
211     {
212         mfd = 3;
213         mtd = 2;
214         mtname = "elastic";
215     }
216
217     card_9
218     {
219         mfd = 3;
220         mtd = 16;
221         mtname = "n2n";
222     }
223
224     card_9
225     {
226         mfd = 3;
227         mtd = 17;
228         mtname = "n3n";
229     }

```

```

230
231     card_9
232     {
233         mfd = 3;
234         mtd = 18;
235         mtname = "fission";
236     }
237
238     card_9
239     {
240         mfd = 3;
241         mtd = 102;
242         mtname = "capture";
243     }
244
245     card_9
246     {
247         mfd = 3;
248         mtd = 251;
249         mtname = "mubar";
250     }
251
252     card_9
253     {
254         mfd = 3;
255         mtd = 252;
256         mtname = "xi";
257     }
258
259     card_9
260     {
261         mfd = 3;
262         mtd = 253;
263         mtname = "gamma";
264     }
265
266     card_9
267     {
268         mfd = 3;
269         mtd = 259;
270         mtname = "1/v";
271     }
272
273     card_9
274     {
275         mfd = 6;
276         mtd = 2;
277         mtname = "elastic";
278     }
279
280     card_9
281     {
282         mfd = 6;
283         mtd = 16;
284         mtname = "n2n";
285     }
286
287     card_9
288     {
289         mfd = 6;
290         mtd = 17;
291         mtname = "n,3n";
292     }
293
294     card_9
295     {
296         mfd = 6;
297         mtd = 18;

```

```

298         mtname = "fission";
299     }
300
301     card_9
302     {
303         mfd = 6;
304         mtd = 51;
305         mtname = "discrete inelastic";
306     }
307
308     card_9
309     {
310         mfd = 6;
311         mtd = -59;
312         mtname = "continued";
313     }
314
315     card_9
316     {
317         mfd = 6;
318         mtd = 91;
319         mtname = "continuum inelastic";
320     }
321
322     /* Terminate temperature 300.0. */
323     card_9
324     {
325         mfd = 0;
326     }
327
328     /* Reactions for temperature 900.0. */
329     card_9
330     {
331         mfd = 3;
332         mtd = 1;
333         mtname = "total";
334     }
335
336     card_9
337     {
338         mfd = 3;
339         mtd = 2;
340         mtname = "elastic";
341     }
342
343     card_9
344     {
345         mfd = 3;
346         mtd = 18;
347         mtname = "fission";
348     }
349
350     card_9
351     {
352         mfd = 3;
353         mtd = 102;
354         mtname = "capture";
355     }
356
357     card_9
358     {
359         mfd = 6;
360         mtd = 2;
361         mtname = "elastic";
362     }
363
364     /* Terminate temperature 900.0. */
365     card_9

```

```

366     {
367         mfd = 0;
368     }
369
370     /* Reactions for temperature 2100.0. */
371     card_9
372     {
373         mfd = 3;
374         mtd = 1;
375         mtname = "total";
376     }
377
378     card_9
379     {
380         mfd = 3;
381         mtd = 2;
382         mtname = "elastic";
383     }
384
385     card_9
386     {
387         mfd = 3;
388         mtd = 18;
389         mtname = "fission";
390     }
391
392     card_9
393     {
394         mfd = 3;
395         mtd = 102;
396         mtname = "capture";
397     }
398
399     card_9
400     {
401         mfd = 6;
402         mtd = 2;
403         mtname = "elastic";
404     }
405
406     /* Terminate temperature 2100.0. */
407     card_9
408     {
409         mfd = 0;
410     }
411
412     /* Terminate group. */
413     card_10
414     {
415         matd = 0;
416     }
417 }
418
419 ccccr
420 {
421     card_1
422     {
423         nin = -25;
424         nisot = 26;
425         nbrks = 27;
426         ndlay = 0; // dlayxs not wanted
427     }
428
429     card_2
430     {
431         lprint = 1;
432         ivers = 1;
433         huse = "t2lanl njoy";

```



```

434     }
435
436     card_3
437     {
438         /* hsetid does not have to be 12 chars? */
439         hsetid = "ccccr tests for njoy87";
440     }
441
442     card_4
443     {
444         ngroup = 50;
445         nggrup = 0;
446         niso = 1; // Denotes number of card_5's.
447         maxord = 4;
448         ifopt = 1; // Blocking by reaction order.
449     }
450
451     card_5
452     {
453         /* Note that the original input does not denote the first four
454            variables as strings.
455            What does the two ' denote? Seems a bit irregular.
456            */
457         hisnm = "pu238";
458         habsid = "pu238";
459         hident = "endfb4";
460         hmat = "1050";
461         imat = 1050;
462         xspo = 10.89;
463     }
464
465     card_1
466     {
467         nsblok = 1;
468         maxup = 0; // Always zero (?).
469         maxdn = 50;
470         ichix = -1; // Vector (using groupr flux).
471     }
472
473     card_4
474     {
475         kbr = 0;
476         amass = 2.3821e02;
477         efiss = 3.3003e-11;
478         ecapt = 1.7461e-12;
479         temp = 0.0;
480         sigpot = 1.0e10;
481         adens = 0.0;
482     }
483
484     card_1
485     {
486         nti = 3;
487         nzi = 6;
488     }
489
490     card_2
491     {
492         /* Number of expected temperatures defined by nti. */
493         atem[0] = 300;
494         atem[1] = 900;
495         atem[2] = 2100;
496     }
497
498     card_3
499     {
500         /* Number of expected sigpo values defined by nzi. */
501         asig[0] = 1.0e5;

```

```

502         asig[1] = 1.0e4;
503         asig[2] = 1000.0;
504         asig[3] = 100.0;
505         asig[4] = 10.0;
506         asig[5] = 1;
507     }
508 }
509
510 moder
511 {
512     card_1
513     {
514         nin = -24;
515         nout = 28;
516     }
517 }

```

### Expected NJOY Input Instructions for Test Problem 02

```

1  moder
2  20 -21/ ### card_1
3  reconr
4  -21 -22/ ### card_1
5  'pendf tape for pu-238 from endf/b-iv tape 404'/ ### card_2
6  1050 3/ ### card_3
7  0.005/ ### card_4
8  '94-pu-238 from endf/b tape t404'/ ### card_5
9  'processed by the njoy nuclear data processing system'/ ### card_5
10 'see original endf/b-iv tape for details of evaluation'/ ### card_5
11 0/ ### card_3
12 broadr
13 -21 -22 -23/ ### card_1
14 1050 3 0 1 0/ ### card_2
15 0.005/ ### card_3
16 300.0 900.0 2100.0/ ### card_4
17 0/ ### card_5
18 moder
19 -23 33/ ### card_1
20 unresr
21 -21 -23 -24/ ### card_1
22 1050 3 7 1/ ### card_2
23 300 900 2100/ ### card_3
24 1.0e10 1.0e5 1.0e4 1000.0 100.0 10.0 1/ ### card_4
25 0/ ### card_2
26 groupr
27 -21 -24 0 -25/ ### card_1
28 1050 5 0 4 3 3 7 1/ ### card_2
29 '94-pu-238'/ ### card_3
30 300.0 900.0 2100.0/ ### card_4
31 1.0e10 1.0e5 1.0e4 1000.0 100.0 10.0 1/ ### card_5
32 0.1 0.025 0.8208e06 1.4e06/ ### card_8c
33 3 1 'total'/ ### card_9
34 3 2 'elastic'/ ### card_9
35 3 16 'n2n'/ ### card_9
36 3 17 'n3n'/ ### card_9
37 3 18 'fission'/ ### card_9
38 3 102 'capture'/ ### card_9
39 3 251 'mubar'/ ### card_9
40 3 252 'xi'/ ### card_9
41 3 253 'gamma'/ ### card_9
42 3 259 '1/v'/ ### card_9
43 6 2 'elastic'/ ### card_9
44 6 16 'n2n'/ ### card_9
45 6 17 'n,3n'/ ### card_9
46 6 18 'fission'/ ### card_9
47 6 51 'discrete inelastic'/ ### card_9
48 6 -59 'continued'/ ### card_9

```

```

49 6 91 'continuum inelastic' / ### card_9
50 0/ ### card_9
51 3 1 'total' / ### card_9
52 3 2 'elastic' / ### card_9
53 3 18 'fission' / ### card_9
54 3 102 'capture' / ### card_9
55 6 2 'elastic' / ### card_9
56 0/ ### card_9
57 3 1 'total' / ### card_9
58 3 2 'elastic' / ### card_9
59 3 18 'fission' / ### card_9
60 3 102 'capture' / ### card_9
61 6 2 'elastic' / ### card_9
62 0/ ### card_9
63 0/ ### card_10
64 ccccr
65 -25 26 27 0/ ### card_1
66 1 1 't2lanl njoy' / ### card_2
67 'cccr tests for njoy87' / ### card_3
68 50 0 1 4 1/ ### card_4
69 'pu238' 'pu238' 'endfb4' '1050' 1050 10.89/ ### card_5
70 1 0 50 -1/ ### card_1
71 0 2.3821e02 3.3003e-11 1.7461e-12 0.0 1.0e10 0.0/ ### card_4
72 3 6/ ### card_1
73 300 900 2100/ ### card_2
74 1.0e5 1.0e4 1000.0 100.0 10.0 1/ ### card_3
75 moder
76 -24 28/ ### card_1
77 stop

```

## B.3 Test Problem 03 (tp03)

### NIF Version of Test Problem 03

```

1 reconr
2 {
3     card_1
4     {
5         nendf = 30;
6         npend = 31;
7     }
8
9     card_2
10    {
11        tlabel = "pendf tape for photon interaction cross sections from dlc7e
12                ";
13    }
14
15    card_3
16    {
17        mat = 1;
18        ncards = 1;
19        ngrid = 0;
20    }
21
22    card_4
23    {
24        err = 0.001; // Note the C-style float format with preceding 0.
25    }
26
27    card_5
28    {
29        cards = "1-hydrogen";
30    }
31    card_3

```

```

32     {
33         mat = 92;
34         ncards = 1;
35         ngrid = 0;
36     }
37
38     card_4
39     {
40         err = 0.001; // Note the C-style float format with preceding 0.
41     }
42
43     card_5
44     {
45         cards = "92-uranium";
46     }
47
48     card_3
49     {
50         mat = 0;
51     }
52 }
53
54 gaminr
55 {
56     card_1
57     {
58         nendf = 32;
59         npend = 31;
60         ngam1 = 0;
61         ngam2 = 33;
62     }
63
64     card_2
65     {
66         matb = 1;
67         igg = 3;
68         iwt = 3;
69         lord = 4;
70         iprint = 1;
71     }
72
73     card_3
74     {
75         title = "12 group photon interaction library";
76     }
77
78     card_6
79     {
80         mfd = -1;
81         mtd = 0;
82     }
83
84     card_7
85     {
86         matd = 92;
87     }
88
89     card_6
90     {
91         mfd = -1;
92         mtd = 0;
93     }
94
95     card_7
96     {
97         matd = 0;
98     }
99 }

```

```

100
101 dtfr
102 {
103     card_1
104     {
105         nin = 33;
106         nout = 34;
107         npend = 31;
108         nplot = 36;
109     }
110
111     card_2
112     {
113         iprint = 1;
114         ifilm = 1;
115         iedit = 0;
116     }
117
118     card_3
119     {
120         nlmax = 5;
121         ng = 12;
122         iptotl = 4;
123         ipingp = 5;
124         itabl = 16;
125         ned = 1;
126         ntherm = 0;
127     }
128
129     card_4
130     {
131         /* iptotl-3 names will be read, i.e. 4-3 = 1 in this case. */
132         edits[0] = "pheat";
133     }
134
135     card_5
136     {
137         /* ned triplets, i.e. 1 triplet in this case. */
138         jpos[0] = 1;
139         mt[0] = 621;
140         mult[0] = 1;
141     }
142
143     card_7
144     {
145         nptabl = 0;
146     }
147
148     /* One card_8 for each table set desired. Empty card denotes termination
149        of dtfr.
150        */
151     card_8
152     {
153         hisnam = "h";
154         mat = 1;
155         jsigz = 1;
156         dtemp = 0.0;
157     }
158
159     card_8
160     {
161         hisnam = "u";
162         mat = 92;
163         jsigz = 1;
164         dtemp = 0.0;
165     }
166
167     card_8 {} // Terminate dtfr.

```

```

168 }
169
170 matxsr
171 {
172     card_1
173     {
174         ngen1 = 0;
175         ngen2 = 33;
176         nmatx = 35;
177     }
178
179     card_2
180     {
181         ivers = 1;
182         huse = "t2lanl njoy";
183     }
184
185     card_3
186     {
187         npart = 1;
188         ntype = 1;
189         nholl = 1;
190         nmat = 2;
191     }
192
193     card_4
194     {
195         hsetid = "12-group photon interaction library";
196     }
197
198     card_5
199     {
200         hpart = "g";
201     }
202
203     card_6
204     {
205         ngrp = 12;
206     }
207
208     card_7
209     {
210         htype = "gscat";
211     }
212
213     card_8
214     {
215         jinp = 1;
216     }
217
218     card_9
219     {
220         joutp = 1;
221     }
222
223     /* One card_10 per material. */
224     card_10
225     {
226         hmat = "h";
227         matno = 1;
228         matgg = 1;
229     }
230
231     card_10
232     {
233         hmat = "u";
234         matno = 92;
235         matgg = 92;

```

```

236     }
237 }
238
239 viewr
240 {
241     /* Documentation names the first two cards as card 1. Use card 0 to
242        denote
243        the first card, just like in plotr.
244        */
245     card_0
246     {
247         infile = 36;
248         nps = 37;
249     }
250 }

```

### Expected NJOY Input Instructions for Test Problem 03

```

1  reconr
2  30 31/ ### card_1
3  'pendf tape for photon interaction cross sections from dlc7e'/ ### card_2
4  1 1 0/ ### card_3
5  0.001/ ### card_4
6  '1-hydrogen'/ ### card_5
7  92 1 0/ ### card_3
8  0.001/ ### card_4
9  '92-uranium'/ ### card_5
10 0/ ### card_3
11 gaminr
12 32 31 0 33/ ### card_1
13 1 3 3 4 1/ ### card_2
14 '12 group photon interaction library'/ ### card_3
15 -1 0/ ### card_6
16 92/ ### card_7
17 -1 0/ ### card_6
18 0/ ### card_7
19 dtfr
20 33 34 31 36/ ### card_1
21 1 1 0/ ### card_2
22 5 12 4 5 16 1 0/ ### card_3
23 'pheat'/ ### card_4
24 1 621 1/ ### card_5
25 0/ ### card_7
26 'h' 1 1 0.0/ ### card_8
27 'u' 92 1 0.0/ ### card_8
28 / ### card_8
29 matxsr
30 0 33 35/ ### card_1
31 1 't2lanl njoy'/ ### card_2
32 1 1 1 2/ ### card_3
33 '12-group photon interaction library'/ ### card_4
34 'g'/ ### card_5
35 12/ ### card_6
36 'gscat'/ ### card_7
37 1/ ### card_8
38 1/ ### card_9
39 'h' 1 1/ ### card_10
40 'u' 92 92/ ### card_10
41 viewr
42 36 37/ ### card_0
43 stop

```

## B.4 Test Problem 04 (tp04)

### NIF Version of Test Problem 04

```

1  moder
2  {
3      card_1
4      {
5          nin = 20;
6          nout = -21;
7      }
8  }
9
10 reconr
11 {
12     card_1
13     {
14         nendf = -21;
15         npend = -22;
16     }
17
18     card_2
19     {
20         tlabel = "u-235 10% pendf for errorr test problem from t511";
21     }
22
23     card_3
24     {
25         mat = 1395;
26     }
27
28     card_4
29     {
30         err = 0.10; // Use C-style floats.
31     }
32
33     card_3
34     {
35         mat = 0;
36     }
37 }
38
39 errorr
40 {
41     card_1
42     {
43         nendf = -21;
44         npend = -22;
45         ngout = 0;
46         nout = 23;
47         nin = 0;
48     }
49
50     card_2
51     {
52         matd = 1395;
53         ign = 19;
54         iwt = 3;
55         iprint = 1;
56         irelco = 1;
57     }
58
59     card_3
60     {
61         mprint = 0;
62         tempin = 0;
63     }
64
65     /* Test problem 04 is using a file of the endf-5 format (iverf = 5) */
66
67     card_7
68     {

```



```

69         iread = 0;
70         mfcov = 33;
71     }
72
73     card_12a
74     {
75         ngn = 1;
76     }
77
78     card_12b
79     {
80         egn[0] = 1.0e0;
81         egn[1] = 1.0e3;
82     }
83 }
84
85 groupr
86 {
87     card_1
88     {
89         nendf = -21;
90         npend = -22;
91         ngout1 = 0;
92         ngout2 = 24;
93     }
94
95     card_2
96     {
97         matb = 1395;
98         ign = 3;
99         igg = 0;
100        iwt = 3;
101        lord = 0;
102        ntemp = 1;
103        nsigz = 1;
104        iprint = 1;
105    }
106
107    card_3
108    {
109        title = "u-235 multigroup nubar calculation";
110    }
111
112    card_4
113    {
114        temp[0] = 0.0;
115    }
116
117    card_5
118    {
119        sigz[0] = 1.0e10;
120    }
121
122    card_9
123    {
124        mfd = 3;
125        mtd = 452;
126        mtname = "total nubar";
127    }
128
129    /* Terminate temperature/material with mfd = 0 as usual. */
130    card_9
131    {
132        mfd = 0;
133    }
134
135    /* Terminate groupr run with matd = 0 as usual. */
136    card_10

```

```

137     {
138         matd = 0;
139     }
140 }
141
142 errorr
143 {
144     card_1
145     {
146         nendf = -21;
147         npend = 0;
148         ngout = 24;
149         nout = 25;
150         nin = 23;
151     }
152
153     card_2
154     {
155         matd = 1395;
156         ign = 1;
157         iwt = 2;
158         iprint = 1;
159         irelco = 1;
160     }
161
162     /* Card 3 omitted since ngout != 0. */
163
164     /* Test problem 04 is using a file of the endf-5 format (iverf = 5) */
165
166     card_7
167     {
168         iread = 0;
169         mfcov = 31;
170     }
171
172     card_12a
173     {
174         ngm = 7;
175     }
176
177     card_12b
178     {
179         egn[0] = 1.0e0;
180         egn[1] = 1.0e1;
181         egn[2] = 1.0e2;
182         egn[3] = 1.0e3;
183         egn[4] = 1.0e4;
184         egn[5] = 1.0e5;
185         egn[6] = 1.0e6;
186         egn[7] = 1.0e7;
187     }
188 }

```

### Expected NJOY Input Instructions for Test Problem 04

```

1  moder
2  20 -21/ ### card_1
3  reconr
4  -21 -22/ ### card_1
5  'u-235 10% pendf for errorr test problem from t511'/ ### card_2
6  1395/ ### card_3
7  0.10/ ### card_4
8  0/ ### card_3
9  errorr
10 -21 -22 0 23 0/ ### card_1
11 1395 19 3 1 1/ ### card_2
12 0 0/ ### card_3

```

```

13 0 33/ ### card_7
14 1/ ### card_12a
15 1.0e0 1.0e3/ ### card_12b
16 groupr
17 -21 -22 0 24/ ### card_1
18 1395 3 0 3 0 1 1/ ### card_2
19 'u-235 multigroup nubar calculation'/ ### card_3
20 0.0/ ### card_4
21 1.0e10/ ### card_5
22 3 452 'total nubar'/ ### card_9
23 0/ ### card_9
24 0/ ### card_10
25 errorr
26 -21 0 24 25 23/ ### card_1
27 1395 1 2 1 1/ ### card_2
28 0 31/ ### card_7
29 7/ ### card_12a
30 1.0e0 1.0e1 1.0e2 1.0e3 1.0e4 1.0e5 1.0e6 1.0e7/ ### card_12b
31 stop

```

## B.5 Test Problem 05 (tp05)

### NIF Version of Test Problem 05

```

1  moder
2  {
3      card_1
4      {
5          nin = 30;
6          nout = -31;
7      }
8  }
9
10 moder
11 {
12     card_1
13     {
14         nin = -31;
15         nout = -32;
16     }
17 }
18
19 errorr
20 {
21     card_1
22     {
23         nendf = -31;
24         npend = -32;
25         ngout = 0;
26         nout = -33;
27     }
28
29     card_2
30     {
31         matd = 1306;
32         ign = 19;
33         iwt = 2;
34         iprint = 1;
35     }
36
37     card_3
38     {
39         mprint = 0;
40         tempin = 0;
41     }
42

```

```

43      /* Test problem 05 is using a file of the endf-5 format (iverf=5) */
44
45      card_7
46      {
47          iread = 0;
48          mfcov = 33;
49      }
50
51      card_12a
52      {
53          ngm = 1;
54      }
55
56      card_12b
57      {
58          egn = 1e-5;
59          egn = 2e7;
60      }
61  }
62
63  covr
64  {
65      card_1
66      {
67          nin = -33;
68          nout = 0;
69          nplot = 34;
70      }
71
72      card_2
73      {
74          icolor = 1;
75      }
76
77      card_2a
78      {
79      }
80
81      card_3a
82      {
83      }
84
85      card_4
86      {
87          mat = 1306;
88      }
89  }
90
91  viewr
92  {
93      /* Documentation names the first two cards as card 1. Use card 0 to
94         denote
95         the first card, just like in plotr.
96         */
97      card_0
98      {
99          infile = 34;
100          nps = 35;
101  }

```

### Expected NJOY Input Instructions for Test Problem 05

```

1  moder
2  30 -31/ ### card_1
3  moder
4  -31 -32/ ### card_1

```

```

5  errorr
6  -31 -32 0 -33/ ### card_1
7  1306 19 2 1/ ### card_2
8  0 0/ ### card_3
9  0 33/ ### card_7
10 1/ ### card_12a
11 1e-5 2e7/ ### card_12b
12 covr
13 -33 0 34/ ### card_1
14 1/ ### card_2
15 / ### card_2a
16 / ### card_3a
17 1306/ ### card_4
18 viewr
19 34 35/ ### card_0
20 stop

```

## B.6 Test Problem 06 (tp06)

### NIF Version of Test Problem 06

```

1  plotr
2  {
3      card_0
4      {
5          nplt = 31;
6      }
7
8      card_1 {}
9
10     /* New axes, new page. */
11     card_2
12     {
13         iplot = 1;
14     }
15
16     card_3
17     {
18         /* e should be delimited by < >? Oh well. */
19         t1 = "<endf/b-v carbon";
20     }
21
22     card_3a
23     {
24         t2 = "<t>otal <c>ross <s>ection";
25     }
26
27     card_4
28     {
29         itype = 4;
30     }
31
32     card_5
33     {
34         el = 1e3;
35         eh = 2e7;
36     }
37
38     card_5a {}
39
40     card_6
41     {
42         yl = 0.5;
43         yh = 10;
44     }
45

```

```

46     card_6a {}
47
48     /* card_7 and card_7a skipped since jtype = 0. */
49
50     card_8
51     {
52         iverf = 5;
53         nin = 30;
54         matd = 1306;
55         mfd = 3;
56         mtd = 1;
57     }
58
59     /* card_9 since it's a 2d plot (indicated by sign of itype in card_4) */
60     card_9 {}
61
62     /* New axes, new page. */
63     card_2
64     {
65         iplot = 1;
66     }
67
68     card_3
69     {
70         /* e should be delimited by < >? Oh well. */
71         t1 = "<endf/b-v carbon";
72     }
73
74     card_3a
75     {
76         t2 = "(n,]a>) with fake data";
77     }
78
79     card_4
80     {
81         itype = 1;
82         jtype = 0;
83         igrd = 2;
84         ileg = 1;
85         xtag = 1.3e7;
86         ytag = 0.32;
87     }
88
89     card_5 {}
90     card_5a {}
91     card_6 {}
92     card_6a {}
93     /* card_7 and card_7a skipped since jtype = 0 */
94
95     card_8
96     {
97         iverf = 5;
98         nin = 30;
99         matd = 1306;
100        mfd = 3;
101        mtd = 107;
102    }
103
104    card_9 {}
105
106    card_10
107    {
108        aleg = "<endf/b-v mat1306";
109    }
110
111    /* Add plot on existing axes. */
112    card_2
113    {

```

```

114         iplot = 2;
115     }
116
117     /* card 3-7 skipped since iplot = 2. */
118
119     card_8
120     {
121         iverf = 0; // Ignore rest of parameters on card.
122     }
123
124     card_9
125     {
126         icon = -1;
127         isym = 0;
128     }
129
130     /* card_10 since ileg = 1. */
131     card_10
132     {
133         aleg = "<s>mith & <s>mith 1914";
134     }
135
136     /* card_12 since iverf = 0. */
137     card_12
138     {
139         nform = 0;
140     }
141
142     /* card_13 since nform = 0. */
143     card_13
144     {
145         xdata = 1.1e7;
146         ydata = 0.08;
147         yerr1 = 0.05;
148         yerr2 = 0.05;
149     }
150
151     card_13
152     {
153         xdata = 1.2e7;
154         ydata = 0.10;
155         yerr1 = 0.05;
156         yerr2 = 0.05;
157     }
158
159     card_13
160     {
161         xdata = 1.3e7;
162         ydata = 0.09;
163         yerr1 = 0.04;
164         yerr2 = 0.04;
165     }
166
167     card_13
168     {
169         xdata = 1.4e7;
170         ydata = 0.08;
171         yerr1 = 0.03;
172         yerr2 = 0.03;
173     }
174
175     /* Terminate card_13 with empty card. */
176     card_13 {}
177
178     /* Add plot on existing axes. */
179     card_2
180     {
181         iplot = 3;

```

```

182     }
183
184     /* Card 3-7 skipped since iplot = 3. */
185
186     card_8
187     {
188         iverf = 0; // Ignore rest of parameters on card.
189     }
190
191     card_9
192     {
193         icon = -1;
194         isym = 2;
195     }
196
197     /* card_10 since ileg = 1. */
198     card_10
199     {
200         aleg = "<b>lack & <b>lue 2008";
201     }
202
203     /* card_12 since iverf = 0. */
204     card_12
205     {
206         nform = 0;
207     }
208
209     /* card_13 since nform = 0. */
210     card_13
211     {
212         xdata = 1.15e7;
213         ydata = 0.07;
214         yerr1 = 0.02;
215         yerr2 = 0.0;
216         xerr1 = 0.2e6;
217         xerr2 = 0.0;
218     }
219
220     card_13
221     {
222         xdata = 1.25e7;
223         ydata = 0.11;
224         yerr1 = 0.02;
225         yerr2 = 0.0;
226         xerr1 = 0.2e6;
227         xerr2 = 0.0;
228     }
229
230     card_13
231     {
232         xdata = 1.35e7;
233         ydata = 0.08;
234         yerr1 = 0.015;
235         yerr2 = 0.0;
236         xerr1 = 0.2e6;
237         xerr2 = 0.0;
238     }
239
240     card_13
241     {
242         xdata = 1.45e7;
243         ydata = 0.075;
244         yerr1 = 0.01;
245         yerr2 = 0.0;
246         xerr1 = 0.2e6;
247         xerr2 = 0.0;
248     }
249

```



```

250      /* Terminate card_13 with empty card. */
251      card_13 {}
252
253      /* New axes, new page. */
254      card_2
255      {
256          iplot = 1;
257      }
258
259      card_3
260      {
261          /* e should be delimited by < >? Oh well. */
262          t1 = "<endf/b-v carbon";
263      }
264
265      card_3a
266      {
267          t2 = "<e>lastic <mf4>";
268      }
269
270      card_4
271      {
272          itype = -1; // 3d axes.
273          jtype = 2;
274      }
275
276      card_5 {}
277      card_5a {}
278      card_6 {}
279      card_6a {}
280      card_7 {}
281      card_7a {}
282
283      card_8
284      {
285          iverf = 5;
286          nin = 30;
287          matd = 1306;
288          mfd = 4;
289          mtd = 2;
290      }
291
292      card_11 {}
293
294      /* New axes, new page. */
295      card_2
296      {
297          iplot = 1;
298      }
299
300      card_3
301      {
302          t1 = "<endf/b-v l>i-6";
303      }
304
305      card_3a
306      {
307          t2 = "(n,2n)]a >neutron distribution";
308      }
309
310      card_4
311      {
312          itype = -1;
313          jtype = 2;
314      }
315
316      card_5 {}
317      card_5a {}

```

```

318
319     card_6
320     {
321         yl = 0;
322         yh = 12e6;
323         ystep = 2e6;
324     }
325
326     card_6a {}
327     card_7 {}
328     card_7a {}
329
330     card_8
331     {
332         iverf = 5;
333         nin = 30;
334         matd = 1303;
335         mfd = 5;
336         mtd = 24;
337     }
338
339     /* 3D plot. */
340     card_11 {}
341
342     /* New axes, new page. */
343     card_2
344     {
345         iplot = 1;
346     }
347
348     card_3
349     {
350         t1 = "<endf/b-v l>i-6";
351     }
352
353     card_3a
354     {
355         t2 = "(n,2n)]a >neutron spectra vs <E>";
356     }
357
358     card_4
359     {
360         itype = 4;
361         jtype = 0;
362         igrd = 2;
363         ileg = 2;
364     }
365
366     card_5
367     {
368         el = 10.0;
369         eh = 2.0e7;
370     }
371
372     card_5a {}
373
374     card_6
375     {
376         yl = 1e-11;
377         yh = 1e-6;
378     }
379
380     card_6a
381     {
382         ylab1 = "<c>ross <s>ection (barns/e<v>)" ;
383     }
384
385     card_8

```

```

386     {
387         iverf = 5;
388         nin = 30;
389         matd = 1303;
390         mfd = 5;
391         mtd = 24;
392         temper = 0.0;
393         nth = 12;
394     }
395
396     card_9 {}
397
398     card_10
399     {
400         aleg = "10 <m>e<v";
401     }
402
403     card_10a
404     {
405         xtag = 1e3;
406         ytag = 2e-11;
407         xpoint = 1e2;
408     }
409
410     /* 2th additional plot on existing axes. */
411     card_2
412     {
413         iplot = 2;
414     }
415
416     card_8
417     {
418         iverf = 5;
419         nin = 30;
420         matd = 1303;
421         mfd = 5;
422         mtd = 24;
423         temper = 0.0;
424         nth = 16;
425     }
426
427     card_9 {}
428
429     /* card 10, 10a since ileg = 2 for the current axes. */
430     card_10
431     {
432         aleg = "14 <m>e<v";
433     }
434
435     card_10a
436     {
437         xtag = 1e4;
438         ytag = 2e-10;
439         xpoint = 2e3;
440     }
441
442     /* 3rd additional plot on existing axes. */
443     card_2
444     {
445         iplot = 3;
446     }
447
448     card_8
449     {
450         iverf = 5;
451         nin = 30;
452         matd = 1303;
453         mfd = 5;

```

```

454         mtd = 24;
455         temper = 0.0;
456         nth = 20;
457     }
458
459     card_9 {}
460
461     card_10
462     {
463         aleg = "20 <m>e<v";
464     }
465
466     card_10a
467     {
468         xtag = 1e5;
469         ytag = 2e-9;
470         xpoint = 4e4;
471     }
472
473     /* Terminate plotting job. */
474     card_2
475     {
476         iplot = 99;
477     }
478 }
479
480 viewr
481 {
482     /* Documentation names the first two cards as card 1. Use card 0 to
483        denote
484        the first card, just like in plotr.
485        */
486     card_0
487     {
488         infile = 31;
489         nps = 32;
490     }

```

## Expected NJOY Input Instructions for Test Problem 06

```

1  plotr
2  31/ ### card_0
3  / ### card_1
4  1/ ### card_2
5  '<endf/b-v carbon'/ ### card_3
6  '<t>otal <c>ross <s>ection'/ ### card_3a
7  4/ ### card_4
8  1e3 2e7/ ### card_5
9  / ### card_5a
10 0.5 10/ ### card_6
11 / ### card_6a
12 5 30 1306 3 1/ ### card_8
13 / ### card_9
14 1/ ### card_2
15 '<endf/b-v carbon'/ ### card_3
16 '(n,[a>) with fake data'/ ### card_3a
17 1 0 2 1 1.3e7 0.32/ ### card_4
18 / ### card_5
19 / ### card_5a
20 / ### card_6
21 / ### card_6a
22 5 30 1306 3 107/ ### card_8
23 / ### card_9
24 '<endf/b-v mat1306'/ ### card_10
25 2/ ### card_2
26 0/ ### card_8

```

```

27 -1 0/ ### card_9
28 '<s>mith & <s>mith 1914'/ ### card_10
29 0/ ### card_12
30 1.1e7 0.08 0.05 0.05/ ### card_13
31 1.2e7 0.10 0.05 0.05/ ### card_13
32 1.3e7 0.09 0.04 0.04/ ### card_13
33 1.4e7 0.08 0.03 0.03/ ### card_13
34 / ### card_13
35 3/ ### card_2
36 0/ ### card_8
37 -1 2/ ### card_9
38 '<b>lack & <b>lue 2008'/ ### card_10
39 0/ ### card_12
40 1.15e7 0.07 0.02 0.0 0.2e6 0.0/ ### card_13
41 1.25e7 0.11 0.02 0.0 0.2e6 0.0/ ### card_13
42 1.35e7 0.08 0.015 0.0 0.2e6 0.0/ ### card_13
43 1.45e7 0.075 0.01 0.0 0.2e6 0.0/ ### card_13
44 / ### card_13
45 1/ ### card_2
46 '<endf/b-v carbon'/ ### card_3
47 '<e>lastic <mf4>'/ ### card_3a
48 -1 2/ ### card_4
49 / ### card_5
50 / ### card_5a
51 / ### card_6
52 / ### card_6a
53 / ### card_7
54 / ### card_7a
55 5 30 1306 4 2/ ### card_8
56 / ### card_11
57 1/ ### card_2
58 '<endf/b-v l>i-6'/ ### card_3
59 '(n,2n)l a >neutron distribution'/ ### card_3a
60 -1 2/ ### card_4
61 / ### card_5
62 / ### card_5a
63 0 12e6 2e6/ ### card_6
64 / ### card_6a
65 / ### card_7
66 / ### card_7a
67 5 30 1303 5 24/ ### card_8
68 / ### card_11
69 1/ ### card_2
70 '<endf/b-v l>i-6'/ ### card_3
71 '(n,2n)l a >neutron spectra vs <E>'/ ### card_3a
72 4 0 2 2/ ### card_4
73 10.0 2.0e7/ ### card_5
74 / ### card_5a
75 1e-11 1e-6/ ### card_6
76 '<c>ross <s>ection (barns/e<v>)/ ### card_6a
77 5 30 1303 5 24 0.0 12/ ### card_8
78 / ### card_9
79 '10 <m>e<v>'/ ### card_10
80 1e3 2e-11 1e2/ ### card_10a
81 2/ ### card_2
82 5 30 1303 5 24 0.0 16/ ### card_8
83 / ### card_9
84 '14 <m>e<v>'/ ### card_10
85 1e4 2e-10 2e3/ ### card_10a
86 3/ ### card_2
87 5 30 1303 5 24 0.0 20/ ### card_8
88 / ### card_9
89 '20 <m>e<v>'/ ### card_10
90 1e5 2e-9 4e4/ ### card_10a
91 99/ ### card_2
92 vieww
93 31 32/ ### card_0
94 stop

```

## B.7 Test Problem 07 (tp07)

### NIF Version of Test Problem 07

```
1  moder
2  {
3      card_1
4      {
5          nin = 20;
6          nout = -21;
7      }
8  }
9
10 reconr
11 {
12     card_1
13     {
14         nendf = -21;
15         npend = -22;
16     }
17
18     card_2
19     {
20         tlabel = "pendf tape for u-235 from endf/b-v tape 511";
21     }
22
23     card_3
24     {
25         mat = 1395;
26         ncards = 3;
27     }
28
29     card_4
30     {
31         /* Note C-style float compared to the original declaration above. */
32         err = 0.005;
33     }
34
35     card_5
36     {
37         cards = "92-u-235 from endf/b-v tape 511 ";
38     }
39
40     card_5
41     {
42         cards = "processed by the njoy nuclear data processing system";
43     }
44
45     card_5
46     {
47         cards = "see original endf/b-v tape for details of evaluation";
48     }
49
50     /* Terminate execution of reconr with mat = 0 as usual. */
51     card_3
52     {
53         mat = 0;
54     }
55 }
56
57 broadr
58 {
59     card_1
60     {
61         nendf = -21;
62         nin = -22;
63         nout = -23;
64     }
```

```

65
66     card_2
67     {
68         mat1 = 1395;
69         ntemp2 = 1;
70         istart = 0;
71         istrap = 1;
72         temp1 = 0;
73     }
74
75     card_3
76     {
77         errthn = 0.005;
78     }
79
80     card_4
81     {
82         temp2[0] = 300;
83     }
84
85     /* Terminate execution of broadr with mat1 = 0 as usual. */
86     card_5
87     {
88         mat1 = 0;
89     }
90 }
91
92 heatr
93 {
94     card_1
95     {
96         nendf = -21;
97         nin = -23;
98         nout = -24;
99         /* nplot not supplied, defaulted to 0? */
100    }
101
102    card_2
103    {
104        matd = 1395;
105    }
106 }
107
108 moder
109 {
110     card_1
111     {
112         nin = -24;
113         nout = 28;
114     }
115 }
116
117 groupr
118 {
119     card_1
120     {
121         nendf = -21;
122         npend = -24;
123         ngout1 = 0;
124         ngout2 = -25;
125     }
126
127     card_2
128     {
129         matb = 1395;
130         ign = 3;
131         igg = 2;
132         iwt = 9;

```

```

133         lord = 0;
134         ntemp = 1;
135         nsigz = 1;
136         iprint = 1;
137     }
138
139     card_3
140     {
141         title = "u-235 from tape 511";
142     }
143
144     card_4
145     {
146         temp[0] = 300.0;
147     }
148
149     card_5
150     {
151         sigz[0] = 1.0e10;
152     }
153
154     card_9
155     {
156         mfd = 16;
157         /* mtd and mtname does not have to be supplied? */
158     }
159
160     /* Terminate temperature/material with mfd = 0 as usual. */
161     card_9
162     {
163         mfd = 0;
164     }
165
166     /* Terminate groupw run with matd = 0 as usual. */
167     card_10
168     {
169         matd = 0;
170     }
171 }
172
173 acer
174 {
175     card_1
176     {
177         nendf = -21;
178         npend = -24;
179         ngend = -25;
180         nace = 26;
181         ndir = 27;
182     }
183
184     card_2
185     {
186         iopt = 1;
187     }
188
189     card_3
190     {
191         hk = "njoy test problem 7";
192     }
193
194     card_5
195     {
196         matd = 1395;
197         tempd = 300.0;
198     }
199
200     card_6

```



```

201      {
202          newfor = 0;
203      }
204
205      card_7 {}
206  }

```

## Expected NJOY Input Instructions for Test Problem 07

```

1  moder
2  20 -21/ ### card_1
3  reconr
4  -21 -22/ ### card_1
5  'pendf tape for u-235 from endf/b-v tape 511'/ ### card_2
6  1395 3/ ### card_3
7  0.005/ ### card_4
8  '92-u-235 from endf/b-v tape 511 '/ ### card_5
9  'processed by the njoy nuclear data processing system'/ ### card_5
10 'see original endf/b-v tape for details of evaluation'/ ### card_5
11 0/ ### card_3
12 broadr
13 -21 -22 -23/ ### card_1
14 1395 1 0 1 0/ ### card_2
15 0.005/ ### card_3
16 300/ ### card_4
17 0/ ### card_5
18 heatr
19 -21 -23 -24/ ### card_1
20 1395/ ### card_2
21 moder
22 -24 28/ ### card_1
23 groupr
24 -21 -24 0 -25/ ### card_1
25 1395 3 2 9 0 1 1/ ### card_2
26 'u-235 from tape 511'/ ### card_3
27 300.0/ ### card_4
28 1.0e10/ ### card_5
29 16/ ### card_9
30 0/ ### card_9
31 0/ ### card_10
32 acer
33 -21 -24 -25 26 27/ ### card_1
34 1/ ### card_2
35 'njoy test problem 7'/ ### card_3
36 1395 300.0/ ### card_5
37 0/ ### card_6
38 / ### card_7
39 stop

```

## B.8 Test Problem 08 (tp08)

### NIF Version of Test Problem 08

```

1  moder
2  {
3      card_1
4      {
5          nin = 20;
6          nout = -21;
7      }
8  }
9
10 reconr
11 {

```

```

12     card_1
13     {
14         nendf = -21;
15         npend = -22;
16     }
17
18     card_2
19     {
20         tlabel = "pendf tape for endf/b-vi.1 28-ni-61a";
21     }
22
23     card_3
24     {
25         mat = 2834;
26         ncards = 1;
27         ngrid = 0;
28     }
29
30     card_4
31     {
32         /* Note C-style float compared to the original declaration above. */
33         err = 0.01;
34     }
35
36     card_5
37     {
38         cards = "28-ni-61a from endf/b-vi.1 t124 (hetrick,fu;ornl)";
39     }
40
41     /* Terminate execution of reconr with mat = 0 as usual. */
42     card_3
43     {
44         mat = 0;
45     }
46 }
47
48 broadr
49 {
50     card_1
51     {
52         nendf = -21;
53         nin = -22;
54         nout = -23;
55     }
56
57     card_2
58     {
59         mat1 = 2834;
60         ntemp2 = 1;
61     }
62
63     card_3
64     {
65         errthn = 0.01;
66     }
67
68     card_4
69     {
70         temp2[0] = 300;
71     }
72
73     /* Terminate execution of broadr with mat1 = 0 as usual. */
74     card_5
75     {
76         mat1 = 0;
77     }
78 }
79

```

```

80  heatr
81  {
82      card_1
83      {
84          nendf = -21;
85          nin = -23;
86          nout = -24;
87          /* nplot not supplied, defaulted to 0? */
88      }
89
90      card_2
91      {
92          matd = 2834;
93          npk = 6;
94          nqa = 0;
95          ntemp = 1;
96          local = 0;
97          iprint = 2;
98      }
99
100     card_3
101     {
102         mtk[0] = 302;
103         mtk[1] = 303;
104         mtk[2] = 304;
105         mtk[3] = 402;
106         mtk[4] = 443;
107         mtk[5] = 444;
108     }
109 }
110
111 moder
112 {
113     card_1
114     {
115         nin = -24;
116         nout = 28;
117     }
118 }
119
120 groupr
121 {
122     card_1
123     {
124         nendf = -21;
125         npend = -24;
126         ngout1 = 0;
127         ngout2 = -22;
128     }
129
130     card_2
131     {
132         matb = 2834;
133         ign = 3;
134         igg = 3;
135         iwt = 9;
136         lord = 4;
137         ntemp = 1;
138         nsigz = 1;
139         iprint = 1;
140     }
141
142     card_3
143     {
144         title = "ni61a endf/b-vi.1 30x12";
145     }
146
147     card_4

```

```

148     {
149         temp[0] = 300;
150     }
151
152     card_5
153     {
154         sigz[0] = 1e10; // No trailing dots. Use C-style floats.
155     }
156
157     card_9
158     {
159         mfd = 3;
160         /* mtd and mtname does not have to be supplied? */
161     }
162
163     card_9
164     {
165         mfd = 3;
166         mtd = 251;
167         mtname = "mubar";
168     }
169
170     card_9
171     {
172         mfd = 3;
173         mtd = 252;
174         mtname = "xi";
175     }
176
177     card_9
178     {
179         mfd = 3;
180         mtd = 253;
181         mtname = "gamma";
182     }
183
184     card_9
185     {
186         mfd = 3;
187         mtd = 259;
188         mtname = "1/v";
189     }
190
191     card_9
192     {
193         mfd = 6;
194         /* mtd and mtname does not have to be supplied? */
195     }
196
197     card_9
198     {
199         mfd = 16;
200         /* mtd and mtname does not have to be supplied? */
201     }
202
203     /* Terminate temperature/material with mfd = 0 as usual. */
204     card_9
205     {
206         mfd = 0;
207     }
208
209     /* Terminate group run with matd = 0 as usual. */
210     card_10
211     {
212         matd = 0;
213     }
214 }
215

```

```

216 acer
217 {
218     card_1
219     {
220         nendf = -21;
221         npend = -24;
222         ngend = 0;
223         nace = 25;
224         ndir = 26;
225     }
226
227     card_2
228     {
229         iopt = 1;
230         iprint = 1;
231         ntype = 1;
232     }
233
234     card_3
235     {
236         hk = "28-ni-61a from endf-vi.1";
237     }
238
239     card_5
240     {
241         matd = 2834;
242         tempd = 300.0;
243     }
244
245     card_6
246     {
247         newfor = 0;
248     }
249
250     card_7 {}
251 }

```

### Expected NJOY Input Instructions for Test Problem 08

```

1  moder
2  20 -21/ ### card_1
3  reconr
4  -21 -22/ ### card_1
5  'pendf tape for endf/b-vi.1 28-ni-61a'/ ### card_2
6  2834 1 0/ ### card_3
7  0.01/ ### card_4
8  '28-ni-61a from endf/b-vi.1 t124 (hetrick,fu;ornl)'/ ### card_5
9  0/ ### card_3
10 broadr
11 -21 -22 -23/ ### card_1
12 2834 1/ ### card_2
13 0.01/ ### card_3
14 300/ ### card_4
15 0/ ### card_5
16 heatr
17 -21 -23 -24/ ### card_1
18 2834 6 0 1 0 2/ ### card_2
19 302 303 304 402 443 444/ ### card_3
20 moder
21 -24 28/ ### card_1
22 groupr
23 -21 -24 0 -22/ ### card_1
24 2834 3 3 9 4 1 1/ ### card_2
25 'ni61a endf/b-vi.1 30x12'/ ### card_3
26 300/ ### card_4
27 1e10/ ### card_5
28 3/ ### card_9

```

```

29 3 251 'mubar' / ### card_9
30 3 252 'xi' / ### card_9
31 3 253 'gamma' / ### card_9
32 3 259 '1/v' / ### card_9
33 6 / ### card_9
34 16 / ### card_9
35 0 / ### card_9
36 0 / ### card_10
37 acer
38 -21 -24 0 25 26 / ### card_1
39 1 1 1 / ### card_2
40 '28-ni-61a from endf-vi.1' / ### card_3
41 2834 300.0 / ### card_5
42 0 / ### card_6
43 / ### card_7
44 stop

```

## B.9 Test Problem 10 (tp10)

### NIF Version of Test Problem 10

```

1  moder
2  {
3      card_1
4      {
5          nin = 20;
6          nout = -21;
7      }
8  }
9
10 reconr
11 {
12     card_1
13     {
14         nendf = -21;
15         npend = -22;
16     }
17
18     card_2
19     {
20         tlabel = "pendf tape for pu-238 from endf/b-iv tape 404";
21     }
22
23     card_3
24     {
25         mat = 1050;
26         ncards = 3;
27     }
28
29     card_4
30     {
31         /* Note C-style float compared to the original declaration above. */
32         err = 0.005;
33     }
34
35     card_5
36     {
37         cards = "94-pu-238 from endf/b tape t404";
38     }
39
40     card_5
41     {
42         cards = "processed by the njoy nuclear data processing system";
43     }
44
45     card_5

```

```

46     {
47         cards = "see original endf/b-iv tape for details of evaluation";
48     }
49
50     /* Terminate execution of reconr with mat = 0 as usual. */
51     card_3
52     {
53         mat = 0;
54     }
55 }
56
57 broadr
58 {
59     card_1
60     {
61         nendf = -21;
62         nin = -22;
63         nout = -23;
64     }
65
66     card_2
67     {
68         mat1 = 1050;
69         ntemp2 = 3;
70         istart = 0;
71         istrap = 1;
72         temp1 = 0;
73     }
74
75     card_3
76     {
77         errthn = 0.005;
78     }
79
80     card_4
81     {
82         temp2[0] = 300.0;
83         temp2[1] = 900.0;
84         temp2[2] = 2100.0;
85     }
86
87     /* Terminate execution of broadr with mat1 = 0 as usual. */
88     card_5
89     {
90         mat1 = 0;
91     }
92 }
93
94 unresr
95 {
96     card_1
97     {
98         nendf = -21;
99         nin = -23;
100        nout = -24;
101    }
102
103    card_2
104    {
105        matd = 1050;
106        ntemp = 3;
107        nsigz = 7;
108        iprint = 1;
109    }
110
111    card_3
112    {
113        temp[0] = 300;

```

```

114         temp[1] = 900;
115         temp[2] = 2100;
116     }
117
118     card_4
119     {
120         sigz[0] = 1.0e10;
121         sigz[1] = 1.0e5;
122         sigz[2] = 1.0e4;
123         sigz[3] = 1000.0;
124         sigz[4] = 100.0;
125         sigz[5] = 10.0;
126         sigz[6] = 1;
127     }
128
129     card_2
130     {
131         matd = 0;
132     }
133 }
134
135 purr
136 {
137     card_1
138     {
139         nendf = -21;
140         nin = -24;
141         nout = -25;
142     }
143
144     card_2
145     {
146         matd = 1050;
147         ntemp = 3;
148         nsigz = 7;
149         nbin = 20;
150         nladr = 4;
151     }
152
153     card_3
154     {
155         temp[0] = 300;
156         temp[1] = 900;
157         temp[2] = 2100;
158     }
159
160     card_4
161     {
162         sigz[0] = 1.0e10;
163         sigz[1] = 1.0e5;
164         sigz[2] = 1.0e4;
165         sigz[3] = 1000.0;
166         sigz[4] = 100.0;
167         sigz[5] = 10.0;
168         sigz[6] = 1;
169     }
170
171     card_2
172     {
173         matd = 0;
174     }
175 }
176
177 acer
178 {
179     card_1
180     {
181         nendf = -21;

```



```

182         npend = -25;
183         ngend = 0;
184         nace = 26;
185         ndir = 27;
186     }
187
188     card_2
189     {
190         iopt = 1;
191     }
192
193     card_3
194     {
195         hk = "njoy test problem 10";
196     }
197
198     card_5
199     {
200         matd = 1050;
201         tempd = 300.0;
202     }
203
204     card_6 {}
205     card_7 {}
206 }
207
208 moder
209 {
210     card_1
211     {
212         nin = -25;
213         nout = 28;
214     }
215 }

```

### Expected NJOY Input Instructions for Test Problem 10

```

1  moder
2  20 -21/ ### card_1
3  reconr
4  -21 -22/ ### card_1
5  'pendf tape for pu-238 from endf/b-iv tape 404'/ ### card_2
6  1050 3/ ### card_3
7  0.005/ ### card_4
8  '94-pu-238 from endf/b tape t404'/ ### card_5
9  'processed by the njoy nuclear data processing system'/ ### card_5
10 'see original endf/b-iv tape for details of evaluation'/ ### card_5
11 0/ ### card_3
12 broadr
13 -21 -22 -23/ ### card_1
14 1050 3 0 1 0/ ### card_2
15 0.005/ ### card_3
16 300.0 900.0 2100.0/ ### card_4
17 0/ ### card_5
18 unresr
19 -21 -23 -24/ ### card_1
20 1050 3 7 1/ ### card_2
21 300 900 2100/ ### card_3
22 1.0e10 1.0e5 1.0e4 1000.0 100.0 10.0 1/ ### card_4
23 0/ ### card_2
24 purrr
25 -21 -24 -25/ ### card_1
26 1050 3 7 20 4/ ### card_2
27 300 900 2100/ ### card_3
28 1.0e10 1.0e5 1.0e4 1000.0 100.0 10.0 1/ ### card_4
29 0/ ### card_2
30 acer

```

```

31 -21 -25 0 26 27/ ### card_1
32 1/ ### card_2
33 'njoy test problem 10'/ ### card_3
34 1050 300.0/ ### card_5
35 / ### card_6
36 / ### card_7
37 moder
38 -25 28/ ### card_1
39 stop

```

## B.10 Test Problem 11 (tp11)

### NIF Version of Test Problem 11

```

1 moder
2 {
3     card_1
4     {
5         nin = 20;
6         nout = -21;
7     }
8 }
9
10 reconr
11 {
12     card_1
13     {
14         nendf = -21;
15         npend = -22;
16     }
17
18     card_2
19     {
20         tlabel = "pendf tape for pu-238 from endf/b-iv tape 404";
21     }
22
23     card_3
24     {
25         mat = 1050;
26         ncards = 3;
27     }
28
29     card_4
30     {
31         err = 0.005; // Use C-style floats.
32     }
33
34     card_5
35     {
36         cards = "94-pu-238 from endf/b tape t404";
37     }
38
39     card_5
40     {
41         cards = "processed by the njoy nuclear data processing system";
42     }
43
44     card_5
45     {
46         cards = "see original endf/b-iv tape for details of evaluation";
47     }
48
49     /* Card 6 skipped since ngrid defaults to 0 in first card 3 */
50
51     /* Terminate reconr. */
52     card_3

```

```

53     {
54         mat = 0;
55     }
56 }
57
58 broadr
59 {
60     card_1
61     {
62         nendf = -21;
63         nin = -22;
64         nout = -23;
65     }
66
67     card_2
68     {
69         mat1 = 1050;
70         ntemp2 = 3;
71         istart = 0;
72         istrap = 1;
73         temp1 = 0;
74     }
75
76     card_3
77     {
78         errrthn = 0.005; // Use C-style floats.
79     }
80
81     card_4
82     {
83         temp2[0] = 300.0; // Use C-style floats.
84         temp2[1] = 900.0;
85         temp2[2] = 2100.0;
86     }
87
88     /* Terminate broadr. */
89     card_5
90     {
91         mat1 = 0;
92     }
93 }
94
95 unresr
96 {
97     card_1
98     {
99         nendf = -21;
100         nin = -23;
101         nout = -24;
102     }
103
104     card_2
105     {
106         matd = 1050;
107         ntemp = 3;
108         nsigz = 7;
109         iprint = 1;
110     }
111
112     card_3
113     {
114         temp[0] = 300;
115         temp[1] = 900;
116         temp[2] = 2100;
117     }
118
119     card_4
120     {

```

```

121         sigz[0] = 1.0e10;
122         sigz[1] = 1.0e5;
123         sigz[2] = 1.0e4;
124         sigz[3] = 1000.0;
125         sigz[4] = 100.0;
126         sigz[5] = 10.0;
127         sigz[6] = 1;
128     }
129
130     /* Terminate unresr. */
131     card_2
132     {
133         matd = 0;
134     }
135 }
136
137 thermr
138 {
139     card_1
140     {
141         nendf = 0;
142         nin = -24;
143         nout = -25;
144     }
145
146     card_2
147     {
148         matde = 0;
149         matdp = 1050;
150         nbin = 8;
151         ntemp = 3;
152         iinc = 1;
153         icoh = 0;
154         natom = 1;
155         mtref = 221;
156         iprint = 0;
157     }
158
159     card_3
160     {
161         tempr[0] = 300.0; // Use C-style floats.
162         tempr[1] = 900.0;
163         tempr[2] = 2100.0;
164     }
165
166     card_4
167     {
168         tol = 0.05; // Use C-style floats.
169         emax = 4.2;
170     }
171 }
172
173 groupr
174 {
175     card_1
176     {
177         nendf = -21;
178         npend = -25;
179         ngout1 = 0;
180         ngout2 = -26;
181     }
182
183     card_2
184     {
185         matb = 1050;
186         ign = 9;
187         igg = 0;
188         iwt = 5;

```

```

189         lord = 3;
190         ntemp = 3;
191         nsigz = 7;
192         iprint = 1;
193     }
194
195     card_3
196     {
197         title = "94-pu-238";
198     }
199
200     card_4
201     {
202         /* ntemp in card_2 denotes the number of expected temperatures. */
203         temp[0] = 300.0;
204         temp[1] = 900.0;
205         temp[2] = 2100.0;
206     }
207
208     card_5
209     {
210         /* nsigz in card_2 denotes the number of expected sigma zeroes. */
211         sigz[0] = 1.0e10;
212         sigz[1] = 1.0e5;
213         sigz[2] = 1.0e4;
214         sigz[3] = 1000.0;
215         sigz[4] = 100.0;
216         sigz[5] = 10.0;
217         sigz[6] = 1;
218     }
219
220     /* Reactions for temperature 300.0. */
221     card_9
222     {
223         mfd = 3;
224         mtd = 1;
225         mtname = "total";
226     }
227
228     card_9
229     {
230         mfd = 3;
231         mtd = 2;
232         mtname = "elastic";
233     }
234
235     card_9
236     {
237         mfd = 3;
238         mtd = 16;
239         mtname = "n2n";
240     }
241
242     card_9
243     {
244         mfd = 3;
245         mtd = 17;
246         mtname = "n3n";
247     }
248
249     card_9
250     {
251         mfd = 3;
252         mtd = 18;
253         mtname = "fission";
254     }
255
256     card_9

```

```

257 {
258     mfd = 3;
259     mtd = 102;
260     mtname = "capture";
261 }
262
263 card_9
264 {
265     mfd = 3;
266     mtd = 221;
267     mtname = "free gas thermal";
268 }
269
270 card_9
271 {
272     mfd = 6;
273     mtd = 2;
274     mtname = "elastic";
275 }
276
277 card_9
278 {
279     mfd = 6;
280     mtd = 16;
281     mtname = "n2n";
282 }
283
284 card_9
285 {
286     mfd = 6;
287     mtd = 17;
288     mtname = "n,3n";
289 }
290
291 card_9
292 {
293     mfd = 6;
294     mtd = 18;
295     mtname = "fission";
296 }
297
298 card_9
299 {
300     mfd = 6;
301     mtd = 51;
302     mtname = "discrete inelastic";
303 }
304
305 card_9
306 {
307     mfd = 6;
308     mtd = -59;
309     mtname = "continued";
310 }
311
312 card_9
313 {
314     mfd = 6;
315     mtd = 91;
316     mtname = "continuum inelastic";
317 }
318
319 card_9
320 {
321     mfd = 6;
322     mtd = 221;
323     mtname = "free gas thermal";
324 }

```

```

325
326      /* Terminate temperature 300.0. */
327      card_9
328      {
329          mfd = 0;
330      }
331
332      /* Reactions for temperature 900.0. */
333      card_9
334      {
335          mfd = 3;
336          mtd = 1;
337          mtname = "total";
338      }
339
340      card_9
341      {
342          mfd = 3;
343          mtd = 2;
344          mtname = "elastic";
345      }
346
347      card_9
348      {
349          mfd = 3;
350          mtd = 18;
351          mtname = "fission";
352      }
353
354      card_9
355      {
356          mfd = 3;
357          mtd = 102;
358          mtname = "capture";
359      }
360
361      card_9
362      {
363          mfd = 3;
364          mtd = 221;
365          mtname = "free gas thermal";
366      }
367
368      card_9
369      {
370          mfd = 6;
371          mtd = 2;
372          mtname = "elastic";
373      }
374
375      card_9
376      {
377          mfd = 6;
378          mtd = 221;
379          mtname = "free gas thermal";
380      }
381
382      /* Terminate temperature 900.0. */
383      card_9
384      {
385          mfd = 0;
386      }
387
388      /* Reactions for temperature 2100.0. */
389      card_9
390      {
391          mfd = 3;
392          mtd = 1;

```

```

393         mtname = "total";
394     }
395
396     card_9
397     {
398         mfd = 3;
399         mtd = 2;
400         mtname = "elastic";
401     }
402
403     card_9
404     {
405         mfd = 3;
406         mtd = 18;
407         mtname = "fission";
408     }
409
410     card_9
411     {
412         mfd = 3;
413         mtd = 102;
414         mtname = "capture";
415     }
416
417     card_9
418     {
419         mfd = 3;
420         mtd = 221;
421         mtname = "free gas thermal";
422     }
423
424     card_9
425     {
426         mfd = 6;
427         mtd = 2;
428         mtname = "elastic";
429     }
430
431     card_9
432     {
433         mfd = 6;
434         mtd = 221;
435         mtname = "free gas thermal";
436     }
437
438     /* Terminate temperature 2100.0. */
439     card_9
440     {
441         mfd = 0;
442     }
443
444     /* Terminate group. */
445     card_10
446     {
447         matd = 0;
448     }
449 }
450
451 wimsr
452 {
453     card_1
454     {
455         ngendf = -26;
456         nout = 27;
457     }
458
459     card_2
460     {

```



```

461         iprint = 1;
462     }
463
464     card_3
465     {
466         mat = 1050;
467         nfid = 1;
468         rdfid = 1050.0;
469     }
470
471     card_4
472     {
473         ntemp = 3;
474         nsigz = 7;
475         sgref = 1e10;
476         ires = 3;
477         sigp = 10.890;
478         mti = 221;
479         mtc = 0;
480     }
481
482     card_7
483     {
484         lambda[0] = 1.0;
485         lambda[1] = 1.0;
486         lambda[2] = 1.0;
487         lambda[3] = 1.0;
488         lambda[4] = 1.0;
489         lambda[5] = 1.0;
490         lambda[6] = 1.0;
491         lambda[7] = 1.0;
492         lambda[8] = 1.0;
493         lambda[9] = 1.0;
494         lambda[10] = 1.0;
495         lambda[11] = 1.0;
496         lambda[12] = 1.0;
497     }
498 }

```

### Expected NJOY Input Instructions for Test Problem 11

```

1  moder
2  20 -21/ ### card_1
3  reconr
4  -21 -22/ ### card_1
5  'pendf tape for pu-238 from endf/b-iv tape 404'/ ### card_2
6  1050 3/ ### card_3
7  0.005/ ### card_4
8  '94-pu-238 from endf/b tape t404'/ ### card_5
9  'processed by the njoy nuclear data processing system'/ ### card_5
10 'see original endf/b-iv tape for details of evaluation'/ ### card_5
11 0/ ### card_3
12 broadr
13 -21 -22 -23/ ### card_1
14 1050 3 0 1 0/ ### card_2
15 0.005/ ### card_3
16 300.0 900.0 2100.0/ ### card_4
17 0/ ### card_5
18 unresr
19 -21 -23 -24/ ### card_1
20 1050 3 7 1/ ### card_2
21 300 900 2100/ ### card_3
22 1.0e10 1.0e5 1.0e4 1000.0 100.0 10.0 1/ ### card_4
23 0/ ### card_2
24 thermr
25 0 -24 -25/ ### card_1
26 0 1050 8 3 1 0 1 221 0/ ### card_2

```

```

27 300.0 900.0 2100.0/ ### card_3
28 0.05 4.2/ ### card_4
29 groupr
30 -21 -25 0 -26/ ### card_1
31 1050 9 0 5 3 3 7 1/ ### card_2
32 '94-pu-238'/ ### card_3
33 300.0 900.0 2100.0/ ### card_4
34 1.0e10 1.0e5 1.0e4 1000.0 100.0 10.0 1/ ### card_5
35 3 1 'total'/ ### card_9
36 3 2 'elastic'/ ### card_9
37 3 16 'n2n'/ ### card_9
38 3 17 'n3n'/ ### card_9
39 3 18 'fission'/ ### card_9
40 3 102 'capture'/ ### card_9
41 3 221 'free gas thermal'/ ### card_9
42 6 2 'elastic'/ ### card_9
43 6 16 'n2n'/ ### card_9
44 6 17 'n,3n'/ ### card_9
45 6 18 'fission'/ ### card_9
46 6 51 'discrete inelastic'/ ### card_9
47 6 -59 'continued'/ ### card_9
48 6 91 'continuum inelastic'/ ### card_9
49 6 221 'free gas thermal'/ ### card_9
50 0/ ### card_9
51 3 1 'total'/ ### card_9
52 3 2 'elastic'/ ### card_9
53 3 18 'fission'/ ### card_9
54 3 102 'capture'/ ### card_9
55 3 221 'free gas thermal'/ ### card_9
56 6 2 'elastic'/ ### card_9
57 6 221 'free gas thermal'/ ### card_9
58 0/ ### card_9
59 3 1 'total'/ ### card_9
60 3 2 'elastic'/ ### card_9
61 3 18 'fission'/ ### card_9
62 3 102 'capture'/ ### card_9
63 3 221 'free gas thermal'/ ### card_9
64 6 2 'elastic'/ ### card_9
65 6 221 'free gas thermal'/ ### card_9
66 0/ ### card_9
67 0/ ### card_10
68 wimsr
69 -26 27/ ### card_1
70 1/ ### card_2
71 1050 1 1050.0/ ### card_3
72 3 7 1e10 3 10.890 221 0/ ### card_4
73 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0/ ### card_7
74 stop

```

## B.11 Test Problem 12 (tp12)

### NIF Version of Test Problem 12

```

1 reconr
2 {
3     card_1
4     {
5         nendf = 20;
6         npend = 21;
7     }
8
9     card_2
10    {
11        tlabel = "pendf tape for endf/b-vi.1 28-ni-61a";
12    }
13

```

```

14     card_3
15     {
16         mat = 2834;
17         ncards = 1;
18         ngrid = 0;
19     }
20
21     card_4
22     {
23         /* Note C-style float compared to the original declaration above. */
24         err = 0.01;
25     }
26
27     card_5
28     {
29         cards = "28-ni-61a from endf/b-vi.1 t124 (hetrick,fu;ornl)";
30     }
31
32     /* Terminate execution of reconr with mat = 0 as usual. */
33     card_3
34     {
35         mat = 0;
36     }
37 }
38
39 gaspr
40 {
41     card_1
42     {
43         nendf = 20;
44         nin = 21;
45         nout = 22;
46     }
47 }
48
49 plotr
50 {
51     card_0
52     {
53         nplt = 23;
54     }
55
56     card_1
57     {
58         lori = 1;
59         istyle = 1;
60         size = 0.3;
61         ipcol = 2;
62     }
63
64     /* New axes, new page. */
65     card_2
66     {
67         iplot = 1;
68         iwcol = 3;
69     }
70
71     card_3
72     {
73         t1 = "<endf/b-vi n>i-61";
74     }
75     card_3a
76     {
77         t2 = "<r>esonance <c>ross <s>ections";
78     }
79
80     card_4
81     {

```

```

82         itype = 2;
83         jtype = 0;
84         igrd = 3;
85         ileg = 1;
86         xtag = 23e3;
87         ytag = 5e2;
88     }
89
90     card_5
91     {
92         el = 0.5e4;
93         eh = 3e4;
94         xstep = 0.5e4;
95     }
96     card_5a {}
97
98     card_6
99     {
100         yl = 1e-3;
101         yh = 1e3;
102     }
103     card_6a {}
104
105     /* card 7 and card 7a skipped since jtype = 0. */
106
107     card_8
108     {
109         iverf = 6;
110         nin = 22;
111         matd = 2834;
112         mfd = 3;
113         mtd = 2;
114     }
115
116     /* itype is positive, resulting in 2d plot. */
117     card_9
118     {
119         icon = 0;
120         isym = 0;
121         idash = 0;
122         iccol = 3;
123         ithick = 2;
124     }
125
126     /* ileg = 1, resulting in card 10 but no card 10a. */
127     card_10
128     {
129         aleg = "elastic";
130     }
131
132     /* card 11-13 skipped since it's a 2d plot and iverf != 0. */
133
134     /* New curve; 2nd additional plot on existing axes. */
135     card_2
136     {
137         iplot = 2;
138     }
139
140     /* card 2-7 skipped since iplot = 2. */
141
142     card_8
143     {
144         iverf = 6;
145         nin = 22;
146         matd = 2834;
147         mfd = 3;
148         mtd = 102;
149     }

```

```

150
151      /* itype is positive on the current axes, resulting in 2d plot. */
152      card_9
153      {
154          icon = 0;
155          isym = 0;
156          idash = 0;
157          iccol = 1;
158          ithick = 2;
159      }
160
161      /* ileg = 1 on current axes, resulting in card 10 but no card 10a. */
162      card_10
163      {
164          aleg = "capture";
165      }
166
167      /* New axes, new page. */
168      card_2
169      {
170          iplot = 1;
171          iwcol = 7;
172      }
173
174      card_3
175      {
176          t1 = "<endf/b-vi n>i-61";
177      }
178      card_3a
179      {
180          t2 = "<g>as <p>roduction";
181      }
182
183      card_4
184      {
185          itype = 1;
186          jtype = 0;
187          igrd = 3;
188          ileg = 1;
189      }
190
191      card_5
192      {
193          el = 0;
194          eh = 2e7;
195          xstep = 5e6;
196      }
197      card_5a {}
198
199      card_6 {}
200      card_6a {}
201
202      /* card 7 and card 7a skipped since jtype = 0. */
203
204      card_8
205      {
206          iverf = 6;
207          nin = 22;
208          matd = 2834;
209          mfd = 3;
210          mtd = 203;
211          temper = 0.0;
212      }
213
214      /* itype is positive, resulting in 2d plot. */
215      card_9
216      {
217          icon = 0;

```

```

218         isym = 0;
219         idash = 0;
220         iccol = 1;
221         ithick = 2;
222     }
223
224     /* ileg = 1, resulting in card 10 but no card 10a. */
225     card_10
226     {
227         aleg = "hydrogen";
228     }
229
230     /* card 11-13 skipped since it's a 2d plot and iverf != 0. */
231
232     /* New curve; 2nd additional plot on existing axes. */
233     card_2
234     {
235         iplot = 2;
236     }
237
238     /* card 2-7 skipped since iplot = 2. */
239
240     card_8
241     {
242         iverf = 6;
243         nin = 22;
244         matd = 2834;
245         mfd = 3;
246         mtd = 207;
247         temper = 0.0;
248     }
249
250     /* itype is positive on the current axes, resulting in 2d plot. */
251     card_9
252     {
253         icon = 0;
254         isym = 0;
255         idash = 0;
256         iccol = 2;
257         ithick = 2;
258     }
259
260     /* ileg = 1 on current axes, resulting in card 10 but no card 10a. */
261     card_10
262     {
263         aleg = "helium-4";
264     }
265
266     /* Terminate plotting job. */
267     card_2
268     {
269         iplot = 99;
270     }
271 }
272
273 viewr
274 {
275     /* Documentation names the first two cards as card 1. Use card 0 to
276        denote
277        the first card, just like in plotr.
278        */
279     card_0
280     {
281         infile = 23;
282         nps = 24;
283     }
284 }

```

## Expected NJOY Input Instructions for Test Problem 12

```

1  reconr
2  20 21/ ### card_1
3  'pendf tape for endf/b-vi.1 28-ni-61a'/ ### card_2
4  2834 1 0/ ### card_3
5  0.01/ ### card_4
6  '28-ni-61a from endf/b-vi.1 t124 (hetrick,fu;ornl)'/ ### card_5
7  0/ ### card_3
8  gaspr
9  20 21 22/ ### card_1
10 plotr
11 23/ ### card_0
12 1 1 0.3 2/ ### card_1
13 1 3/ ### card_2
14 '<endf/b-vi n>i-61'/ ### card_3
15 '<r>esonance <c>ross <s>ections'/ ### card_3a
16 2 0 3 1 23e3 5e2/ ### card_4
17 0.5e4 3e4 0.5e4/ ### card_5
18 / ### card_5a
19 1e-3 1e3/ ### card_6
20 / ### card_6a
21 6 22 2834 3 2/ ### card_8
22 0 0 0 3 2/ ### card_9
23 'elastic'/ ### card_10
24 2/ ### card_2
25 6 22 2834 3 102/ ### card_8
26 0 0 0 1 2/ ### card_9
27 'capture'/ ### card_10
28 1 7/ ### card_2
29 '<endf/b-vi n>i-61'/ ### card_3
30 '<g>as <p>roduction'/ ### card_3a
31 1 0 3 1/ ### card_4
32 0 2e7 5e6/ ### card_5
33 / ### card_5a
34 / ### card_6
35 / ### card_6a
36 6 22 2834 3 203 0.0/ ### card_8
37 0 0 0 1 2/ ### card_9
38 'hydrogen'/ ### card_10
39 2/ ### card_2
40 6 22 2834 3 207 0.0/ ### card_8
41 0 0 0 2 2/ ### card_9
42 'helium-4'/ ### card_10
43 99/ ### card_2
44 viewr
45 23 24/ ### card_0
46 stop

```

## B.12 Test Problem 13 (tp13)

### NIF Version of Test Problem 13

```

1  moder
2  {
3      card_1
4      {
5          nin = 20;
6          nout = -21;
7      }
8  }
9
10 reconr
11 {
12     card_1
13     {

```

```

14         nendf = -21;
15         npend = -22;
16     }
17
18     card_2
19     {
20         tlabel = "pendf tape for endf/b-vi.1 28-ni-61a";
21     }
22
23     card_3
24     {
25         mat = 2834;
26         ncards = 1;
27         ngrid = 0;
28     }
29
30     card_4
31     {
32         err = 0.01;
33     }
34
35     card_5
36     {
37         cards = "28-ni-61a from endf/b-vi.1 t124 (hetrick,fu;ornl)";
38     }
39
40     card_3
41     {
42         mat = 0;
43     }
44 }
45
46 broadr
47 {
48     card_1
49     {
50         nendf = -21;
51         nin = -22;
52         nout = -23;
53     }
54
55     card_2
56     {
57         mat1 = 2834;
58         ntemp2 = 1;
59     }
60
61     card_3
62     {
63         errthn = 0.01;
64     }
65
66     card_4
67     {
68         temp2[0] = 300;
69     }
70
71     card_5
72     {
73         mat1 = 0;
74     }
75 }
76
77 heatr
78 {
79     card_1
80     {
81         nendf = -21;

```



```

82         nin = -23;
83         nout = -24;
84         /* nplot is not required? */
85     }
86
87     card_2
88     {
89         matd = 2834;
90         npk = 6;
91         nqa = 0;
92         ntemp = 1;
93         local = 0;
94         iprint = 2;
95     }
96
97     card_3
98     {
99         /* npk = 6 -> 6 values for mtk */
100        /* Note that mtk has been defined as an array. */
101        mtk[0] = 302;
102        mtk[1] = 303;
103        mtk[2] = 304;
104        mtk[3] = 402;
105        mtk[4] = 443;
106        mtk[5] = 444;
107    }
108 }
109
110 gaspr
111 {
112     card_1
113     {
114         nendf = -21;
115         nin = -24;
116         nout = -25;
117     }
118 }
119
120 moder
121 {
122     card_1
123     {
124         nin = -25;
125         nout = 28;
126     }
127 }
128
129 acer
130 {
131     card_1
132     {
133         nendf = -21;
134         npend = -25;
135         ngend = 0;
136         nace = 26;
137         ndir = 27;
138     }
139
140     card_2
141     {
142         iopt = 1;
143         iprint = 0;
144         ntype = 1;
145     }
146
147     card_3
148     {
149         hk = "28-ni-61a endf-vi.1 njoy99";

```

```

150     }
151
152     card_5
153     {
154         matd = 2834;
155         tempd = 300;
156     }
157
158     card_6 {}
159     card_7 {}
160 }
161
162 acer
163 {
164     card_1
165     {
166         nendf = 0;
167         npend = 26;
168         ngend = 33;
169         nace = 34;
170         ndir = 35;
171     }
172
173     card_2
174     {
175         iopt = 7;
176         iprint = 1;
177         ntype = 2;
178     }
179
180     card_3
181     {
182         hk = "28-ni-61a endf-vi.1 njoy99";
183     }
184 }
185
186 viewr
187 {
188     /* Documentation names the first two cards as card 1. Use card 0 to
189        denote
190        the first card, just like in plotr.
191        */
192     card_0
193     {
194         infile = 33;
195         nps = 36;
196     }

```

### Expected NJOY Input Instructions for Test Problem 13

```

1  moder
2  20 -21/ ### card_1
3  reconr
4  -21 -22/ ### card_1
5  'pendf tape for endf/b-vi.1 28-ni-61a'/ ### card_2
6  2834 1 0/ ### card_3
7  0.01/ ### card_4
8  '28-ni-61a from endf/b-vi.1 t124 (hetrick,fu;ornl)'/ ### card_5
9  0/ ### card_3
10 broadr
11 -21 -22 -23/ ### card_1
12 2834 1/ ### card_2
13 0.01/ ### card_3
14 300/ ### card_4
15 0/ ### card_5
16 heatr

```

```

17 -21 -23 -24/ ### card_1
18 2834 6 0 1 0 2/ ### card_2
19 302 303 304 402 443 444/ ### card_3
20 gaspr
21 -21 -24 -25/ ### card_1
22 moder
23 -25 28/ ### card_1
24 acer
25 -21 -25 0 26 27/ ### card_1
26 1 0 1/ ### card_2
27 '28-ni-61a endf-vi.1 njoy99'/ ### card_3
28 2834 300/ ### card_5
29 / ### card_6
30 / ### card_7
31 acer
32 0 26 33 34 35/ ### card_1
33 7 1 2/ ### card_2
34 '28-ni-61a endf-vi.1 njoy99'/ ### card_3
35 viewr
36 33 36/ ### card_0
37 stop

```

## B.13 Test Problem 14 (tp14)

### NIF Version of Test Problem 14

```

1 acer
2 {
3     card_1
4     {
5         endf_input = 20;
6         pendf_input = 21;
7         multigroup_photon_input = 0;
8         ace_output = 31;
9         mcnp_directory_output = 32;
10    }
11
12    card_2
13    {
14        acer_run_option = 1;
15        print_control = 0;
16        ace_output_type = 1;
17
18        /* id suffix for zaid (default = 0.00), and
19         number of iz,aw pairs to read in (default = 0) are set to their
20         default values since they are not provided.
21        */
22    }
23
24    card_3
25    {
26        description = "proton + 7-n-14 apt la150 njoy99 mcnp";
27    }
28
29    card_5
30    {
31        material = 725;
32        temperature = 0; // No trailing dots allowed. Use C-style floats.
33    }
34
35    /* Card 6 and 7 are empty; the default values will be used. */
36    card_6 {} // Use new cumulative angle distributions.
37    card_7 {} // No thinning.
38 }
39
40 acer

```

```

41 {
42     card_1
43     {
44         endf_input = 0;
45         pendf_input = 31;
46         multigroup_photon_input = 33;
47         ace_output = 34;
48         mcnpx_directory_output = 35;
49     }
50
51     card_2
52     {
53         acer_run_option = 7;
54         print_control = 1;
55         ace_output_type = 2;
56     }
57
58     card_3
59     {
60         description = "proton + 7-n-14 apt la150 njoy99 mcnpx";
61     }
62 }
63
64 viewr
65 {
66     /* Documentation names the first two cards as card 1. Use card 0 to
67        denote
68        the first card, just like in plotr.
69        */
70     card_0
71     {
72         input = 33;
73         output = 36;
74     }
75 }
76 /* The translator appends the 'stop' instruction, no need to explicitly
77    declare it.
78    */

```

### Expected NJOY Input Instructions for Test Problem 14

```

1 acer
2 20 21 0 31 32/ ### card_1
3 1 0 1/ ### card_2
4 'proton + 7-n-14 apt la150 njoy99 mcnpx'/ ### card_3
5 725 0/ ### card_5
6 / ### card_6
7 / ### card_7
8 acer
9 0 31 33 34 35/ ### card_1
10 7 1 2/ ### card_2
11 'proton + 7-n-14 apt la150 njoy99 mcnpx'/ ### card_3
12 viewr
13 33 36/ ### card_0
14 stop

```

## B.14 Test Problem 17 (tp17)

### NIF Version of Test Problem 17

```

1 reconr
2 {
3     card_1

```

```

4      {
5          nendf = 21;
6          npend = 41;
7      }
8
9      card_2
10     {
11         tlabel = "processing jendl-3.3 238u.";
12     }
13
14     card_3
15     {
16         mat = 9237;
17         ncards = 0;
18         ngrid = 0;
19     }
20
21     card_4
22     {
23         err = 0.001;
24     }
25
26     card_3
27     {
28         mat = 0;
29     }
30 }
31
32 broadr
33 {
34     card_1
35     {
36         nendf = 21;
37         nin = 41;
38         nout = 31;
39     }
40
41     card_2
42     {
43         mat1 = 9237;
44         ntemp2 = 1;
45         istart = 0;
46         istrap = 0;
47         temp1 = 0;
48     }
49
50     card_3
51     {
52         errthn = 0.001;
53     }
54
55     card_4
56     {
57         temp2[0] = 300.0;
58     }
59
60     card_5
61     {
62         mat1 = 0;
63     }
64 }
65
66 reconr
67 {
68     card_1
69     {
70         nendf = 22;
71         npend = 42;

```

```

72     }
73
74     card_2
75     {
76         tlabel = "processing jendl-3.3 235u.";
77     }
78
79     card_3
80     {
81         mat = 9228;
82         ncards = 0;
83         ngrid = 0;
84     }
85
86     card_4
87     {
88         err = 0.001;
89     }
90
91     card_3
92     {
93         mat = 0;
94     }
95 }
96
97 broadr
98 {
99     card_1
100    {
101        nendf = 22;
102        nin = 42;
103        nout = 32;
104    }
105
106    card_2
107    {
108        mat1 = 9228;
109        ntemp2 = 1;
110        istart = 0;
111        istrap = 0;
112        temp1 = 0;
113    }
114
115    card_3
116    {
117        errthn = 0.001;
118    }
119
120    card_4
121    {
122        temp2[0] = 300.0;
123    }
124
125    card_5
126    {
127        mat1 = 0;
128    }
129 }
130
131 reconr
132 {
133     card_1
134     {
135         nendf = 23;
136         npend = 43;
137     }
138
139     card_2

```

```

140     {
141         tlabel = "processing jendl-3.3 239pu.";
142     }
143
144     card_3
145     {
146         mat = 9437;
147         ncards = 0;
148         ngrid = 0;
149     }
150
151     card_4
152     {
153         err = 0.001;
154     }
155
156     card_3
157     {
158         mat = 0;
159     }
160 }
161
162 broadr
163 {
164     card_1
165     {
166         nendf = 23;
167         nin = 43;
168         nout = 33;
169     }
170
171     card_2
172     {
173         mat1 = 9437;
174         ntemp2 = 1;
175         istart = 0;
176         istrap = 0;
177         temp1 = 0;
178     }
179
180     card_3
181     {
182         errthn = 0.001;
183     }
184
185     card_4
186     {
187         temp2[0] = 300.0;
188     }
189
190     card_5
191     {
192         mat1 = 0;
193     }
194 }
195
196 groupr
197 {
198     card_1
199     {
200         nendf = 21;
201         npend = 31;
202         ngout1 = 0;
203         ngout2 = 91;
204     }
205
206     card_2
207     {

```

```

208         matb = 9237;
209         ign = 3;
210         igg = 0;
211         iwt = 6;
212         lord = 1;
213         ntemp = 1;
214         nsigz = 1;
215         iprint = 0;
216     }
217
218     card_3
219     {
220         title = "u-238";
221     }
222
223     card_4
224     {
225         temp[0] = 300.0;
226     }
227
228     card_5
229     {
230         sigz[0] = 1.0e10; // No trailing dots. Use C-style floats.
231     }
232
233     card_9
234     {
235         mfd = 3;
236         /* mtd and mtname does not have to be supplied? */
237     }
238
239     card_9
240     {
241         mfd = 3;
242         mtd = 251;
243         mtname = "mubar";
244     }
245
246     card_9
247     {
248         mfd = 3;
249         mtd = 252;
250         mtname = "xi";
251     }
252
253     card_9
254     {
255         mfd = 3;
256         mtd = 452;
257         mtname = "nu";
258     }
259
260     card_9
261     {
262         mfd = 3;
263         mtd = 455;
264         mtname = "nu";
265     }
266
267     card_9
268     {
269         mfd = 3;
270         mtd = 456;
271         mtname = "nu";
272     }
273
274     card_9
275     {

```



```

276         mfd = 5;
277         mtd = 18;
278         mtname = "xi";
279     }
280
281     /* Terminate temperature/material with mfd = 0 as usual. */
282     card_9
283     {
284         mfd = 0;
285     }
286
287     /* Terminate groupr run with matd = 0 as usual. */
288     card_10
289     {
290         matd = 0;
291     }
292 }
293
294 groupr
295 {
296     card_1
297     {
298         nendf = 22;
299         npend = 32;
300         ngout1 = 0;
301         ngout2 = 92;
302     }
303
304     card_2
305     {
306         matb = 9228;
307         ign = 3;
308         igg = 0;
309         iwt = 6;
310         lord = 1;
311         ntemp = 1;
312         nsigz = 1;
313         iprint = 0;
314     }
315
316     card_3
317     {
318         title = "u-235";
319     }
320
321     card_4
322     {
323         temp[0] = 300.0;
324     }
325
326     card_5
327     {
328         sigz[0] = 1.0e10; // No trailing dots. Use C-style floats.
329     }
330
331     card_9
332     {
333         mfd = 3;
334         /* mtd and mtname does not have to be supplied? */
335     }
336
337     /* Terminate temperature/material with mfd = 0 as usual. */
338     card_9
339     {
340         mfd = 0;
341     }
342
343     /* Terminate groupr run with matd = 0 as usual. */

```

```

344     card_10
345     {
346         matd = 0;
347     }
348 }
349
350 groupr
351 {
352     card_1
353     {
354         nendf = 23;
355         npend = 33;
356         ngout1 = 0;
357         ngout2 = 93;
358     }
359
360     card_2
361     {
362         matb = 9437;
363         ign = 3;
364         igg = 0;
365         iwt = 6;
366         lord = 1;
367         ntemp = 1;
368         nsigz = 1;
369         iprint = 0;
370     }
371
372     card_3
373     {
374         title = "pu-239";
375     }
376
377     card_4
378     {
379         temp[0] = 300.0;
380     }
381
382     card_5
383     {
384         sigz[0] = 1.0e10; // No trailing dots. Use C-style floats.
385     }
386
387     card_9
388     {
389         mfd = 3;
390         /* mtd and mtname does not have to be supplied? */
391     }
392
393     /* Terminate temperature/material with mfd = 0 as usual. */
394     card_9
395     {
396         mfd = 0;
397     }
398
399     /* Terminate groupr run with matd = 0 as usual. */
400     card_10
401     {
402         matd = 0;
403     }
404 }
405
406 moder
407 {
408     card_1
409     {
410         nin = 2;
411         nout = 99;

```

```

412     }
413
414     card_2
415     {
416         tpid = "merge u235, u-238 and pu-239";
417     }
418
419     card_3
420     {
421         nin = 92;
422         matd = 9228;
423     }
424
425     card_3
426     {
427         nin = 91;
428         matd = 9237;
429     }
430
431     card_3
432     {
433         nin = 93;
434         matd = 9437;
435     }
436
437     /* Terminate moder by setting nin = 0. */
438     card_3
439     {
440         nin = 0;
441     }
442 }
443
444 errorr
445 {
446     card_1
447     {
448         nendf = 21;
449         npend = 0;
450         ngout = 99;
451         nout = 26;
452         nin = 0;
453         nstan = 0;
454     }
455
456     card_2
457     {
458         matd = 9237;
459         ign = 3;
460         iwt = 6;
461         iprint = 1;
462     }
463
464     /* Test problem 17 is using a file of the endf-5 format (iverf = 5) */
465
466     card_7
467     {
468         iread = 2;
469         mfcov = 33;
470         irespr = 1;
471         legord = 1;
472         ifissp = -1;
473     }
474
475     card_10
476     {
477         mat1 = 9228;
478         mt1 = 18;
479     }

```

```

480
481     card_10
482     {
483         mat1 = 9437;
484         mt1 = 18;
485     }
486
487     card_10
488     {
489         mat1 = 0;
490     }
491 }

```

### Expected NJOY Input Instructions for Test Problem 17

```

1  reconr
2  21 41/ ### card_1
3  'processing_jendl-3.3 238u.'/ ### card_2
4  9237 0 0/ ### card_3
5  0.001/ ### card_4
6  0/ ### card_5
7  broadr
8  21 41 31/ ### card_1
9  9237 1 0 0 0/ ### card_2
10 0.001/ ### card_3
11 300.0/ ### card_4
12 0/ ### card_5
13 reconr
14 22 42/ ### card_1
15 'processing_jendl-3.3 235u.'/ ### card_2
16 9228 0 0/ ### card_3
17 0.001/ ### card_4
18 0/ ### card_5
19 broadr
20 22 42 32/ ### card_1
21 9228 1 0 0 0/ ### card_2
22 0.001/ ### card_3
23 300.0/ ### card_4
24 0/ ### card_5
25 reconr
26 23 43/ ### card_1
27 'processing_jendl-3.3 239pu.'/ ### card_2
28 9437 0 0/ ### card_3
29 0.001/ ### card_4
30 0/ ### card_5
31 broadr
32 23 43 33/ ### card_1
33 9437 1 0 0 0/ ### card_2
34 0.001/ ### card_3
35 300.0/ ### card_4
36 0/ ### card_5
37 groupr
38 21 31 0 91/ ### card_1
39 9237 3 0 6 1 1 0/ ### card_2
40 'u-238'/ ### card_3
41 300.0/ ### card_4
42 1.0e10/ ### card_5
43 3/ ### card_9
44 3 251 'mubar'/ ### card_9
45 3 252 'xi'/ ### card_9
46 3 452 'nu'/ ### card_9
47 3 455 'nu'/ ### card_9
48 3 456 'nu'/ ### card_9
49 5 18 'xi'/ ### card_9
50 0/ ### card_9
51 0/ ### card_10
52 groupr

```

```

53 22 32 0 92/ ### card_1
54 9228 3 0 6 1 1 1 0/ ### card_2
55 'u-235'/ ### card_3
56 300.0/ ### card_4
57 1.0e10/ ### card_5
58 3/ ### card_9
59 0/ ### card_9
60 0/ ### card_10
61 groupr
62 23 33 0 93/ ### card_1
63 9437 3 0 6 1 1 1 0/ ### card_2
64 'pu-239'/ ### card_3
65 300.0/ ### card_4
66 1.0e10/ ### card_5
67 3/ ### card_9
68 0/ ### card_9
69 0/ ### card_10
70 moder
71 2 99/ ### card_1
72 'merge u235, u-238 and pu-239'/ ### card_2
73 92 9228/ ### card_3
74 91 9237/ ### card_3
75 93 9437/ ### card_3
76 0/ ### card_3
77 errorr
78 21 0 99 26 0 0/ ### card_1
79 9237 3 6 1/ ### card_2
80 2 33 1 1 -1/ ### card_7
81 9228 18/ ### card_10
82 9437 18/ ### card_10
83 0/ ### card_10
84 stop

```