SAE The Engineering Society For Advancing Mobility Land Sea Air and Space® INTERNATIONAL
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

TABLE OF CONTENTS

1. General Information 3
1.1 Overview 3
1.2 History 3
1.3 Manual Format 3
1.4 FMEA Implementation 3

2. References 3

3. Potential Failure Mode and Effects Analysis in Design (Design FMEA) 3
3.1 Introduction 3
3.1.1 Customer Defined 4
3.1.2 Team Effort 4
3.2 Development of a Design FMEA 7
3.2.1 (1) FMEA Number 7
3.2.2 (2) System, Subsystem, or Component Name and Number 7
3.2.3 (3) Design Responsibility 7
3.2.4 (4) Prepared By 7
3.2.5 (5) Model Year(s)/Vehicle(s) 7
3.2.6 (6) Key Date 7
3.2.7 (7) FMEA Date 7
3.2.8 (8) Core Team 7
3.2.9 (9) Item/Function 9
3.2.10 (10) Potential Failure Mode 9
3.2.11 (11) Potential Effect(s) of Failure 9
3.2.12 (12) Severity (S) 11
3.2.13 (13) Classification 11
3.2.14 (14) Potential Cause(s)/Mechanism(s) of Failure 13
3.2.15 (15) Occurrence (O) 13
3.2.16 (16) Current Design Controls 15
3.2.17 (17) Detection (D) 15

Printed in U.S.A.
90-1202B EG

3.2.18 (18) Risk Priority Number (RPN) 17
3.2.19 (19) Recommended Action(s) 17
3.2.20 (20) Responsibility (for the Recommended Action) 19
3.2.21 (21) Actions Taken 19
3.2.22 (22) Resulting RPN 19
3.2.23 (23) Follow-Up 19

4. Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA) 21
4.1 Introduction 21
4.1.1 Customer Defined 21
4.1.2 Team Effort 21
4.2 Development of a Process FMEA 23
4.2.1 (1) FMEA Number 23
4.2.2 (2) Item 23
4.2.3 (3) Process Responsibility 23
4.2.4 (4) Prepared By 23
4.2.5 (5) Model Year(s)/Vehicle(s) 23
4.2.6 (6) Key Date 23
4.2.7 (7) FMEA Date 23
4.2.8 (8) Core Team 23
4.2.9 (9) Process Function/Requirements 23
4.2.10 (10) Potential Failure Mode 25
4.2.11 (11) Potential Effect(s) of Failure 25
4.2.12 (12) Severity (S) 27
4.2.13 (13) Classification 27
4.2.14 (14) Potential Cause(s)/Mechanism(s) of Failure 29
4.2.15 (15) Occurrence (O) 29
4.2.16 (16) Current Process Controls 31
4.2.17 (17) Detection (D) 31
4.2.18 (18) Risk Priority Number (RPN) 33
4.2.19 (19) Recommended Action(s) 33
4.2.20 (20) Responsibility (for the Recommended Action) 33
4.2.21 (21) Actions Taken 33
4.2.22 (22) Resulting RPN 35
4.2.23 (23) Follow-Up 35

Appendix A—Design FMEA Block Diagram Example 36
Appendix B—Design FMEA Example 37
Appendix C—Process FMEA Flow Chart/Risk Assessment Example 38
Appendix D—Process FMEA Example 39
Appendix E—Glossary 40
Appendix F—Standard Form for Design FMEA 41
Appendix G—Standard Form for Process FMEA 42

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 compaigns.

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.

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, <u>the responsible engineer is expected to directly and actively involve representatives from all affected areas.</u> 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 <u>should</u> 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

THIS PAGE IS LEFT BLANK INTENTIONALLY

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
(DESIGN FMEA)

____ 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 (Dalton, Fraser, Henley Assembly Plants) (8)

Design Responsibility Body Engineering (3)
Key Date 9X 03 01 ER (6)

FMEA Number 1234 (1)
Page 1 of 1
Prepared by A. Tate - X 6412 - Body Engr (4)
FMEA Date (Orig.) 8X 03 22 (Rev.) 8X 07 14 (7)

Item (9) / Function	Potential Failure Mode (10)	Potential Effect(s) of Failure (11) (12)→	Sev	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Design Controls (16) (17)→	Detec	R. P. N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results: Actions Taken (21)	Sev	Occ	Det	R. P. N. (22)
Front door L.H. H8HX-0000-A ■ Ingress to and egress from vehicle ■ Occupant protection from weather, noise, and side impact ■ Support anchorage for door hardware including mirror, hinges, latch and window regulator ■ Provide proper surface for appearance items - paint and soft trim	Corroded interior lower door panels	Deteriorated life of door leading to: ■ Unsatisfactory appearance due to rust through paint over time ■ Impaired function of interior door hardware	7		Upper edge of protective wax application specified for inner door panels is too low	6	Vehicle general durability test veh. T-118 T-109 T-301	7	294	Add laboratory accelerated corrosion testing	A Tate-Body Engrg 8X 09 30	Based on test results (Test No. 1481) upper edge spec raised 125 mm	7	2	2	28
					Insufficient wax thickness specified	4	Vehicle general durability testing - as above	7	196	Add laboratory accelerated corrosion testing Conduct Design of Experiments (DOE) on wax thickness	Combine w/test for wax upper edge verification A Tate-Body Engrg 9X 01 15	Test results (Test No. 1481) show specified thickness is adequate DOE shows 25% variation in specified thickness is acceptable	7	2	2	28
					Inappropriate wax formulation specified	2	Physical and Chem Lab test - Report No. 1265	2	28	None						
					Entrapped air prevents wax from entering corner/edge access	5	Design aid investigation with nonfunctioning spray head	8	280	Add team evaluation using production spray equipment and specified wax	Body Engrg & Assy Ops 8X 11 15	Based on test, 3 additional vent holes will be provided in affected areas	7	1	3	21
					Wax application plugs door drain holes	3	Laboratory test using "worst case" wax application and hole size	1	21	None						
					Insufficient room between panels for spray head access	4	Drawing evaluation of spray head access **SAMPLE**	4	112	Add team evaluation using design aid buck and spray head	Body Engrg & Assy Ops 8X 09 15	Evaluation showed adequate access	7	1	1	7

FIGURE 1—DESIGN FMEA FORM

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.)

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
(DESIGN FMEA)

____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 (Dalton, Fraser, Henley Assembly Plants) (8)

Design Responsibility Body Engineering (3)
Key Date 9X 03 01 ER (6)

FMEA Number 1234 (1)
Page 1 of 1
Prepared by A. Tate - X 6412 - Body Engr (4)
FMEA Date (Orig.) 8X 03 22 (Rev.) 8X 07 14 (7)

Item (9) Function	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	Sev (12)→	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Design Controls (16) (17)→	Detec	R.P.N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	Sev	Occ	Det	R.P.N.
Front door L.H. H8HX-0000-A	Corroded interior lower door panels	Deteriorated life of door leading to: ■ Unsatisfactory appearance due to rust through paint over time ■ Impaired function of interior door hardware	7		Upper edge of protective wax application specified for inner door panels is too low	6	Vehicle general durability test veh. T-118 T-109 T-301	7	294	Add laboratory accelerated corrosion testing	A Tate-Body Engrg 8X 09 30	Based on test results (Test No. 1481) upper edge spec raised 125 mm	7	2	2	28
■ Ingress to and egress from vehicle ■ Occupant protection from weather, noise, and side impact					Insufficient wax thickness specified	4	Vehicle general durability testing - as above	7	196	Add laboratory accelerated corrosion testing Conduct Design of Experiments (DOE) on wax thickness	Combine w/test for wax upper edge verification A Tate-Body Engrg 9X 01 15	Test results (Test No. 1481) show specified thickness is adequate DOE shows 25% variation in specified thickness is acceptable	7	2	2	28
■ Support anchorage for door hardware including mirror, hinges, latch and window regulator					Inappropriate wax formulation specified	2	Physical and Chem Lab test - Report No. 1265	2	28	None						
■ Provide proper surface for appearance items - paint and soft trim					Entrapped air prevents wax from entering corner/edge access	5	Design aid investigation with nonfunctioning spray head	8	280	Add team evaluation using production spray equipment and specified wax	Body Engrg & Assy Ops 8X 11 15	Based on test, 3 additional vent holes will be provided in affected areas	7	1	3	21
					Wax application plugs door drain holes	3	Laboratory test using "worst case" wax application and hole size	1	21	None						
					Insufficient room between panels for spray head access	4	Drawing evaluation of spray head access	4	112	Add team evaluation using design aid buck and spray head	Body Engrg & Assy Ops 8X 09 15	Evaluation showed adequate access	7	1	1	7

SAMPLE

FIGURE 2—DESIGN FMEA FORM

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.)

<u>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.</u> 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)
Model Year(s)/Vehicle(s) 199X/Lion 4dr/Wagon (5)
Core Team T. Fender - Car Product Dev., C. Childers - Manufacturing, J. Ford - Assy Ops (Dalton, Fraser, Henley Assembly Plants) (8)

Design Responsibility Body Engineering (3)
Key Date 9X 03 01 ER (6)

FMEA Number 1234 (1)
Page 1 of 1
Prepared by A. Tate - X 6412 - Body Engr (4)
FMEA Date (Orig.) 8X 03 22 (Rev.) 8X 07 14 (7)

Item (9) Function	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	S e v (12)	C l a s s	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	O c c u r	←(15) Current Design Controls (16) (17)→	D e t e c	R. P. N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	S e v	O c c	D e t	R. P. N.
Front door L.H. H8HX-0000-A ■ Ingress to and egress from vehicle ■ Occupant protection from weather, noise, and side impact ■ Support anchorage for door hardware including mirror, hinges, latch and window regulator ■ Provide proper surface for appearance items - paint and soft trim	Corroded interior lower door panels	Deteriorated life of door leading to: ■ Unsatisfactory appearance due to rust through paint over time ■ Impaired function of interior door hardware	7		Upper edge of protective wax application specified for inner door panels is too low	6	Vehicle general durability test veh. T-118 T-109 T-301	7	294	Add laboratory accelerated corrosion testing	A Tate-Body Engrg 8X 09 30	Based on test results (Test No. 1481) upper edge spec raised 125 mm	7	2	2	28
					Insufficient wax thickness specified	4	Vehicle general durability testing - as above	7	196	Add laboratory accelerated corrosion testing Conduct Design of Experiments (DOE) on wax thickness	Combine w/test for wax upper edge verification A Tate-Body Engrg 9X 01 15	Test results (Test No. 1481) show specified thickness is adequate DOE shows 25% variation in specified thickness is acceptable	7	2	2	28
					Inappropriate wax formulation specified	2	Physical and Chem Lab test - Report No. 1265	2	28	None						
					Entrapped air prevents wax from entering corner/edge access	5	Design aid investigation with nonfunctioning spray head	8	280	Add team evaluation using production spray equipment and specified wax	Body Engrg & Assy Ops 8X 11 15	Based on test, 3 additional vent holes will be provided in affected areas	7	1	3	21
					Wax application plugs door drain holes	3	Laboratory test using "worst case" wax application and hole size	1	21	None						
					Insufficient room between panels for spray head access	4	Drawing evaluation of spray head access	4	112	Add team evaluation using design aid buck and spray head	Body Engrg & Assy Ops 8X 09 15	Evaluation showed adequate access	7	1	1	7

SAMPLE

FIGURE 3—DESIGN FMEA FORM

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.

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
(DESIGN FMEA)

____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 (Dalton, Fraser, Henley Assembly Plants) (8)

Design Responsibility Body Engineering (3)
Key Date 9X 03 01 ER (6)

FMEA Number 1234 (1)
Page 1 of 1
Prepared by A. Tate - X 6412 - Body Engr (4)
FMEA Date (Orig.) 8X 03 22 (Rev.) 8X 07 14 (7)

Item (9) Function	Potential Failure Mode (10)	Potential Effect(s) of Failure (11) (12)→	Sev	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Design Controls (16) (17)→	Detec	R.P.N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	Sev	Occ	Det	R.P.N.
Front door L.H. H8HX-0000-A ■ Ingress to and egress from vehicle ■ Occupant protection from weather, noise, and side impact ■ Support anchorage for door hardware including mirror, hinges, latch and window regulator ■ Provide proper surface for appearance items - paint and soft trim	Corroded interior lower door panels	Deteriorated life of door leading to: ■ Unsatisfactory appearance due to rust through paint over time ■ Impaired function of interior door hardware	7		Upper edge of protective wax application specified for inner door panels is too low	6	Vehicle general durability test veh. T-118 T-109 T-301	7	294	Add laboratory accelerated corrosion testing	A Tate-Body Engrg 8X 09 30	Based on test results (Test No. 1481) upper edge spec raised 125 mm	7	2	2	28
					Insufficient wax thickness specified	4	Vehicle general durability testing - as above	7	196	Add laboratory accelerated corrosion testing Conduct Design of Experiments (DOE) on wax thickness	Combine w/test for wax upper edge verification A Tate-Body Engrg 9X 01 15	Test results (Test No. 1481) show specified thickness is adequate DOE shows 25% variation in specified thickness is acceptable	7	2	2	28
					Inappropriate wax formulation specified	2	Physical and Chem Lab test - Report No. 1265	2	28	None						
					Entrapped air prevents wax from entering corner/edge access	5	Design aid investigation with nonfunctioning spray head	8	280	Add team evaluation using production spray equipment and specified wax	Body Engrg & Assy Ops 8X 11 15	Based on test, 3 additional vent holes will be provided in affected areas	7	1	3	21
					Wax application plugs door drain holes	3	Laboratory test using "worst case" wax application and hole size	1	21	None						
					Insufficient room between panels for spray head access	4	Drawing evaluation of spray head access **SAMPLE**	4	112	Add team evaluation using design aid buck and spray head	Body Engrg & Assy Ops 8X 09 15	Evaluation showed adequate access	7	1	1	7

FIGURE 4—DESIGN FMEA FORM

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 <u>design</u> 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.

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
(DESIGN FMEA)

____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 (Dalton, Fraser, Henley Assembly Plants) (8)

Design Responsibility Body Engineering (3)
Key Date 9X 03 01 ER (6)

FMEA Number 1234 (1)
Page 1 of 1
Prepared by A. Tate - X 6412 - Body Engr (4)
FMEA Date (Orig.) 8X 03 22 (Rev.) 8X 07 14 (7)

Item (9) / Function	Potential Failure Mode (10)	Potential Effect(s) of Failure (11) (12)→	Sev	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Design Controls (16) (17)→	Detec	R. P. N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	Sev	Occ	Det	R. P. N.
Front door L.H. H8HX-0000-A ■ Ingress to and egress from vehicle ■ Occupant protection from weather, noise, and side impact ■ Support anchorage for door hardware including mirror, hinges, latch and window regulator ■ Provide proper surface for appearance items - paint and soft trim	Corroded interior lower door panels	Deteriorated life of door leading to: ■ Unsatisfactory appearance due to rust through paint over time ■ Impaired function of interior door hardware	7		Upper edge of protective wax application specified for inner door panels is too low	6	Vehicle general durability test veh. T-118 T-109 T-301	7	294	Add laboratory accelerated corrosion testing	A Tate-Body Engrg 8X 09 30	Based on test results (Test No. 1481) upper edge spec raised 125 mm	7	2	2	28
					Insufficient wax thickness specified	4	Vehicle general durability testing - as above	7	196	Add laboratory accelerated corrosion testing Conduct Design of Experiments (DOE) on wax thickness	Combine w/test for wax upper edge verification A Tate-Body Engrg 9X 01 15	Test results (Test No. 1481) show specified thickness is adequate DOE shows 25% variation in specified thickness is acceptable	7	2	2	28
					Inappropriate wax formulation specified	2	Physical and Chem Lab test - Report No. 1265	2	28	None						
					Entrapped air prevents wax from entering corner/edge access	5	Design aid investigation with nonfunctioning spray head	8	280	Add team evaluation using production spray equipment and specified wax	Body Engrg & Assy Ops 8X 11 15	Based on test, 3 additional vent holes will be provided in affected areas	7	1	3	21
					Wax application plugs door drain holes	3	Laboratory test using "worst case" wax application and hole size	1	21	None						
					Insufficient room between panels for spray head access	4	Drawing evaluation of spray head access	4	112	Add team evaluation using design aid buck and spray head	Body Engrg & Assy Ops 8X 09 15	Evaluation showed adequate access	7	1	1	7

SAMPLE

FIGURE 5—DESIGN FMEA FORM

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	≥ 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	≤ 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.

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
(DESIGN FMEA)

____System
____Subsystem
____Component 01.03/Body Closures (2)
Model Year(s)/Vehicle(s) 199X/Lion 4dr/Wagon (5)

Design Responsibility Body Engineering (3)
Key Date 9X 03 01 ER (6)

FMEA Number 1234 (1)
Page 1 of 1
Prepared by A. Tate - X 6412 - Body Engr (4)
FMEA Date (Orig.) 8X 03 22 (Rev.) 8X 07 14 (7)

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

Item (9) / Function	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	(12)→ Sev	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Design Controls (16) (17)→	Detec	R. P. N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	Sev	Occ	Det	R. P. N.
Front door L.H. H8HX-0000-A	Corroded interior lower door panels	Deteriorated life of door leading to: ■ Unsatisfactory appearance due to rust through paint over time ■ Impaired function of interior door hardware	7		Upper edge of protective wax application specified for inner door panels is too low	6	Vehicle general durability test veh. T-118 T-109 T-301	7	294	Add laboratory accelerated corrosion testing	A Tate-Body Engrg 8X 09 30	Based on test results (Test No. 1481) upper edge spec raised 125 mm	7	2	2	28
■ Ingress to and egress from vehicle ■ Occupant protection from weather, noise, and side impact					Insufficient wax thickness specified	4	Vehicle general durability testing - as above	7	196	Add laboratory accelerated corrosion testing Conduct Design of Experiments (DOE) on wax thickness	Combine w/test for wax upper edge verification A Tate-Body Engrg 9X 01 15	Test results (Test No. 1481) show specified thickness is adequate DOE shows 25% variation in specified thickness is acceptable	7	2	2	28
■ Support anchorage for door hardware including mirror, hinges, latch and window regulator					Inappropriate wax formulation specified	2	Physical and Chem Lab test - Report No. 1265	2	28	None						
■ Provide proper surface for appearance items - paint and soft trim					Entrapped air prevents wax from entering corner/edge access	5	Design aid investigation with nonfunctioning spray head	8	280	Add team evaluation using production spray equipment and specified wax	Body Engrg & Assy Ops 8X 11 15	Based on test, 3 additional vent holes will be provided in affected areas	7	1	3	21
					Wax application plugs door drain holes	3	Laboratory test using "worst case" wax application and hole size	1	21	None						
					Insufficient room between panels for spray head access	4	Drawing evaluation of spray head access **SAMPLE**	4	112	Add team evaluation using design aid buck and spray head	Body Engrg & Assy Ops 8X 09 15	Evaluation showed adequate access	7	1	1	7

FIGURE 6—DESIGN FMEA FORM

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.)

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

The Risk Priority Number, as the product S x O x 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.

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (DESIGN FMEA)

____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 (Dalton, Fraser, Henley Assembly Plants) (8)

Design Responsibility Body Engineering (3)
Key Date 9X 03 01 ER (6)

FMEA Number 1234 (1)
Page 1 of 1
Prepared by A. Tate - X 6412 - Body Engr (4)
FMEA Date (Orig.) 8X 03 22 (Rev.) 8X 07 14 (7)

Item (9) / Function	Potential Failure Mode (10)	Potential Effect(s) of Failure (11) (12)→	Sev	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Design Controls (16) (17)→	Detec	R.P.N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	Sev	Occ	Det	R.P.N.
Front door L.H. H8HX-0000-A ■ Ingress to and egress from vehicle ■ Occupant protection from weather, noise, and side impact ■ Support anchorage for door hardware including mirror, hinges, latch and window regulator ■ Provide proper surface for appearance items - paint and soft trim	Corroded interior lower door panels	Deteriorated life of door leading to: ■ Unsatisfactory appearance due to rust through paint over time ■ Impaired function of interior door hardware	7		Upper edge of protective wax application specified for inner door panels is too low	6	Vehicle general durability test veh. T-118 T-109 T-301	7	294	Add laboratory accelerated corrosion testing	A Tate-Body Engrg 8X 09 30	Based on test results (Test No. 1481) upper edge spec raised 125 mm	7	2	2	28
					Insufficient wax thickness specified	4	Vehicle general durability testing - as above	7	196	Add laboratory accelerated corrosion testing Conduct Design of Experiments (DOE) on wax thickness	Combine w/test for wax upper edge verification A Tate-Body Engrg 9X 01 15	Test results (Test No. 1481) show specified thickness is adequate DOE shows 25% variation in specified thickness is acceptable	7	2	2	28
					Inappropriate wax formulation specified	2	Physical and Chem Lab test - Report No. 1265	2	28	None						
					Entrapped air prevents wax from entering corner/edge access	5	Design aid investigation with nonfunctioning spray head	8	280	Add team evaluation using production spray equipment and specified wax	Body Engrg & Assy Ops 8X 11 15	Based on test, 3 additional vent holes will be provided in affected areas	7	1	3	21
					Wax application plugs door drain holes	3	Laboratory test using "worst case" wax application and hole size	1	21	None						
					Insufficient room between panels for spray head access	4	Drawing evaluation of spray head access	4	112	Add team evaluation using design aid buck and spray head	Body Engrg & Assy Ops 8X 09 15	Evaluation showed adequate access	7	1	1	7

SAMPLE

FIGURE 7—DESIGN FMEA FORM

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

THIS PAGE IS LEFT BLANK INTENTIONALLY

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, <u>the responsible engineer is expected to directly and actively involve representatives from all affected areas.</u> 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.

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 - X6521 - Assy Ops (4)

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

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 - OC, R. James - Production, J. Jones - Maintenance (8)

Process Function (9) Requirements	Potential Failure Mode (10)	Potential Effect(s) of Failure (11) (12)→	Sev	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Process Controls (16) (17)→	Detec	R.P.N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	Sev	Occ	Det	R.P.N.
Manual application 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: ■ Unsatisfactory appearance due to rust through paint over time ■ 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 9X 10 15	Stop added, sprayer checked on line	7	2	5	70
										Automate spraying	Mfg Engrg 9X 12 15	Rejected due to complexity of different doors on same line				
					Spray head clogged - Viscosity too high - Temperature too low - 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 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
					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 timer	Maintenance 9X 09 15	Automatic spray timer installed - operator starts spray, timer controls shut-off - control charts show process is in control Cpk = 2.05	7	1	7	49

SAMPLE

FIGURE 8—PROCESS FMEA FORM

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 - X6521 - Assy Ops (4)
Model Year(s)/Vehicle(s) 199X/Lion 4dr/Wagon (5)
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 - OC, R. James - Production, J. Jones - Maintenance (8)

Process Function (9) Requirements	Potential Failure Mode (10)	Potential Effect(s) of Failure (11) (12)→	Sev	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Process Controls (16) (17)→	Detec	R.P.N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	Sev	Occ	Det	R.P.N.
Manual application 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: ■ Unsatisfactory appearance due to rust through paint over time ■ 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 9X 10 15	Stop added, sprayer checked on line	7	2	5	70
										Automate spraying	Mfg Engrg 9X 12 15	Rejected due to complexity of different doors on same line				
					Spray head clogged - Viscosity too high - Temperature too low - 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 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
					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 timer	Maintenance 9X 09 15	Automatic spray timer installed - operator starts spray, timer controls shut-off - control charts show process is in control Cpk = 2.05	7	1	7	49

SAMPLE

FIGURE 9—PROCESS FMEA FORM

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	
Binding	Burred
Handling Damage	Cracked
Deformed	Dirty
Improper Set-up	Grounded
Open Circuited	Short 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	
Rough	Erratic Operation
Excessive Effort Required	Inoperative
Unpleasant Odor	Unstable
Operation Impaired	Draft
Intermittent Operation	Poor Appearance
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	

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 - X6521 - Assy Ops (4)

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

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 - OC, R. James - Production, J. Jones - Maintenance (8)

Process Function (9) Requirements	Potential Failure Mode (10)	Potential Effect(s) of Failure (11) (12)→	Sev	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Process Controls (16) (17)→	Detec	R.P.N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	Sev	Occ	Det	R.P.N.
Manual application of wax inside door To cover inner door, lower surfaces at minimum wax thicness to retard corrosion	Insufficient wax coverage over specified surface	Deteriorated life of door leading to: ■ Unsatisfactory appearance due to rust through paint over time ■ 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 9X 10 15	Stop added, sprayer checked on line	7	2	5	70
										Automate spraying	Mfg Engrg 9X 12 15	Rejected due to complexity of different doors on same line				
					Spray head clogged - Viscosity too high - Temperature too low - 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 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
					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 timer	Maintenance 9X 09 15	Automatic spray timer installed - operator starts spray, timer controls shut-off - control charts show process is in control Cpk = 2.05	7	1	7	49

SAMPLE

FIGURE 10—PROCESS FMEA FORM

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.)

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 - X6521 - Assy Ops (4)

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

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 - OC, R. James - Production, J. Jones - Maintenance (8)

Process Function (9) Requirements	Potential Failure Mode (10)	Potential Effect(s) of Failure (11) (12)→	Sev	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Process Controls (16) (17)→	Detec	R. P. N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	Sev	Occ	Det	R. P. N.
Manual application of wax inside door To cover inner door, lower surfaces at minimum wax thicness to retard corrosion	Insufficient wax coverage over specified surface	Deteriorated life of door leading to: ■ Unsatisfactory appearance due to rust through paint over time ■ 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 9X 10 15	Stop added, sprayer checked on line	7	2	5	70
										Automate spraying	Mfg Engrg 9X 12 15	Rejected due to complexity of different doors on same line				
					Spray head clogged - Viscosity too high - Temperature too low - 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 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
					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 **SAMPLE**	7	392	Install spray timer	Maintenance 9X 09 15	Automatic spray timer installed - operator starts spray, timer controls shut-off - control charts show process is in control Cpk = 2.05	7	1	7	49

FIGURE 11—PROCESS FMEA FORM

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

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 - X6521 - Assy Ops (4)

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

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 - OC, R. James - Production, J. Jones - Maintenance (8)

Process Function (9) Requirements	Potential Failure Mode (10)	Potential Effect(s) of Failure (11) (12)→	Sev	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Process Controls (16) (17)→	Detec	R. P. N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	Sev	Occ	Det	R. P. N.
Manual application of wax inside door To cover inner door, lower surfaces at minimum wax thicness to retard corrosion	Insufficient wax coverage over specified surface	Deteriorated life of door leading to: ■ Unsatisfactory appearance due to rust through paint over time ■ 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 9X 10 15	Stop added, sprayer checked on line	7	2	5	70
										Automate spraying	Mfg Engrg 9X 12 15	Rejected due to complexity of different doors on same line				
					Spray head clogged - Viscosity too high - Temperature too low - 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 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
					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 timer	Maintenance 9X 09 15	Automatic spray timer installed - operator starts spray, timer controls shut-off - control charts show process is in control Cpk = 2.05	7	1	7	49

SAMPLE

FIGURE 12—PROCESS FMEA FORM

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

Detection	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	Ranking
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

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
(PROCESS FMEA)

Item __Front Door L.H./H8HX-0000-A__ (2)

Model Year(s)/Vehicle(s) __199X/Lion 4dr/Wagon__ (5)

Process Responsibility __Body Engineering__ (3)

Key Date __9X 03 01 ER__ __9X 08 26 Job #1__ (6)

FMEA Number __1450__ (1)

Page __1__ of __1__

Prepared by __J. Ford - X6521 - Assy Ops__ (4)

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) Requirements	Potential Failure Mode (10)	Potential Effect(s) of Failure (11) (12)→	Sev	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Process Controls (16) (17)→	Detec	R. P. N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	Sev	Occ	Det	R. P. N.
Manual application of wax inside door To cover inner door, lower surfaces at minimum wax thicness to retard corrosion	Insufficient wax coverage over specified surface	Deteriorated life of door leading to: ■ Unsatisfactory appearance due to rust through paint over time ■ 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 9X 10 15	Stop added, sprayer checked on line	7	2	5	70
										Automate spraying	Mfg Engrg 9X 12 15	Rejected due to complexity of different doors on same line				
					Spray head clogged - Viscosity too high - Temperature too low - 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 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
					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 timer	Maintenance 9X 09 15	Automatic spray timer installed - operator starts spray, timer controls shut-off - control charts show process is in control Cpk = 2.05	7	1	7	49

SAMPLE

FIGURE 13—PROCESS FMEA FORM

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.)

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

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.)

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 - X6521 - Assy Ops (4)

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

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 - OC, R. James - Production, J. Jones - Maintenance (8)

Process Function (9) Requirements	Potential Failure Mode (10)	Potential Effect(s) of Failure (11) (12)→	Sev	Class	←(13) Potential Cause(s)/ Mechanism(s) of Failure (14)	Occur	←(15) Current Process Controls (16) (17)→	Detec	R. P. N.	←(18) Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22): Actions Taken (21)	Sev	Occ	Det	R. P. N.
Manual application of wax inside door To cover inner door, lower surfaces at minimum wax thicness to retard corrosion	Insufficient wax coverage over specified surface	Deteriorated life of door leading to: ■ Unsatisfactory appearance due to rust through paint over time ■ 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 9X 10 15	Stop added, sprayer checked on line	7	2	5	70
										Automate spraying	Mfg Engrg 9X 12 15	Rejected due to complexity of different doors on same line				
					Spray head clogged - Viscosity too high - Temperature too low - 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 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
					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 timer	Maintenance 9X 09 15	Automatic spray timer installed - operator starts spray, timer controls shut-off - control charts show process is in control Cpk = 2.05	7	1	7	49

SAMPLE

FIGURE 14—PROCESS FMEA FORM