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# User's Guide for the Updated EST/BEST Software System

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February 2003

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## A.1 Interactive Input General Information

The structure of the IPACS input file reflects the modularity of each module. The structured format helps the user locate specific input data and manually enter or edit it. The IPACS input file can have any user-specified filename, but must have a .DAT extension. The input file may consist of up to six input data blocks; the data blocks must be separated by delimiters beginning with the $ character. If multiple sections are desired, they must be arranged in the following order:

$COB
- Automatic Mesh Generation Input -
  •
  •
  •

$PIC
- Material Property Uncertainty Input -
  •
  •
  •

$NES
- Finite Element Input -
  •
  •
  •

$RAN
- Structure Level Random Variable Input -
  •
  •
  •

$FPI
- Probabilistic Output Request Input -
  •
  •
  •

$EXE2
-Execution Control Input
  •
  •
  •

The delimiters may be abbreviated to the first four characters (i.e. $COB, $PIC, $NES, $FPI).

The structure of the NESSUS input file is same as that is described in the NESSUS manual.

During interactive processing of NESSUS input blocks, scratch files may also be created with the following extensions and formatting:

| | | |
|---|---|---|
| IPACS/NESSUS Body Force Block | Card 1: | *BODY, IBODY(I) |
| *input filename*.BODY | Card 2 (IBODY=1): | X-COMP(F), Y-COMP(F), Z-COMP(F) |
| | Card 2 (IBODY=2): | X1(F), Y1(F), Z1(F) |
| | Card 3 (IBODY=2): | X2(F), Y2(F), Z2(F) |
| IPACS/NESSUS Boundary Conditions Block | | |
| *input filename*.BOUND | Cards 1 thru N: | NODE #(I), DOF #(I), DISP(F) |
| NESSUS Material Properties Block | | |
| *input filename*.prop | Cards 1 thru N: | NODE #(I), NODE(J) ,(PROP(I),I=1,5) |
| NESSUS Layer Temperature Block | | |
| *input filename*.temp | Cards 1 thru N: | NODE #(I), NODE(J) ,(TEMP(I),I=1,5) |
| IPACS/NESSUS Element Connectivity Block | | |
| *input filename*.CONN | Cards 1 thru N: | ELEM #(I), INODE(I), JNODE(I), KNODE(I), NODE(I) |
| IPACS/NESSUS Nodal Coordinates Block | | |
| *input filename*.COORD | Cards 1 thru N: | NODE #(I), X(F), Y(F), Z(F), TH(F) |
| IPACS/NESSUS Random Variable Coordinates Block | | |
| *input filename*.CRDxxx | Card 1: | MEAN(F), STD DEV(F), DIST TYPE(I) |
| | Cards 2 thru N: | NODE #(I), X-SDF(F), Y-SDF(F), Z-SDF(F), TH-SDF(F) |
| IPACS/NESSUS Distributed Loads Block | | |
| *input filename*.DIST | Cards 1 thru N: | BEG ELEM(I), END ELEM(I), ICODE(I), TRAC(F), PRESS(F), BODY FORCE(F) |
| IPACS/NESSUS Random Variable Distributed Loads Block | | |
| *input filename*.DSTxxx | Card 1: | MEAN(F), STD DEV(F), DIST TYPE(I) |
| | Cards 2 thru N: | BEG ELEM(I), END ELEM(I), ICODE(I), TRAC SDF(F), PRESS SDF(F), BODY FORCE SDF(F) |
| IPACS/NESSUS Duplicate Nodes Block | | |
| *input filename*.DUPL | Cards 1 thru N: | MASTER NODE(I), SLAVE NODE(I) |

IPACS/NESSUS Nodal Forces Block

| | | |
|---|---|---|
| *input filename*.FORCE | Cards 1 thru N: | NODE #(I), DOF #(I), FORCE(F) |

IPACS/NESSUS Random Variable Forces Block

| | | |
|---|---|---|
| *input filename*.FRCxxx | Card 1: | MEAN(F), STD DEV(F), DIST TYPE(I) |
| | Cards 2 thru N: | NODE #(I), DOF #(I), FORCE SDF(F) |

IPACS Material Orientation Block

| | | |
|---|---|---|
| *input filename*.orie | Cards 1 thru N: | BEG NODE(I), END NODE(I), X-COMP(F), Y-COMP(F), Z-COMP(F) |

where xxx is a three-digit number identifying the random variable and where (I) indicates integer and (F) indicates floating point numbers.

The IPACS/NESSUS scratch files are useful in recovering data following a program abort or a system failure. To recover data, use the "Input Existing File" options found on many of the menus, after reentering the input module using a filename different than the one used in the previous run. The quantities found in each of these files are written in free format consistent with the IPACS/NESSUS convention. This feature also allows users to import their own mesh, boundary conditions, and loads from outside the input module. To import this data, use the scratch file naming convention described above and simply have the data read into the program.

## A.2 Detailed Description of the Interactive Input Module

As described in section 3.1, the IPACS/NESSUS input file consists of five separate sections including automatic mesh generation module, a module to compute probabilistic composite material properties, probabilistic finite element analysis module, and probability algorithm module.

The IPACS code contains an interactive input module that allows the user to interactively create or edit an IPACS input file and submit it for processing. Interactive module enables an inexperienced user to prepare the input in a user-friendly manner in a short time without making common mistakes. This module allows creating or editing the input file with little or no knowledge of the file's structure and format, and thus allows an inexperienced user to run the code and come up to speed more quickly.

The interactive input module is designed for ease of use. An input session need not be completed in one sitting: once an IPACS input file has been created it can be saved and returned to later for further editing, or in order to enter the execution mode and run the code. (For example, the user can enter or change the finite element mesh inputs, save the entries or edits, exit the IPACS program, and return later to add or edit the material specifications.)

An input session is begun at the main menu, which offers six options that allow the user quick access to input functions (refer to Figure 3.2.1of the IPACS manual). The six input options may be selected and run in any order. The options access a series of menus in which the user is prompted for information to enter or change.

## A.3 Batch Input

IPACS input can be prepared manually or by using any other preprocessor and processing it in a batch mode. The procedure to prepare the input is described in the following section.

As described in section A.1, the input file is divided into several different blocks. The block pertaining to the automatic mesh generation data should not be used in the batch mode. Each of the material property uncertainty input and finite element input data blocks are divided into parameter and model data groups. The parameter group of a data block defines the size of the problem, whereas the model group of the data block contains the actual model data. In both the data blocks, the model group always follows the parameter group. Also, a 'END' card marks end of the parameter group in a data block. The $PIC input data block contains the data related to the material properties and the lay-up configuration of composites in the structure. The $NES input data block contains the actual finite element data. Detailed input information on each block is discussed below:

### A.3.1 Material Property Uncertainty Input Data Block:

The material property uncertainty input data block begins with a '$PIC' card. The composite lay-up configuration and material property uncertainties are defined in this block.

Normally, the $PIC data block ends with the beginning of the $NES data block (i.e., with a '$NESSUS' card). Different key words (a key word always begins with an '*'; asterisk) used in the material property uncertainty data block are discussed below:

### A.3.1.1 Material Property Uncertainty Parameter Input Data Group:

CFEM

The above card is used to flag ifemx (MV) analysis

$PICn

where n = 0 is used if material properties PDF computation is desired

= 1 is used material properties PDF computation is to be bypassed

*PROSOL

The keyword PROSOL is used to define the probabilistic structural analysis solution method. The general format is

*PROSOL

NSOL

NMCS

where NSOL is the probabilistic solution method. Different available probabilistic solution methods and their NSOL values are given below:

NSOL = 21 PV Based method using fast probability integrator

= 22 Monte Carlo simulation technique for material property related uncertainties

NMCS = No. of samples for Monte-Carlo simulation (required for NSOL = 22)

*INDZON

The keyword INDZON is used to define the total number of statistically independent zones in the structure. The general input format is

*INDZON

NDZON

where NDZON is the total number of independent zones in a composite structure.

*PLYGRP

The keyword PLYGRP is used to specify the total number of ply groups in each independent zone. The general input format is

*PLYGRP

| | |
|---|---|
| INDI(1) | NLGRP(1) |
| INDI(2) | NLGRP(2) |
| INDI(3) | NLGRP(3) |
| . | . |
| . | . |
| . | . |
| INDI(n) | NLGRP(n) |

Where INDI is the independent zone no. NLGRP is the total number of ply groups in an independent zone.

There will be NDZON number of lines under this keyboard.

**Note:** *INDZON key word card must precede *PLYGRP key word card.

*NODGRP

The above keyword is used to specify the total number of node groups. A node group used to identify the common independent zone and the common layer group for all the nodes in a group. The general format is:

*NODGRP

NGRP

where NGRP is the total number of node groups.

*PLIES

The keyword PLIES is used to specify the maximum number of plies that exists in an independent zone. The general input format is:

*PLIES

| | |
|---|---|
| INDI(1) | NMAXPL(1) |
| INDI(2) | NMAXPL(2) |
| INDI(3) | NMAXPL(3) |
| . | . |
| . | . |
| . | . |
| INDI(n) | NMAXPL(n) |

where INDI is the independent zone No., and NMAXPL is the maximum number of plies in an independent zone. The maximum number of plies for all the independent zones must be defined.

**Note:** *INDZON key word card must precede *PLIES key word card.

*MATSYS

The keyword MATSYS is used to specify the total number of material systems in a structure. The general input format is:

*MATSYS

NMAT

where NMAT is the total number of material systems in a structure.

*ORISYS

The keyword ORISYS is used to specify the total number of orientation systems in a structure. The general input format is:

*ORISYS

NORI

where NORI is the maximum number of orientation systems in a structure.

*THKSYS

The keyword THKSYS is used to specify the total number of thickness systems in a structure. The general input format is:

*THKSYS

NTHK

where NTHK is the total number of thickness systems in a structure.

*RNDGRP

This key word is used to specify the maximum number of random field groups related to material properties for each independent zone in a structure.

The general input format is:

*RNDGRP

| | |
|---|---|
| INDI(1) | NRFT(1) |
| INDI(2) | NRFT(2) |
| INDI(3) | NRFT(3) |
| INDI(n) | NRFT(n) |

where INDI is the independent zone number NRFT is the total number of random field groups (*CORTAB) related to the constituent material properties in an independent zone.

The number of random field groups related to the constituent material properties for all the independent zones must be defined.

**Note:** *INDZON key word card must precede *RNDGRP card.

*RANTEM

This key word is used to specify the maximum number of random variables related thermal loads and corresponding number of perturbation sets.

The general input format is:

*RANTEM

| | |
|---|---|
| NRTEM | NTPER |

where NRTEM is the number of temperature related random variables and NRPER is the total number of perturbations related to the temperature related random variables.

The number of random variables related to the temperatures for all the independent zones must be defined.

*END

This key word card is always required to terminate the parameter data block input. It must always be put at the very end of parameter data input block. The general input format is

*END

### A.3.1.2 Material Property Uncertainty Model Input Data Group:

*NODGRP

The keyword NODGRP is used to specify the node numbers that belong to a specific ply group of a specific independent zone. The general input format is shown below:

*NODGRP
IG
NODB(IG) NODE(IG) INDZ(IG) ILAY(IG)
where IG is the node group number
NODB(IG) is the beginning node number of a series of nodes in group IG,
NODE(IG) is the end node number of a series of nodes in group IG,
ILAY(IG) is the ply group number to which NODB(IG) through NODE(IG) belongs
INDZ(IG) is the independent zone number to which NODB(IG) through NODE(IG) belongs

Remember that the node groups for all the ply groups and all the independent zones must be specified.

*RESTAB

The keyword RESTAB is used to specify the plies and their responses for which the probabilistic simulation is desired. The response table for all the plies within an independent zone must be specified. The code used to specify the computational request is 0(zero) or 1(one). 0 means the probabilistic ply response computation is not desired and 1 means the probabilistic ply response computation is desired. The general input format is:

*RESTAB
IZ
NPB, NPE
IEX(1) IEXE(2) … (EX(23)
where
IZ is the independent zone number
NPB is the beginning ply number of independent zone IZ
NPE is the end ply number of independent zone IZ
IXE(I) is the code to request $i^{th}$ probabilistic ply response

Following is the list of ply responses for which the probabilistic analysis can be performed.

1 Longitudinal strain
2 Transverse strain
3 Shear strain
4 Longitudinal stress
5 Transverse stress
6 Shear stress

7 Longitudinal tensile strength
8 Longitudinal compressive strength
9 Transverse tensile strength
10 Transverse compressive strength
11 Shear strength

12 Modified distortion energy failure criterion
13 Hoffman's failure criterion
14 Interply delamination failure criterion

15 Fiber crushing criterion (compressive strength)
16 Delamination criterion (compressive strength)
17 Fiber micro buckling criterion (compressive strength)

18 Failure in longitudinal direction
19 Failure in transverse direction
20 Failure in Shear strength

21 Out of plane Shear 13
22 Out of plane Shear 23
23 Sigma zz

*PLYTAB

The keyword PLYTAB is used to specify the ply configuration of a laminate in a ply group of any independent zone. The ply configuration of a laminate is specified by the existence of a ply. The code used to specify the existence is 0(zero) or 1(one). 0 means the ply does not exists and 1 means the ply exists. The general input format is:

*PLYTAB
IZ, LG,
NPL(1,IZ,LG), NPL(2,IZ,LG), ... NPL(NMAXPL(IZ),IZ,LG)
where

| | |
|---|---|
| IZ | is the independent zone number |
| LG | is the ply group number of independent zone IZ |
| NMAXPL(IZ) | is the maximum number of plies in an independent zone IZ |
| NPL | is the ply existence code, either 0 or 1. Code zero indicates that the ply does not exist and 1 indicates that the ply exists |

*MATSYS

The keyword MATSYS is used to specify the uncertainties of a specific material. The general input format is:

*MATSYS
I
'KEY(I)KEYS(I)' FVRM(I) VVRM(I) FRS(I) FVRMS(I) VVRMS(I)
C(1,I) C(2,I) C(3,I) ... C(29,I)
CF(I), CVV(I), CFRS(I), CFS(I), CVVS(I)
CS(1,I)CS(2,I)CS(3,I)... CS(29,I)
IM(1,I)IM(2,I)IM(3,I)... IM(29,I)
IF(I), IV(I), IFR(I), IFS(I), IVS(I)
IMS(1,I) IMS(2,I) IMS(3,I) ... IMS(29,I)

where I is the material system number KEY(I) and KEYS(I) are the acronyms defining the I th primary and secondary composite material system . The acronym must be specified in quotes ('). The acronym is used to pull the mean values of composite material properties from the data bank. Refer to Table 3.4.1.1 and Table 3.4.1.2 of the IPACS manual for the description of composite material acronyms. FVRM(I), VVRM(I), FRS(I), FVRMS(I), and VVRMS(I) are mean values of the primary system fiber volume ratio, the primary system void volume ratio, fraction of secondary system, the secondary system fiber volume ratio and the secondary system void volume ratio respectively of the I th material system. C(n,I) is the coefficient of variation for the $n^{th}$ primary material property random field of the I th material system. The list of the random field numbers is given in section 3.5 of IPACS manual. CF(I), CVV(I), CFRS(I), CFS(I), CVVS(I) are the coefficient of variation for the primary system fiber volume ratio, the primary system void volume ratio, fraction of secondary system, the secondary system fiber volume ratio and the secondary system void volume ratio respectively of the I th material system. IM(n,I) is the distribution type for the n-th material property random field number of I th primary material system. IF(I), IV(I), IFR(I), IFS(I), IVS(I) are the distribution types for the primary system fiber volume ratio, the primary system void volume ratio, fraction of secondary system, the secondary system fiber volume ratio and the secondary system void volume ratio respectively of the I th material system.

IMS(n,I) is the distribution types for the $n^{th}$ secondary system material property number. No more than ten integer numbers and eight real numbers in a given line can be specified. If there are more numbers for a particular data type, then their input should continue in the subsequent lines.

*ORISYS

The keyword ORISYS is used to specify uncertainties of the ply orientations. The general input format is:

```
*ORISYS
    OM(1) OM(2) ...    OM(NORI)
    OC(1)  OC(2)  ...    OC(NORI)
    IO(1)   IO(2)   ...    IO(NORI)
```

where OM(i), OC(i) and IO(i) are the mean, a constant to specify standard deviation (standard deviation = 90 x constant), and the distribution type respectively of the $i^{th}$ orientation angle system. NORI is the total number of orientation systems.

*THKSYS

The keyword THKSYS is used to specify uncertainties of the ply thickness. The general input format is:

```
*THKSYS
    TM(1) TM(2) ...    TM(NTHK)
    TC(1)  TC(2)  ...    TC(NTHK)
    IT(1)   IT(2)   ...    IT(NTHK)
```

where TM(i), TC(i) and IT(i) are the mean, the coefficient of variation and distribution type respectively of the $i^{th}$ thickness system. NORI is the total number of orientation systems. NTHK is the total number of thickness systems.

*MATTAB

The keyword MATTAB is used to specify the material of each ply of a laminate in an independent zone. The material property uncertainty specification of a ply in an independent zone corresponds to a material system id. All the plies of an independent zone must have a material system id defined, and the material property uncertainty for that id must also be defined in

*MATSYS card. The general input format is:

*MATTAB
IZ
NMT(IZ,1) NMT(IZ,2) NMT(IZ,3) ... NMT(IZ,NMAXPL(IZ))

where IZ is the independent zone number. NMT(IZ,n) is the material system number of the $n^{th}$ ply of independent zone IZ, and NMAXPL(IZ) is the maximum number of plies in independent zone IZ.

*ORITAB

The keyword ORITAB is used to specify the uncertainties of each ply orientation of a laminate in an independent zone. The orientation uncertainty specification of a ply in an independent zone corresponds to an orientation system id. All the plies of an independent zone must have an orientation system id defined, and the orientation uncertainty for that id must also be defined in

*ORISYS card. The general input format is:

*ORITAB
IZ
NOT(IZ,1) NOT(IZ,2) NOT(IZ,3) ... NOT(IZ,NMAXPL(IZ))

where IZ is the independent zone number, NOT(IZ,n) is the orientation system number of the $n^{th}$ ply of independent zone IZ, and NMAXPL(IZ) is the maximum number of plies in independent zone IZ.

*THKTAB

The keyword THKTAB is used to specify the uncertainties of each ply thickness of a laminate in an independent zone. The thickness uncertainty specification of a ply in an independent zone corresponds to a thickness system id. All the plies of an independent zone must have a thickness system id defined, and the thickness uncertainty for that id must also be defined in

*THKSYS card. The general input format is

*THKTAB
IZ
NTT(IZ,1) NTT(IZ,2) NTT(IZ,3) ... NTT(IZ,NMAXPL(IZ))

where IZ is the independent zone number and NTT(IZ,n) is the thickness system number of $n^{th}$ ply of independent zone IZ, and NMAXPL(IZ) is the maximum number of plies in independent zone IZ.

*CORTAB

This key word is used only in case of a primitive variable based method to specify the correlation of a particular random field between different plies (correlation table) of a composite material. Refer to Appendix A for the definition of a correlation table. The general input format for the primitive variable based method is:

*CORTAB
IZ
NRFi NRFj
ICOR(1) ICOR(2) ... ICOR (NMAXPL(IZ))

Where IZ is the independent zone number
NRFi is the beginning material related random field number. NRFj is the end material related random field number (Legal list of material related random field numbers are given in Appendix A, Section A.3).
ICOR(i) is the correlation id number for the $i^{th}$ ply 0<= ICOR(i) <=NMAXPL(IZ)
NMAXPL(IZ) is the maximum number of plies in independent zone, IZ.

The cards (NRFi NRFj) and (ICOR(1), ... ,ICOR(NMAXPL(IZ)) can be repeated for additional random fields in independent zone, IZ. For additional independent zones the data should be specified in the same order discussed above.

Remember that the correlation table for all the material related random fields of all the independent zones should be specified. The random field automatically becomes deterministic if its correlation table is not defined.

*MEANTM

This key word is used to specify mean ply temperatures at different nodes. The temperature groups and the number of node groups must be exactly same. The correlated temperatures at different nodes can be specified using the *RELPER card. The standard deviations for the temperatures are specified in the *STDVTM card. The first ply is the bottom ply based on the local z-definition. The general input format for the definition of the mean ply temperatures is:

*MEANTM
NODi NODj

PT1 PT2 … PTn

NODi is the beginning ply number.
NRFj is the last node number in a group.
PTi is the mean $i^{th}$ ply temperature
The cards (NODi NODj) and (PT1, ... ,PTn) can be repeated for additional nodes.

*STDVTM

This key word is used to specify standard deviation of the ply temperatures at different nodes. The temperature groups and the number of node groups must be exactly same. The first ply is the bottom ply based on the local z-definition. The general input format for the definition of the ply temperature standard deviation is:

*STDVTM
NODi NODj

PSTD1 PSTD2 … PSTDn

NODi is the beginning ply number.
NRFj is the last node number in a group.
PSTDi is the $^{ith}$ ply temperature standard deviation
The cards (NODi NODj) and (PSTD1, ... ,PSTDn) can be repeated for additional nodes.

*RELPER

This key word is used to specify the autocorrelation matrix for random temperature variables. Basically, it represents the eigen-vectors of the correlation matrix. The general input format for the definition of the ply temperature standard deviation is:

*RELPER
NR
NODi NODj
EG1 EG2 … EGn

NODi is the beginning ply number.
NRFj is the end lst ply number.
EGi is the $i^{th}$ ply autocorrelation coefficient
The cards (NODi NODj) and (EG1, ... ,EGn) can be repeated for additional nodes.

*IRVPER

This key word is used to specify the perturbation of particular temperature random variables. Any random variable can be perturbed for any number of times. It also signifies in what order the variables shall be perturbed. Input entry in this card must be used in conjunction with the *ABSPER card which specifies the corresponding perturbation magnitude. Basically, it represents the eigen-vectors of the correlation matrix. The general input format for the definition of the temperature random variables perturbation definition is:

*IRVPER
NP(1) NP(2) … NP(n)

where NP(i) represents the $i^{th}$ perturbation of random variable NP(i).
The cards (NPi NPn) can be repeated for additional variable perturbations.

*ABSPER

This key word is used in conjunction with the *IRVPER input card. It is used to specify the magnitude of the perturbation for the corresponding random variable in the *IRVPER card. The general input format for the definition of the perturbation magnitude is:

*ABSPER
PV(1) PV(2) … PV(n)

where PV(i) represents the magnitude of the $i^{th}$ perturbation of random variable NP(i) specified in *IRVPER card.

The cards (PVi PVn) can be repeated for additional variable perturbations.

*REFTEM

This key word is used to specify the reference temperature of the material. The general input format for the definition of the reference temperature is:

*REFTEM
IZ
REFTM

where IZ represents the independent zone and the REFTEM the reference temperature in °F units. The cards IZ and REFTM can be repeated for additional independent zones.

### A.3.2 Input for Probabilistic Output Request:

This section of input always begins with $FPI card. The response locations on the structure and the type of probabilistic analysis are defined in this section of input. The input details are given in the following card:

*STRU
ISTAT NTYPE NODN IDUMP IDUMP NCOMP
where

| | |
|---|---|
| ISTAT | = 1 for the Static Analysis |
| | = 2 for the Buckling Analysis |
| | = 3 for the Frequency Analysis |
| NTYPE | = 1 for Displacement Response |
| | = 2 for Ply Strain/Stress Response |
| NODN | Node Number where probabilistic output is requested |
| IDUMP | Reserved for future use |
| NCOMP | displacement or stress/strain component in static analysis |
| | mode number in case of buckling or frequency analysis |

### A.3.3 IPACS Execution Control Input:

The input to this section always begins with $EXE2 card. The IPACS execution control is defined in this section. The input to this section is as follows:

IX1 IX2 IX3 IX4 IX5

where the variables IX1, IX2, IX3, IX4 and IX5 could be either 0 (zero) or 1. 0 means suppress the execution of the analysis type discussed below. 1 means perform the analysis.

IX1 = 1 Compute the perturbed material properties at every scale.
IX2 = 1 Prepare the input file for the probabilistic finite element analysis.
IX3 = 1 Perform the probabilistic finite element analysis.
IX4 = 1 Extract desired structural responses as indicated in $FPI section.
IX5 = 1 Compute the CDF of desired structural responses

### A.3.4 Output

The user generally controls IPACS output. However, by default IPACS provides minimum necessary output required for the probabilistic assessment of composite structure. The minimum output consists of the following: (i) an echo of the input, (ii) CDF of the material properties and the desired structural response, (iii) the sensitivity factors of the primitive variables for the material properties and the desired structural response. The important output files are xxx21.fpimov, xxx21.nesout and xxx21.rantab. The names of these files and their respective contents are listed in Table A.3.4.1, on the next page.

Several other output files are created at intermediate computation stage or at the end of the computations. Some of these files provide an interface between different modules or serve as a database system. These files contain information for the user to study the overall problem behavior in greater detail.

**Table A.3.4.1 List of Output Files**

jn - jobname
IZ - Independent Zone No.
LG - Ply Group No.
IPM - Method No.
$$ - A unique job number assigned by the computer

| File Name | File Contents |
|---|---|
| jn.msp-IZ-LG | Mean value and standard deviations for ply material properties. |
| jn.cpp-IZ-LG | CDF of ply material properties |
| jn.cpl-IZ-LG | CDF of laminate material properties |
| jn-IZ-LG-IPM-IC.PIC | If IC = 0 Mean Values of material properties. Perturbations of A, C, and D matrices terms for primitive variable based method |
| jn-IZ-IPM.dat | Data required for finite element analysis. The file contains the data supplied by the user and that generated by the program |
| jn-IZ-IPM.pdb | Perturbation database. |
| jn-IZ-IPM.datu | Perturbation data for each desired response. |
| jn-IZ-IPM.dist | Statistics of Primitive Variables for each independent zone. |
| jn-IPM.datu | FPI input file. |
| jn-IPM.dist | Statistics of primitive variables required for the probabilistic analysis of structural response. |
| jn-IPM.fpinp | Input file prepared by program to perform fast probability integration. |
| jn-IPM.fpimov | Sensitivity factors of primitive variables at cumulative probability levels of 0.001 and 0.999. |
| jn-IPM.fpibin | FPI logfile |
| jn-IPM.nesout | Discretized CDF of a structural response. |
| jn-IZ-IPM.out | Echo of FEM input and Results of Unperturbed Solution. |
| jn-IBM.FPIMOV | Sensitivity factors for independent random variables at probability levels 0.001 and 0.999. |

**SAMPLE INPUT FILE:**

```
CFEM
$PIC1
*INDZON
       1
*NODGRP
       1
*PROSOL
      21
*PLYGRP
   1   1
*PLIES
   1   8
*RNDGRP
   1   2
*MATSYS
       1
*ORISYS
       4
*THKSYS
       1
*RANTEM
       1       4
*END
*NODGRP
       1
       1       9       1       1
*RESTAB
       1
       1       8
c      o-skip  fpi         1-with fpi
       0       0       0       1       1       0      0      0      0      0
       0       0       0       0       0       0      0      0      0      0
       0       0       0
*PLYTAB
       1       1
       1       1       1       1      1      1      1      1
*MATSYS
       1
'AS--EPOXAS--EPOX'   0.60    0.02    0.000001    0.60  0.02
    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05
    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05
    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05
    0.05    0.05    0.05    0.05    0.05
    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05
    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05
    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05
       2       2       2       2       2       2       2       2       2       2
       2       2       2       2       2       1       1       2       2       2
       2       2       2       2       1       1       1       2       2
       2       2       2       2       2
       2       2       2       2       2       2       2       2       2       2
       2       2       2       2       2       1       1       2       2       2
       2       2       2       2       1       1       1       2       2
*MATTAB
       1
       1       1       1       1       1       1       1       1
*ORISYS
   -45.0     0.0    45.0    90.0
    0.02    0.02    0.02    0.02
       2       2       2       2
*ORITAB
       1
       3       1       2       4       4       2       1       3
```

```
*THKSYS
   0.020
   0.050
       2
*THKTAB
       1
       1       1       1       1       1       1       1       1
*CORTAB
       1
       1       1
       1       1       1       1       1       1       1       1
      33      33
       1       1       1       1       1       1       1       1
*MEANTM
       1       9
   200.0   200.0   200.0   200.0   200.0   200.0   200.0   200.0
*STDVTM
       1       9
    10.0    10.0    10.0    10.0    10.0    10.0    10.0    10.0
*RELPER
       1
       1       9
     1.0     1.0     1.0     1.0     1.0     1.0     1.0     1.0
*IRVPER
       1       1       1       1
*ABSPER
    -2.0    -1.0     1.0     2.0
*END
$NES
*FEM
*DISP
*FORC 1
*ELEM 4
  75
*COMPOSITE
*TEMP
*PERT
*NODES 9
*BOUN 18
*CONS 0
*PRIN
*END
*INC
   0
*ITER
      100    0.0001   0.0001   0.0001   0.0001
*COOR
     1     0.000     0.000     0.000     1.0
     2     1.000     0.000     0.000     1.0
     3     2.000     0.000     0.000     1.0
     4     0.000     1.000     0.000     1.0
     5     1.000     1.000     0.000     1.0
     6     2.000     1.000     0.000     1.0
     7     0.000     2.000     0.000     1.0
     8     1.000     2.000     0.000     1.0
     9     2.000     2.000     0.000     1.0
*ELEM    75
     1    1    2    5    4
     2    2    3    6    5
     3    4    5    8    7
     4    5    6    9    8
*BOUN
    1    1    0
    4    1    0
    7    1    0
    1    2    0
    4    2    0
```

```
    7    2    0
    1    3    0
    4    3    0
    7    3    0
    1    4    0
    4    4    0
    7    4    0
    1    5    0
    4    5    0
    7    5    0
    1    6    0
    4    6    0
    7    6    0
*FORC
    5    3  1000.0
*ORIEN
    1   9   1.00   0.00   0.00
    1   9   0.00   0.00   1.00
C*LAMI
INCLUDE
*PRINTOPTION
 REACTION
 STRESS
 STRAIN
 TOTALDISPLACEMENT
*END
$RAN
*DEFI    1
 1000.0   100.0   2
 FORCE
    5    3    1.0
$FPI
*STRU
    1    1    5    0    0    3
$EXE2
    1    1    1    1    1
```

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**13. ABSTRACT** ***(Maximum 200 words)***

This User's Guide describes the structure of the IPACS input file that reflects the modularity of each module. The structured format helps the user locate specific input data and manually enter or edit it. The IPACS input file can have any user-specified filename, but must have a DAT extension. The input file may consist of up to six input data blocks; the data blocks must be separated by delimiters beginning with the $ character. If multiple sections are desired, they must be arranged in the order listed.

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