EG&G Idaho, Inc.

Report No. RE-A-78-241

Date: October, 1978

MASTER

# INTERNAL TECHNICAL REPORT



Title: AUTOMATED COMMON CAUSE ANALYSIS USING AUTOCC

Organization: Engineering Analysis Division
Reliability and Statistics Branch

Author: James R. Wilson

Checked By: DM Rasmuson

Approved By: [illegible]

[redacted]

---

## ABSTRACT

This is a user's manual for AUTOCC, a code which prepares common cause analysis input for COMCAN II. Basic events are automatically analyzed for common cause susceptibilities, and data about initiators is reformatted into generic cause common locations. AUTOCC is written in Fortran IV for the CDC 7600.

TABLE OF CONTENTS



FIGURES



TABLES

## ACKNOWLEDGMENTS

The support of F. X. Gavigan and J. H. Carlson of the US DOE was crucial to this work. R. J. Crump provided important analysis input and D. M. Rasmuson, constructive advice and editorial help.

# AUTOMATED COMMON CAUSE ANALYSIS USING AUTOCC

## I. INTRODUCTION

This report is a user's manual for AUTOCC, a code for automatic preparation of common cause analysis input to COMCAN II.[1] The reader is assumed to be a potential user of COMCAN II and familiar with COMCAN terminology. AUTOCC evolved during the common cause analysis of two systems: CRBRP[2] (Clinch River Breeder Reactor Plant) and PLBR[3] (Prototype Large Breeder Reactor).

The most time-consuming part of a common cause analysis - after the hardware fault tree or logic model is constructed - is the assignment of potential component dependencies and location effects.

A significant component dependency consists of two things:

(1) all the members of a system cut set have a common weakness (common susceptibilities), and

(2) an initiator (common cause) which exploits that common weakness can exist in the relevant area.

Special attention must be given to event chains where one component failure causes others. Treatment of event chains is discussed in Section II.

The location effects are represented by the initiator; each potential initiator in the system is analyzed to determine how far it spreads. Building structure - doors, walls, ventilation ducts, blowout panels, pipe sleeves - influences the spread of each initiator (for illustration, see Section II).

The computer code, AUTOCC, helps the analyst in two ways to prepare his input for a common cause analysis:

(1) Individual component weaknesses - "generic cause susceptibilities" - are assigned from a library which can be changed to reflect the analyst's insight.

(2) Location effects are accounted for by reformatting the analyst's input of initiators and rooms into "common locations".

Section II details the construction of the common locations. Section III describes the assignment of the generic cause susceptibilities based on the susceptibility library. Limitations to the analysis are described in Section IV.

## II. COMMON LOCATIONS

A common location is a group of areas which have a common environment, or are susceptible to a common initiator. A cut set must share a common cause and common location in order to be of concern. To build common locations, each potential initiator must be broken down into the constituent generic causes and affected rooms.

The analyst must examine each room for initiators generated by the environment or by the system components placed there. Then the surroundings are analyzed to see whether the walls, doors, shields, grates, etc., would prevent each initiator from propagating to adjoining spaces. This portion of the analysis is greatly aided by 3-D information.

Each initiator generates generic causes and room groups. For example, in Figure 1, fire has a high probability of occurring due to fuel oil stored in Room 203. The fire may then spread only to Room 205. Since the generic cause, oxidation, is caused by fire, one common location for oxidation contains Rooms 203 and 205.

The fire wall between Rooms 205 and 207 will stop a fire, but some heat can be conducted across the fire wall. Rooms 206 and 208 are separated far enough to avoid the heat and combustion of the fire. Thus, one high temperature common location consists of Rooms 203, 205, and 207.

Poisonous smoke from the fire cannot penetrate the fire wall, but can enter Rooms 206 and 208 through vents. Therefore, a biological hazards common location consists of Rooms 203, 205, 206, and 208. Any cut set, consisting of components requiring manual activation located within these four rooms, could fail if the fire occurred in Room 203.

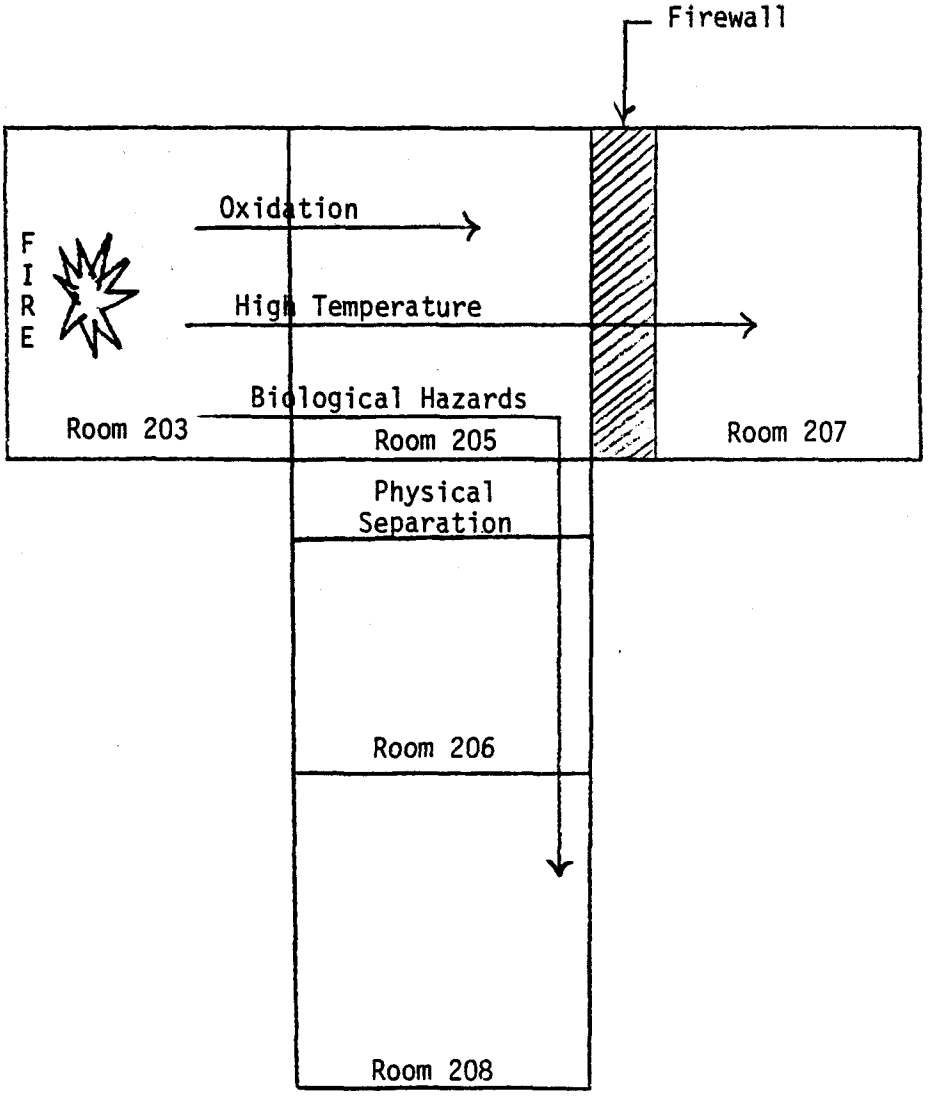


Fig. 1 Common locations generated by the fire initiator in room 203.

The format for gathering the data is presented in Figure 2. Columns 1 through 4 give the location of the initiator (left justified). Columns 6 through 23 list suggested initiators, with relevant generic cause code and category (Appendix A) in parenthesis. The analyst rates each room for potential generic causes, even if the suggested initiator is not present. For example, if maintenance men moving large equipment in a room can cause impact damage. the column under "missiles" can be marked.

The likelihood of severity of occurrence of the generic causes or initiators is ranked from 0 to 9, with 9 representing high frequency and severity. These numbers can be used to control the size of the common locations deck using the CUTOFF parameter in SUBROUTINE PUNCHS.

The effect of an initiator on adjoining rooms is recorded on the following cards with columns 1 through 4 blank. Columns 25 through 28 list adjoining rooms (left adjusted) which may be affected by the generic cause occurring in the room listed in columns 1 through 4 of the original initiator card. The numbers in that row represent the likelihood of occurrence and propagation to the room listed. In all cases, this number must be less than or equal to the number for the room of origin (columns 1 through 4 of the original initiator card).

If an initiator could occur in a room and produce other initiators, this was noted under the original initiator. For example, if a room contained a large open deck supporting heavy equipment, an earthquake may cause this to fall, causing additional damage. This would be represented by a larger number in the earthquake column.

When a component failure generates other component failures, special treatment is required. The best way to represent this event chain is to treat it with a common link code, such as "C1". Every event in that particular chain is labeled with a "C1" in Category IV. The next chain of events would be labeled with a "C2", etc. The level of sensitivity can be input, also, making a three-character code.

| Columns 1 - 4 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 25 - 28 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Initiator Location | Fire (R-3) | Flood (M-2) | Earthquake (I-1) | Steam (M-2, T-1) | High Temperature (T-1) | Pressure (P-1) | Humidity (O-3, M-2) | Freezing (F-1) | Missile (I-1) | Pipe Whip (I-1) | Wind (I-1) | Dust (G-1) | Radiation (R-2) | Corrosion (R-3) | Induced Voltage (E-2) | Vibration (V-1) | Solvent (A-3, M-2) | Biological Hazard (B-3) | Affected Location | Map Code |
| 454 | 4 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 4 | 0 | 0 | 1 | 0 | 1 | 9 | 4 | 1 | 4 | | |
| | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 451 | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 467 | |
| 445 | 3 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 3 | | |
| | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 431 | |

Fig. 2 Initiator data format.

The initiator and affected locations in the initiator deck do not contain a building or map code. The purpose of this code is to ensure unique identification of rooms from different buildings or area maps. If all rooms have unique four-character names, column 30 may be left blank, and the map code defaults to a blank.

In the CRBRP analysis,[2] common locations had to be structured from more than a thousand initiators for a hundred rooms. To reduce the volume of input data, only common locations formed by the more significant initiators were selected. The cutoff is set in SUBROUTINE PUNCHS. A cutoff of seven reduced the number of CRBRP common locations to about 100.

# III. GENERIC CAUSE SUSCEPTIBILITIES

The CRBRP system required susceptibility analysis of over 2000 basic events. To conserve analyst efforts a susceptibility library (Table I) was constructed. The library assigned generic cause susceptibilities and "levels" to each basic event, based on the type of component.

The "level" of a susceptibility represents the sensitivity of the component to that generic cause. These susceptibility numbers (0 to 9, with 9 being the most susceptible) allow the cost and thoroughness of the COMCAN II analysis to be adjusted. By using the LEVEL option in COMCAN II, basic events with susceptibility levels below the specified cutoff are eliminated, reducing the scope of the common cause analysis.

The susceptibility assignment was based on the second and third letters of the basic event name. In two cases - "OO" (operator) and "HO" (house event) - these letters did not represent actual components, so the library contains a blank line (Figure 3).

The last line in the library warns that the basic event component was not found in the library. The message, "*** Invalid Type. See Printout ***", is punched out on the basic event card, and additional warnings are placed in the printout. The processing of the basic events continues until all component types are processed. The analyst can then add new component types to the library and rerun the code, but the "invalid type" card must always be the last card in the library.

## 1. INPUT FORMAT

The susceptibility library is input to the code after the initiator deck. The library is preceded by a blank card and followed by an "END" (columns 1 through 3) card.

| | | | |
|---|---|---|---|
| AB | I5T6F4G1V3 | M9R1E1 | R9C6A3B2 |
| AT | I9T9G5V3 | M9R1 | R9C7B7 |
| AV | I8T8F2V2 | M6R1E2 | R9C2B5 |
| BC | I9T9G2V3 | M9R1E1 | R9C7B7 |
| BS | I9T9G5V8 | M9R3E2 | R9C7B6 |
| BY | I9T9F9G1V4 | M6R2E1 | R9C5A1B7 |
| CA | I9T4V5 | M4R3E6 | R9C4B9 |
| CB | I7T7G1V1 | M9 | R7C5A1B9 |
| CH | I9T8F1G1V3 | M9 | R9C6A3B9 |
| CL | I2T2G1V4 | M1R1 | R3B1 |
| CM | I8T9F1G1V5 | M9R2 | R9C6A4B9 |
| CN | I5T8F1G1V3 | M9 | R9C6A3 |
| CO | I5T8P1G1V1 | M9R1 | R7C8A5 |
| CP | I9T4V5 | M4R3 | R9C4B9 |
| CR | I6T8P5F3V3 | M8R1E1 | R9C8A3B1 |
| CS | I4T2F2V1 | M2 | R4B1 |
| CV | I4T2F1V1 | M1 | R4B1 |
| DL | I9T9F2G3V5 | M9R2E1 | R9C2A4B9 |
| DP | I7T9G1V3 | M9R1 | R9C7B7 |
| FE | I8T2V3 | M1R1 | R3A1 |
| FL | I1G4V1 | | R5B2 |
| FN | I8T9F1G1V5 | M9R2 | R9C6A4B7 |
| GC | I8T4F1V2 | M6R1E2 | R7C1B5 |
| HD | I8T9P7F3V7 | M9R3E4 | R9C8A4B3 |
| HE | I5T1V3 | | R1 |
| HN | I6T1V5 | M2 | R1 |
| HO | | | |
| IV | I9T9G2V3 | M9R1E1 | R9C7B7 |
| LC | I9T9G5V8 | M9R5E7 | R9C7B9 |
| LD | I9T9F2G3V5 | M9R2E1 | R9C2A4B9 |
| MN | I7T8F2G1V4 | M9R2 | R9C6A2B5 |
| MS | I8T9G4V1 | M9R3E3 | R9C5A1B9 |
| MV | I7T8F1G1V4 | M9R2 | R9C6A2B5 |
| NP | I6T1F1V1 | M4 | R1 |
| OC | | | |
| OT | I7T9G1V1 | M9R1 | R9C2A1B4 |
| PE | I5T9V2 | M9R2 | R9C6B1 |
| PM | I9T8F1G3V3 | M9R2 | R9C6A3B9 |
| PN | I9T8F2G3V3 | M9R2 | R9C6A3B9 |
| PP | I6T1V1 | | R1 |
| PT | I9T9F1G1V3 | M6R2E4 | R9C6A1B9 |
| RD | I6T2F2V5 | M1R1 | R2 |
| RN | I9T7F4G1V6 | M2R1 | R7B2 |
| RV | I9T7F2G1V6 | M1R1 | R7B2 |
| SD | I9T3V7 | M2 | R3A1 |
| SR | I6T2F3V5 | M4R1 | R2 |
| SV | I8T8F2V2 | M6R1E2 | R9C2B5 |
| SW | I9T9G5V3 | M9R1 | R9C7B9 |
| TK | I5T1V1 | | R1 |
| TN | I5T1F1V1 | M2 | R1 |
| TR | I8T9P2V2 | M9R3 | R9C9A5B2 |
| VS | I8T8F3V2 | M6R1E2 | R9C2B5 |
| VV | I8T8F2V2 | M6R1E2 | R9C2B7 |
| XN | I5T1F3V2 | M3 | R7B9 |
| XV | I5T1F2V2 | M1 | R7B9 |
| CC | | | |
| HO | | | |
| | ******** INVALID TYPE. SEE PRINTOUT ******** | | |
| ND | | | |

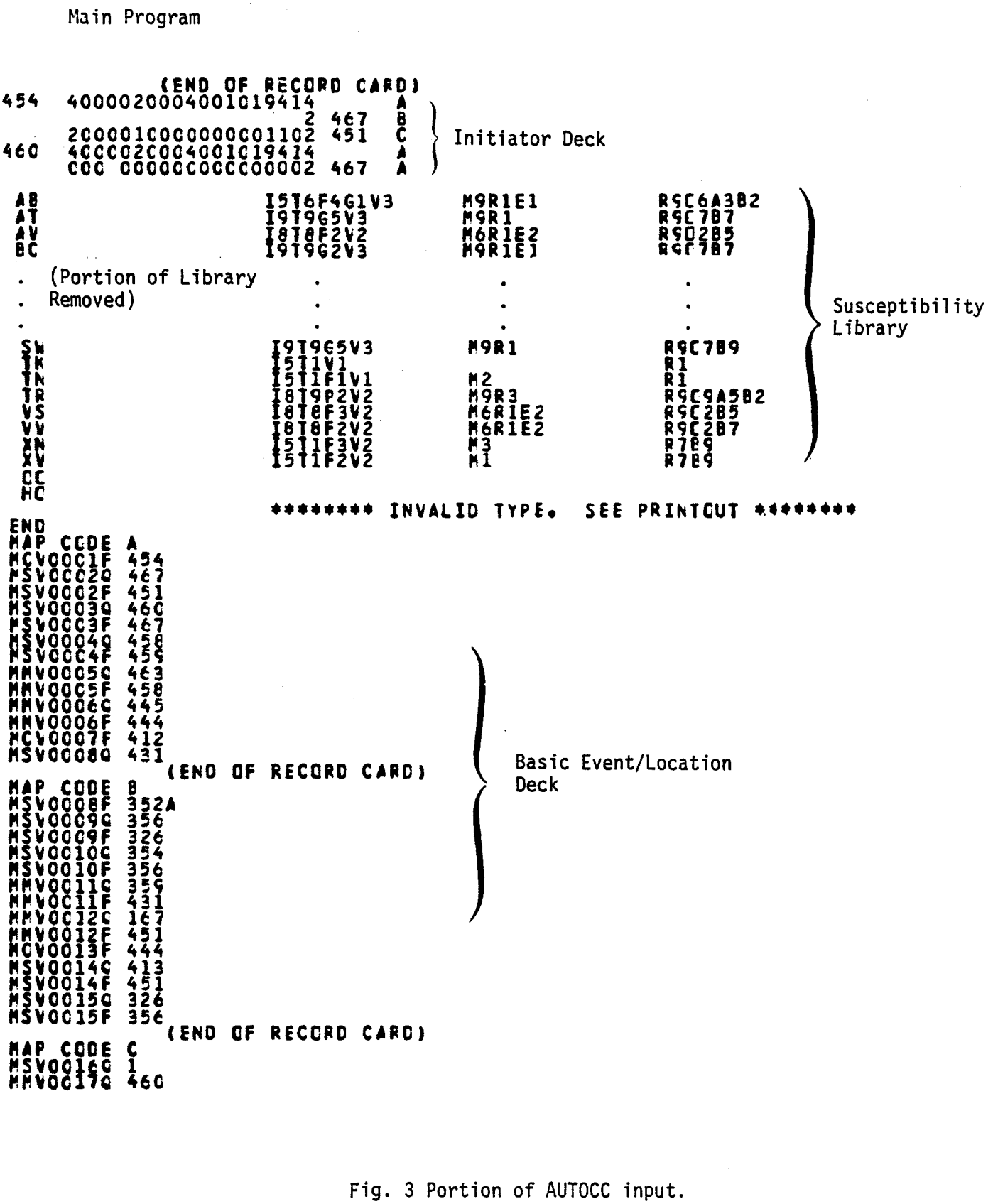


Fig. 3 Portion of AUTOCC input.

The component type occupies columns two and three. Category I susceptibilities and levels occupy columns 21 through 35; Category II, columns 36 through 50; and Category III, columns 51 through 65 (see Figure 3). Any Category IV susceptibilities should be on the individual basic event cards, since these susceptibilities are system dependent.

The basic event deck comes next, preceded by the "END" card and followed by an end-of-record card.

The basic event card contains the basic event (columns 1 through 8), component location (columns 10 through 13, left justified), and the Category IV common links (columns 66 through 80). These common links must be assigned individually to the basic events because they are system dependent and often failure mode dependent. For instance, a basic event involving operator error or maintenance has common links which the same component in an independent failure mode does not have. Each common link is represented by two characters, with a third character, the level of sensitivity, being optional.

The component location on the basic event card does not contain a building or map code. The purpose of this code is to distinguish between identically numbered rooms from different buildings or area maps. Each set of basic event cards must be preceded by the "MAP CODE X" card (columns 1 through 10, where "X" represents the building of map identifier), and followed by an end-of-record card. If all rooms have unique numbers, only one card is required at the head of the deck ("MAP CODE", columns 1 through 8). This agrees with the default value, from the initiator deck.

In summary, the user must supply the initiator deck (input deck #1), the basic event/location deck (input deck #3), and add any missing component cards to the susceptibility deck (input deck #2). The inputs are separated as follows:

(1) Main Program

(2) End-of-Record Card

(3) Initiator Deck

(4) Blank Card

(5) Susceptibility Library

(6) "Invalid Type" Card

(7) "END" Card

(8) "MAP CODE" Card

(9) Basic Event/Location Deck for the first Map Code

(10) Additional End-of-Record and "MAP CODE" Cards, along with corresponding Basic Event/Location Decks

(11) End-of-File Card

# IV. OUTPUT

AUTOCC punches out a basic event susceptibility deck and common locations deck in a format compatible with COMCAN II. The susceptibility deck contains the component location and Category I through IV susceptibilities and levels for each basic event.

The common locations deck lists each generic cause and the rooms affected. The size of this deck is controlled by the cutoff parameter in SUBROUTINE PUNCHS.

Figure 4 contains a sample output. Extra common location title cards should be removed before inputting the deck to COMCAN II, as indicated in the Figure.

```
 DOMAIN NUMBER     1
3-R
2-M
1-I   Delete
1-T
1-G
2-E
     1       A454
     4       A46C
1-V
3-A   Delete
3-B
MCV00001F  A454        I4T2F1V1          M1                R4B1
MSV00002C  A467        I8T8F2V2          M6R1E2            R9C2B5
MSV00002F  A451        I8T8F2V2          M6R1E2            R9C2B5
MSV00003C  A460        I8T8F2V2          M6R1E2            R9C2B5
MSV00003F  A467        I8T8F2V2          M6R1E2            R9C2B5
MSV00004C  A458        I8T8F2V2          M6R1E2            R9C2B5
MSV00004F  A459        I8T8F2V2          M6R1E2            R9C2B5
MMV00005C  A463        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00005F  A458        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00006C  A445        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00006F  A444        I7T8F1G1V4        M9R2              R9C6A2B5
MCV00007F  A412        I4T2F1V1          M1                R4B1
MSV00008C  A431        I8T8F2V2          M6R1E2            R9C2B5
MSV00008F  B352A       I8T8F2V2          M6R1E2            R9C2B5
MSV00009C  B356        I8T8F2V2          M6R1E2            R9C2B5
MSV00009F  B326        I8T8F2V2          M6R1E2            R9C2B5
MSV00010C  B354        I8T8F2V2          M6R1E2            R9C2B5
MSV00010F  B356        I8T8F2V2          M6R1E2            R9C2B5
MMV00011C  B359        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00011F  B431        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00012C  B167        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00012F  B451        I7T8F1G1V4        M9R2              R9C6A2B5
MCV00013F  B444        I4T2F1V1          M1                R4B1
MSV00014C  B413        I8T8F2V2          M6R1E2            R9C2B5
MSV00014F  B451        I8T8F2V2          M6R1E2            R9C2B5
MSV00015C  B326        I8T8F2V2          M6R1E2            R9C2B5
MSV00015F  B356        I8T8F2V2          M6R1E2            R9C2B5
MSV00016C  C1          I8T8F2V2          M6R1E2            R9C2B5
MMV00017C  C460        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00017F  C356        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00018C  C359        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00018F  C431        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00019C  C413        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00019F  C412        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00020C  C445        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00020F  C444        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00021C  C356        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00021F  C431        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00021X  C356        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00022C  C356        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00022F  C467        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00023C  C451        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00023F  C454        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00061C  C412        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00061F  C454        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00061X  C454        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00024C  C431        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00024F  C456        I7T8F1G1V4        M9R2              R9C6A2B5
MXV00025C  C467        I5T1F2V2          M1                R7B9
MXV00025F  C359        I5T1F2V2          M1                R7B9
MPM00001S  C358        I9T8F1G3V3        M9R2              R9C6A3B9
MPM00001F  C356        I9T8F1G3V3        M9R2              R9C6A3B9
MMV00026C  C467        I7T8F1G1V4        M9R2              R9C6A2B5
MMV00026F  C451        I7T8F1G1V4        M9R2              R9C6A2B5
MXV00027C  C460        I5T1F2V2          M1                R7B9
MXV00027F  C431        I5T1F2V2          M1                R7B9
```

Fig. 4 Sample output.

# V. LIMITATIONS TO THE ANALYSIS

A limited level of information can pose a problem in the common cause analysis. If component locations are unknown, the basic event card is input without a location. Similar parts and Category IV common links can still be analyzed, although any cut set with this basic event will be excluded from Category I through III analyses because the unknown location is not represented in any common location. This results in an incomplete analysis. If a majority of the locations are unknown, no location data should be input; this produces overconservative results which the analyst can examine further.

Often, administrative procedures and design are not finalized, making the common links analysis very general. For instance, basic events involving maintenance error may have to be lumped under one general maintenance common link rather than maintenance type or individual maintenance area common links. This will increase computer time, so a more detailed analysis should be done as soon as possible.

## VI. REFERENCES


1. D. M. Rasmuson, et al, COMCAN - A Computer Program for Common Cause Failure Analysis, TREE-1289, EG&G Idaho, Inc., September 1978.
2. J. R. Wilson and D. M. Rasmuson, "Automated Common Cause Analysis of the Clinch River Breeder Reactor", RE-A-78-231, EG&G Idaho, Inc., September 1978.
3. J. R. Wilson and D. M. Rasmuson, "Optimization and Common Cause Analysis of a Prototype Large Breeder Reactor Shutdown Heat Removal System", RE-A-78-226, EG&G Idaho, Inc., September 1978.

# APPENDIX A

# GENERIC CAUSE TABLES

# APPENDIX A

## GENERIC CAUSE TABLES

The following generic cause and codes were used in the CRBRP analysis to represent the basic event susceptibilities and initiator data. Tables A-I through A-III are abbreviated from the COMCAN II report.[A-1]

### TABLE A-I

### CATEGORY I: GENERIC CAUSES OF A MECHANICAL OR THERMAL NATURE

| Symbol | Generic Cause |
|---|---|
| I | Impact |
| V | Vibration |
| P | Pressure |
| G | Grit |
| T | Temperature |
| F | Freezing |

TABLE A-II

CATEGORY II: GENERIC CAUSES OF AN ELECTRICAL OR RADIATION NATURE

| Symbol | Generic Cause |
|---|---|
| E | Electromagnetic Interference (EMI) |
| R | Radiation |
| M | Conducting Medium |

TABLE A-III

CATEGORY III: GENERIC CAUSES OF A CHEMICAL OR MISCELLANEOUS NATURE

| Symbol | Generic Cause |
|---|---|
| A | Corrosion (Acid) |
| O | Corrosion (Oxidation) |
| R | Other Chemical Reactions |
| B | Biological Hazards |

TABLE A-IV

COMMON LINKS RESULTING IN DEPENDENCIES AMONG COMPONENTS

| Symbol | Common Link | Example Situations |
|---|---|---|
| E | Energy source | Common drive shaft, same power supply. |
| C | Calibration | Misprinted calibration instructions. |
| I | Installations contractor | Same subcontractor or crew. |
| M | Maintenance | Incorrect procedure, inadequately trained person. |
| O | Operator or operation | Operator disabled or overstressed, faulty operating procedures. |
| P | Proximity | Location of all components of a cut set in one cabinet (common location exposes all of the components to many unspecified common causes). |
| T | Test procedure | Faulty test procedures which may affect all components normally tested together. |
| N | Energy flow paths | Location in same hydraulic loop, location in same electrical circuit. |

The common links of Table A-IV receive special treatment in an analysis because they incorporate location and are system dependent. Common causes from the first three categories require the generic cause and the common location; common causes from Category IV require no separate common location check. The analysis with the first three categories depends upon component design; the analysis with Category IV depends upon system design and administrative procedures.

## REFERENCE

A-1. D. M. Rasmuson, et. al., COMCAN - A Computer Program for Common Cause Failure Analysis, TREE-1289, EG&G Idaho, Inc., September 1978.

# APPENDIX B

# COMPONENT-TYPE CODES

# APPENDIX B

## COMPONENT-TYPE CODES

These codes represented the component type for each basic event, and are used in the susceptibility library.

TABLE B-I

SUMMARY OF COMPONENT CODES

| Code | Component |
|---|---|
| AT | Auto Transfer Switch |
| AV | Pneumatic Valve |
| BC | Battery Charger |
| BS | Motor Control Center |
| BY | Battery Bank |
| CA | Instrument Cable |
| CB | Circuit Breaker |
| CH | Chiller |
| CL | Clutch |
| CN | Condenser |
| CO | Connector |
| CP | Condensate Polishing System |
| CR | Cooler |
| CV | Check Valve |
| DL | Diesel |
| CP | Distribution Panel |
| FE | Flow Element |
| FL | Screen |
| FN | Fan |
| GC | Governor Valve Controller |
| HD | Leak Detector |
| HE | Heat Exchanger |

TABLE B-I

SUMMARY OF COMPONENT CODES

(Continued)

| Code | Component |
|---|---|
| HO | HOUSE Event |
| IV | Inverter |
| LC | Logic |
| MS | Motor Starter |
| MV | Motor Operated Valve |
| OO | Operator |
| PM | Pump |
| PP | Pipe |
| PT | Turbine Driven Pump |
| RD | Rupture Disc |
| RV | Relief Valve |
| SD | Steam Drum |
| SV | Solenoid Valve |
| SW | Switch, Hand |
| TK | Tank |
| TR | Power Transformer |
| VV | Valve System |
| XV | Manual Valve |

# APPENDIX C

# ANALYSIS ASSUMPTIONS

# APPENDIX C

## ANALYSIS ASSUMPTIONS

The following assumptions were made in the analysis of CRBRP and may be helpful to analysts of other systems:

(1) The occurrence rate and severity for each initiator was represented on a scale from 0 to 9, with 9 being the highest rate and severity.

(2) The effect of earthquake can be mitigated by engineered safeguards, or amplified by heavy objects toppled, or rotating equipment damaged, by the quake. Therefore, one contributor to the generic cause, impact, is a function of earthquake frequency. This function is represented by a multiplicative factor from 0 to 9. Earthquake frequency is represented in Subroutine TRNSLT by a number from 0.1 to 1.0. These numbers are relative; they are not probabilities. A sample calculation for the effect of impact in a given location is

IMPACT (EARTHQUAKE) = LOCATION FACTOR * EARTHQUAKE FREQUENCY

= 3.0 * 1.0 = 3

where the location factor equals 3 due to the possibility of increased earthquake damage from support failure under the heavy equipment stored in this location. Then this impact number is combined with the impact numbers from other initiators.

(3) All firedoors are assumed to cut in half the effect of initiators upon adjoining rooms. Two firedoors in series were assumed to isolate the areas on either side. The reasoning was that one firedoor may be left ajar or fail, but the likelihood of two unsecured firedoors was assumed to be negligible.

(4) Argon inerted cells cut frequency of fire by half. This is because the cell may be de-inerted when the fire occurs.

(5) Catch pans cut fire frequency by half.

(6) The dust initiator is represented by a "1" in non-inert cells, a "0" in inert cells, and a high number between 5 and 9 around fans and air handling units.

(7) Conditional events (e.g. "given that one loop is unavailable, loop 1 is that loop") have no impact on the qualitative common cause analysis and are therefore not considered in the analysis.