



400 Commonwealth Drive, Warrendale, PA 15096-0001

# SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

SAE J1739

Issued 1994-07

## POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS IN DESIGN (DESIGN FMEA) AND POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS IN MANUFACTURING AND ASSEMBLY PROCESSES (PROCESS FMEA) REFERENCE MANUAL

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**1. General Information**

- 1.1 Overview**—This SAE Recommended Practice was jointly developed by Chrysler, Ford, and General Motors under the sponsorship of the United States Council for Automotive Research (USCAR).

This document introduces the topic of potential Failure Mode and Effects Analysis (FMEA) and gives general guidance in the application of the technique. An FMEA can be described as a systemized group of activities intended to: (a) recognize and evaluate the potential failure of a product/process and its effects, (b) identify actions which could eliminate or reduce the chance of the potential failure occurring, and (c) document the process. It is complementary to the design process of defining positively what a design must do to satisfy the customer.

- 1.2 History**—Although engineers have always performed an FMEA type of analysis on their designs and manufacturing processes, the first formal application of the FMEA discipline was an innovation of the aerospace industry in the mid-1960s.
- 1.3 Manual Format**—For ease of use, this reference manual retains the presentation of the FMEA preparation instructions in two distinct sections (design and process). However, having both sections in the same manual facilitates the comparison of techniques used to develop the different types of FMEAs, as a means to more clearly demonstrate their proper application and interrelation.
- 1.4 FMEA Implementation**—Because of a company's commitment to continually improve its products whenever possible, the need for using the FMEA as a disciplined technique to identify and help eliminate potential concern is as important as ever. Studies of vehicle campaigns have shown that a fully implemented FMEA program could have prevented many of the campaigns.

Although responsibility for the "preparation" of the FMEA must, of necessity, be assigned to an individual, FMEA input should be a team effort. A team of knowledgeable individuals should be assembled: e.g., engineers with expertise in Design, Manufacturing, Assembly, Service, Quality, and Reliability.

One of the most important factors for the successful implementation of an FMEA program is timeliness. It is meant to be a "before-the-event" action, not an "after-the-fact" exercise. To achieve the greatest value, the FMEA must be done before a design or process failure mode has been unknowingly designed into the product. Up front time spent in doing a comprehensive FMEA well, when product/process changes can be most easily and inexpensively implemented, will alleviate late change crises. An FMEA can reduce or eliminate the chance of implementing a corrective change which would create an even larger concern. Properly applied, it is an interactive process which is never ending.

- 2. References**—There are no referenced publications specified herein.

**3. Potential Failure Mode and Effects Analysis in Design (Design FMEA)**

- 3.1 Introduction**—A Design potential FMEA is an analytical technique utilized primarily by a Design Responsible Engineer/Team as a means to assure that, to the extent possible, potential failure modes and their associated causes/mechanisms have been considered and addressed. End items, along with every related system, subassembly and component, should be evaluated. In its most rigorous form, an FMEA is a summary of an engineer's and the team's thoughts (including an analysis of items that could go wrong based on experience and past concerns) as a component, subsystem, or system is designed. This systematic approach parallels, formalizes, and documents the mental disciplines that an engineer normally goes through in any design process.

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The Design potential FMEA supports the design process in reducing the risk of failures by:

- a. Aiding in the objective evaluation of design requirements and design alternatives.
- b. Aiding in the initial design for manufacturing and assembly requirements.
- c. Increasing the probability that potential failure modes and their effects on system and vehicle operation have been considered in the design/development process.
- d. Providing additional information to aid in the planning of thorough and efficient design, test, and development programs.
- e. Developing a list of potential failure modes ranked according to their effect on the "customer," thus establishing a priority system for design improvements and development testing.
- f. Providing an open issue format for recommending and tracking risk reducing actions.
- g. Providing future reference to aid in analyzing field concerns, evaluating design changes and developing advanced designs.

3.1.1 CUSTOMER DEFINED—The definition of "CUSTOMER" for a Design potential FMEA is not only the "END USER," but also the design responsible engineers/teams of the vehicle or higher level assemblies, and/or the manufacturing process responsible engineers in activities such as Manufacturing, Assembly, and Service.

When fully implemented, the FMEA discipline requires a Design FMEA for all new parts, changed parts, and carryover parts in new applications or environments. It is initiated by an engineer from the responsible design activity, which for a proprietary design may be the supplier.

3.1.2 TEAM EFFORT—During the initial Design potential FMEA process, the responsible engineer is expected to directly and actively involve representatives from all affected areas. These areas should include, but are not limited to: assembly, manufacturing, materials, quality, service, and suppliers, as well as the design area responsible for the next assembly. The FMEA should be a catalyst to stimulate the interchange of ideas between the functions affected and thus promote a team approach. In addition, for any (internal/external) supplier designed items, the responsible design engineer should be consulted.

The Design FMEA is a living document and should be initiated before or at design concept finalization, be continually updated as changes occur or additional information is obtained throughout the phases of product development, and be fundamentally completed before the production drawings are released for tooling.

Considering that manufacturing/assembly needs have been incorporated, the Design FMEA addresses the design intent and assumes the design will be manufactured/assembled to this intent. Potential failure modes and/or causes/mechanisms which can occur during the manufacturing or assembly process need not, but may be included in a Design FMEA. When not included, their identification, effect and control are covered by the Process FMEA.

The Design FMEA does not rely on process controls to overcome potential weaknesses in the design, but it does take the technical/physical limits of a manufacturing/assembly process into consideration, e.g.:

- a. Necessary mold drafts
- b. Limited surface finish
- c. Assembling space/access for tooling
- d. Limited hardenability of steels
- e. Process capability/performance

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System \_\_\_\_\_  
 Subsystem \_\_\_\_\_  
 Component 91.03/Body Closure (2)  
 Model Year(s)/Vehicle(s) 1993/1.0L 4dr/Hatchback (5)  
 Core Team I. Fender - Car Product Dev., C. Chidley - Manufacturing, J. Ford - Assy Ops (Quality, Process, Header Assembly Plants) (8)

FMEA Number 1224 (1)  
 Page 1 of 1  
 Prepared by A. Taha - X 6412 - BODY ENGR (4)  
 FMEA Date (Orig.) 03 03 92 (Rev.) 03 07 94 (7)

Design Responsibility Body Engineering (3)  
 Key Date 03 03 91 ER (6)

POTENTIAL  
 FAILURE MODE AND EFFECTS ANALYSIS  
 (DESIGN FMEA)

| Item<br>Function<br>(9)                                                                                                                                                                               | Potential<br>Failure<br>Mode<br>(10)   | Potential<br>Effect(s) of<br>Failure<br>(11)                                                                                                                          | C<br>I<br>S<br>R<br>S | O<br>C<br>U<br>R | D<br>T<br>C<br>P<br>N | R.<br>P.<br>N. | ←(15)<br>Current<br>Design<br>Controls<br>(16)                         | ←(18)<br>Recommended<br>Action(s)<br>(19)                                                                           | Responsibility<br>& Target<br>Completion Date<br>(20)                                    | Action Results                                                                                                                                            |        |        |                | (22) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------|-----------------------|----------------|------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|----------------|------|
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                       |                  |                       |                |                                                                        |                                                                                                                     |                                                                                          | S<br>v                                                                                                                                                    | O<br>c | D<br>t | R.<br>P.<br>N. |      |
| Front door L.H.<br>HBX-0000-A                                                                                                                                                                         | Corroded interior<br>lower door panels | Deteriorated life of door<br>leading to:<br>■ Unsatisfactory<br>appearance due to rust<br>through paint over time<br>■ Impaired function of<br>interior door hardware | 7                     | 6                | 7                     | 294            | Vehicle general durability<br>test veh.<br>T-109<br>T-301              | Add laboratory<br>accelerated<br>corrosion testing                                                                  | A. Taha-Body<br>Engg<br>03 09 90                                                         | Based on test<br>results (Test No.<br>1481) upper<br>edge spec raised<br>125 mm                                                                           | 7      | 2      | 2              | 28   |
| ■ Ingress to and<br>egress from<br>vehicle<br>■ Occupant<br>protection<br>from weather,<br>noise, and<br>side impact                                                                                  |                                        |                                                                                                                                                                       |                       | 4                | 7                     | 196            | Vehicle general durability<br>testing - as above                       | Add laboratory<br>accelerated<br>corrosion testing<br>Conduct Design<br>of Experiments<br>(DOE) on wax<br>thickness | Combine wheel<br>for wax upper<br>edge verification<br>A. Taha-<br>Body Engg<br>03 01 15 | Test results<br>(Test No. 1481)<br>show specified<br>thickness is<br>adequate<br>DOE shows 25%<br>variation in<br>specified<br>thickness is<br>acceptable | 7      | 2      | 2              | 28   |
| ■ Support<br>anchorage for<br>door hardware<br>including<br>mirror,<br>hinges, latch<br>and window<br>regulator<br>■ Provide proper<br>surface for<br>appearance<br>items<br>- paint and<br>soft trim |                                        |                                                                                                                                                                       |                       | 2                | 2                     | 28             | Physical and Chem Lab<br>test - Report No. 1265                        | None                                                                                                                |                                                                                          |                                                                                                                                                           |        |        |                |      |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                       | 5                | 8                     | 290            | Design aid investigation<br>with nonfunctioning<br>spray head          | Add team<br>evaluation<br>using production<br>spray equipment<br>and specified<br>wax                               | Body Engg &<br>Assy Ops<br>03 11 15                                                      | Based on test, 3<br>additional vent<br>holes will be<br>provided in<br>affected areas                                                                     | 7      | 1      | 3              | 21   |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                       | 3                | 1                     | 21             | Laboratory test using<br>"worst case" wax<br>application and hole size | None                                                                                                                |                                                                                          |                                                                                                                                                           |        |        |                |      |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                       | 4                | 4                     | 112            | Drawing evaluation of<br>spray head access                             | Add team<br>evaluation<br>using design aid<br>buck and spray<br>head                                                | Body Engg &<br>Assy Ops<br>03 09 15                                                      | Evaluation<br>showed<br>adequate access                                                                                                                   | 7      | 1      | 1              | 7    |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                       |                  |                       |                | <b>SAMPLE</b>                                                          |                                                                                                                     |                                                                                          |                                                                                                                                                           |        |        |                |      |

FIGURE 1—DESIGN FMEA FORM

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**3.2 Development of a Design FMEA**—The design responsible engineer has at his or her disposal a number of documents that will be useful in preparing the Design potential FMEA. The process begins by developing a listing of what the design is expected to do, and what it is expected not to do, i.e., the design intent. Customer wants and needs, as may be determined from sources such as Quality Function Deployment (QFD), Vehicle Requirements Documents, known product requirements and/or manufacturing/assembly requirements should be incorporated. The better the definition of the desired characteristics, the easier it is to identify potential failure modes for corrective action.

A Design FMEA should begin with a block diagram for the system, subsystem, and/or component being analyzed. An example block diagram is shown in Appendix A. The block diagram can also indicate the flow of information, energy, force, fluid, etc. The object is to understand the deliverables (input) to the block, the process (function) performed in the block, and the deliverables (output) from the block.

The diagram illustrates the primary relationship between the items covered in the analysis and establishes a logical order to the analysis. Copies of the diagrams used in FMEA preparation should accompany the FMEA.

In order to facilitate documentation of the analysis of potential failures and their consequences, a form has been designed and is in Appendix F. (See Figure F1.)

Application of the form is described as follows: Points are numbered according to the numbers encircled on the reference Figures. An example of a completed form is contained in Appendix B. (See Figure B1.)

**3.2.1 (1) FMEA NUMBER**—Enter the FMEA document number, which may be used for tracking. (See Figure 1.)

**3.2.2 (2) SYSTEM, SUBSYSTEM, OR COMPONENT NAME AND NUMBER**—Indicate the appropriate level of analysis and enter the name and number of the system, subsystem, or component being analyzed. (See Figure 1.)

**3.2.3 (3) DESIGN RESPONSIBILITY**—Enter the OEM, department, and group. Also include the supplier name if known. (See Figure 1.)

**3.2.4 (4) PREPARED BY**—Enter the name, telephone number, and company of the engineer responsible for preparing the FMEA. (See Figure 1.)

**3.2.5 (5) MODEL YEAR(S)/VEHICLE(S)**—Enter the intended model year(s) and vehicle line(s) that will utilize and/or be affected by the design being analyzed (if known). (See Figure 1.)

**3.2.6 (6) KEY DATE**—Enter the initial FMEA due date, which should not exceed the scheduled production design release date. (See Figure 1.)

**3.2.7 (7) FMEA DATE**—Enter the date the original FMEA was compiled, and the latest revision date. (See Figure 1.)

**3.2.8 (8) CORE TEAM**—List the names of the responsible individuals and departments which have the authority to identify and/or perform tasks. (It is recommended that all team members names, departments, telephone numbers, addresses, etc., be included on a distribution list.) (See Figure 1.)

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**POTENTIAL  
FAILURE MODE AND EFFECTS ANALYSIS  
(DESIGN FMEA)**

System \_\_\_\_\_ FMEA Number 1234 \_\_\_\_\_ of 1 \_\_\_\_\_ (1)  
 Subsystem \_\_\_\_\_ Page 1 \_\_\_\_\_  
 Component 01.03/Body Closures \_\_\_\_\_ (2) Design Responsibility Body Engineering \_\_\_\_\_ (3) Prepared by A. Tate - X 6412 - Body Eng \_\_\_\_\_ (4)  
 Model Year(s)/Vehicle(s) 199X/Lon 4dr/Wagon \_\_\_\_\_ (5) Key Date 9X 03 01 ER \_\_\_\_\_ (6) FMEA Date (Orig.) 8X 03 22 \_\_\_\_\_ (Rev.) 8X 07 14 \_\_\_\_\_ (7)  
 Core Team T. Fender - Car Product Dev., C. Chittors - Manufacturing, J. Ford - Assy Ops (Daiton, Fraser, Henley Assembly Plants) \_\_\_\_\_ (8)

| Step<br>(1)                                                                                                                                                                                                      | Function<br>(2)                | Potential<br>Failure<br>Mode<br>(3)    | Potential<br>Effect(s) of<br>Failure<br>(4)                                                                                                                         | (12)→                                                        | C<br>I<br>S<br>V<br>S<br>(5)               | O<br>C<br>U<br>R<br>R<br>E<br>N<br>C<br>Y<br>(6) | ←(13) Potential<br>Cause(s)/<br>Mechanism(s)<br>of Failure<br>(14)                           | (17)→<br>Current<br>Design<br>Controls<br>(16)                         | D<br>e<br>t<br>e<br>r<br>m<br>i<br>n<br>e<br>d<br>C<br>o<br>n<br>t<br>r<br>o<br>l<br>s<br>(18) | ←(19)<br>Recommended<br>Action(s)<br>(19)                                                                               | Responsibility<br>& Target<br>Completion Date<br>(20)                                        | Action Results                                                                                                                                                |                                              |                                                        |                                                                  |    |  |  |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|--------------------------------------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|--------------------------------------------------------|------------------------------------------------------------------|----|--|--|--|
|                                                                                                                                                                                                                  |                                |                                        |                                                                                                                                                                     |                                                              |                                            |                                                  |                                                                                              |                                                                        |                                                                                                |                                                                                                                         |                                                                                              | Actions<br>Taken<br>(21)                                                                                                                                      | S<br>e<br>v<br>e<br>r<br>i<br>t<br>y<br>(22) | O<br>c<br>c<br>u<br>r<br>r<br>e<br>n<br>c<br>y<br>(23) | D<br>i<br>s<br>t<br>r<br>i<br>b<br>u<br>t<br>i<br>o<br>n<br>(24) |    |  |  |  |
| ■ Ingress to and<br>egress from<br>vehicle<br>■ Occupant<br>protection<br>from weather,<br>noise, and<br>side impact                                                                                             | Front door L.H.<br>H81X-0000-A | Corroded interior<br>lower door panels | Deteriorated life of door<br>leading to:<br>■ Unacceptable<br>appearance due to rust<br>through paint over time<br>■ Impaired function of<br>interior door hardware | (13)→                                                        | 7                                          | 6                                                | Upper edge of protective<br>wax application specified<br>for inner door panels is<br>too low | Vehicle general durability<br>test veh.<br>T-118<br>T-109<br>T-301     | 294                                                                                            | Add laboratory<br>accelerated<br>corrosion testing                                                                      | A Tate-Body<br>Engng<br>8X 09 30                                                             | Based on test<br>results (Test No.<br>1481) upper<br>edge spec raised<br>125 mm                                                                               | 7                                            | 2                                                      | 2                                                                | 28 |  |  |  |
|                                                                                                                                                                                                                  |                                |                                        |                                                                                                                                                                     |                                                              | 4                                          | 4                                                | Insufficient wax thickness<br>specified                                                      | Vehicle general durability<br>testing - as above                       | 198                                                                                            | Add laboratory<br>accelerated<br>corrosion testing<br><br>Conduct Design<br>of Experiments<br>(DOE) on wax<br>thickness | Combine wheel<br>for wax upper<br>edge verification<br><br>A Tate-<br>Body Engng<br>8X 01 15 | Test results<br>(Test No. 1481)<br>show specified<br>thickness is<br>adequate<br><br>DOE shows 25%<br>variation in<br>specified<br>thickness is<br>acceptable | 7                                            | 2                                                      | 2                                                                | 28 |  |  |  |
|                                                                                                                                                                                                                  |                                |                                        |                                                                                                                                                                     |                                                              | 2                                          | 2                                                | Inappropriate wax<br>formulation specified                                                   | Physical and Chem Lab<br>test - Report No. 1265                        | 28                                                                                             | None                                                                                                                    |                                                                                              |                                                                                                                                                               |                                              |                                                        |                                                                  |    |  |  |  |
|                                                                                                                                                                                                                  |                                |                                        |                                                                                                                                                                     |                                                              | 5                                          | 5                                                | Entrapped air prevents<br>wax from entering<br>corner/edge access                            | Design aid investigation<br>with nonfunctioning<br>spray head          | 280                                                                                            | Add team<br>evaluation<br>using production<br>spray equipment<br>and specified<br>wax                                   | Body Engng &<br>Assy Ops<br>8X 11 15                                                         | Based on test, 3<br>additional vent<br>holes will be<br>provided in<br>affected areas                                                                         | 7                                            | 1                                                      | 3                                                                | 21 |  |  |  |
| ■ Support<br>anchorage for<br>door hardware<br>including<br>locking<br>latch,<br>hinges, latch<br>and window<br>regulator<br>■ Provide proper<br>surface for<br>appearance<br>flares<br>■ Paint and<br>soft trim |                                |                                        |                                                                                                                                                                     |                                                              |                                            | 3                                                | Wax application plugs<br>door drain holes                                                    | Laboratory test using<br>"worst case" wax<br>application and hole size | 1                                                                                              | 21                                                                                                                      | None                                                                                         |                                                                                                                                                               |                                              |                                                        |                                                                  |    |  |  |  |
|                                                                                                                                                                                                                  |                                | 4                                      | 4                                                                                                                                                                   | Insufficient room between<br>panels for spray head<br>access | Drawing evaluation of<br>spray head access | 112                                              | Add team<br>evaluation<br>using design aid<br>buck and spray<br>head                         | Body Engng &<br>Assy Ops<br>8X 09 15                                   | Evaluation<br>showed<br>adequate access                                                        | 7                                                                                                                       | 1                                                                                            | 1                                                                                                                                                             | 7                                            |                                                        |                                                                  |    |  |  |  |
|                                                                                                                                                                                                                  |                                |                                        |                                                                                                                                                                     |                                                              |                                            |                                                  |                                                                                              |                                                                        |                                                                                                |                                                                                                                         |                                                                                              |                                                                                                                                                               |                                              |                                                        |                                                                  |    |  |  |  |

FIGURE 2—DESIGN FMEA FORM

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3.2.9 (9) ITEM/FUNCTION—Enter the name and number of the item being analyzed. Use the nomenclature and show the design level as indicated on the engineering drawing. Prior to initial release, experimental numbers should be used. (See Figure 2.)

Enter, as concisely as possible, the function of the item being analyzed to meet the design intent. Include information regarding the environment in which this system operates (e.g., define temperature, pressure, humidity ranges). If the item has more than one function with different potential modes of failure, list all the functions separately.

3.2.10 (10) POTENTIAL FAILURE MODE—Potential Failure Mode is defined as the manner in which a component, subsystem, or system could potentially fail to meet the design intent. The potential failure mode may also be the cause of a potential failure mode in a higher level subsystem, or system, or be the effect of one in a lower level component. (See Figure 2.)

List each potential failure mode for the particular item and item function. The assumption is made that the failure could occur, but may not necessarily occur. A recommended starting point is a review of past things-gone-wrong, concerns, reports, and group brainstorming.

Potential failure modes that could only occur under certain operating conditions (i.e., hot, cold, dry, dusty, etc.) and under certain usage conditions (i.e., above average mileage, rough terrain, only city driving, etc.) should be considered.

Typical failure modes could be, but are not limited to:

|          |                              |
|----------|------------------------------|
| Cracked  | Sticking                     |
| Deformed | Short circuited (electrical) |
| Loosened | Oxidized                     |
| Leaking  | Fractured                    |

NOTE—Potential failure modes should be described in "physical" or technical terms, not as a symptom noticeable by the customer.

3.2.11 (11) POTENTIAL EFFECT(S) OF FAILURE—Potential Effects of Failure are defined as the effects of the failure mode on the function, as perceived by the customer. (See Figure 2.)

Describe the effects of the failure in terms of what the customer might notice or experience, remembering that the customer may be an internal customer as well as the ultimate end user. State clearly if the function could impact safety or noncompliance to regulations. The effects should always be stated in terms of the specific system, subsystem, or component being analyzed. Remember that a hierarchical relationship exists between the component, subsystem, and system levels. For example, a part could fracture, which may cause the assembly to vibrate, resulting in an intermittent system operation. The intermittent system operation could cause performance to degrade, and ultimately lead to customer dissatisfaction. The intent is to forecast the failure effects to the Team's level of knowledge.

Typical failure effects could be, but are not limited to:

|                        |                    |
|------------------------|--------------------|
| Noise                  | Rough              |
| Erratic Operation      | Inoperative        |
| Poor Appearance        | Unpleasant Odor    |
| Unstable               | Operation Impaired |
| Intermittent Operation |                    |

## SAE J1739 Issued JUL94

**POTENTIAL  
FAILURE MODE AND EFFECTS ANALYSIS  
(DESIGN FMEA)**

System \_\_\_\_\_  
Subsystem \_\_\_\_\_

Component 01.03/Body Closures (2) \_\_\_\_\_ (3) \_\_\_\_\_ (4) \_\_\_\_\_

Model Year(s)/Vehicle(s) 1992/Len 4dr/Reason (5) \_\_\_\_\_

Design Responsibility Body Engineering (6) \_\_\_\_\_

Key Date 9X 03 01 ER (6) \_\_\_\_\_

Prepared by A. Tate - X 6412 - Body Engr (4) \_\_\_\_\_

FMEA Number 1234 (1) \_\_\_\_\_

Page 1 of 1

FMEA Date (Orig.) 9X 03 22 (Rev.) 9X 07 14 (7)

Core Team I. Fender - Car Product Dev., C. Childers - Manufacturing, J. Ford - Assy Ops (Dalton), Fraser, Henley Assembly Plants (8)

| Item<br>(B)<br>Function                                                                                                                                                                               | Potential<br>Failure<br>Mode<br>(10) | Potential<br>Effect(s) of<br>Failure<br>(11)                                                                                                                          | (12)   |        | C<br>I<br>S | ←(13)<br>Cause(s)/<br>Mechanism(s)<br>of Failure<br>(14)                                     | O<br>C<br>U<br>R                                                       | ←(15)<br>Current<br>Design<br>Controls<br>(16) | D<br>E<br>T<br>C<br>T | R.<br>P.<br>N. | ←(18)<br>Recommended<br>Action(s)<br>(19)                                                                               | Responsibility<br>& Target<br>Completion Date<br>(20)                                         | Action Results |                |                          |                                                                                                                                                             |        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|-------------|----------------------------------------------------------------------------------------------|------------------------------------------------------------------------|------------------------------------------------|-----------------------|----------------|-------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------|----------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
|                                                                                                                                                                                                       |                                      |                                                                                                                                                                       | S<br>V | O<br>C |             |                                                                                              |                                                                        |                                                |                       |                |                                                                                                                         |                                                                                               | D<br>E         | R.<br>P.<br>N. | Actions<br>Taken<br>(21) | S<br>V                                                                                                                                                      | O<br>C |
| Front door L.H.<br>H814X-000-A                                                                                                                                                                        | Commod interior<br>lower door panels | Deteriorated life of door<br>leading to:<br>■ Unsatisfactory<br>appearance due to rust<br>through paint over time<br>■ Impaired function of<br>interior door hardware | 7      |        | 6           | Upper edge of protective<br>wax application specified<br>for inner door panels is<br>too low | Vehicle general durability<br>test veh:<br>T-118<br>T-301              | 7                                              | 294                   |                | Add laboratory<br>accelerated<br>corrosion testing                                                                      | A Tail-Body<br>Engng<br>BX 09 30                                                              | 7              | 2              | 2                        | Based on test<br>results (Test No.<br>1481) upper<br>edge spec raised<br>125 mm                                                                             |        |
| ■ Ingress to and<br>egress from<br>vehicle<br>■ Occupant<br>protection<br>from weather,<br>noise, and<br>side impact                                                                                  |                                      |                                                                                                                                                                       |        |        | 4           | Insufficient wax thickness<br>specified                                                      | Vehicle general durability<br>testing - as above                       | 7                                              | 196                   |                | Add laboratory<br>accelerated<br>corrosion testing<br><br>Conduct Design<br>of Experiments<br>(DOE) on wax<br>thickness | Combine w/test<br>for wax upper<br>edge verification<br><br>A Tail-<br>Body Engng<br>BX 01 15 | 7              | 2              | 2                        | Test results<br>(Test No. 1481)<br>show specified<br>thickness is<br>adequate<br><br>DOE shows 25%<br>variation in<br>applied<br>thickness is<br>acceptable |        |
| ■ Support<br>anchorage for<br>door hardware<br>including<br>mirror,<br>hinges, latch<br>and window<br>regulator<br>■ Provide proper<br>surface for<br>appearance<br>items<br>- paint and<br>soft trim |                                      |                                                                                                                                                                       |        |        | 2           | Inappropriate wax<br>formulation specified                                                   | Physical and Chem Lab<br>test - Report No. 1265                        | 2                                              | 28                    |                | None                                                                                                                    |                                                                                               |                |                |                          |                                                                                                                                                             |        |
|                                                                                                                                                                                                       |                                      |                                                                                                                                                                       |        |        | 5           | Entrapped air prevents<br>wax from entering<br>corner/edge access                            | Design aid investigation<br>with nonfunctioning<br>spray head          | 8                                              | 280                   |                | Add team<br>evaluation<br>using production<br>spray equipment<br>and specified<br>wax                                   | Body Engng &<br>Asy Ops<br>BX 11 15                                                           | 7              | 1              | 3                        | Based on test, 3<br>additional vent<br>holes will be<br>provided in<br>affected areas                                                                       |        |
|                                                                                                                                                                                                       |                                      |                                                                                                                                                                       |        |        | 3           | Wax application plugs<br>door drain holes                                                    | Laboratory test using<br>"worst case" wax<br>application and hole size | 1                                              | 21                    |                | None                                                                                                                    |                                                                                               |                |                |                          |                                                                                                                                                             |        |
|                                                                                                                                                                                                       |                                      |                                                                                                                                                                       |        |        | 4           | Insufficient room between<br>panels for spray head<br>access                                 | Drawing evaluation of<br>spray head access                             | 4                                              | 112                   |                | Add team<br>evaluation<br>using design aid<br>buck and spray<br>head                                                    | Body Engng &<br>Asy Ops<br>BX 09 15                                                           | 7              | 1              | 1                        | Evaluation<br>showed<br>adequate access                                                                                                                     |        |

FIGURE 3—DESIGN FMEA FORM

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3.2.12 (12) **SEVERITY(S)**—Severity is an assessment of the seriousness of the effect (listed in the previous column) of the potential failure mode to the next component, subsystem, system, or customer if it occurs. Severity applies to the effect only. A reduction in Severity Ranking index can be effected only through a design change. Severity should be estimated on a "1" to "10" scale. (See Figure 3.)

3.2.12.1 *Suggested Evaluation Criteria*—The team should agree on an evaluation criteria and ranking system, which is consistent, even if modified for individual product analysis. (See Table 1.)

TABLE 1—SUGGESTED SEVERITY EVALUATION CRITERIA

| Effect                    | Criteria: Severity of Effect                                                                                                                                      | Ranking |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| Hazardous-without warning | Very high severity ranking when a potential failure mode affects safe vehicle operation and/or involves noncompliance with government regulation without warning. | 10      |
| Hazardous-with warning    | Very high severity ranking when a potential failure mode affects safe vehicle operation and/or involves noncompliance with government regulation with warning.    | 9       |
| Very High                 | Vehicle/item inoperable, with loss of primary function.                                                                                                           | 8       |
| High                      | Vehicle/item operable, but at reduced level of performance. Customer dissatisfied.                                                                                | 7       |
| Moderate                  | Vehicle/item operable, but Comfort/Convenience item(s) inoperable. Customer experiences discomfort.                                                               | 6       |
| Low                       | Vehicle/item operable, but Comfort/Convenience item(s) operable at reduced level of performance. Customer experiences some dissatisfaction.                       | 5       |
| Very Low                  | Fit & Finish/Squeak & Rattle item does not conform. Defect noticed by most customers.                                                                             | 4       |
| Minor                     | Fit & Finish/Squeak & Rattle item does not conform. Defect noticed by average customer.                                                                           | 3       |
| Very Minor                | Fit & Finish/Squeak & Rattle item does not conform. Defect noticed by discriminating customer.                                                                    | 2       |
| None                      | No Effect.                                                                                                                                                        | 1       |

3.2.13 (13) **CLASSIFICATION**—This column may be used to classify any special product characteristics (e.g., critical, key, major, significant) for components, subsystems, or systems that may require additional process controls. (See Figure 3.)

Any item deemed to require special process controls should be identified on the Design FMEA form with the appropriate character or symbol in the Classification column and should be addressed in the Recommended Actions column.

Each special product characteristic should have the special process controls identified in the Process FMEA.

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POTENTIAL  
FAILURE MODE AND EFFECTS ANALYSIS  
(DESIGN FMEA)

\_\_\_\_\_ System FMEA Number 1234 \_\_\_\_\_ (1)  
 \_\_\_\_\_ Subsystem Page 1 of 1 \_\_\_\_\_

\_\_\_\_\_ Component 01.03/Body Closures \_\_\_\_\_ (2)  
 \_\_\_\_\_ Model Year(s)/Vehicle(s) 199X/Lion 4dr/Vanagon \_\_\_\_\_ (5)  
 \_\_\_\_\_ Design Responsibility Body Engineering \_\_\_\_\_ (3)  
 \_\_\_\_\_ Prepared by A. Tate - X-6412 - Body Engr \_\_\_\_\_ (4)  
 \_\_\_\_\_ Key Date 9X 03 01 ER \_\_\_\_\_ (6)  
 \_\_\_\_\_ FMEA Date (Orig.) 9X 03 22 \_\_\_\_\_ (Rev.) 9X 07 14 \_\_\_\_\_ (7)

Core Team I. Fender - Car Product Dev., C. Childers - Manufacturing, J. Ford - Assy Ops (Dalton, Fraser, Hanley Assembly Plants) \_\_\_\_\_ (8)

| Item<br>(9)<br>Function                                                                                                                                                                               | Potential<br>Failure<br>Mode<br>(10)   | Potential<br>Effect(s) of<br>Failure<br>(11)                                                                                                                          | C<br>I<br>S<br>V<br>S | O<br>C<br>C<br>C<br>C | P<br>C<br>C<br>C<br>C | D<br>C<br>C<br>C<br>C | R.<br>P.<br>N. | Recommended<br>Action(s)<br>(19)                                                                                    | Responsibility<br>& Target<br>Completion Date<br>(20)                                   | Action Results                                                                                                                                            |        |        |                | (22) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------|---------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|----------------|------|
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                       |                       |                       |                       |                |                                                                                                                     |                                                                                         | Actions<br>Taken<br>(21)                                                                                                                                  | S<br>v | O<br>c | R.<br>P.<br>N. |      |
| Front door L.H.<br>H82X-0000-A                                                                                                                                                                        | Corroded interior<br>lower door panels | Deteriorated life of door<br>leading to:<br>■ Unsatisfactory<br>appearance due to rust<br>through paint over time<br>■ Impaired function of<br>interior door hardware | 7                     | 5                     | 5                     | 7                     | 294            | Add laboratory<br>accelerated<br>corrosion testing                                                                  | A Tate-Body<br>Engr<br>9X 09 30                                                         | Based on test<br>results (Test No.<br>1481) upper<br>edge spec raised<br>125 mm                                                                           | 7      | 2      | 2              | 28   |
| ■ Ingress to and<br>egress from<br>vehicle<br>■ Occupant<br>protection<br>from weather,<br>noise, and<br>side impact                                                                                  |                                        |                                                                                                                                                                       |                       |                       |                       |                       | 196            | Add laboratory<br>accelerated<br>corrosion testing<br>Conduct Design<br>of Experiments<br>(DOE) on wax<br>thickness | Combine wheel<br>for wax upper<br>edge verification<br>A Tate-<br>Body Engr<br>9X 01 15 | Test results<br>(Test No. 1481)<br>show specified<br>thickness is<br>adequate<br>DOE shows 25%<br>variation in<br>specified<br>thickness is<br>acceptable | 7      | 2      | 2              | 28   |
| ■ Support<br>anchorage for<br>door hardware<br>including<br>mirror,<br>hinges, latch<br>and window<br>regulator<br>■ Provide proper<br>surface for<br>appearance<br>items<br>- paint and<br>soft trim |                                        |                                                                                                                                                                       |                       |                       |                       |                       | 28             | None                                                                                                                |                                                                                         |                                                                                                                                                           |        |        |                |      |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                       |                       |                       |                       | 280            | Add team<br>evaluation<br>using production<br>spray equipment<br>and specified<br>wax                               | Body Engr &<br>Assy Ops<br>9X 11 15                                                     | Based on test, 3<br>additional vent<br>holes will be<br>provided in<br>affected areas                                                                     | 7      | 1      | 3              | 21   |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                       |                       |                       |                       | 21             | None                                                                                                                |                                                                                         |                                                                                                                                                           |        |        |                |      |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                       |                       |                       |                       | 112            | Add team<br>evaluation<br>using design aid<br>buck and spray<br>head                                                | Body Engr &<br>Assy Ops<br>9X 09 15                                                     | Evaluation<br>showed<br>adequate access                                                                                                                   | 7      | 1      | 1              | 7    |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                       |                       |                       |                       |                |                                                                                                                     |                                                                                         |                                                                                                                                                           |        |        |                |      |

FIGURE 4—DESIGN FMEA FORM

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**3.2.14 (14) POTENTIAL CAUSE(S)/MECHANISM(S) OF FAILURE**—Potential Cause of Failure is defined as an indication of a design weakness, the consequence of which is the failure mode. (See Figure 4.)

List, to the extent possible, every conceivable failure cause and/or failure mechanism for each failure mode. The cause/mechanism should be listed as concisely and completely as possible so that remedial efforts can be aimed at pertinent causes.

Typical failure causes may include, but are not limited to:

- Incorrect Material Specified
- Inadequate Design Life Assumption
- Over-stressing
- Insufficient Lubrication Capability
- Inadequate Maintenance Instructions
- Poor Environment Protection
- Incorrect Algorithm

Typical failure mechanisms may include, but are not limited to:

- Yield
- Fatigue
- Material Instability
- Creep
- Wear
- Corrosion

**3.2.15 (15) OCCURRENCE (O)**—Occurrence is the likelihood that a specific cause/mechanism (listed in the previous column) will occur. The likelihood of occurrence ranking number has a meaning rather than a value. Removing or controlling one or more of the causes/mechanisms of the failure mode through a design change is the only way a reduction in the occurrence can be effected. (See Figure 4.)

Estimate the likelihood of occurrence of potential failure cause/mechanism on a "1" to "10" scale. In determining this estimate, questions such as the following should be considered:

- a. What is the service history/field experience with similar components or subsystems?
- b. Is component carryover or similar to a previous level component or subsystem?
- c. How significant are changes from a previous level component or subsystem?
- d. Is component radically different from a previous level component?
- e. Is component completely new?
- f. Has the component application changed?
- g. What are the environmental changes?
- h. Has an engineering analysis been used to estimate the expected comparable occurrence rate for the application?

A consistent occurrence ranking system should be used to ensure continuity. The "Design Life Possible Failure Rates" are based on the number of failures which are anticipated during the design life of the component, subsystem, or system. The occurrence ranking number is related to the rating scale and does not reflect the actual likelihood of occurrence.

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FMEA Number 1234 Page 1 of 1 (1)  
 POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (DESIGN FMEA)  
 Design Responsibility Body Engineering (3)  
 Key Date 9X 03 01 ER (6)  
 Model Year(s)/Vehicle(s) 199X/Lion 4dr/Wagon (5)  
 Component 01.03/Body Closures  
 Prepared by A. Tate - X 6412 - Body Engr (4)  
 FMEA Date (Orig.) 9X 03 22 (Rev.) 9X 07 14 (7)  
 Core Team T. Fender - Car Product Dev., C. Childers - Manufacturing, J. Ford - Assy Ops (Dalton, Fraser, Hanley Assembly Plants) (8)

| Item<br>(9)                                                                                                                                                                                           | Potential<br>Failure<br>Mode<br>(10)                              | Potential<br>Effect(s) of<br>Failure<br>(11)                                                                                                                          | C<br>I<br>S<br>S<br>U<br>E<br>(12) | ←(13) Potential<br>Cause(s)/<br>Mechanism(s)<br>of Failure<br>(14)                           | O<br>C<br>C<br>U<br>R<br>R<br>E<br>N<br>C<br>Y<br>(15) | ←(16) Current<br>Design<br>Controls<br>(17)→                           | D<br>I<br>S<br>T<br>I<br>N<br>G<br>U<br>I<br>S<br>H<br>I<br>N<br>G<br>(18) | R.<br>P.<br>N.<br>(19) | Recommended<br>Action(s)<br>(20)                                                                                    | Responsibility<br>& Target<br>Completion Date<br>(21)                                   | Action Results<br>Actions<br>Taken<br>(22)                                                                                                                | S<br>v<br>e<br>n<br>t<br>u<br>r<br>e<br>(23) | O<br>c<br>c<br>u<br>r<br>r<br>e<br>n<br>c<br>y<br>(24) | D<br>e<br>t<br>e<br>r<br>i<br>o<br>r<br>a<br>t<br>i<br>o<br>n<br>(25) | R.<br>P.<br>N.<br>(26) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|----------------------------------------------------------------------------------------------|--------------------------------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------------------|------------------------|---------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|--------------------------------------------------------|-----------------------------------------------------------------------|------------------------|
| Front door L.H.<br>H84X 0000-A                                                                                                                                                                        | Corroded interior<br>lower door panels                            | Deteriorated life of door<br>leading to:<br>■ Unsatisfactory<br>appearance due to rust<br>through paint over time<br>■ Impaired function of<br>interior door hardware | 7                                  | Upper edge of protective<br>wax application specified<br>for inner door panels is<br>too low | 6                                                      | Vehicle general durability<br>test veh. T-118<br>T-109<br>T-301        | 7                                                                          | 294                    | Add laboratory<br>accelerated<br>corrosion testing                                                                  | A Tate-Body<br>Engr<br>9X 08 30                                                         | Based on test<br>results (Test No.<br>1481) upper<br>edge spec raised<br>125 mm                                                                           | 7                                            | 2                                                      | 2                                                                     | 28                     |
| ■ Ingress to and<br>egress from<br>vehicle<br>■ Occupant<br>protection<br>from weather,<br>noise, and<br>side impact                                                                                  | Insufficient wax thickness<br>specified                           |                                                                                                                                                                       |                                    |                                                                                              | 4                                                      | Vehicle general durability<br>testing - as above                       | 7                                                                          | 196                    | Add laboratory<br>accelerated<br>corrosion testing<br>Conduct Design<br>of Experiments<br>(DOE) on wax<br>thickness | Combine wheel<br>for wax upper<br>edge verification<br>A Tate-<br>Body Engr<br>9X 01 15 | Test results<br>(Test No. 1481)<br>show specified<br>thickness is<br>adequate<br>DOE shows 25%<br>variation in<br>specified<br>thickness is<br>acceptable | 7                                            | 2                                                      | 2                                                                     | 28                     |
| ■ Support<br>anchorage for<br>door hardware<br>including<br>mirror,<br>hinges, latch<br>and window<br>regulator<br>■ Provide proper<br>surface for<br>appearance<br>items<br>- paint and<br>soft trim | Inappropriate wax<br>formulation specified                        |                                                                                                                                                                       |                                    |                                                                                              | 2                                                      | Physical and Chem Lab<br>test - Report No. 1285                        | 2                                                                          | 28                     | None                                                                                                                |                                                                                         |                                                                                                                                                           |                                              |                                                        |                                                                       |                        |
|                                                                                                                                                                                                       | Entrapped air prevents<br>wax from entering<br>corner/edge access |                                                                                                                                                                       |                                    |                                                                                              | 5                                                      | Design and investigation<br>with nonintruding<br>spray head            | 3                                                                          | 280                    | Add team<br>evaluation<br>using production<br>spray equipment<br>and specified<br>wax                               | Body Engr &<br>Assy Ops<br>9X 11 15                                                     | Based on test, 3<br>additional vent<br>holes will be<br>provided in<br>affected areas                                                                     | 7                                            | 1                                                      | 3                                                                     | 21                     |
|                                                                                                                                                                                                       | Wax application plugs<br>door drain holes                         |                                                                                                                                                                       |                                    |                                                                                              | 3                                                      | Laboratory test using<br>"worst case" wax<br>application and hole size | 1                                                                          | 21                     | None                                                                                                                |                                                                                         |                                                                                                                                                           |                                              |                                                        |                                                                       |                        |
|                                                                                                                                                                                                       | Insufficient room between<br>panels for spray head<br>access      |                                                                                                                                                                       |                                    |                                                                                              | 4                                                      | Drawing evaluation of<br>spray head access                             | 4                                                                          | 112                    | Add team<br>evaluation<br>using design aid<br>back and spray<br>head                                                | Body Engr &<br>Assy Ops<br>9X 09 15                                                     | Evaluation<br>showed<br>adequate access                                                                                                                   | 7                                            | 1                                                      | 1                                                                     | 7                      |
| <b>SAMPLE</b>                                                                                                                                                                                         |                                                                   |                                                                                                                                                                       |                                    |                                                                                              |                                                        |                                                                        |                                                                            |                        |                                                                                                                     |                                                                                         |                                                                                                                                                           |                                              |                                                        |                                                                       |                        |

FIGURE 5—DESIGN FMEA FORM

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**3.2.15.1 Suggested Evaluation Criteria**—The team should agree on an evaluation criteria and ranking system, which is consistent, even if modified for individual product analysis. (See Table 2.)

**TABLE 2—SUGGESTED OCCURRENCE EVALUATION CRITERIA**

| Probability of Failure                  | Possible Failure Rates | Ranking |
|-----------------------------------------|------------------------|---------|
| Very High: Failure is almost inevitable | $\geq 1$ in 2          | 10      |
|                                         | 1 in 3                 | 9       |
| High: Repeated failures                 | 1 in 8                 | 8       |
|                                         | 1 in 20                | 7       |
| Moderate: Occasional failures           | 1 in 80                | 6       |
|                                         | 1 in 400               | 5       |
|                                         | 1 in 2000              | 4       |
| Low: Relatively few failures            | 1 in 15 000            | 3       |
|                                         | 1 in 150 000           | 2       |
| Remote: Failure is unlikely             | $\leq 1$ in 1 500 000  | 1       |

**3.2.16 (16) CURRENT DESIGN CONTROLS**—List the prevention, design validation/verification (DV), or other activities which will assure the design adequacy for the failure mode and/or cause/mechanism under consideration. Current controls (e.g., road testing, design reviews, fail/safe (pressure relief valve), mathematical studies, rig/lab testing, feasibility review, prototype tests, fleet testing) are those that have been or are being used with the same or similar designs. (See Figure 5.)

There are three types of Design Controls/features to consider; those that:

1. Prevent the cause/mechanism or failure mode/effect from occurring, or reduce their rate of occurrence,
2. Detect the cause/mechanism and lead to corrective actions, and
3. Detect the failure mode.

The preferred approach is to first use type (1) controls if possible; second, use the type (2) controls; and third, use the type (3) controls. The initial occurrence rankings will be affected by the type (1) controls provided they are integrated as part of the design intent. The initial detection rankings will be based on the type (2) or type (3) current controls, provided the prototypes and models being used are representative of design intent.

**3.2.17 (17) DETECTION (D)**—Detection is an assessment of the ability of the proposed type (2) current design controls, listed in column 16, to detect a potential cause/mechanism (design weakness), or the ability of the proposed type (3) current design controls to detect the subsequent failure mode, before the component, subsystem, or system is released for production. (See Figure 5.) In order to achieve a lower ranking, generally the planned design control (e.g., preventative, validation, and/or verification activities) has to be improved.

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 Page 1  
 POTENTIAL  
 FAILURE MODE AND EFFECTS ANALYSIS  
 (DESIGN FMEA)  
 Design Responsibility Body Engineering (3)  
 Prepared by A. Tate - X 6412 - Body Eng (4)  
 Key Date 9X 03 01 ER (6)  
 FMEA Date (Orig.) 9X 03 22 (Rev.) 9X 07 14 (7)  
 Component 01.03/Body Closures (2)  
 Model Year(s)/Vehicle(s) 199X/Lion 4dr/Wagon (5)  
 Core Team T. Fender - Car Product Dev., C. Childers - Manufacturing, J. Ford - Assy Ops, J. Dalton, Fraser, Hanley Assembly Plants (8)

| Item<br>Function<br>(9)                                                                                                                                                                               | Potential<br>Failure<br>Mode<br>(10)   | Potential<br>Effect(s) of<br>Failure<br>(11)                                                                                                                          | C<br>I<br>S<br>C<br>(12) | ←(15) Potential<br>Cause(s)/<br>Mechanism(s)<br>of Failure<br>(14)                           | O<br>C<br>C<br>U<br>R<br>(15) | Current<br>Design<br>Controls<br>(16)                                  | D<br>I<br>S<br>C<br>(17) | R.<br>P.<br>N.<br>(18) | ←(19) Recommended<br>Action(s)<br>(19)                                                                              | Responsibility<br>& Target<br>Completion Date<br>(20)                                   | Action Results<br>Taken<br>(21)                                                                                                                           | S<br>e<br>v<br>(22) | O<br>c<br>c<br>u<br>r<br>(23) | D<br>i<br>s<br>c<br>o<br>n<br>(24) | R.<br>P.<br>N.<br>(25) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------------|-------------------------------|------------------------------------------------------------------------|--------------------------|------------------------|---------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-------------------------------|------------------------------------|------------------------|
| Front door L.H.<br>H81X-0000-A                                                                                                                                                                        | Corroded interior<br>lower door panels | Deteriorated life of door<br>leading to:<br>■ Unsatisfactory<br>appearance due to rust<br>through paint over time<br>■ Impaired function of<br>inferior door hardware | 7                        | Upper edge of protective<br>wax application specified<br>for inner door panels is<br>too low | 6                             | Vehicle general durability<br>test veh.<br>T-118<br>T-109<br>T-301     | 7                        | 284                    | Add laboratory<br>accelerated<br>corrosion testing                                                                  | A Tate-Body<br>Engg<br>9X 09 30                                                         | Based on test<br>results (Test No.<br>1481) upper<br>edge spec raised<br>125 mm                                                                           | 7                   | 2                             | 2                                  | 28                     |
| ■ Ingress to and<br>egress from<br>vehicle<br>■ Occupant<br>protection<br>from weather,<br>noise, and<br>side impact                                                                                  |                                        |                                                                                                                                                                       |                          | Inadequate wax thickness<br>specified                                                        | 4                             | Vehicle general durability<br>testing - as above                       | 7                        | 196                    | Add laboratory<br>accelerated<br>corrosion testing<br>Conduct Design<br>of Experiments<br>(DOE) on wax<br>thickness | Combines what<br>for wax upper<br>edge verification<br>A Tate-<br>Body Engg<br>9X 01 15 | Test results<br>(Test No. 1481)<br>show specified<br>thickness is<br>adequate<br>DOE shows 25%<br>variation in<br>specified<br>thickness is<br>acceptable | 7                   | 2                             | 2                                  | 28                     |
| ■ Support<br>anchorage for<br>door hardware<br>including<br>mirror,<br>hinges, latch<br>and window<br>regulator<br>■ Provide proper<br>surface for<br>appearance<br>items<br>- paint and<br>soft trim |                                        |                                                                                                                                                                       |                          | Inappropriate wax<br>formulation specified                                                   | 2                             | Physical and Chem Lab<br>test - Report No. 1265                        | 2                        | 28                     | None                                                                                                                |                                                                                         |                                                                                                                                                           |                     |                               |                                    |                        |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                          | Entrapped air prevents<br>wax from entering<br>corner/edge access                            | 5                             | Design aid investigation<br>with nonfunctioning<br>spray head          | 8                        | 220                    | Add team<br>evaluation<br>using production<br>spray equipment<br>and specified<br>wax                               | Body Engg &<br>Assy Ops<br>9X 11 15                                                     | Based on test, 3<br>additional vent<br>holes will be<br>provided in<br>affected areas                                                                     | 7                   | 1                             | 3                                  | 21                     |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                          | Wax application plugs<br>door drain holes                                                    | 3                             | Laboratory test using<br>"worst case" wax<br>application and hole size | 1                        | 21                     | None                                                                                                                |                                                                                         |                                                                                                                                                           |                     |                               |                                    |                        |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                          | Inadequate room between<br>panels for spray head<br>access                                   | 4                             | Drawing evaluation of<br>spray head access                             | 4                        | 112                    | Add team<br>evaluation<br>using design aid<br>back and spray<br>head                                                | Body Engg &<br>Assy Ops<br>9X 09 15                                                     | Evaluation<br>showed<br>adequate access                                                                                                                   | 7                   | 1                             | 1                                  | 7                      |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                          |                                                                                              |                               |                                                                        |                          |                        |                                                                                                                     |                                                                                         |                                                                                                                                                           |                     |                               |                                    |                        |

FIGURE 6—DESIGN FMEA FORM

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**3.2.17.1 Suggested Evaluation Criteria**—The team should agree on an evaluation criteria and ranking system, which is consistent, even if modified for individual product analysis. (See Table 3.)

**TABLE 3—SUGGESTED DETECTION EVALUATION CRITERIA**

| Detection            | Criteria: Likelihood of Detection by Design Control                                                                                   | Ranking |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------|---------|
| Absolute Undertainty | Design Control will not and/or can not detect a potential cause/mechanism and subsequent failure mode; or there is no Design Control. | 10      |
| Very Remote          | Very remote chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.                            | 9       |
| Remote               | Remote chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.                                 | 8       |
| Very Low             | Very Low chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.                               | 7       |
| Low                  | Low chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.                                    | 6       |
| Moderate             | Moderate chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.                               | 5       |
| Moderately High      | Moderately high chance the Design Control will detect potential cause/mechanism and subsequent failure mode.                          | 4       |
| High                 | High chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.                                   | 3       |
| Very High            | Very High chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.                              | 2       |
| Almost Certain       | Design Control will almost certainly detect a potential cause/mechanism and subsequent failure mode.                                  | 1       |

**3.2.18 (18) RISK PRIORITY NUMBER (RPN)**—The Risk Priority Number is the product of the Severity (S), Occurrence (O), and Detection (D) ranking. (See Figure 6 and Equation 1.)

$$RPN = (S) \times (O) \times (D) \quad (\text{Eq. 1})$$

The Risk Priority Number, as the product  $S \times O \times D$ , is a measure of design risk. This value should be used to rank order the concerns in the design (e.g., in Pareto fashion). The RPN will be between "1" and "1000". For high RPNs, the team must undertake efforts to reduce this calculated risk through corrective action(s). In general practice, regardless of the resultant RPN, special attention should be given when severity is high.

**3.2.19 (19) RECOMMENDED ACTION(S)**—When the failure modes have been rank ordered by RPN, corrective action should be first directed at the highest ranked concerns and critical items. The intent of any recommended action is to reduce any one or all of the occurrence, severity, and/or detection rankings. An increase in design validation/verification actions will result in a reduction in the detection ranking only. A reduction in the occurrence ranking can be effected only by removing or controlling one or more of the causes/mechanisms of the failure mode through a design revision. Only a design revision can bring about a reduction in the severity ranking. Actions such as the following should be considered, but are not limited to: (See Figure 6.)

- a. Design of experiments (particularly when multiple or interactive causes are present)
- b. Revised Test Plan
- c. Revised Design
- d. Revised Material Specification

If no actions are recommended for a specific cause, indicate this by entering a "NONE" in this column.

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\_\_\_\_\_ System  
 \_\_\_\_\_ Subsystem  
 \_\_\_\_\_ Component 01.03/Body Closures \_\_\_\_\_ (2)  
 Model Year(s)/Vehicle(s) 199X/Lion 4dr/Wagon \_\_\_\_\_ (5)  
 Core Team T. Fender - Car Product Dev., C. Childers - Manufacturing, J. Ford - Assy Ops (Dallin, Fraser, Henley Assembly Plants) \_\_\_\_\_ (8)  
 FMEA Number 1234 \_\_\_\_\_ (1)  
 Page 1 \_\_\_\_\_ of 1 \_\_\_\_\_  
 Design Responsibility Body Engineering \_\_\_\_\_ (3)  
 Key Date 9X.03.01 ER \_\_\_\_\_ (6)  
 Prepared by A. Tate - X 6412 - Body Engr \_\_\_\_\_ (4)  
 FMEA Date (Orig.) 9X.03.22 \_\_\_\_\_ (Rev.) 9X.07.14 \_\_\_\_\_ (7)

**POTENTIAL  
FAILURE MODE AND EFFECTS ANALYSIS  
(DESIGN FMEA)**

| Item<br>Function<br>(9)                                                                                                                                                                               | Potential<br>Failure<br>Mode<br>(10)   | Potential<br>Effect(s) of<br>Failure<br>(11)                                                                                                                          | C<br>I<br>S<br>V<br>(12)→ | O<br>C<br>U<br>F<br>(13) | Current<br>Design<br>Controls<br>(16)                                  | D<br>t<br>P<br>N<br>(17)→ | Recommended<br>Action(s)<br>(18)                                                                                           | Responsibility<br>& Target<br>Completion Date<br>(20)                                       | Action<br>Number<br>(21)                                                                                                                       | Severity<br>S<br>(22) | Occurrence<br>O<br>(23) | D<br>P<br>(24) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|--------------------------|------------------------------------------------------------------------|---------------------------|----------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-------------------------|----------------|
| Front door L.H.<br>H8HX-0000-A                                                                                                                                                                        | Corroded interior<br>lower door panels | Deteriorated life of door<br>leading to:<br>■ Unsatisfactory<br>appearance due to rust<br>through paint over time<br>■ Impaired function of<br>interior door hardware | 7                         | 6                        | Vehicle general durability<br>test veh.<br>T-118<br>T-109<br>T-301     | 7                         | 294<br>Add laboratory<br>accelerated<br>corrosion testing                                                                  | A. Tate-Body<br>Engr<br>9X.08.20                                                            | Based on test<br>results (Test No.<br>1481) upper<br>edge area reduced<br>125 mm                                                               | 7                     | 2                       | 28             |
| ■ Ingress to and<br>egress from<br>vehicle<br>■ Occupant<br>protection<br>from weather,<br>noise, and<br>side impact                                                                                  |                                        |                                                                                                                                                                       |                           | 4                        | Vehicle general durability<br>testing - as above                       | 7                         | 196<br>Add laboratory<br>accelerated<br>corrosion testing<br>Conduct Design<br>of Experiments<br>(DOE) on wax<br>thickness | Continue without<br>for wax upper<br>edge verification<br>A. Tate-<br>Body Engr<br>9X.01.15 | Test results<br>(Test No. 1481)<br>show acceptable<br>thickness in<br>edge area<br>DOE shows 25%<br>variation in<br>thickness is<br>acceptable | 7                     | 2                       | 28             |
| ■ Support<br>anchorage for<br>door hardware<br>including<br>mirror,<br>hinges, latch<br>and window<br>regulator<br>■ Provide proper<br>surface for<br>appearance<br>items<br>- paint and<br>soft trim |                                        |                                                                                                                                                                       |                           | 2                        | Physical and Chem Lab<br>test - Report No. 1285                        | 2                         | 28<br>None                                                                                                                 |                                                                                             |                                                                                                                                                |                       |                         |                |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                           | 5                        | Design aid investigation<br>with nonfunctioning<br>spray head          | 8                         | 280<br>Add team<br>evaluation<br>using production<br>spray equipment<br>and specified<br>wax                               | Body Engr &<br>Assy Ops<br>9X.11.15                                                         | Based on test, 3<br>additional vent<br>holes will be<br>provided in<br>affected areas                                                          | 7                     | 1                       | 21             |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                           | 3                        | Laboratory test using<br>"worst case" wax<br>application and hole size | 1                         | 21<br>None                                                                                                                 |                                                                                             |                                                                                                                                                |                       |                         |                |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                           | 4                        | Drawing evaluation of<br>spray head access                             | 4                         | 112<br>Add team<br>evaluation<br>using design aid<br>buck and spray<br>head                                                | Body Engr &<br>Assy Ops<br>9X.06.15                                                         | Evaluation<br>showed<br>adequate access                                                                                                        | 7                     | 1                       | 7              |
|                                                                                                                                                                                                       |                                        |                                                                                                                                                                       |                           |                          | <b>SAMPLE</b>                                                          |                           |                                                                                                                            |                                                                                             |                                                                                                                                                |                       |                         |                |

FIGURE 7—DESIGN FMEA FORM

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**3.2.20 (20) RESPONSIBILITY (FOR THE RECOMMENDED ACTION)**—Enter the Organization and individual responsible for the recommended action and the target completion date. (See Figure 7.)

**3.2.21 (21) ACTIONS TAKEN**—After an action has been implemented, enter a brief description of the actual action and effective date. (See Figure 7.)

**3.2.22 (22) RESULTING RPN**—After the corrective action has been identified, estimate and record the resulting severity, occurrence, and detection rankings. Calculate and record the resulting RPN. If no actions are taken, leave the "Resulting RPN" and related ranking columns blank. (See Figure 7.)

All Resulting RPNs should be reviewed and if further action is considered necessary, repeat 3.2.19 through 3.2.22.

**3.2.23 FOLLOW-UP**—The design responsible engineer is responsible for assuring that all actions recommended have been implemented or adequately addressed. The FMEA is a living document and should always reflect the latest design level, as well as the latest relevant actions, including those occurring after start of production.

The design responsible engineer has several means of assuring that concerns are identified and that recommended actions are implemented. They include, but are not limited to the following:

- a. Assuring design requirements are achieved
- b. Review of engineering drawings and specifications
- c. Confirmation of incorporation to assembly/manufacturing documentation
- d. Review of Process FMEAs and Control Plans

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## SAE J1739 Issued JUL94

**4. Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)**

**4.1 Introduction**—A Process potential FMEA is an analytical technique utilized by a Manufacturing Responsible Engineer/Team as a means to assure that, to the extent possible, potential failure modes and their associated causes/mechanisms have been considered and addressed. In its most rigorous form, an FMEA is a summary of the engineer's/team's thoughts (including an analysis of items that could go wrong based on experience and past concerns) as a process is developed. This systematic approach parallels and formalizes the mental discipline that an engineer normally goes through in any manufacturing planning process.

The Process potential FMEA:

- a. Identifies potential product related process failure modes.
- b. Assesses the potential customer effects of the failures.
- c. Identifies the potential manufacturing or assembly process causes and identifies process variables on which to focus controls for occurrence reduction or detection of the failure conditions.
- d. Develops a ranked list of potential failure modes, thus establishing a priority system for corrective action considerations.
- e. Documents the results of the manufacturing or assembly process.

**4.1.1 CUSTOMER DEFINED**—The definition of "CUSTOMER" for a Process potential FMEA should normally be seen as the "END USER." However, customer can also be a subsequent or downstream manufacturing or assembly operation, as well as a service operation.

When fully implemented, the FMEA discipline requires a Process FMEA for all new parts/processes, changed parts/processes, and carryover parts/processes in new applications or environments. It is initiated by an engineer from the responsible process engineering department.

**4.1.2 TEAM EFFORT**—During the initial Process potential FMEA process, the responsible engineer is expected to directly and actively involve representatives from all affected areas. These areas should include, but are not limited to, design, assembly, manufacturing, materials, quality, service, and suppliers, as well as the area responsible for the next assembly. The FMEA should be a catalyst to stimulate the interchange of ideas between the areas affected and thus promote a team approach.

The Process FMEA is a living document and should be initiated before or at the feasibility stage, prior to tooling for production, and take into account all manufacturing operations, from individual components to assemblies. Early review and analysis of new or revised processes is promoted to anticipate, resolve, or monitor potential process concerns during the manufacturing planning stages of a new model or component program.

The Process FMEA assumes the product as designed will meet the design intent. Potential failure modes which can occur because of a design weakness need not, but may be included in a Process FMEA. Their effect and avoidance is covered by the Design FMEA.

The Process FMEA does not rely on product design changes to overcome weaknesses in the process, but does take into consideration a product's design characteristics relative to the planned manufacturing or assembly process to assure that, to the extent possible, the resultant product meets customer needs and expectations.

The FMEA discipline will also assist in developing new machines or equipment. The methodology is the same, however, the machine or equipment being designed is considered the product. When potential failure modes are identified, corrective action can be initiated to eliminate them or continuously reduce their potential for occurrence.

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POTENTIAL  
FAILURE MODE AND EFFECTS ANALYSIS  
(PROCESS FMEA)

FMEA Number 1658  
Page 1 of 1

Prepared by J. Ford - J16521 - Assy Dpt  
(5)

FMEA Date (Orig) 9X 06 17 (Rev) 9X 11 06 (7)

Process Responsibility Body Engineering (5)

Key Date 9X 03 01 ER 9X 08 28 Job #1 (8)

Item Front Door LH J16521-000-A (2)

Model Year(s) Vehicle(s) 1992/Lion 4dr/Wagon (5)

Core Team A. Tate Body Engr., J. Smith - QC, R. James - Production, J. Jones - Maintenance (8)

| Process Function (9)<br>Requirements                                                                                   | Potential Failure Mode (10)                      | Potential Effect(s) of Failure (11)                                                                                                                       | Cause(s) / Mechanism(s) of Failure (12)                                                   | O C U R (13) | D (14) | R. P. N. (15) | Recommended Action(s) (16)                                                                                 | Responsibility & Target Completion Date (17) | Action Results (18)                                                                                                                        | (22)     |
|------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|--------------|--------|---------------|------------------------------------------------------------------------------------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|----------|
| Manual application of wax to the door To cover inner door, lower surfaces at minimum wax thickness to related controls | Insufficient wax coverage over specified surface | Deteriorated life of door leading to:<br>■ Unsatisfactory appearance due to rust through paint over time<br>■ Impaired function of interior door hardware | Manually inserted spray head not inserted far enough                                      | 8            | 5      | 280           | Visual check each hour - 1/4 inch for film thickness (depth meter) and coverage                            | MFG Engrg 9X 10 15                           | Stop added, sprayer checked on line                                                                                                        | 7 2 5 70 |
|                                                                                                                        |                                                  |                                                                                                                                                           | Spray head clogged<br>- Viscosity too high<br>- Temperature too low<br>- Pressure too low | 5            | 3      | 105           | Test spray pattern at start-up and after idle periods, and preventative maintenance program to clean heads | Mfg Engrg 9X 10 01                           | Temp and press limits were determined and limit controls have been installed - control charts show process is in control<br>Cpk = 1.85     | 7 1 3 21 |
|                                                                                                                        |                                                  |                                                                                                                                                           | Spray head deformed due to impact                                                         | 2            | 2      | 28            | Preventative maintenance program to maintain heads                                                         |                                              |                                                                                                                                            |          |
|                                                                                                                        |                                                  |                                                                                                                                                           | Spray time insufficient                                                                   | 8            | 7      | 392           | Operator instructions and lot sampling (10 doors/shift) to check for coverage of critical areas            | Maintenance 9X 09 15                         | Automatic spray timer installed - operator starts spray, timer controls shut-off - control charts show process is in control<br>Cpk = 2.05 | 7 1 7 49 |
| <b>SAMPLE</b>                                                                                                          |                                                  |                                                                                                                                                           |                                                                                           |              |        |               |                                                                                                            |                                              |                                                                                                                                            |          |

FIGURE 8—PROCESS FMEA FORM

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**4.2 Development of a Process FMEA**—A Process FMEA should begin with a flow chart/risk assessment (see Appendix C) of the general process. This flow chart should identify the product/process characteristics associated with each operation. Identification of some product effects from the corresponding Design FMEA, should be included, if available. Copies of the flow chart/risk assessment used in FMEA preparation should accompany the FMEA.

In order to facilitate documentation of the analysis of potential failures and their consequences, a Process FMEA form was developed and is in Appendix G. (See Figure G1.)

Application of the form is described as follows. Points are numbered according to the numbers encircled on the reference Figures. An example of a completed form is contained in Appendix D. (See Figure D1.)

- 4.2.1 (1) **FMEA NUMBER**—Enter the FMEA document number, which may be used for tracking. (See Figure 8.)
- 4.2.2 (2) **ITEM**—Enter the name and number of the system, subsystem, or component, for which the process is being analyzed. (See Figure 8.)
- 4.2.3 (3) **PROCESS RESPONSIBILITY**—Enter the OEM, department, and group. Also include the supplier name if known. (See Figure 8.)
- 4.2.4 (4) **PREPARED BY**—Enter the name, telephone number, and company of the engineer responsible for preparing the FMEA. (See Figure 8.)
- 4.2.5 (5) **MODEL YEAR(S)/VEHICLE(S)**—Enter the intended model year(s) and vehicle line(s) that will utilize and/or be affected by the design/process being analyzed (if known). (See Figure 8.)
- 4.2.6 (6) **KEY DATE**—Enter the initial FMEA due date, which should not exceed the scheduled start of production date. (See Figure 8.)
- 4.2.7 (7) **FMEA DATE**—Enter the date the original FMEA was compiled, and the latest revision date. (See Figure 8.)
- 4.2.8 (8) **CORE TEAM**—List the names of the responsible individuals and departments which have the authority to identify and/or perform tasks. (It is recommended that all team members names, departments, telephone numbers, addresses, etc., be included on a distribution list.) (See Figure 8.)
- 4.2.9 (9) **PROCESS FUNCTION/REQUIREMENTS**—Enter a simple description of the process or operation being analyzed (e.g., turning, drilling, tapping, welding, assembling). Indicate as concisely as possible the purpose of the process or operation being analyzed. Where the process involves numerous operations (e.g., assembling) with different potential modes of failure, it may be desirable to list the operations as separate processes. (See Figure 9.)

## POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

FMEA Number 1450 (1)  
Page 1 of 1

|      |                             |     |
|------|-----------------------------|-----|
| Item | Front Door L.H./H8HX-0000-A | (2) |
|------|-----------------------------|-----|

Process Responsibility **Body Engineering (3)**Prepared by J. Ford - X8521 - Ass'y Ops

Model Year(s)/Vehicle(s) 199X/Lion 4dr/Wagon (5)

Key Date 9X0301ER 9X0826Job #1 (6)

FMEA Date (Orig.) 9X 05 17 (Rev.) 9X 11 06 71

Core Team **A. Tate** Body Engng., **J. Smith** - OC, **R. James** - Production, **J. Jones** - Maintenance

| Process Function<br>(9)                                                          | Potential Failure Mode<br>(10)                   | Potential Effect(s) of Failure<br>(11)                                                                                                                    | Cause(s)/ Mechanism(s)<br>(12)                                                            | O<br>(13) | ←(15)<br>Current Process Controls<br>(16)                                                                  | D<br>(17) | R.<br>P.<br>N.<br>(18) | Recommended Action(s)<br>(19)                                             | Responsibility & Target Completion Date<br>(20) | Action Results<br>(21)                                                                                                                     | S<br>(22) | O<br>(23) | D<br>(24) | R.<br>(25) | P.<br>(26) | N.<br>(27) |
|----------------------------------------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-----------|------------------------------------------------------------------------------------------------------------|-----------|------------------------|---------------------------------------------------------------------------|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------|-----------|------------|------------|------------|
| Manual application of wax inside door                                            | Inconsistent wax coverage over specified surface | Deteriorated life of door leading to:<br>■ Unsatisfactory appearance due to rust through paint over time<br>■ Impaired function of interior door hardware | Manually inserted spray head not inserted far enough                                      | 8         | Visual check each hour - 1/minit for film thickness (depth meter) and coverage                             | 5         | 280                    | Add positive depth stop to sprayer                                        | MFG Engrg<br>9X 10 15                           | Stop added, sprayer checked on line                                                                                                        | 7         | 2         | 5         | 70         |            |            |
| To cover inner door, lower surfaces at minimum wax thickness to retard corrosion |                                                  |                                                                                                                                                           | Spray head clogged<br>- Viscosity too high<br>- Temperature too low<br>- Pressure too low | 5         | Test spray pattern at start-up and after idle periods, and preventative maintenance program to clean heads | 3         | 105                    | Use Design of Experiments (DOE) on viscosity vs. temperature vs. pressure | Mfg Engrg<br>9X 10 01                           | Temp and press limits were determined and limit controls have been installed - control charts show process is in control<br>Cpk = 1.85     | 7         | 1         | 3         | 21         |            |            |
|                                                                                  |                                                  |                                                                                                                                                           | Spray head deformed due to impact                                                         | 2         | Preventative maintenance program to maintain heads                                                         | 2         | 28                     | None                                                                      |                                                 |                                                                                                                                            |           |           |           |            |            |            |
|                                                                                  |                                                  |                                                                                                                                                           | Spray time insufficient                                                                   | 8         | Operator instructions and lot sampling (10 doors/ shift) to check for coverage of critical areas           | 7         | 392                    | Install spray liner                                                       | Maintenance<br>9X 09 15                         | Automatic spray liner installed - operator starts spray, liner controls shut-off - control charts show process is in control<br>Cpk = 2.05 | 7         | 1         | 7         | 49         |            |            |

FIGURE 9—PROCESS FMEA FORM

## SAE J1739 Issued JUL94

**4.2.10 (10) POTENTIAL FAILURE MODE**—Potential Failure Mode is defined as the manner in which the process could potentially fail to meet the process requirements and/or design intent. It is a description of the nonconformance at that specific operation. It can be a cause associated with a potential failure mode in a subsequent (downstream) operation or an effect associated with a potential failure in a previous (upstream) operation. However, in preparation of the FMEA, the assumption should be made that the incoming part(s)/material(s) are correct. (See Figure 9.)

List each potential failure mode for the particular operation in terms of a component, subsystem, system, or process characteristic. The assumption is made that the failure could occur, but may not necessarily occur. The process engineer/team should be able to pose and answer the following questions:

- a. How can the process/part fail to meet specifications?
- b. Regardless of engineering specifications, what would a customer (end user, subsequent operations, or service) consider objectionable?

A comparison of similar processes and a review of customer (end user and subsequent operation) claims relating to similar components is a recommended starting point. In addition a knowledge of the purpose of the design is necessary. Typical failure modes could be, but are not limited to:

|                 |                 |
|-----------------|-----------------|
| Bent            | Burred          |
| Binding         | Cracked         |
| Handling Damage | Dirty           |
| Deformed        | Grounded        |
| Improper Set-up | Short Circuited |
| Open Circuited  |                 |
| Tool Worn       |                 |

**4.2.11 (11) POTENTIAL EFFECT(S) OF FAILURE**—Potential Effects of Failure are defined as the effects of the failure mode on the customer(s). The customer(s) in this context could be the next operation, subsequent operations or locations, the dealer, and/or the vehicle owner. Each must be considered when assessing the potential effect of a failure. (See Figure 9.)

Describe the effects of the failure in terms of what the customer(s) might notice or experience. For the End User, the effects should always be stated in terms of product or system performance, such as:

|                           |                   |
|---------------------------|-------------------|
| Noise                     | Erratic Operation |
| Rough                     | Inoperative       |
| Excessive Effort Required | Unstable          |
| Unpleasant Odor           | Draft             |
| Operation Impaired        | Poor Appearance   |
| Intermittent Operation    |                   |
| Vehicle Control Impaired  |                   |

If the customer is the next operation or subsequent operation(s)/location(s), the effects should be stated in terms of process/operation performance, such as:

|                    |                   |
|--------------------|-------------------|
| Can not fasten     | Does not fit      |
| Can not bore/tap   | Does not connect  |
| Can not mount      | Does not match    |
| Can not face       | Damages equipment |
| Endangers operator |                   |

## SAE J1739 Issued JUL94

**POTENTIAL  
FAILURE MODE AND EFFECTS ANALYSIS  
(PROCESS FMEA)**

Item Front Door L.H./R.H.X-0000-A (2) FMEA Number 1450 (1)  
 Model Year(s) Vehicle(s) 1993/Lion 4dr/Wagon (5) Page 1 of 1  
 Process Responsibility Body Engineering (3) Prepared by J. Ford - X6821 - Assy Ops (4)  
 Key Date 9X 03 01 ER 9X 08 28 Job #1 (6) FMEA Date (Orig.) 9X 05 17 (Rev.) 9X 11 06 (7)  
 Core Team A. Tate Body Engrg., J. Smith - OC, R. James - Production, J. Jones - Maintenance (8)

| Process Function (9)                                                             | Potential Failure Mode (10)                      | Potential Effect(s) of Failure (11)                                                                                                                       | Q | I | C | O | D | R. P. N. | ←(15)→<br>Current Process Controls (16)                                                                    | ←(17)→<br>Current Process Controls (18)                                   | ←(19)→<br>Recommended Action(s) (19) | Responsibility & Target Completion Date (20)                                                                                            | Action Results (22) |   |   |    |    |
|----------------------------------------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|---|----------|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|---------------------|---|---|----|----|
|                                                                                  |                                                  |                                                                                                                                                           |   |   |   |   |   |          |                                                                                                            |                                                                           |                                      |                                                                                                                                         | Actions Taken (21)  | S | O | D  | R. |
| Manual application of wax inside door                                            | Insufficient wax coverage over specified surface | Deteriorated life of door leading to:<br>■ Unsatisfactory appearance due to rust through paint over time<br>■ Impaired function of interior door hardware | 7 |   |   | 8 | 5 | 280      | Visual check each hour - 1/8" for film thickness (depth meter) and coverage                                | Add positive depth stop to sprayer                                        | Mfg Engrg 9X 10 15                   | Stop added sprayer checked on line                                                                                                      | 7                   | 2 | 5 | 70 |    |
| To cover inner door, lower surfaces at minimum wax thickness to retard corrosion |                                                  |                                                                                                                                                           |   |   |   |   |   |          |                                                                                                            |                                                                           | Mfg Engrg 9X 12 15                   | Rejected due to complexity of different doors on same line                                                                              |                     |   |   |    |    |
|                                                                                  |                                                  |                                                                                                                                                           |   |   |   | 5 | 3 | 105      | Test spray pattern at start-up and after idle periods, and preventative maintenance program to clean heads | Use Design of Experiments (DOE) on viscosity vs. temperature vs. pressure | Mfg Engrg 9X 10 01                   | Temp and press limits were determined and limit controls have been installed - control charts show process is in control Cpk = 1.85     | 7                   | 1 | 3 | 21 |    |
|                                                                                  |                                                  |                                                                                                                                                           |   |   |   | 2 | 2 | 28       | Preventative maintenance program to maintain heads                                                         | None                                                                      |                                      |                                                                                                                                         |                     |   |   |    |    |
|                                                                                  |                                                  |                                                                                                                                                           |   |   |   | 8 | 7 | 392      | Operator instructions and lot sampling (10 doors/shift) to check for coverage of critical areas            | Initial spray liner                                                       | Maintenance 9X 09 15                 | Automatic spray liner installed - operator starts spray, liner controls shut-off - control charts show process is in control Cpk = 2.05 | 7                   | 1 | 7 | 49 |    |
|                                                                                  |                                                  |                                                                                                                                                           |   |   |   |   |   |          |                                                                                                            |                                                                           |                                      |                                                                                                                                         |                     |   |   |    |    |

FIGURE 10—PROCESS FMEA FORM

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4.2.12 (12) **SEVERITY (S)**—Severity is an assessment of the seriousness of the effect (listed in the previous column) of the potential failure mode to the customer. Severity applies to the effect only. If the customer affected by a failure mode is the assembly plant or the product user, assessing the severity may lie outside the immediate process engineer's/team's field of experience or knowledge. In these cases, the design FMEA, design engineer, and/or subsequent manufacturing or assembly plant process engineer should be consulted. Severity should be estimated on a "1" to "10" scale. (See Figure 10.)

4.2.12.1 *Suggested Evaluation Criteria*—The team should agree on an evaluation criteria and ranking system, which is consistent, even if modified for individual process analysis. (See Table 4.)

TABLE 4—SUGGESTED SEVERITY EVALUATION CRITERIA

| Effect                    | Criteria: Severity of Effect                                                                                                                                                                                                     | Ranking |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| Hazardous-without warning | May endanger machine or assembly operator. Very high severity ranking when a potential failure mode affects safe vehicle operation and/or involves noncompliance with government regulation. Failure will occur without warning. | 10      |
| Hazardous-with warning    | May endanger machine or assembly operator. Very high severity ranking when a potential failure mode affects safe vehicle operation and/or involves noncompliance with government regulation. Failure will occur with warning.    | 9       |
| Very High                 | Major disruption to production line. 100% of product may have to be scrapped. Vehicle/item inoperable, loss of primary function. Customer very dissatisfied.                                                                     | 8       |
| High                      | Minor disruption to production line. Product may have to be sorted and a portion (less than 100%) scrapped. Vehicle operable, but at a reduced level of performance. Customer dissatisfied.                                      | 7       |
| Moderate                  | Minor disruption to production line. A portion (less than 100%) of the product may have to be scrapped (no sorting). Vehicle/item operable, but some Comfort/Convenience item(s) inoperable. Customer experiences discomfort.    | 6       |
| Low                       | Minor disruption to production line. 100% of product may have to be reworked. Vehicle/item operable, but some Comfort/Convenience item(s) operable at reduced level of performance. Customer experiences some dissatisfaction.   | 5       |
| Very Low                  | Minor disruption to production line. The product may have to be sorted and a portion (less than 100%) reworked. Fit & Finish/Squeak & Rattle item does not conform. Defect noticed by most customers.                            | 4       |
| Minor                     | Minor disruption to production line. A portion (less than 100%) of the product may have to be reworked on-line but out-of-station. Fit & Finish/Squeak & Rattle does not conform. Defect noticed by average customers.           | 3       |
| Very Minor                | Minor disruption to production line. A portion (less than 100%) of the product may have to be reworked on-line but in-station. Fit & Finish/Squeak & Rattle item does not conform. Defect noticed by discriminating customers.   | 2       |
| None                      | No Effect.                                                                                                                                                                                                                       |         |

4.2.13 (13) **CLASSIFICATION**—This column may be used to classify any special process characteristics (e.g., critical, key, major, significant) for components, subsystems, or systems that may require additional process controls. If a classification is identified in the Process FMEA, notify the design responsible engineer since this may affect the engineering documents concerning control item identification. (See Figure 10.)

SAE J1739 Issued JUL94

**POTENTIAL  
FAILURE MODE AND EFFECTS ANALYSIS  
(PROCESS FMEA)**

FMEA Number 1450 (1)  
Page 1 of 1  
Prepared by J. Ford - X6521 - Army Ops (4)  
FMEA Date (Orig.) 9X 05 17 (Rev.) 9X 11 08 (7)

Item Front Door L.H./R.H.X-0000-A (2)  
Model Year(s)/Vehicle(s) 199X/Lon 4dr/Wagon (5)  
Process Responsibility Body Engineering (3)  
Key Date 9X 03 01 ER 9X 08 28 Job #1 (6)

Core Team A. Tate Body Engrg., J. Smith - Oc R. James - Production, J. Jones - Maintenance (8)

| Process Function Requirements (9)                                                | Potential Failure Mode (10)                      | Potential Effects of Failure (11)                                                                                                                         | C<br>I<br>S<br>V<br>S | O<br>C<br>M<br>S<br>F | Q<br>C<br>M<br>S<br>F | D<br>C<br>M<br>S<br>F | R.<br>P.<br>N. | ←(18)<br>Recommended Action(s)<br>(19)                                    | Responsibility & Target Completion Date (20) | Action Results                                                                                                                             |             |             |             |                | (22) |
|----------------------------------------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------|---------------------------------------------------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------|-------------|----------------|------|
|                                                                                  |                                                  |                                                                                                                                                           |                       |                       |                       |                       |                |                                                                           |                                              | Actions Taken (21)                                                                                                                         | S<br>C<br>V | O<br>C<br>V | D<br>C<br>V | R.<br>P.<br>N. |      |
| Manual application of wax inside door                                            | Insufficient wax coverage over specified surface | Deteriorated life of door leading to:<br>■ Unsatisfactory appearance due to rust through paint over time<br>■ Impaired function of interior door hardware | 7                     | 8                     | 8                     | 5                     | 280            | Add positive depth stop to sprayer                                        | MFG Engrg<br>9X 10 15                        | Stop added, sprayer checked on line                                                                                                        | 7           | 2           | 5           | 70             |      |
| To cover inner door, lower surfaces at minimum wax thickness to retard corrosion |                                                  |                                                                                                                                                           |                       |                       |                       |                       |                | Automatic spraying                                                        | Mfg Engrg<br>9X 12 15                        | Rejected due to complexity of different doors on same line                                                                                 |             |             |             |                |      |
|                                                                                  |                                                  |                                                                                                                                                           |                       |                       |                       | 3                     | 105            | Use Design of Experiments (DOE) on viscosity vs. temperature vs. pressure | Mfg Engrg<br>9X 10 01                        | Temp and press limits were determined and limit controls have been installed - control charts show process is in control<br>Cpk = 1.85     | 7           | 1           | 3           | 21             |      |
|                                                                                  |                                                  |                                                                                                                                                           |                       |                       |                       | 2                     | 28             | Preventative maintenance program to maintain heads                        |                                              |                                                                                                                                            |             |             |             |                |      |
|                                                                                  |                                                  |                                                                                                                                                           |                       |                       |                       | 7                     | 392            | Install spray timer                                                       | Maintenance<br>9X 09 15                      | Automatic spray timer installed - operator starts spray, timer controls shut-off - control charts show process is in control<br>Cpk = 2.05 | 7           | 1           | 7           | 49             |      |
|                                                                                  |                                                  |                                                                                                                                                           |                       |                       |                       |                       |                |                                                                           |                                              |                                                                                                                                            |             |             |             |                |      |

**SAMPLE**

FIGURE 11—PROCESS FMEA FORM

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**4.2.14 (14) POTENTIAL CAUSE(S)/MECHANISM(S) OF FAILURE**—Potential Cause of Failure is defined as how the failure could occur, described in terms of something that can be corrected or can be controlled. (See Figure 11.)

List, to the extent possible, every conceivable failure cause assignable to each potential failure mode. If a cause is exclusive to the failure mode, i.e., if correcting the cause has a direct impact on the failure mode, then this portion of the FMEA thought process is completed. Many causes, however, are not mutually exclusive, and to correct or control the cause, a design of experiments, for example, may be considered to determine which root causes are the major contributors and which can be most easily controlled. The causes should be described so that remedial efforts can be aimed at those causes which are pertinent. Typical failure causes may include, but are not limited to:

Improper torque - over, under  
Inaccurate gauging  
Inadequate gating/venting  
Part missing or mislocated

Improper weld - current, time, pressure  
Improper heat treat - time, temperature  
Inadequate or no lubrication

Only specific errors or malfunctions (e.g., operator fails to install seal) should be listed; ambiguous phrases (e.g., operator error, machine malfunction) should not be used.

**4.2.15 (15) OCCURRENCE (O)**—Occurrence is how frequently the specific failure cause/mechanism is projected to occur (listed in the previous column). The occurrence ranking number has a meaning rather than a value.

Estimate the likelihood of the occurrence on a "1" to "10" scale. Only occurrences resulting in the failure mode should be considered for this ranking; failure detecting measures are not considered here. (See Figure 11.)

The following occurrence ranking system should be used to ensure consistency. The "Possible Failure Rates" are based on the number of failures which are anticipated during the process execution.

If available from a similar process, statistical data should be used to determine the occurrence ranking. In all other cases, a subjective assessment can be made by utilizing the word descriptions in the left column of the table, along with any historical data available for similar processes.

**4.2.15.1 Suggested Evaluation Criteria**—The team should agree on an evaluation criteria and ranking system, which is consistent, even if modified for individual process analysis. (See Table 5.)

**TABLE 5—SUGGESTED OCCURRENCE EVALUATION CRITERIA**

| Probability of Failure                                                                                                                                | Possible Failure Rates | Cpk   | Ranking |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------|---------|
| Very High: Failure is almost inevitable.                                                                                                              | ≥ 1 in 2               | <0.33 | 10      |
|                                                                                                                                                       | 1 in 3                 | ≥0.33 | 9       |
| High: Generally associated with processes similar to previous processes that have often failed.                                                       | 1 in 8                 | ≥0.51 | 8       |
|                                                                                                                                                       | 1 in 20                | ≥0.67 | 7       |
| Moderate: Generally associated with processes similar to previous processes which have experienced occasional failures, but not in major proportions. | 1 in 80                | ≥0.83 | 6       |
|                                                                                                                                                       | 1 in 400               | ≥1.00 | 5       |
|                                                                                                                                                       | 1 in 2000              | ≥1.17 | 4       |
| Low: Isolated failures associated with similar processes.                                                                                             | 1 in 15 000            | ≥1.33 | 3       |
| Very Low: Only isolated failures associated with almost identical processes.                                                                          | 1 in 150 000           | ≥1.50 | 2       |
| Remote: Failure is unlikely. No failures ever associated with almost identical processes.                                                             | ≤ 1 in 1 500 000       | ≥1.67 | 1       |

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POTENTIAL  
FAILURE MODE AND EFFECTS ANALYSIS  
(PROCESS FMEA)

FMEA Number 1450 \_\_\_\_\_ (1)  
Page 1 of 1

Prepared by J. Ford - X6521 - Assy Ops  
(4)

Process Responsibility Body Engineering (3)

Key Date 9X 03 01 ER 9X 08 26 Job #1 (6)

FMEA Date (Orig.) 9X 05 17 (Rev.) 9X 11 06 (7)

Core Team A. Tate Body Engrg., J. Smith - Og. B. James - Production, J. Jones - Maintenance

| Process Function (9)                                                             | Potential Failure Mode (10)                      | Potential Effect(s) of Failure (11)                                                                                                                       | C | I | S | O | C | D | R. P. N. | ←(18) Recommended Action(s) (19)                                          | Responsibility & Target Completion Date (20) | Action Results (22)                                                                                                                     |   |   |   |    |
|----------------------------------------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|---|---|----------|---------------------------------------------------------------------------|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|---|---|---|----|
|                                                                                  |                                                  |                                                                                                                                                           |   |   |   |   |   |   |          |                                                                           |                                              | Actions Taken (21)                                                                                                                      | S | O | D | R. |
| Manual application of wax inside door                                            | Insufficient wax coverage over specified surface | Deteriorated life of door leading to:<br>■ Unsatisfactory appearance due to rust through paint over time<br>■ Impaired function of interior door hardware | 7 |   |   | 8 | 1 | 1 | 280      | Add positive depth stop to sprayer                                        | MFG Engrg 9X 10 15                           | Stop added sprayer checked on line                                                                                                      | 7 | 2 | 5 | 70 |
| To cover inner door, lower surfaces at minimum wax thickness to retard corrosion |                                                  |                                                                                                                                                           |   |   |   |   |   |   |          | Automatic spraying                                                        | Mfg Engrg 9X 12 15                           | Rejected due to complexity of different doors on same line                                                                              |   |   |   |    |
|                                                                                  |                                                  |                                                                                                                                                           |   |   |   | 5 |   | 3 | 105      | Use Design of Experiments (DOE) on viscosity vs. temperature vs. pressure | Mfg Engrg 9X 10 01                           | Temp and press limits were determined and limit controls have been installed - control charts show process is in control Cpk = 1.85     | 7 | 1 | 3 | 21 |
|                                                                                  |                                                  |                                                                                                                                                           |   |   |   | 2 |   | 2 | 28       | None                                                                      |                                              |                                                                                                                                         |   |   |   |    |
|                                                                                  |                                                  |                                                                                                                                                           |   |   |   | 8 |   | 7 | 392      | Install spray liner                                                       | Maintenance 9X 08 15                         | Automatic spray liner installed - operator starts spray, liner controls shut-off - control charts show process is in control Cpk = 2.05 | 7 | 1 | 7 | 49 |
|                                                                                  |                                                  |                                                                                                                                                           |   |   |   |   |   |   |          |                                                                           |                                              |                                                                                                                                         |   |   |   |    |

FIGURE 12—PROCESS FMEA FORM

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**4.2.16 (16) CURRENT PROCESS CONTROLS**—Current Process Controls are descriptions of the controls that either prevent to the extent possible the failure mode from occurring or detect the failure mode should it occur. These controls can be process controls such as fixture error-proofing or Statistical Process Control (SPC), or can be post-process evaluation. The evaluation may occur at the subject operation or at subsequent operations. (See Figure 12.)

There are three types of Process Controls/features to consider; those that:

1. Prevent the cause/mechanism or failure mode/effect from occurring, or reduce their rate of occurrence
2. Detect the cause/mechanism and lead to corrective actions, and
3. Detect the failure mode

The preferred approach is to first use type (1) controls if possible; second, use the type (2) controls; and third, use the type (3) controls. The initial occurrence rankings will be affected by the type (1) controls provided they are integrated as part of the design intent. The initial detection rankings will be based on the type (2) or type (3) current controls, provided the process being used is representative of process intent.

**4.2.17 (17) DETECTION (D)**—Detection is an assessment of the probability that the proposed type (2) current process controls, listed in column 16, will detect a potential cause/mechanism (process weakness), or the probability that the proposed type (3) process controls will detect the subsequent failure mode, before the part or component leaves the manufacturing operation or assembly location. A "1" to "10" scale is used. Assume the failure has occurred and then assess the capabilities of all "Current Process Controls" to prevent shipment of the part having this failure mode or defect. Do not automatically presume that the detection ranking is low because the occurrence is low (e.g., when Control Charts are used), but do assess the ability of the process controls to detect low frequency failure modes or prevent them from going further in the process. (See Figure 12.)

Random quality checks are unlikely to detect the existence of an isolated defect and should not influence the detection ranking. Sampling done on a statistical basis is a valid detection control.

**4.2.17.1 Suggested Evaluation Criteria**—The team should agree on an evaluation criteria and ranking system which is consistent, even if modified for individual process analysis. (See Table 6.)

**TABLE 6—SUGGESTED DETECTION EVALUATION CRITERIA**

| <b>Detection</b>  | <b>Criteria: Likelihood the Existence of a Defect will be Detected by Process Controls Before Next or Subsequent Process, or Before Part or Component Leaves the Manufacturing or Assembly Location</b> | <b>Ranking</b> |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| Almost Impossible | No known control(s) available to detect failure mode.                                                                                                                                                   | 10             |
| Very Remote       | Very remote likelihood current control(s) will detect failure mode.                                                                                                                                     | 9              |
| Remote            | Remote likelihood current control(s) will detect failure mode.                                                                                                                                          | 8              |
| Very Low          | Very low likelihood current control(s) will detect failure mode.                                                                                                                                        | 7              |
| Low               | Low likelihood current control(s) will detect failure mode.                                                                                                                                             | 6              |
| Moderate          | Moderate likelihood current control(s) will detect failure mode.                                                                                                                                        | 5              |
| Moderately High   | Moderately high likelihood current control(s) will detect failure mode.                                                                                                                                 | 4              |
| High              | High likelihood current control(s) will detect failure mode.                                                                                                                                            | 3              |
| Very High         | Very high likelihood current control(s) will detect failure mode.                                                                                                                                       | 2              |
| Almost Certain    | Current control(s) almost certain to detect the failure mode. Reliable detection controls are known with similar processes.                                                                             | 1              |

## SAE J1739 Issued JUL94

**POTENTIAL  
FAILURE MODE AND EFFECTS ANALYSIS  
(PROCESS FMEA)**

Item Front Door L.H./R.H.HX-0000-A (2) FMEA Number 1450 (1)  
 Model Year(s)/Vehicle(s) 199X/Lon 4dr/Wagon (5) Page 1 of 1  
 Process Responsibility Body Engineering (3) Prepared by J.Ford - X6521 - Assy Ops (4)  
 Key Date 9X 03 01 ER 9X 08 26 Job #1 (6) FMEA Date (Orig.) 9X 05 17 (Rev.) 9X 11 06 (7)  
 Core Team A. Tate Body Engng., J. Smith OC, R. James - Production, J. Jones - Maintenance (8)

| Process Function Requirements (9)                                                                                                         | Potential Failure Mode (10)                      | Potential Effect(s) of Failure (11)                                                                                                                       | C<br>I<br>S<br>V | D<br>t<br>c | ←(15) Recommended Action(s) (18) | R<br>P<br>N        | D<br>t<br>c | ←(16) Current Process Controls (19)                                                                        | D<br>t<br>c | Responsibility & Target Completion Date (20)                                                                                         | Action Results (22)  |        |        |             |    |
|-------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------|----------------------------------|--------------------|-------------|------------------------------------------------------------------------------------------------------------|-------------|--------------------------------------------------------------------------------------------------------------------------------------|----------------------|--------|--------|-------------|----|
|                                                                                                                                           |                                                  |                                                                                                                                                           |                  |             |                                  |                    |             |                                                                                                            |             |                                                                                                                                      | Actions Taken (21)   | S<br>V | O<br>C | R<br>P<br>N |    |
| Manual application of wax inside door of wax inside door To cover inner door, lower surfaces at minimum wax thickness to retard corrosion | Insufficient wax coverage over specified surface | Deteriorated life of door leading to:<br>■ Unsatisfactory appearance due to rust through paint over time<br>■ Impaired function of interior door hardware | 7                | 5           | 200                              | 200                | 5           | Visual check each hour - 1/4 inch for film thickness (depth meter) and coverage                            | 5           | Add positive depth map to spray                                                                                                      | APG Engng 9X 10 15   | 7      | 2      | 5           | 70 |
|                                                                                                                                           |                                                  |                                                                                                                                                           |                  |             | Automatic spraying               | APG Engng 9X 12 15 |             |                                                                                                            |             | Replaced due to complexity of different doors on same line                                                                           |                      |        |        |             |    |
|                                                                                                                                           |                                                  |                                                                                                                                                           |                  |             | 100                              | 100                | 3           | Test spray pattern at start-up and after idle periods, and preventative maintenance program to clean heads | 3           | Use Design of Experiments (DOE) on viscosity vs. temperature vs. pressure                                                            | APG Engng 9X 10 01   | 7      | 1      | 3           | 21 |
|                                                                                                                                           |                                                  |                                                                                                                                                           |                  |             | 28                               | 28                 | 2           | Preventative maintenance program to maintain heads                                                         | 2           | None                                                                                                                                 |                      |        |        |             |    |
|                                                                                                                                           |                                                  |                                                                                                                                                           |                  |             | 502                              | 502                | 7           | Operator instructions and lot sampling (10 doors/shift) to check for coverage of critical areas            | 7           | Visual spray time                                                                                                                    | Maintenance 9X 09 15 | 7      | 1      | 7           | 49 |
|                                                                                                                                           |                                                  |                                                                                                                                                           |                  |             |                                  |                    |             |                                                                                                            |             | Automatic spray time applied - operator starts spray, timer controls shut-off - control checks show process is in control Cpk = 2.05 |                      |        |        |             |    |
|                                                                                                                                           |                                                  |                                                                                                                                                           |                  |             |                                  |                    |             |                                                                                                            |             |                                                                                                                                      |                      |        |        |             |    |

FIGURE 13—PROCESS FMEA FORM

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4.2.18 (18) RISK PRIORITY NUMBER (RPN)—The Risk Priority Number is the product of the Severity (S), Occurrence (O), and Detection (D) rankings. (See Figure 13 and Equation 2.)

$$RPN = (S) \times (O) \times (D) \quad (\text{Eq.2})$$

This value should be used to rank order the concerns in the process (e.g., in Pareto fashion). The RPN will be between "1" and "1000". For high RPNs, the team must undertake efforts to reduce this calculated risk through corrective action(s). In general practice, regardless of the resultant RPN, special attention should be given when severity is high.

4.2.19 (19) RECOMMENDED ACTION(S)—When the failure modes have been rank ordered by RPN, corrective action should be first directed at the highest ranked concerns and critical items. If for example, the causes are not fully understood, a recommended action might be determined by a statistical designed experiment (DOE). The intent of any recommended action is to reduce the severity, occurrence, and/or detection rankings. If no actions are recommended for a specific cause, then indicate this by entering a "NONE" in this column. (See Figure 13.)

In all cases where the effect of an identified potential failure mode could be a hazard to manufacturing/assembly personnel, corrective actions should be taken to prevent the failure mode by eliminating or controlling the cause(s), or appropriate operator protection should be specified.

The need for taking specific, positive corrective actions with quantifiable benefits, recommending actions to other activities and following-up all recommendations cannot be overemphasized. A thoroughly thought out and well developed Process FMEA will be of limited value without positive and effective corrective actions. It is the responsibility of all affected activities to implement effective follow-up programs to address all recommendations.

Actions such as the following should be considered:

- a. To reduce the probability of occurrence, process and/or design revisions are required. An action-oriented study of the process using statistical methods could be implemented with an ongoing feedback of information to the appropriate operations for continuous improvement and defect prevention.
- b. Only a design and/or process revision can bring about a reduction in the severity ranking.
- c. To increase the probability of detection, process and/or design revisions are required. Generally, improving detection controls is costly and ineffective for quality improvements. Increasing quality controls inspection frequency is not positive corrective action and should only be utilized as a temporary measure, permanent corrective action is required. In some cases, a design change to a specific part may be required to assist in the detection. Changes to the current control system may be implemented to increase this probability. Emphasis must, however, be placed on preventing defects (i.e., reducing the occurrence) rather than detecting them. An example would be the use of Statistical Process Control and process improvement rather than random quality checks or associated inspection.

4.2.20 (20) RESPONSIBILITY (FOR THE RECOMMENDED ACTION)—Enter the Organization and individual responsible for the recommended action, and the target completion date. (See Figure 13.)

4.2.21 (21) ACTIONS TAKEN—After an action has been implemented, enter a brief description of the action and effective date. (See Figure 13.)

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**POTENTIAL  
FAILURE MODE AND EFFECTS ANALYSIS  
(PROCESS FMEA)**

Item: Front Door L.H. TBHX-0000-A (2)

Process Responsibility: Body Engineering (3)

Key Date: 9X 03 01 ER 9X 08 28 Job #1 (6)

Model Year(s)/Vehicle(s): 199XJL Gen 4dr/Wagon (5)

Core Team: A. Tate Body Engng., J. Smith - O.G. B. James - Production, J. Jones - Maintenance (8)

FMEA Number: 1450 (1)

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Prepared by: J.L. Ford - X6521 - Assy Ops (4)

FMEA Date (Orig.): 9X 05 17 (Rev.): 9X 11 06 (7)

| Process Function (9)                                                             | Potential Failure Mode (10)                      | Potential Effect(s) of Failure (11) →                                                                                                                     | C | ←(13) Potential Cause(s) Mechanism(s) of Failure (14)                                     | O | ←(15) Current Process Controls (16)                                                                        | D | R. P. N. | ←(18) Recommended Action(s) (19)                                          | Responsibility & Target Completion Date (20) | Actions Taken (21)                                                                                                                         | Actions Planned (22) |
|----------------------------------------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|---|-------------------------------------------------------------------------------------------|---|------------------------------------------------------------------------------------------------------------|---|----------|---------------------------------------------------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| Manual application of wax inside door                                            | Insufficient wax coverage over specified surface | Deteriorated life of door leading to:<br>■ Unsatisfactory appearance due to rust through paint over time<br>■ Impaired function of interior door hardware | 7 | Manually inserted spray head not inserted far enough                                      | 8 | Visual check each hour - 1 shift for film thickness (depth meter) and coverage                             | 5 | 280      | Add positive depth stop to sprayer                                        | MFG Engrg<br>9X 10 15                        | Stop added, sprayer checked on line                                                                                                        | 7 2 5 70             |
| To cover inner door, lower surfaces at minimum wax thickness to retard corrosion |                                                  |                                                                                                                                                           |   |                                                                                           |   |                                                                                                            |   |          | Automatic spraying                                                        | Mfg Engrg<br>9X 12 15                        | Rejected due to complexity of different doors on same line                                                                                 |                      |
|                                                                                  |                                                  |                                                                                                                                                           |   | Spray head clogged<br>- Viscosity too high<br>- Temperature too low<br>- Pressure too low | 5 | Test spray pattern at start-up and after idle periods, and preventative maintenance program to clean heads | 3 | 105      | Use Design of Experiments (DOE) on viscosity vs. temperature vs. pressure | Mfg Engrg<br>9X 10 01                        | Temp and press limits were determined and limit controls have been installed - control charts show process is in control<br>Cpk = 1.85     | 7 1 5 21             |
|                                                                                  |                                                  |                                                                                                                                                           |   | Spray head deformed due to impact                                                         | 2 | Preventative maintenance program to maintain heads                                                         | 2 | 28       | None                                                                      |                                              |                                                                                                                                            |                      |
|                                                                                  |                                                  |                                                                                                                                                           |   | Spray time insufficient                                                                   | 8 | Operator instructions and lot sampling (10 doors/ shift) to check for coverage of critical areas           | 7 | 352      | Install spray timer                                                       | Maintenance<br>9X 09 15                      | Automatic spray timer installed - operator starts spray, timer controls shut-off - control charts show process is in control<br>Cpk = 2.05 | 7 1 7 49             |

FIGURE 14—PROCESS FMEA FORM