OVERVIEW OF THE COMPUTER CODE PACKAGE FOR FAULT TREE ANALYSIS, RELIABILITY AND PROBABILISTIC RISK ASSESSMENT

FTA ASSOCIATES
Howard E. Lambert, Ph.D., P.E.
3728 Brunell Drive
Oakland, California, USA 94602
510-482-1492
FAX 510-482-0631

The code package includes:

- FTAP
- postprocessor to FTAP (optional use)
- IMPORTANCE
- MONTE

The inputs and outputs to each computer code are shown in Figures 1-1 and 1-2. FTAP performs the qualitative evaluation, IMPORTANCE, the probabilistic evaluation and MONTE, the uncertainty analysis. Applications of the code package are described in Chapter 2 of this document. The postprocessor and MONTE are described further in Chapters 3 and 4 respectively. Boeing Aerospace Company (Reference 1) ranked these codes number one in suiting the needs of the U.S. Air Force. These codes are used by corporations and government agencies worldwide. FTAP (Willie, 1978) accepts as input a Boolean equation for each gate event in the fault tree or logic model. FTAP can accept complemented events and k-out-of-n gates. FTAP carefully checks the input fault tree for logic errors. The code can eliminate min cut sets according to probability (as well as order) which is particularly useful for analysis of complex systems. The postprocessor is particularly useful for analysis of reactor accident sequences produced by the event tree-fault tree approach. Features of the postprocessor include:

- conducting common cause analysis
- dropping complemented events and performing the subsequent Boolean minimization
- generating block files (i.e., sets of Boolean equations) for subsystems.

These codes have been used extensively for nuclear power plant PRA applications. Examples include:

- event tree-fault tree analyses
- seismic PRA analysis
- AC power reliability studies
- heavy load drop analyses
- prioritizing system design changes and upgrades with cost constraints

IMPORTANCE accepts as input:

- basic event data, i.e., failure rates, repair times, and inspection intervals
- min cut sets from FTAP

and generates as output:

- Top Event occurrence frequency
- mean occurrence of the Top Event
- system unavailability
- the ranking of basic events and min cut sets according to various importance measures.

Dunglinson and Lambert, 1983, (Appendix A of this document) use the code package described in this document and show how rankings of basic events and min cut sets can suggest system design changes and/or procedural changes to improve safety and/or reliability.

IMPORTANCE (Dunglinson and Lambert, 1983) has been revised so its calculations can perform reliability analysis of control systems. The code can distinguish between two types of basic events:

- initiating events
- enabling events.

Initiating events are sources of system disturbances and place a demand on the control system to respond. Examples include:

- control devices or sensors failing high, low, or reversed
- loss of utilities (e.g., loss of instrument air, cooling water, or electricity).

Enabling events represent failure of system mitigative actions, either active or passive, that permit initiating events to cause system failure. Examples include:

- control device inactive
- pressure relief valve jammed closed
- interlock relay fails to open.

Enabling events do not cause disturbances but inactive protective features.

By conducting a Monte Carlo analysis, MONTE performs an uncertainty analysis due to uncertainty in the basic event data. Two probability distributions are allowed for the basic events:

- log normal
- normal.

By performing a Monte Carlo analysis, confidence intervals are generated for the Top Event probability and for basic event and min cut set importance rankings.

References

1. Nuclear Safety Analysis Computer Program Description Document, Boeing Aerospace Company, Report D2-118655-1, February, 1979.

2. Willie, R., Computer Aided Fault Tree Analysis, Operations Research Center, Report No. 78-14, University of California, Berkeley; Report No. UCRL-13981, Lawrence Livermore National Laboratory, (1978).

3. Dunglinson, C. and Lambert, H. E., "Interval Reliability for Initiating and Enabling Events," IEEE Transactions on Reliability, Vol. R-32, June, 1983.

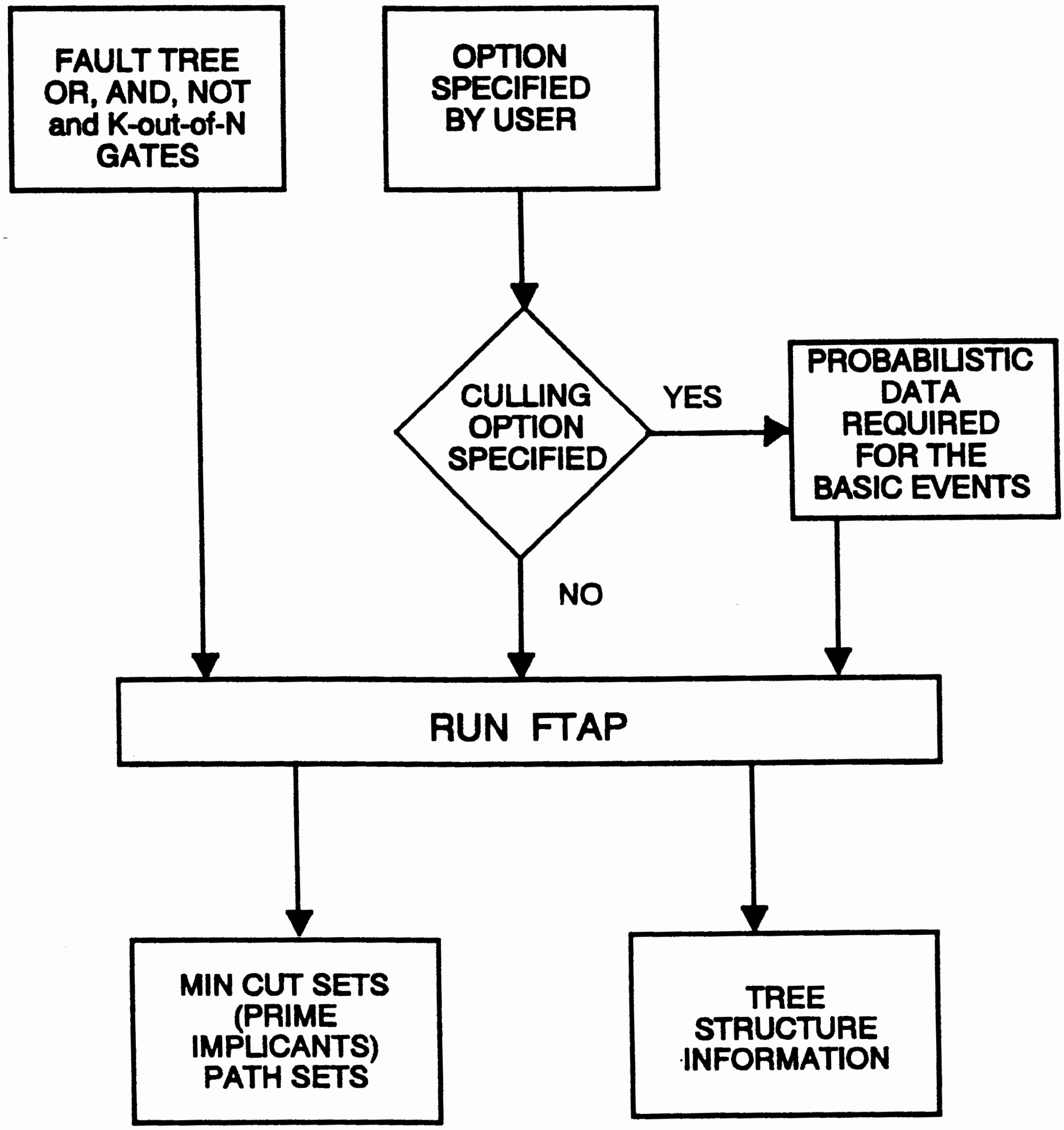


Figure 1-1

INPUT -- OUTPUT, FTAP

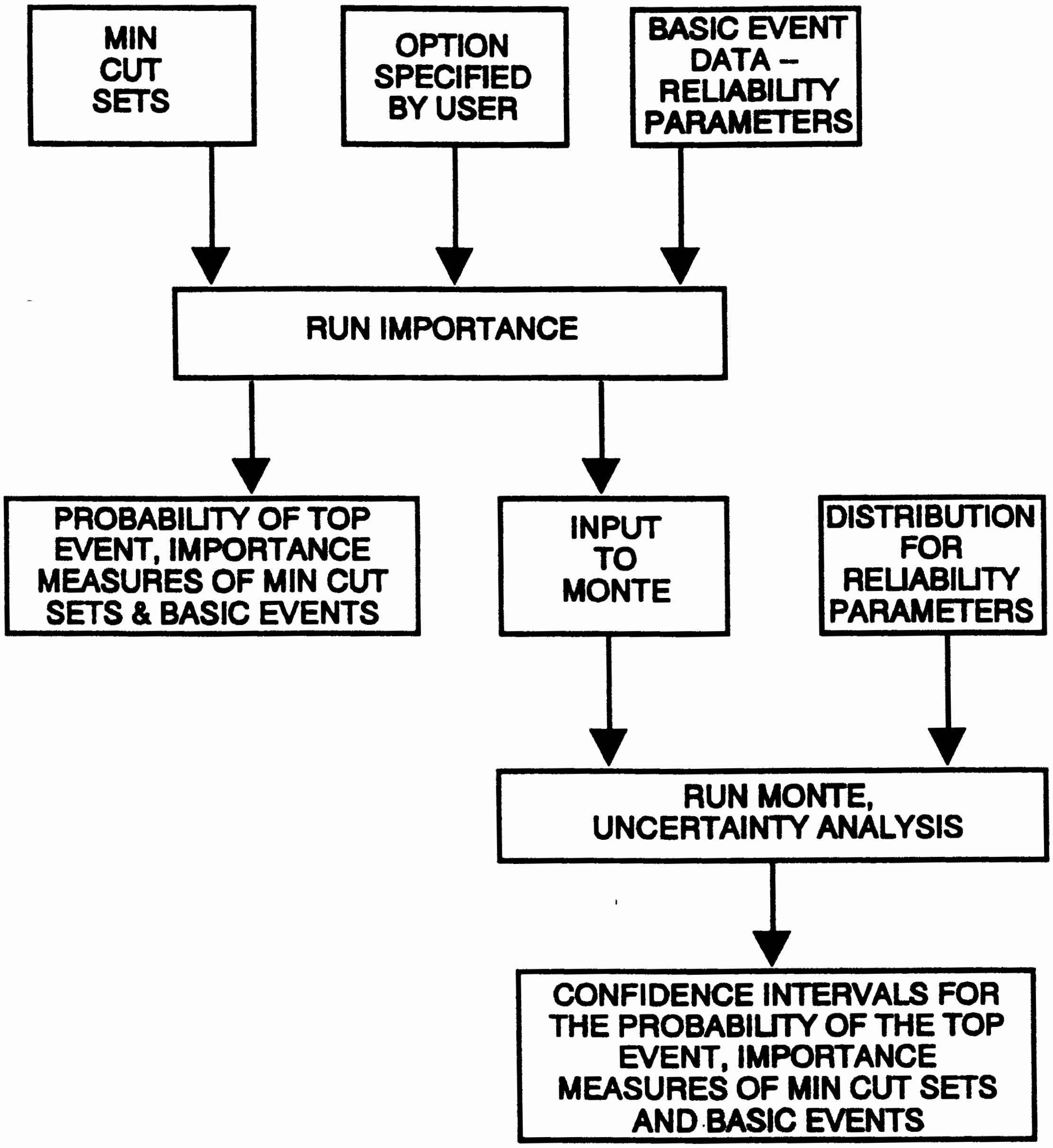


Figure 1-2

INPUT -- OUTPUT

IMPORTANCE and MONTE

DEMONSTRATION OF THE USE OF THE COMPUTER CODE PACKAGE

INTRODUCTION

The purpose of this paper is to give a brief overview of the computer code package for fault tree analysis and probabilistic risk assessment (PRA). The package consists of the following codes:

- FTAP
- Postprocessor to FTAP
- BUILD
- IMPORTANCE
- MONTE

FTAP and the postprocessor to FTAP perform qualitative calculations (Boolean Algebra manipulations) such as:

- finding min cut sets (system modes of failure) to fault trees
- conducting common cause analysis.

IMPORTANCE and MONTE perform quantitative (probabilistic) calculations. IMPORTANCE computes mean top event occurrence frequency, system unavailability and ranking of basic event and min cut sets according to various importance measures. Importance measures are useful for 1) identifying dominant risk contributors and 2) for conducting design tradeoffs. MONTE conducts the uncertainty analysis. It generates percentiles of the top event occurrence frequency and for various basic event and min cut set importance measures.

The code package contains a number of useful options. Only a small subset of these options will be demonstrated in this paper. We present an example of an analysis of a station blackout at a nuclear power plant. This example will demonstrate that the code package is applicable to a wide range of industries in which PRA can be applied, e.g. aerospace/DOD, chemical processing, transportation, etc.

EXAMPLE:

The accident scenario that we will consider is a loss of offsite power (LOSP) transient at a nuclear power plant. For this transient, the main power conversion system is lost and backup cooling/makeup systems must operate to prevent core melt. For this example, the onsite AC power system consists of three diesel generators. For station blackout to occur, all three diesel generators must fail to start and assume load when LOSP occurs. It must be emphasized that nuclear power plants generally have steam driven pumps that can operate several hours without AC power. For this example, we want to compute the frequency (events per year) of station blackout.

We do not consider recovery of offsite power or repair of diesel generators that fail to start. Hence the frequency of core melt due to station blackout will be much less than the station blackout frequency computed for this example.

The limiting conditions of operation (LCO) disallow the simultaneous maintenance of two or more diesel generators. We assume that LCO are not violated in this example. The frequency of LOSP is .2 per year. Plant data indicates that the probability of one diesel failing to start upon demand is 4.1 E-2. (We pool the data for all three diesels and assume that all three diesels are from the same population.) The fractional downtime due to maintenance is 6.4 E-3. Plant data indicates that start failures are statistically dependent, i.e.,

P (2 DG start failures/1 DG start failure) = .19
P (3 DG start failures/2 DG start failures) = .63

The event tree for station blackout is shown in Figure 2-1. The fault tree for loss of onsite AC power when LOSP occurs is given in Figure 2-2. Events in the fault tree are coded according to alphanumeric names.

FTAP

The FTAP input for the Figure 2-2 fault tree is shown in Figure 2-3. The input consists of three groups:

- fault tree specification terminating with the ENDTREE instruction (+ indicates OR logic; * indicates AND logic)
- option cards (e.g. PUNCH)
- execution card (e.g. *XEQ).

The FTAP output is shown in Figure 2-4. Eight min cut sets (i.e. implicants) are displayed. Min cut sets numbered 3, 5, 6 and 7 contain mutually exclusive events and are eliminated by the use of the postprocessor. Figure 2-5 displays the PUNCH file, another output file to FTAP.

POSTPROCESSOR

The input to the postprocessor is shown in Figure 2-6. The MEX command indicates that events DG-A-M, DG-B-M and DG-C-M are mutually exclusive. Min cut sets containing two or more of these events will be eliminated. The SUB command indicates that a substitution process will occur for min cut sets containing a specified set of basic events (listed after the single asterisk) will be substituted for another set (listed after the double asterisks). The substitution process allows dependent events to be considered when using IMPORTANCE. The slash "/" in a basic event indicates a dependency, e.g.

DG-C/A&B

means the event that diesel generator C fails to start given diesel generators A and B fail to start. Dependent failure analysis can be used for conducting a detailed task analysis in which human error events are not statistically independent. The postprocessor output (an FTAP input) is shown in Figure 2-7.

IMPORTANCE

The IMPORTANCE input is displayed in Figure 2-8. This input is generated from the BUILD program which takes as input the PUNCH file, Figure 2-5. BUILD generates an output file, Figure 2-9, which is then edited to obtain the IMPORTANCE input file, Figure 2-8. Option 5 (the Monte Carlo Option) in IMPORTANCE is invoked. Basic event data is given in terms of a mean probability and an error factor to express uncertainty about the mean estimate. The IMPORTANCE output is displayed in Figure 2-10. The mean station blackout frequency is computed to be 1.1 E-3 per year. In addition, importance rankings for basic events and min cut sets are displayed. These rankings are weighted according to the mean core melt frequency.

MONTE

The MONTE output is displayed in Figure 2-11. Percentiles are displayed for the mean station blackout frequency and for basic event and min cut set importance measures. The number of simulation trails is 1000 (a variable set in the source listing for MONTE).

EVENT TREE FOR STATION BLACKOUT

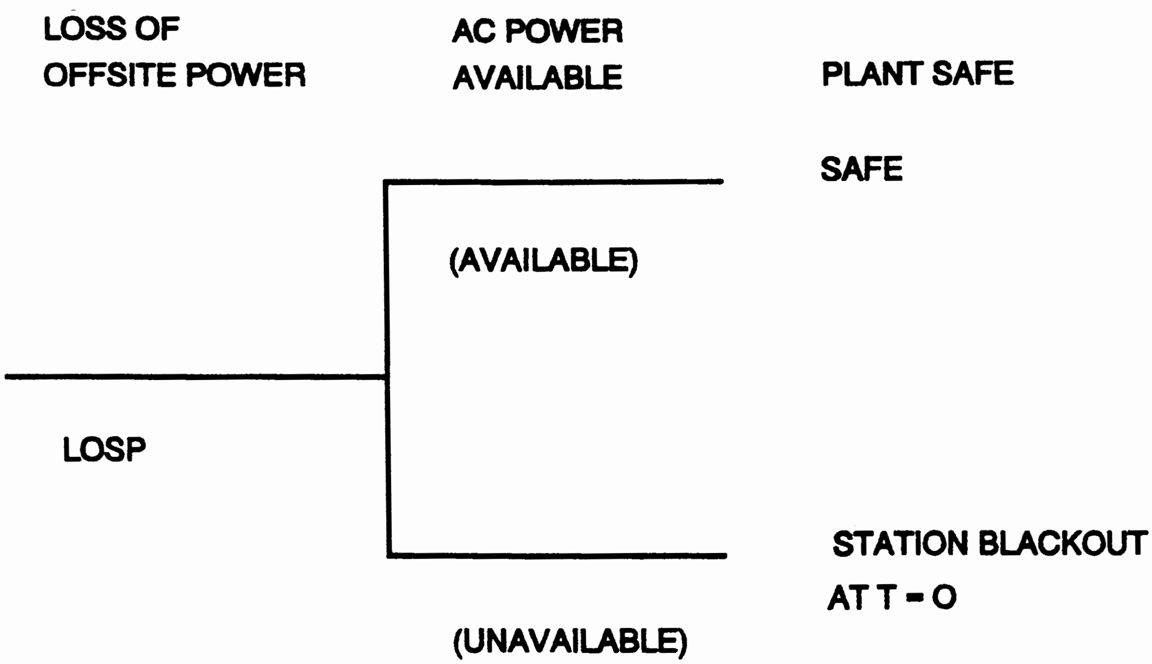


Figure 2-1

EVENT TREE

FAULT TREE FOR LOSS OF AC POWER WHEN LOSS OF OFFSITE POWER OCCURS

AC POWER SYSTEM -- THREE DIESEL GENERATORS
4.16 KV BUSES A, B, AND C

SUCCESS CRITERIA -- ANY ONE OUT OF THREE THAT SUCCESSFULLY STARTS AND ASSUMES LOAD

LIMIT CONDITIONS OF OPERATION -- NO SIMULATANEOUS MAINTENANCE ON DIESEL GENERATORS ALLOWED

```
                                    AC POWER UNAVAILABLE WHEN
                                  LOSS OF OFFSITE POWER OCCURS
                                                *
                                                *
                                               AND    (NO AC)
                                                *
                  **************************************************************
                  *                             *                              *
        DIESEL A UNAVAILABLE          DIESEL B UNAVAILABLE           DIESEL C UNAVAILABLE
        WHEN LOSP OCCURS              WHEN LOSP OCCURS               WHEN LOSP OCCURS
                  *                             *                              *
                  OR    (A)                     OR    (B)                      OR    (C)
                  *                             *                              *
  ****************************   ****************************   ****************************
  *                          *   *                          *   *                          *
DIESEL A FAILS  DIESEL A DOWN  DIESEL B FAILS  DIESEL B DOWN  DIESEL C FAILS  DIESEL C DOWN
TO START DUE TO DUE TO         TO START DUE TO DUE TO         TO START DUE    DUE TO
RANDOM CAUSES   MAINTENANCE    RANDOM CAUSES   MAINTENANCE    RANDOM CAUSES   MAINTENANCE

  (DG-A)          (DG-A-M)       (DG-B)          (DG-B-M)       (DG-C)          (DG-C-M)
```

NOTE:

1. EVENTS DG-A, DG-B AND DG-C ARE DEPENDENT EVENTS
2. EVENTS DG-A-M, DG-B-M AND DG-C-M ARE MUTUALLY EXCLUSIVE EVENTS

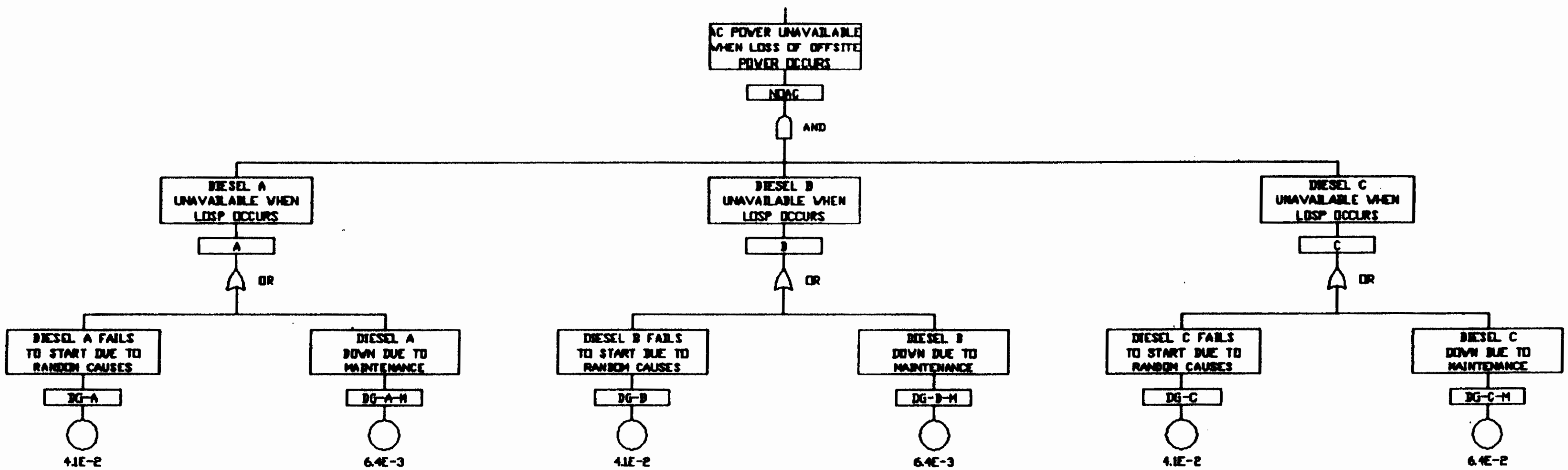
FIG. 2-2 -- FAULT TREE

FAULT TREE FOR LOSS OF AC POWER WHEN LOSS OF OFFSITE POWER OCCURS

AC POWER SYSTEM: THREE DIESEL GENERATORS – 4.16 KV BUSES A, B AND C

SUCCESS CRITERIA: ANY ONE OUT OF THREE THAT SUCCESSFULLY STARTS AND ASSUMES LOAD

LIMIT CONDITIONS OF OPERATION: NO SIMULTANEOUS MAINTENANCE ON DIESEL GENERATORS ALLOWED



NOTE:

1. EVENTS DG–A, DG–B AND DG–C ARE DEPENDENT EVENTS
2. EVENTS DG–A–M, DG–B–M AND DG–C–M ARE MUTUALLY EXCLUSIVE EVENTS

FIG. 2–2 -- FAULT TREE

```
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
↓         ↓         ↓         ↓         ↓         ↓         ↓         ↓

START OF INPUT --


** FTAP INPUT
** DIESEL GENERATOR PROBLEM
BLACKOUT  *         LOSP      NO-AC
NO-AC     *         A         B         C
A         +         DG-A      DG-A-M
B         +         DG-B      DG-B-M
C         +         DG-C      DG-C-M
ENDTREE
PUNCH
*XEQ
ENDJOB
```

Fig. 2-3 -- FTAP Input

```
** TIME AND DATE OF RUN --  14:53:01.08  OCT 26, 1988        dg.FO

1FAULT TREE ANALYSIS PROGRAM  VERSION ONE  MOD ONE                                   OPERATIONS RESEARCH CENTER


OFAULT TREE INPUT

        BLACKOUT  *        LOSP      NO-AC
        NO-AC     *        A         B         C
        A         +        DG-A      DG-A-M
        B         +        DG-B      DG-B-M
        C         +        DG-C      DG-C-M
        ENDTREE
OTOP NODE(S)

        BLACKOUT
OGATE NODES

        A         B        BLACKOUT  C         NO-AC
OBASIC NODES

        DG-A      DG-A-M   DG-B      DG-B-M    DG-C      DG-C-M    LOSP
1RUN  1

 PROGRAM INSTRUCTIONS

        PUNCH
        *XEQ
1                                     A N A L Y S I S  O F  P R I M A L  T R E E
OIMPLICANTS IN TERMS OF BASIC EVENTS

0     IMPLICANTS FOR EVENT  BLACKOUT

0          1         DG-A      DG-B      DG-C-M    LOSP
0          2         DG-A-M    DG-B      DG-C-M    LOSP
0          3         DG-A      DG-B-M    DG-C      LOSP
0          4         DG-A-M    DG-B-M    DG-C      LOSP
0          5         DG-A      DG-B-M    DG-C-M    LOSP
0          6         DG-A-M    DG-B-M    DG-C-M    LOSP
0          7         DG-A      DG-B      DG-C      LOSP
0          8         DG-A-M    DG-B      DG-C      LOSP


 CPU TIME FOR RUN       .160 SEC
```

Fig 2-4 -- FTAP Output

```
NAMES          11
    1 - DG-A          2 - DG-A-M        3 - DG-B          4 - DG-B-M       5 - DG-C
    6 - DG-C-M        7 - LOSP          8 - DG-B/A        9 - DG-C/A&B    10 - DG-C/A
   11 - DG-C/B
IMPME
EVENT   BLACKOUT           4         20
    4     1     8     6    7
    4     1     4    10    7
    4     1     8     9    7
    4     2     3    11    7
```

Fig. 2-5 -- FTAP PUNCH File

```
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
↓         ↓         ↓         ↓         ↓         ↓         ↓         ↓

START OF INPUT --


** DIESEL GENERATOR PROBLEM
**DG
PRTDNF
FRMBLK
MEX
DG-A-M    DG-B-M    DG-C-M
SUB
*
DG-A      DG-B      DG-C
**
DG-A      DG-B/A    DG-C/A&B
*
DG-A      DG-B
**
DG-A      DG-B/A
*
DG-A      DG-C
**
DG-A      DG-C/A
*
DG-B      DG-C
**
DG-B      DG-C/B
```

Fig. 2-6 Postprocessor Input

```
** TITLE -- ** DIESEL GENERATOR PROBLEM
**DG  --  SYSTEM CODE
** TOP EVENT  --  BLACKOUT
** TIME AND DATE OF RUN --  17:13:35.55  OCT 26, 1988         dg.blk

** MIN CUT SET INFORMATION
** COMPLEMENTED EVENTS ? -- NO
** TOTAL NUMBER OF IMPLICANTS =     4
**
** ORDER               1       2       3       4
** NUMBER OF           0       0       0       4
** IMPLICANTS
**
** THE FOLLOWING      4 MIN CUT SETS CONTAINED MUTUALLY EXCLUSIVE EVENTS
**      2,     4,     5,     6,
** THE FOLLOWING      4 MIN CUT SETS CONTAINED SUBSTITUTED EVENTS
**      1,     3,     7,     8,
** MIN CUT   ORDER
** SET NO.
DG-----1       4    DG-A      DG-B/A    DG-C-M    LOSP
DG-----2       4    DG-A      DG-B-M    DG-C/A    LOSP
DG-----3       4    DG-A      DG-B/A    DG-C/A&B  LOSP
DG-----4       4    DG-A-M    DG-B      DG-C/B    LOSP
** TOP EVENT DEFINITION
BLACKOUT  +         DG-----1  DG-----2  DG-----3  DG-----4
```

Fig 2-7 -- Postprocessor Output
(Block File)

```
123456789012345678901234567890123456789012345678901234567890123456789012345678901
         10        20        30        40        50        60        70        80

START OF INPUT --

 STATION BLACKOUT CAUSED BY LOSS OF OFFSITE POWER
         5
         1

BE FV
CS FV              5
ENDIM
DETAILCS          100     1.0E-2
NOPTION
DG-A         4.1E-2        3.0    DG A FAILS TO START RANDOM CAUSES
DG-A-M       6.4E-3        6.0    DG A DOWN DUE TO MAINTENANCE
DG-B         4.1E-2        3.0    DG B FAILS TO START RANDOM CAUSES
DG-B-M       6.4E-3        6.0    DG B DOWN DUE TO MAINTENANCE
DG-C         4.1E-2        3.0    DG C FAILS TO START RANDOM CAUSES
DG-C-M       6.4E-2        6.0    DG C DOWN DUE TO MAINTENANCE
LOSP         0.2E-0        3.0    YR-1 LOSS OF OFFSITE POWER TRANSIENT
DG-B/A       1.9E-1        2.0    DG B FAILS TO START GIVEN DG A FAILURE
DG-C/A&B     .63E-0        2.0    DG C FAILS TO START GIVEN DG A & B FAILURE
DG-C/A       1.9E-1        2.0    DG C FAILS TO START GIVEN DG A FAILURE
DG-C/B       1.9E-1        2.0    DG C FAILS TO START GIVEN DG B FAILURE
NDATA
NAMES        11
    1 - DG-A         2 - DG-A-M       3 - DG-B         4 - DG-B-M       5 - DG-C
    6 - DG-C-M       7 - LOSP         8 - DG-B/A       9 - DG-C/A&B    10 - DG-C/A
   11 - DG-C/B
IMPME
EVENT  BLACKOUT          4        20
    4    1    8    6     7
    4    1    4   10     7
    4    1    8    9     7
    4    2    3   11     7
```

Fig. 2-8 -- IMPORTANCE Input

```
TITLE
         5
         1

BE FV
CS FV
ENDIM
DETAILCS        100    1.0E-2
NOPTION
DG-A        1.0E-0      10.0    ______________________________
DG-A-M      1.0E-0      10.0    ______________________________
DG-B        1.0E-0      10.0    ______________________________
DG-B-M      1.0E-0      10.0    ______________________________
DG-C        1.0E-0      10.0    ______________________________
DG-C-M      1.0E-0      10.0    ______________________________
LOSP        1.0E-0      10.0    ______________________________
NDATA
NAMES         7
    1 - DG-A        2 - DG-A-M      3 - DG-B        4 - DG-B-M      5 - DG-C
    6 - DG-C-M      7 - LOSP
IMPBE         1
EVENT  BLACKOUT          8          40
    4    1    3    6    7
    4    2    3    6    7
    4    1    4    5    7
    4    2    4    5    7
    4    1    4    6    7
    4    2    4    6    7
    4    1    3    5    7
    4    2    3    5    7
```

Fig. 2-9 -- Example of Build Program
(File to be edited to obtain
IMPORTANCE input file, fig 2-8)

** TIME AND DATE OF RUN -- 17:24:33 OCT 26, 1988

****

STATION BLACKOUT CAUSED BY LOSS OF OFFSITE POWER

****

OPTION 5 -- BASIC EVENT PROBABILITIES AND ERROR FACTORS

Fig. 2-10 -- IMPORTANCE Output

****

** BASIC EVENT OPTIONS USED **

BIRNBAUM	CRITICA-LITY	UPGRADING FUNCTION	FUSSELL-VESELY	INITIATOR (BARLOW-PROSCHAN)	ENABLER (CONTRIB-UTORY)	STRUCTURAL
NO	NO	NO	YES	NO	NO	NO

****

** MIN CUT SET OPTIONS USED **

INITIATOR (BARLOW-PROSCHAN)	FUSSELL-VESELY
NO	YES

****

MAXIMUM CUT SET ORDER FOR THE FUSSELL-VESELY MEASURE OF CUT SET IMPORTANCE = 5

INFORMATION ON DETAILED CUT SET OUTPUT -- NM =100 AND FACTOR = .100E-01

1 ******************** STATION BLACKOUT CAUSED BY LOSS OF OFFSITE POWER ********************

** BASIC EVENT DATA **

BASIC EVENT NAME	PROBABILITY		ERROR FACTOR	DISTRIBUTION	DESCRIPTION
DG-A	.410E-01	MEAN	3.0	LOGNORMAL	DG A FAILS TO START RANDOM CAUSES
DG-A-M	.640E-02	MEAN	6.0	LOGNORMAL	DG A DOWN DUE TO MAINTENANCE
DG-B	.410E-01	MEAN	3.0	LOGNORMAL	DG B FAILS TO START RANDOM CAUSES
DG-B-M	.640E-02	MEAN	6.0	LOGNORMAL	DG B DOWN DUE TO MAINTENANCE
DG-C	.410E-01	MEAN	3.0	LOGNORMAL	DG C FAILS TO START RANDOM CAUSES
DG-C-M	.640E-01	MEAN	6.0	LOGNORMAL	DG C DOWN DUE TO MAINTENANCE
LOSP	.200E+00	MEAN	3.0	LOGNORMAL	YR-1 LOSS OF OFFSITE POWER TRANSIENT
DG-B/A	.190E+00	MEAN	2.0	LOGNORMAL	DG B FAILS TO START GIVEN DG A FAILURE
DG-C/A&B	.630E+00	MEAN	2.0	LOGNORMAL	DG C FAILS TO START GIVEN DG A & B FAILURE
DG-C/A	.190E+00	MEAN	2.0	LOGNORMAL	DG C FAILS TO START GIVEN DG A FAILURE
DG-C/B	.190E+00	MEAN	2.0	LOGNORMAL	DG C FAILS TO START GIVEN DG B FAILURE

STEADY STATE CALCULATIONS

TOP EVENT PROBABILITY = .11011E-02

RANK	BASIC EVENT	IMPORTANCE	MEAN PROBABILITY	ERROR FACTOR	DISTRIBUTION	BASIC EVENT DESCRIPTION
1	LOSP	1.00	.200	3.00	LOGNORML	YR-1 LOSS OF OFFSITE POWER TRANSIENT
2	DG-A	.991	.410E-01	3.00	LOGNORML	DG A FAILS TO START RANDOM CAUSES
3	DG-B/A	.982	.190	2.00	LOGNORML	DG B FAILS TO START GIVEN DG A FAILURE
4	DG-C/A&B	.891	.630	2.00	LOGNORML	DG C FAILS TO START GIVEN DG A & B FAILURE
5	DG-C-M	.906E-01	.640E-01	6.00	LOGNORML	DG C DOWN DUE TO MAINTENANCE
6	DG-B	.906E-02	.410E-01	3.00	LOGNORML	DG B FAILS TO START RANDOM CAUSES
6	DG-B-M	.906E-02	.640E-02	6.00	LOGNORML	DG B DOWN DUE TO MAINTENANCE
6	DG-A-M	.906E-02	.640E-02	6.00	LOGNORML	DG A DOWN DUE TO MAINTENANCE
6	DG-C/A	.906E-02	.190	2.00	LOGNORML	DG C FAILS TO START GIVEN DG A FAILURE
6	DG-C/B	.906E-02	.190	2.00	LOGNORML	DG C FAILS TO START GIVEN DG B FAILURE

****

FUSSELL VESELY MEASURE OF MIN CUT SET IMPORTANCE (MEASURE OF SYSTEM UNAVAILABILITY)

****

GROUP RANK	CUMULATIVE IMPORTANCE	RESIDUAL IMPORTANCE
1	.891438	.109
2	.981908	.181E-01
3	1.000000	.000

Fig. 2-10 -- Continued

1 ********************** STATION BLACKOUT CAUSED BY LOSS OF OFFSITE POWER **********************

FUSSELL-VESELY MEASURE OF CUT SET IMPORTANCE (MEASURE OF SYSTEM UNAVAILABILTY)

TOP EVENT PROBABILITY = .11011E-02

RANK IMPORTANCE

1 .891E+00 CUT SET 3

GROUP RANK CUMULATIVE/RESIDUAL

MIN CUT SET PROBABILITY = .982E-03 .891438/ .109

BASIC EVENT	MEAN PROBABILITY	ERROR FACTOR	DISTRIBUTION	BASIC EVENT DESCRIPTION
DG-A	.410E-01	3.00	LOGNORML	DG A FAILS TO START RANDOM CAUSES
DG-B/A	.190E+00	2.00	LOGNORML	DG B FAILS TO START GIVEN DG A FAILURE
DG-C/A&B	.630E+00	2.00	LOGNORML	DG C FAILS TO START GIVEN DG A & B FAILURE
LOSP	.200E+00	3.00	LOGNORML	YR-1 LOSS OF OFFSITE POWER TRANSIENT

2 .906E-01 CUT SET 1

GROUP RANK CUMULATIVE/RESIDUAL

MIN CUT SET PROBABILITY = .997E-04 .981908/ .181E-01

BASIC EVENT	MEAN PROBABILITY	ERROR FACTOR	DISTRIBUTION	BASIC EVENT DESCRIPTION
DG-A	.410E-01	3.00	LOGNORML	DG A FAILS TO START RANDOM CAUSES
DG-B/A	.190E+00	2.00	LOGNORML	DG B FAILS TO START GIVEN DG A FAILURE
DG-C-M	.640E-01	6.00	LOGNORML	DG C DOWN DUE TO MAINTENANCE
LOSP	.200E+00	3.00	LOGNORML	YR-1 LOSS OF OFFSITE POWER TRANSIENT

3 .906E-02 CUT SET 2

GROUP RANK CUMULATIVE/RESIDUAL

DG-A	.410E-01	3.00	LOGNORML	DG A FAILS TO START RANDOM CAUSES
DG-B-M	.640E-02	6.00	LOGNORML	DG B DOWN DUE TO MAINTENANCE
DG-C/A	.190E+00	2.00	LOGNORML	DG C FAILS TO START GIVEN DG A FAILURE
LOSP	.200E+00	3.00	LOGNORML	YR-1 LOSS OF OFFSITE POWER TRANSIENT

3 .906E-02 CUT SET 4

GROUP RANK CUMULATIVE/RESIDUAL

MIN CUT SET PROBABILITY = .997E-05 1.000000/ .000

BASIC EVENT	MEAN PROBABILITY	ERROR FACTOR	DISTRIBUTION	BASIC EVENT DESCRIPTION
DG-A-M	.640E-02	6.00	LOGNORML	DG A DOWN DUE TO MAINTENANCE
DG-B	.410E-01	3.00	LOGNORML	DG B FAILS TO START RANDOM CAUSES
DG-C/B	.190E+00	2.00	LOGNORML	DG C FAILS TO START GIVEN DG B FAILURE
LOSP	.200E+00	3.00	LOGNORML	YR-1 LOSS OF OFFSITE POWER TRANSIENT

1 REFERENCE TABLE FOR MIN CUT SETS

ORDER	1	2	3	4
NO. OF MIN CUT SETS	0	0	0	4

NO. OF MIN CUT SETS = 4

CUT SET NO.	ORDER	BASIC EVENTS			
1	4	DG-A	DG-B/A	DG-C-M	LOSP
2	4	DG-A	DG-B-M	DG-C/A	LOSP
3	4	DG-A	DG-B/A	DG-C/A&B	LOSP
4	4	DG-A-M	DG-B	DG-C/B	LOSP

Fig. 2-10 Continued

STATION BLACKOUT CAUSED BY LOSS OF OFFSITE POWER

Fig. 2-11 -- MONTE Output

MONTE CARLO SIMULATION RESULTS (1000 TRIALS)

INDEX OF SORTED VALUE		10	50	100	500	900	950	990
CONFIDENCE LEVEL IN PER CENT		(98)	(90)	(80)		(80)	(90)	(98)
PERCENTILE		1	5	10	50	90	95	99
MEAN FROM IMPORTANCE/ COMPUTED MEAN								
PROB OF TOP EVENT .110E-02/	.105E-02	.452E-04	.871E-04	.132E-03	.547E-03	.238E-02	.386E-02	.814E-02

1

MONTE CARLO SIMULATION RESULTS (1000 TRIALS)

INDEX OF SORTED VALUE			10	50	100	500	900	950	990
CONFIDENCE LEVEL IN PER CENT			(98)	(90)	(80)		(80)	(90)	(98)
PERCENTILE			1	5	10	50	90	95	99
MEAN FROM IMPORTANCE/ COMPUTED MEAN									
RANK BASIC EVENT									
1 LOSP	.100E+01/	.100E+01	.100E+01	.100E+01	.100E+01	.100E+01	.100E+01	.100E+01	.100E+01
2 DG-A	.991E+00/	.980E+00	.768E+00	.914E+00	.952E+00	.994E+00	.999E+00	.100E+01	.100E+01
3 DG-B/A	.982E+00/	.969E+00	.767E+00	.891E+00	.927E+00	.984E+00	.996E+00	.998E+00	.999E+00
4 DG-C/A&B	.891E+00/	.874E+00	.489E+00	.652E+00	.737E+00	.909E+00	.969E+00	.977E+00	.985E+00
5 DG-C-M	.906E-01/	.943E-01	.333E-02	.977E-02	.152E-01	.582E-01	.224E+00	.312E+00	.489E+00
6 DG-B	.906E-02/	.201E-01	.142E-03	.369E-03	.723E-03	.623E-02	.475E-01	.846E-01	.219E+00
6 DG-B-M	.906E-02/	.112E-01	.272E-03	.586E-03	.104E-02	.547E-02	.253E-01	.405E-01	.843E-01
6 DG-A-M	.906E-02/	.201E-01	.142E-03	.369E-03	.723E-03	.623E-02	.475E-01	.846E-01	.219E+00
6 DG-C/A	.906E-02/	.112E-01	.272E-03	.586E-03	.104E-02	.547E-02	.253E-01	.405E-01	.843E-01
6 DG-C/B	.906E-02/	.201E-01	.142E-03	.369E-03	.723E-03	.623E-02	.475E-01	.846E-01	.219E+00

POSTPROCESSOR

The purpose of the postprocessor is to read the punch file from FTAP and generate an output file in a format which can be read by FTAP, (similar to the blockfile concept in SETS). The postprocessor can implement a number of useful commands not found in FTAP. Features of the postprocessor include:

- conducting common cause and dependent event analysis
- dropping complemented events and performing the subsequent minimization
- generating block files (i.e., sets of Boolean equations) for subsystems
- eliminating min cut sets with mutually exclusive events.

As described in Figure 3-1, the postprocessor requires two inputs:

- data input file (specifies title system code and options)
- the punch file from FTAP.

Figure 3-2 describes the data input file. The first line is the title line (the first two columns must contain asterisks). The second line is a two digit alphanumeric code that uniquely identifies the Boolean equations given in the blockfile (again the first two columns must contain asterisks). Each run of the postprocessor must have a unique system code. The options commands start on line 3. To print the contents of the blockfile, the postprocessor input must contain either the command PRTDNF or FRMBLK. The command PRTDNF (print equation in disjunctive normal form) is handy when the analyst wants to display the contents of a punch file in readable form. The FRMBLK command (form block) is required to generate an FTAP input file. The command NOCMPL drops complemented events (i.e., assumes that they are true) and performs the subsequent minimization. The command SORT sorts min cut sets according to order. It is necessary to sort the punch file to run IMPORTANCE if min cut sets are not listed according to order in the punch file (which occurs when probabilistically culling in FTAP when using the IMPORT instruction).

Figures 3-2 and 2-6 describe additional commands, MEX and SUB that must follow the commands described above. MEX and SUB are optional commands. The MEX command must precede the SUB command. The MEX command sets equal to false basic events that are pairwise mutually exclusive. For the SUB command, the user identifies sets of basic events within min cut sets (called original sets) that are to be substituted by another set of basic events (called substituted sets). The SUB command is useful for identifying basic events within min cut sets that have either a common cause or statistical dependency.

The MEX and commands follow the convention of FTAP, seven fields to a line, format 7(A8, 2X). A field is an alphanumeric name that is left justified. For the MEX command, the first line is MEX. The second and subsequent lines consist of groups of basic events that are pairwise mutually exclusive. To extend the group to the next line (and subsequent lines) the first field must be blank. Up to 100 names per group are allowed. A new group starts when a non-blank character is encountered in the first field. The number of pairs that are mutually exclusive is n!/[(n-2)! x 2!], where n is the number of basic events in the group.

For the SUB command, the first line is SUB. The second and subsequent lines follow the general pattern.

*	(single asterisk) original set (format 7(A8, 2X))
**	(double asterisk) substituted set (format 7(A8, 2X))

The original set of basic events and the substituted set cannot exceed 99 basic events.

It is important to note that the original set of basic events are eliminated upon substitution in the min cut sets. Hence ordering of the input data is important when using the SUB command.

For both the MEX and SUB commands, complemented basic events will be ignored.

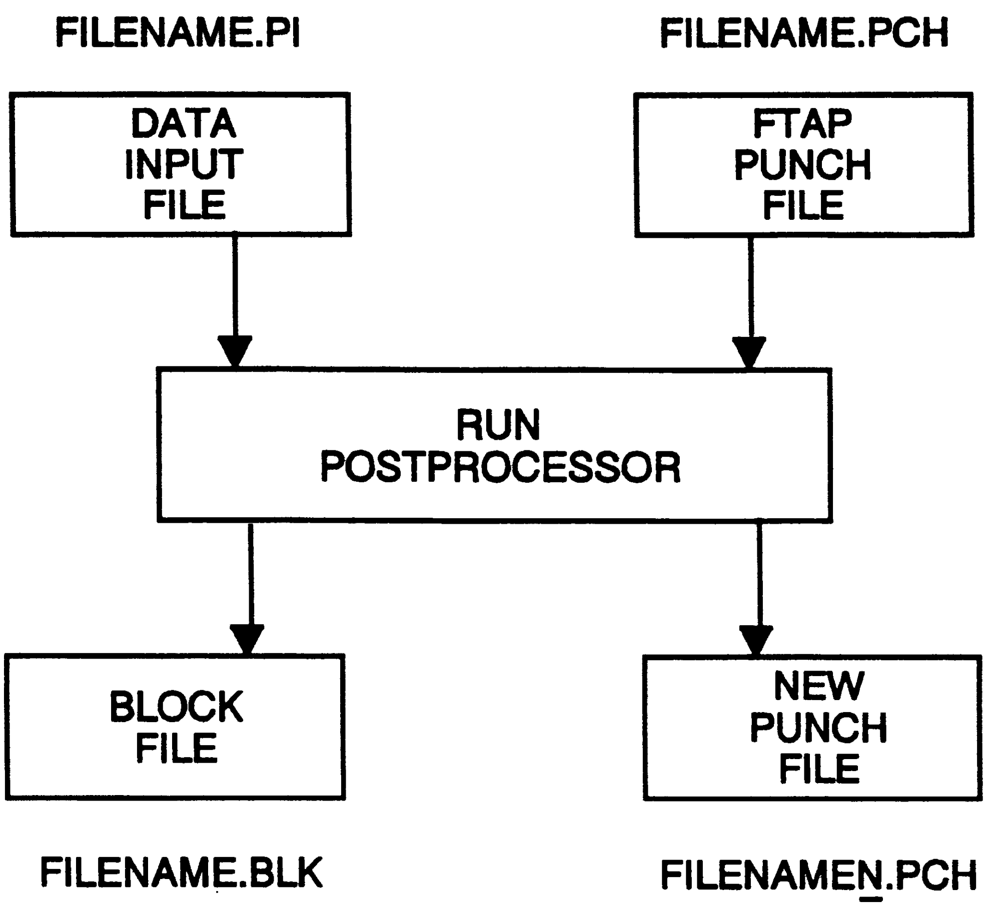


Figure 3-1
FILE STRUCTURE FOR THE POSTPROCESSOR

line number	description of line	column 1	
1	title card	** TITLE	
2	system code (any two numbers or letters)	** SC	
3	eliminates complemented events and performs the subsequent minimization on the cut sets (this command is optional)	NOCMPL	Optional Commands any order
4	prints min cut sets in 8 character FTAP format (i.e. prints disjunctive normal form)	PRTDNF	
5	prints min cut sets in 8 character FTAP format (same as the command PRTDNF) <u>and</u> generates a Boolean equation for the Top Event	FRMBLK	
6	sorts min cut sets according to order (optional command)	SORT	

FIG. 3-2

Postprocessor input -- file 6

MONTE

MONTE uses a Monte Carlo sampling procedure by assuming a probability distribution for the error in the estimate of the basic event probability. MONTE computes confidence intervals for:

- Top Event Probability
- Fussell-Vesely measure of basic event importance
- Fussell-Vesely measure of min cut set importance.

To run MONTE, one must employ option 5 as input to IMPORTANCE and one must run only those two measures stated above. IMPORTANCE generates an output FORTRAN file 9 which is input to MONTE (see figure 4-1).

For option 5 of IMPORTANCE, lamda is the probability of occurrence of the basic event and tau is the error factor with interpretation.

Value of tau	Distribution	Upper 90% confidence interval
Positive	log normal	lamda times error factor
Negative	normal	lamda times error factor
zero (blank)	constant	not applicable

For the log normal distribution, if lamda has blank units (column 20), then it is assumed that the mean is given--if lamda has units of M, then it is assumed that the median is given.

In IMPORTANCE, median basic event probabilities are converted to mean probabilities using the following expression:

$$\mu_x = X_{50}\exp(\sigma_y 2/2)$$

where

μ_x is the mean of a log normal distribution
X_{50} is the 50% percentile (median) of the log normal distribution
σ_y is the standard deviation of the normal distribution.

It can be shown that

$$\sigma_y = (LN[EF])/1.645$$

where LN represents natural logarithm to the base e and EF represents the error factor described above. It is important to note that MONTE uses truncated log normal and normal distributions. This means that if, on a sampling trial, a probability greater than 1 or less than 0 is generated, MONTE will resample until the probability generated is between 0 and 1.

Figure 4-2 shows a typical input to IMPORTANCE illustrating option 5, the Monte Carlo Option. The basic event data appears on lines 10 through 61. All other data is either log normal or constant. On lines 10, 11, 12, 13, 14, 16, 21, 22, 23, 36, 37, 38, 39, 50, 52, 58 and 59, median data is given as evidenced by an M in column 20.

Figure 4-3 shows a typical output for MONTE which uses the data given in Figure 4-2. The number of sampling trials is indicated. This number can be changed in MONTE. The 98, 90, 80 and 50 percentiles are displayed for

- probability of the Top Event
- Fussell-Vesely measures of basic event and min cut set importances.

The mean from IMPORTANCE and the computed mean from MONTE is displayed. These numbers can differ for two reasons:

- sampling error
- truncated distributions used in MONTE but not IMPORTANCE.

Pages 4-7 through 4-11 describe the properties of the lognormal distribution. Pages 4-12 through 4-16 display some typical data with error factors.

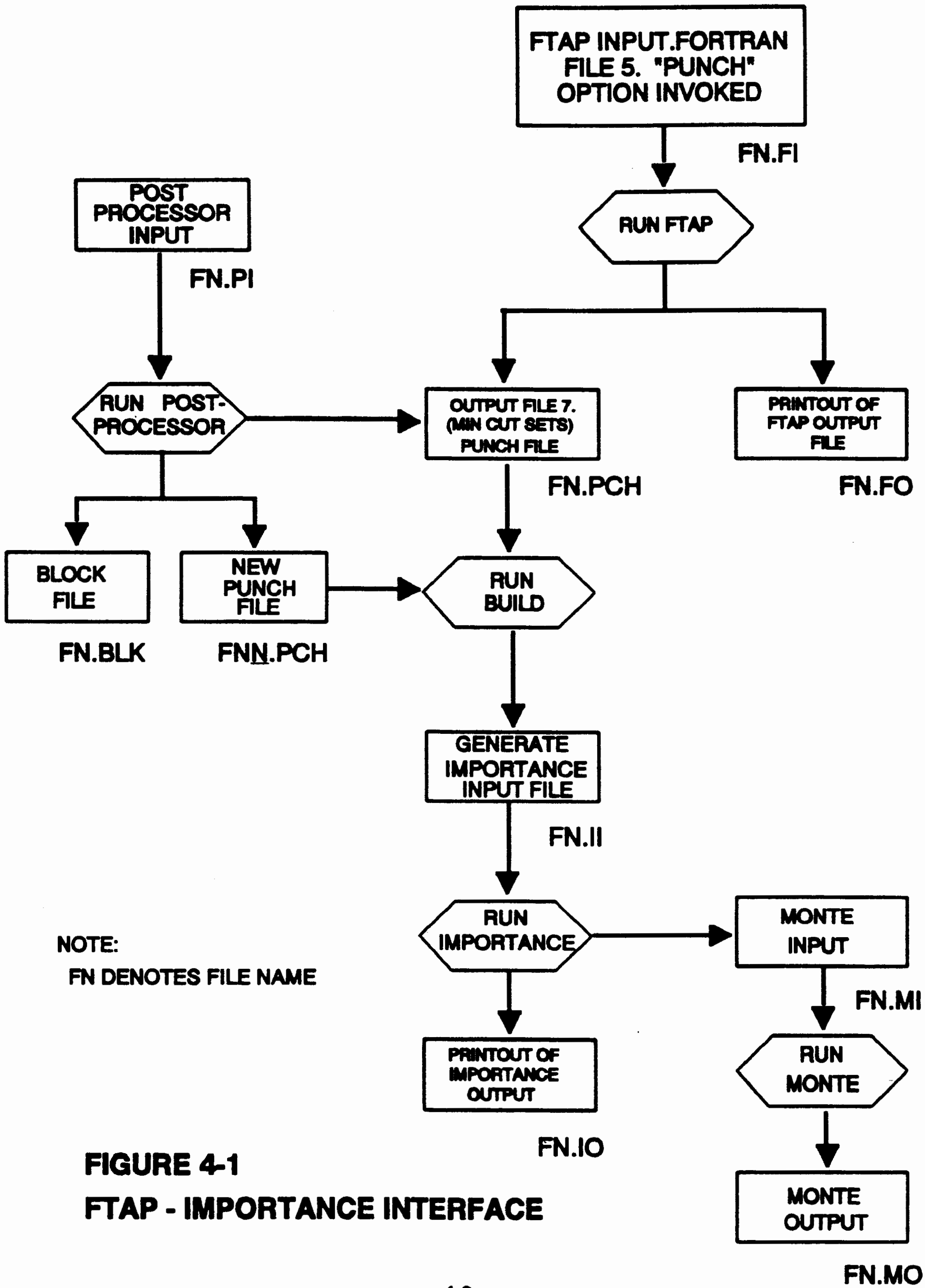


FIGURE 4-1
FTAP - IMPORTANCE INTERFACE

FIGURE 4-2: **Sample input file illustrating the use of option 5 in IMPORTANCE**

line number

```
 EXAMPLE OF MONTE CARLO OPTION
          5
          1

BE FV
CS FV
ENDIM
DETAILCS          100     1.E-20
NOPTION
1B1CLOSE     1.0E-4M      3.0   1B1 CONTACTS FAIL TO OPEN
1FL-CONT     1.0E-4M      3.0   FIELD LOSS RELAY CONTACTS FAIL TO OPEN
1FL-OCCT     1.0E-4M      3.0   FIELD LOSS RELAY COIL OPEN CIRCUIT
1MACLOSE     1.0E-4M      3.0   1MA CONTACTS FAIL TO OPEN
1MSHOIST     1.0E-5M     10.0   MS CONTACTS STICK IN HOIST POSITION
1R5          2.5E-7      10.0   1R5 RESISTOR OPEN OR SHORT CIRCUIT
1UV          1.0E-4M      3.0   UNDER VOLTAGE RELAY CONTACTS FAIL TO OPEN
BINDING      1.0E-0       0.0   ** BINDING ON GUIDE STUDS **
BRAKE1       1.7E-5      10.0   SPRING BRAKE 1 FAILS TO ENGAGE
BRAKE2       1.0E-2      10.0   SPRING BRAKE 2 FAILS TO ENGAGE
DURINGLF     1.0E-0       0.0   ** DROP ABOVE INITIAL LIFT HEIGHT **
GENERATR     2.5E-6M     10.0   OPEN CIRCUIT IN GENERATOR
GLSCLOSE     5.0E-3M      2.0   GEAR LIMIT SWITCH CONTACTS FAIL TO OPEN
GRPA         7.5E-7M     10.0   REVERSING POWER AMPLIFIER FAILURE OFF
HANDSYSX     1.0E-0       0.0   HANDLING SYSTEM FAILURE GIVEN LOAD HANGUP
HEADSTUC     1.0E-2      10.0   REACTOR HEAD STUCK IN PLACE
HLFSTRCI     2.6E-6      10.0   STRUCTURAL FAIL HEAD LIFT DEVICE
ILFSTRCI     2.6E-6      10.0   STRUCTURAL FAIL INTERNALS LIFT DEVICE
IMPROPRC     2.6E-5      10.0   IMPROPER CONNECTION OF INTERNALS RIG
INITIALF     1.0E-0       0.0   ** DROP DURING INITIAL LIFT **
INSTALL      1.0E-0       0.0   ** DROP DURING INSTALLATION **
INTERNST     1.0E-2      10.0   INTERNALS STUCK IN PLACE
LCELSTRI     2.6E-6      10.0   STRUCTURAL FAILURE OF LOAD CELL
LCRLOW       6.3E-6      10.0   LOW CELL READS LOW
LNKSTRCI     2.6E-6      10.0   STRUCTURAL FAILURE OF LINK ASSEMBLY
LOADHANG     1.0E-0       0.0   ** LOAD HANGUP **
MFP          7.5E-7M     10.0   MOTOR PROGRAMMER OFF
MOTOR-A      2.5E-6M      3.0   OPEN OR SHORT CCT AMARATURE HOIST MOTOR
MOTOR-SF     2.5E-6M      3.0   OPEN OR SHORT CCT SHUNT FIELD HOIST MOTOR
MPA          7.5E-7M     10.0   MAGNETIC FIELD AMP FAILS TO FUNCTION
OPBIND       1.0E-2      10.0   OPERATOR MOVES CRANE DURING LIFT CAUSES BIND
OPEMER2B     1.0E-2      10.0   OPERATOR FAILS TO PRESS EMERGENCY STOP
OPHOIST2     1.0E-3      10.0   OPERATOR CONTINUES TO HOIST DURING TWO BLOCK
OPHOISTB     1.0E-3      10.0   OPERATOR CONTINUES TO HOIST DURING BINDING
OPLOADHP     1.0E-3      10.0   OPERATOR CONTINUES TO HOIST DURING HANGUP
OPMSOFF      1.0E-0       0.0   OPERATOR PLACES MASTER SWITCH OFF
OVERSPED     1.0E-0       0.0   ** OVERSPEED EVENT **
REMOVAL      1.0E-0       0.0   ** REMOVAL OF LOAD **
RIGBIND      1.0E-3      10.0   BOTH RIGGERS FAIL TO OBSERVE BINDING
RIGGERS      1.0E-3      10.0   BOTH RIGGERS MISREAD LOAD CELL
RPA          7.5E-7M      3.0   REVERSING POWER AMPLIFIER FAILS TO FUNCTION
RSCRANEI     8.5E-6      10.0   STRUCTURAL FAILURE OF CRANE SYSTEM
SCR-MPA      7.5E-7M     10.0   SCR FAILURE TO MOTOR POWER AMPLIFIER
STRUCTAH     3.0E-8      10.0   STRUCT FAIL OF CRANE, LIFTING HEAD
STRUCTAI     0.0E-0       0.0   STRUCT FAIL OF CRANE, LIFTING INTERNALS
STRUCTBH     1.0E-4      10.0   STRUCT FAIL OF CRANE -- GIVEN BINDING -- HEAD
STRUCTBI     0.0E-0       0.0   STRUCT FAIL OF CRANE -- GIVEN BINDING -- INT
STRUCTIL     1.0E-0       0.0   ** STRUCTURAL FAILURE DURING INITIAL LIFT **
TR-GRPA      .25E-6M      3.0   TRANSFORMER FAILURE TO RPA
TR-MPA       .25E-6M      3.0   TRANSFORMER FAILURE TO MPA
TWOBLOCK     1.0E-0       0.0   ** TWO BLOCKING EVENT **
WLSCLOSE     1.0E-2       2.0   WEIGHT LIMIT SWITCH CONTACTS FAIL TO OPEN
NDATA
```

FIGURE 4-3: Output of MONTE

EXAMPLE OF MONTE CARLO OPTION

MONTE CARLO SIMULATION RESULTS (1000 TRIALS)								
INDEX OF SORTED VALUE		10	50	100	500	900	950	990
CONFIDENCE LEVEL IN PER CENT		(98)	(90)	(80)		(80)	(90)	(98)
PERCENTILE		1	5	10	50	90	95	99
MEAN FROM IMPORTANCE/ COMPUTED MEAN								
PROB OF TOP EVENT	0.742E-04/ 0.718E-04	0.150E-04	0.202E-04	0.249E-04	0.503E-04	0.138E-03	0.185E-03	0.336E-03

0.310E-04 0.950E-04

1

MONTE CARLO SIMULATION RESULTS (1000 TRIALS)								
INDEX OF SORTED VALUE		10	50	100	500	900	950	990
CONFIDENCE LEVEL IN PER CENT		(98)	(90)	(80)		(80)	(90)	(98)
PERCENTILE		1	5	10	50	90	95	99
MEAN FROM IMPORTANCE/ COMPUTED MEAN								
RANK BASIC EVENT								
1 REMOVAL	0.807E 00/ 0.780E 00	0.673E 00	0.684E 00	0.693E 00	0.763E 00	0.896E 00	0.926E 00	0.960E 00
2 INITIALF	0.613E 00/ 0.560E 00	0.345E 00	0.365E 00	0.384E 00	0.525E 00	0.791E 00	0.853E 00	0.919E 00
3 OVERSPED	0.578E 00/ 0.657E 00	0.119E 00	0.214E 00	0.309E 00	0.707E 00	0.921E 00	0.947E 00	0.978E 00
4 DURINGLF	0.387E 00/ 0.440E 00	0.796E-01	0.144E 00	0.209E 00	0.474E 00	0.616E 00	0.633E 00	0.652E 00
5 HANDSYSX	0.271E 00/ 0.173E 00	0.117E-02	0.356E-02	0.844E-02	0.897E-01	0.468E 00	0.633E 00	0.835E 00
5 LOADHANG	0.271E 00/ 0.173E 00	0.117E-02	0.356E-02	0.844E-02	0.897E-01	0.468E 00	0.633E 00	0.835E 00
5 HEADSTUC	0.271E 00/ 0.173E 00	0.117E-02	0.356E-02	0.844E-02	0.897E-01	0.468E 00	0.633E 00	0.835E 00
6 GENERATR	0.269E 00/ 0.250E 00	0.411E-02	0.144E-01	0.278E-01	0.178E 00	0.594E 00	0.718E 00	0.851E 00
7 INSTALL	0.193E 00/ 0.220E 00	0.398E-01	0.720E-01	0.103E 00	0.237E 00	0.307E 00	0.316E 00	0.326E 00
8 STRUCTIL	0.150E 00/ 0.167E 00	0.507E-02	0.139E-01	0.227E-01	0.108E 00	0.406E 00	0.532E 00	0.694E 00
9 OPLOADHP	0.135E 00/ 0.876E-01	0.134E-03	0.963E-03	0.203E-02	0.270E-01	0.260E 00	0.375E 00	0.742E 00
9 RIGGERS	0.135E 00/ 0.845E-01	0.268E-03	0.995E-03	0.179E-02	0.269E-01	0.252E 00	0.385E 00	0.670E 00
10 MOTOR-A	0.126E 00/ 0.189E 00	0.141E-01	0.310E-01	0.465E-01	0.153E 00	0.383E 00	0.467E 00	0.618E 00
11 RSCRANEI	0.115E 00/ 0.120E 00	0.129E-02	0.463E-02	0.751E-02	0.575E-01	0.332E 00	0.473E 00	0.656E 00
12 SCR-MPA	0.808E-01/ 0.881E-01	0.985E-03	0.346E-02	0.617E-02	0.430E-01	0.220E 00	0.342E 00	0.593E 00
12 GRPA	0.808E-01/ 0.981E-01	0.137E-02	0.355E-02	0.647E-02	0.488E 01	0.257E 00	0.366E 00	0.598E 00
13 HLFSTRCI	0.351E-01/ 0.469E-01	0.370E-03	0.140E-02	0.278E-02	0.190E-01	0.118E 00	0.190E 00	0.358E 00
14 TR-GRPA	0.126E-01/ 0.204E-01	0.144E-02	0.282E-02	0.402E-02	0.142E-01	0.443E-01	0.583E-01	0.106E 00
15 BRAKE2	0.688E-02/ 0.929E-02	0.969E-05	0.515E-04	0.103E-03	0.139E-02	0.209E-01	0.396E-01	0.109E 00

FIGURE 4-3: **Output of MONTE Continued**

MONTE CARLO SIMULATION RESULTS (1000 TRIALS)

INDEX OF SORTED VALUE			10	50	100	500	900	950	990
CONFIDENCE LEVEL IN PER CENT			(98)	(90)	(80)		(80)	(90)	(98)
PERCENTILE			1	5	10	50	90	95	99
RANK	MIN CUT SET	MEAN FROM IMPORTANCE/ COMPUTED MEAN							
1	70	0.135E 00/ 0.886E-01	0.269E-03	0.842E-03	0.181E-02	0.258E-01	0.260E 00	0.419E 00	0.770E 00
1	69	0.135E 00/ 0.873E-01	0.212E-03	0.992E-03	0.205E-02	0.267E-01	0.259E 00	0.403E 00	0.623E 00
2	3	0.115E 00/ 0.124E 00	0.141E-02	0.539E-02	0.939E-02	0.639E-01	0.318E 00	0.470E 00	0.710E 00
3	17	0.898E-01/ 0.815E-01	0.152E-02	0.492E-02	0.832E-02	0.564E-01	0.196E 00	0.237E 00	0.291E 00
3	18	0.898E-01/ 0.815E-01	0.152E-02	0.492E-02	0.832E-02	0.564E-01	0.196E 00	0.237E 00	0.291E 00
3	12	0.898E-01/ 0.815E-01	0.152E-02	0.492E-02	0.832E-02	0.564E-01	0.196E 00	0.237E 00	0.291E 00
4	7	0.421E-01/ 0.610E-01	0.482E-02	0.109E-01	0.153E-01	0.492E-01	0.122E 00	0.157E 00	0.199E 00
4	5	0.421E-01/ 0.610E-01	0.482E-02	0.109E-01	0.153E-01	0.492E-01	0.122E 00	0.157E 00	0.199E 00
4	10	0.421E-01/ 0.610E-01	0.482E-02	0.109E-01	0.153E-01	0.492E-01	0.122E 00	0.157E 00	0.199E 00
5	4	0.351E-01/ 0.452E-01	0.503E-03	0.126E-02	0.237E-02	0.179E-01	0.110E 00	0.171E 00	0.395E 00
6	15	0.269E-01/ 0.313E-01	0.384E-03	0.117E-02	0.221E-02	0.153E-01	0.836E-01	0.123E 00	0.200E 00
6	8	0.269E-01/ 0.313E-01	0.384E-03	0.117E-02	0.221E-02	0.153E-01	0.836E-01	0.123E 00	0.200E 00
6	13	0.269E-01/ 0.323E-01	0.498E-03	0.112E-02	0.195E-02	0.148E-01	0.890E-01	0.125E 00	0.217E 00
6	14	0.269E-01/ 0.323E-01	0.498E-03	0.112E-02	0.195E-02	0.148E-01	0.890E-01	0.125E 00	0.217E 00
6	11	0.269E-01/ 0.323E-01	0.498E-03	0.112E-02	0.195E-02	0.148E-01	0.890E-01	0.125E 00	0.217E 00
6	19	0.269E-01/ 0.313E-01	0.384E-03	0.117E-02	0.221E-02	0.153E-01	0.836E-01	0.123E 00	0.200E 00
7	9	0.421E-02/ 0.713E-02	0.447E-03	0.970E-03	0.148E-02	0.500E-02	0.159E-01	0.201E-01	0.352E-01
7	16	0.421E-02/ 0.713E-02	0.447E-03	0.970E-03	0.148E-02	0.500E-02	0.159E-01	0.201E-01	0.352E-01
7	6	0.421E-02/ 0.713E-02	0.447E-03	0.970E-03	0.148E-02	0.500E-02	0.159E-01	0.201E-01	0.352E-01
8	72	0.229E-02/ 0.303E-02	0.394E-05	0.128E-04	0.316E-04	0.492E-03	0.617E-02	0.157E-01	0.402E-01
8	67	0.229E-02/ 0.303E-02	0.394E-05	0.128E-04	0.316E-04	0.492E-03	0.617E-02	0.157E-01	0.402E-01
8	68	0.229E-02/ 0.303E-02	0.394E-05	0.128E-04	0.316E-04	0.492E-03	0.617E-02	0.157E-01	0.402E-01
9	71	0.849E-03/ 0.974E-03	0.207E-05	0.610E-05	0.127E-04	0.159E-03	0.218E-02	0.406E-02	0.121E-01
10	58	0.737E-03/ 0.117E-02	0.592E-05	0.187E-04	0.328E-04	0.294E-03	0.278E-02	0.502E-02	0.146E-01
11	2	0.405E-03/ 0.685E-03	0.471E-05	0.180E-04	0.301E-04	0.207E-03	0.140E-02	0.238E-02	0.676E-02