

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

REFERENCE MANUAL

The content of this document is the technical equivalent of SAE J-1739. Potential Failure Mode and Effects Analysis (FMEA) should be used by suppliers to companies subscribing to QS-9000.



FOREWORD

This reference Manual and Reporting Format was developed by the Failure Mode and Effects Analysis (FMEA) teams at Chrysler, Ford and General Motors, working under the auspices of the Automotive Division of the American Society for Quality Control (ASQC) and the Automotive Industry Action Group (AIAG).

734-662-0499 APPR FMEA SECTION

The ASQC/AIAG Task Force charter is to standardize the reference manuals, procedures, reporting formats and technical nomenclature used by Chrysler, Ford, and General Motors in their respective supplier quality systems. Accordingly, this manual and format, which is approved and endorsed by Chrysler, Ford and General Motors, should be used by suppliers implementing FMEA techniques into their design/manufacturing processes.

In the past, Chrysler, Ford and General Motors each had their own guidelines and formats for insuring supplier FMEA compliance. Differences between these guidelines and formats resulted in additional demands on supplier resources. To improve upon this situation, Chrysler, Ford and General Motors agreed to develop, and, through AIAG, distribute this Manual. The work group responsible for the Manual was led by George Baumgartner of Ford Motor Company.

This Manual provides general guidelines for preparing an FMEA. It does not give specific instructions on how to arrive at each FMEA entry, a task best left to each FMEA team. This Manual also is not intended to be a comprehensive FMEA reference source or training document.

While these guidelines are intended to cover all situation normally occurring either in the design phase or process analysis, there will be questions that arise. These questions should be directed to your customer's Supplier Quality Assurance (SQA) activity. If you are uncertain as to how to contact the appropriate SQA activity, the buyer in your customer's Purchasing office can help.

The Task Force gratefully acknowledges: the leadership and commitment of Vice Presidents Thomas T. Stallkamp at Chrysler, Norman F. Ehlers at Ford, and J. Ignacio Lopez de Arriortua of General Motors; the assistance of the AIAG in the development, production, and distribution of the Procedure; the guidance of Task Force principals Russ Jacobs (Chrysler), Steve Walsh (Ford), Dan Reid (General Motors), and Rad Smith; and the assistance of the ASQC Automotive Division Reading Team. This team, led by Tripp Martin (Peterson Spring), reviewed the Manual for technical content and accuracy and made valuable contributions to form and content. Since the Manual was developed to meet specific needs of the automotive industry, the ASQC voluntary standards process defined by ASQC policies and procedures was not used in its development.

Additional copies can be ordered from AIAG and/or permission to copy portions of this Procedure for use within supplier organizations should be obtained from AIAG at 810-358-3003.





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Ford





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Ford





GENERAL INFORMATION

Overview

This manual introduces the topic 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: 1) recognize and evaluate the potential failure of a product/process and its effects, 2) identify actions which could eliminate or reduce the chance of the potential failure occurring, and 3) document the process. It is complementary to the design process of defining positively what a design must do to satisfy the customer.

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.

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.

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 could create an even larger concern. Properly applied, it is an interactive process which is never ending.





DESIGN FMEA

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
IN
DESIGN
(DESIGN FMEA)
REFERENCE MANUAL



DESIGN FMEA



DESIGN FMEA

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:

- Aiding in the objective evaluation of design requirements and design alternatives.
- Aiding in the initial design for manufacturing and assembly requirements.
- Increasing the probability that potential failure modes and their effects on system and vehicle operation have been considered in the design/development process.
- Providing additional information to aid in the planning of thorough and efficient design test and development programs.
- 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.
- Providing an open issue format for recommending and tracking risk reducing actions.
- Providing future reference to aid in analyzing field concerns, evaluating design changes and developing advanced designs.

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.



DESIGN FMEA



DESIGN FMEA

INTRODUCTION (Continued)

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 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.:

- necessary mold drafts
- limited surface finish
- assembling space/access for tooling
- limited hardenability of steels
- process capability/performance

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.



DESIGN FMEA

FMEA Number: 1234
 Page 1 of 1
 Prepared By: A. Tate - A6112 Body Eng
 FMEA Date (Orig): BX 03 22 (Rev): BX 07 14

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (DESIGN FMEA)

System: Subsystem: Component: 01.03/Body Closures
 Model Year(s): 199X
 Vehicle(s): 199X
 Design Responsibility: Body Engineering
 Key Date: BX 03 01 ER
 Design Responsibility: Body Engineering
 Key Date: BX 03 01 ER

Core Team: J. Fender, S. Can, P. Rodal, Dev. Charters, Manufacturing, J. Ford, Assv. Ops., Dalton, F. Hester, Assembly Plants

Item	Function	Potential Failure Mode	Potential Effect(s) of Failure	S e v e r i t y	C a u s e s	P o t e n t i a l Cause(s)/ Mechanism(s) of Failure	O c c u r r e n c e	C u r r e n t Design Controls	D e t e c t	R. P. N.	Recommended Action(s)	Responsibility & Target Completion Date	Action Results			
													Actions Taken	S O C I E T Y	R. P. N.	
9	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	7	Upper edge of protective wax application specified for inner door panels is too low	6	Vehicle general durability test vab. T-118 T-109 T-301	7	294	Add laboratory accelerated corrosion testing	A. Tate-Body Engg BX 09 30	7	2	2	28
			Insufficient wax thickness specified		4	Insufficient wax thickness specified	4	Vehicle general durability testing- as above	7	196	Add laboratory accelerated corrosion testing	Combine w/ test for wax upper edge verification	7	2	2	28
			Inappropriate wax formulation specified		2	Inappropriate wax formulation specified	2	Physical and Chem Lab test- Report No. 1265	2	28	None	A. Tate Body Engg 9X 01 15				
			Entrapped air prevents wax from entering corner/edge access		5	Entrapped air prevents wax from entering corner/edge access	5	Design aid investigation with non-functioning spray head	8	280	Add team evaluation using production spray equipment and specified wax	Body Engg & Assv Ops BX 11 15	7	1	3	21
			Wax application plugs door drain holes		3	Wax application plugs door drain holes	3	Laboratory test using "worst case" wax application and hole size	1	21	None		Based on test, 3 additional vent holes provided in affected areas			
			Insufficient room between panels for spray head access		4	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 Engg & Assv Ops	7	1	1	7

SAMPLE



DESIGN FMEA

DEVELOPMENT OF A DESIGN FMEA (Continued)

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.

Application of the form is described below; points are numbered according to the numbers encircled on the form shown on the facing page. An example of a completed form is contained in Appendix B and on the facing pages of this section.

- 1) **FMEA Number**
Enter the FMEA document number, which may be used for tracking.
- 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.
- 3) **Design Responsibility**
Enter the OEM, department and group. Also include the supplier name if known.
- 4) **Prepared By**
Enter the name, telephone number, company of the engineer responsible for preparing the FMEA.
- 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).
- 6) **Key Date**
Enter the initial FMEA due date, which should not exceed the scheduled production design release date.
- 7) **FMEA Date**
Enter the date the original FMEA was compiled, and the latest revision date.
- 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.)



DESIGN FMEA

FMEA Number 1234 (1)
 Page 1 of 1 (4)
 Prepared By A. Tate - X6412- Body Engr. (7)
 FMEA Date (Orig.) 8X 03 22 (Rev.) 8X 07 14

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (DESIGN FMEA)

Design Responsibility Body Engineering (3)
 Key Date 8X 03 01 ER (6)

Model Year(s)/Vehicle(s) 199X/Lon 4dr/Wagon (2)
01.03/Body Closures (5)

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

Item	Function	Potential Failure Mode	Potential Cause(s)/Mechanism(s) of Failure	Occurrence	Current Design Controls	Detection	Recommended Action(s)	Responsibility & Target Completion Date	Action Results	
									Actions Taken	S O D R. S e c e P. V c t N.
9	Front Door L/R RBHX-0000-A Ingress to and egress from vehicle Occupant Protection Front 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 (10)	Deteriorated life of door leading to: • Unsatisfactory appearance due to rust through paint over time • Impaired function of interior door hardware (11)	7	Vehicle general durability T-118 T-109 T-301 (16)	7	294 Add laboratory accelerated corrosion testing (19)	A Tate-Body Engr 8X 09 30 (20)	Based on test results (Test No. 1481) upper edge spec raised 125mm (21)	7 2 2 28
			Insufficient wax thickness specified (14)	4	Vehicle general durability testing- as above (17)	7	196 Add laboratory accelerated corrosion testing Conduct Design of Experiments (DOE) on wax thickness (18)	Combine w/test for wax upper edge verification A Tate Body Engr 9X 01 15 (20)	Test results (Test No. 1481) show specified thickness is adequate. DOE shows 25% variation in specified thickness is acceptable. (21)	7 2 2 28
			Inappropriate wax formulation specified	2	Physical and Chem Lab test- Report No.1265 (17)	2	28 None (18)			
			Entrapped air prevents wax from entering corner/edge access	5	Design aid investigation with non-functioning spray head (17)	8	280 Add team evaluation using production spray equipment and specified wax (19)	Body Engr & Assy Ops 8X 11 15 (20)		7 1 3 21
			Wax application plugs door drain holes	3	Laboratory test using "worst case" wax application and hole size (17)	1	21 None (18)		Based on test, 3 additional vent holes provided in affected areas (21)	
			Insufficient room between panels for spray head access	4	Drawing evaluation of spray head access (17)	4	112 Add team evaluation using design aid buck and spray head (19)	Body Engr & Assy Ops (20)	Evaluation showed adequate access (21)	7 1 1 7

SAMPLE



DESIGN FMEA

DEVELOPMENT OF A DESIGN FMEA (Continued)

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.

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.

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.

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.

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.

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.



DESIGN FMEA

FMEA Number 1234

Page 1 of 1

Prepared By A. Tate - X6412-Body Engr

FMEA Date (Orig.) BX 03 22 (Rev.) BX 07 14

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (DESIGN FMEA)

Design Responsibility Body Engineering

Key Date 9X 03 01 ER

Core Team T. Fender-Car Product Dev., Childers-Manufacturing, J. Ford-Assy Ops, Dalton, Fraser, Hanley, Assembly Plants

1

3

2

5

4

7

8

Item	Function	Potential Failure Mode	Potential Effect(s) of Failure	Cause(s)/Mechanism(s) of Failure	O C C U R	D e t P. N.	R. P. N.	Recommended Action(s)	Responsibility & Target Completion Date	Action Results			
										Actions Taken	S O D R. S E C E P. V I C L N.		
9	Front Door L.H. H8HX-0000-A	Corroded interior lower door panels	Deteriorated life of door leading to: <ul style="list-style-type: none"> Unsatisfactory appearance due to rust through paint over time Impaired function of interior door hardware 	Upper edge of protective wax application specified for inner door panels is too low	6	7	294	Add laboratory accelerated corrosion testing	A Tate-Body Engr 09 30	7	21	28	
				Insufficient wax thickness specified	4	7	196	Add laboratory accelerated corrosion testing	Combine w/next for wax upper edge verification	7	21	28	
				Inappropriate wax formulation specified	2	2	28	None	A Tate Body Engr 09 01 15				
				Entrapped air prevents wax from entering corner/edge access	5	8	280	Conduct Design of Experiments (DOE) on wax thickness	Body Engr & Assy Ops 09 11 15	7	1	3	21
				Wax application plugs door drain holes	3	1	21	Add team evaluation using production spray equipment and specified wax	Body Engr & Assy Ops 09 11 15				
				Insufficient room between panels for spray head access	4	4	112	None	Based on test, 3 additional vent holes provided in affected areas				
								Add team evaluation using spray head and spray head	Body Engr & Assy Ops	7	1	1	7

SAMPLE



DESIGN FMEA

DEVELOPMENT OF A DESIGN FMEA (Continued)

**11) Potential Effect(s)
of Failure (Continued)**

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

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

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.

Suggested Evaluation Criteria:

(The team should agree on an evaluation criteria and ranking system, which is consistent, even if modified for individual product analysis.)

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

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.



DESIGN FMEA

FMEA Number 1234

Page 1 of 1

Prepared By A. Tate - X6412-Body Engr

FMEA Date (Orig) 8X_03_22 (Rev.) 8X_07_14

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (DESIGN FMEA)

Design Responsibility Body Engineering

Key Date 9X_03_01_ER

System X Subsystem Component 01.03/Body Closures

Model Year(s)/Vehicle(s) 199X/1.0n_4dr/Wagon

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

Item	Function	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Occurrence	Detection	Current Design Controls	D R. P. N.	Recommended Action(s)	Responsibility & Target Completion Date	Action Results	
											Actions Taken	S O D R. P. N.
9	Front Door L.H. H8HX-0000-A	Corroded interior lower door panels	Deteriorated life of door leading to: <ul style="list-style-type: none"> Unsatisfactory appearance due to rust through paint over time Impaired function of interior door hardware 	7	6	7	Vehicle general durability test veh. T-118 T-109 T-301	7 294	Add laboratory accelerated corrosion testing	A. Tate-Body Engr 8X 09 30	7 2 2 28	22
							Vehicle general durability testing- as above	7 196	Add laboratory accelerated corrosion testing	Combine w/test for wax upper edge verification	7 2 2 28	
							Physical and Chem Lab test- Report No.1265	2 28	None	A. Tate Body Engr 9X 01 15		
							Design aid investigation with non-functioning spray head	B 280	Add team evaluation using production spray equipment and specified wax.	Body Engrg & Assy Ops 8X 11 15	7 1 3 21	
							Laboratory test using "worst case" wax application and hole size	1 21	None			
							Drawing evaluation of spray head access	4 112	Add team evaluation using design aid buck and spray head	Body Engrg & Assy Ops	7 1 1 7	

SAMPLE



DESIGN FMEA

DEVELOPMENT OF A DESIGN FMEA (Continued)

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 item identified above in the Design FMEA should have the special process controls identified in the Process FMEA.

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.

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 | Creep |
| Fatigue | Wear |
| Material Instability | Corrosion |

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 ranking can be effected.

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:

- What is the service history/field experience with similar components or subsystems?
- Is component carryover or similar to a previous level component or subsystem?
- How significant are changes from a previous level component or subsystem?
- Is component radically different from a previous level component?
- Is component completely new?



DESIGN FMEA

FMEA Number 1234 (1)
 Page 1 of 1
 Prepared By A. Tate - X6412 - Body Engr (4)
 FMEA Date (Orig.) BX 03 22 (Rev.) BX 07 14 (7)

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (DESIGN FMEA)

System X
 Subsystem 01.03/Body Closures (2)
 Component 199X/Lon 4dr/Wagon (5)
 Design Responsibility Body Engineering (3)
 Key Date 9X 03 01 ER (6)

MODEL Year(s)/Vehicle(s) 199X/Lon 4dr/Wagon (6)
 Core Team J. Ferndt-Cat Product Dev., Childers-Manufacturing, J. Ford-Assy_Ops (Dalton, Fraser, Henley, Assembly Plants)

Item	Function	Potential Failure Mode	Potential Effect(s) of Failure	Cause(s) of Failure	Current Design Controls	D e t e c t	R. P. N.	Recommended Action(s)	Responsibility & Target Completion Date	Action Results	
										Actions Taken	S O D R. e c e P. v e c t i N.
7	Front Door L.H. H8HX-0000-A	Corroded interior lower door panels	Deteriorated life of door leading to: <ul style="list-style-type: none"> Unsatisfactory appearance due to rust through paint over time Impaired function of interior door hardware 	Upper edge of protective wax application specified for inner door panels is too low	Vehicle general durability test plan T-178 T-109 T-301	7	294	Add laboratory accelerated corrosion testing	A Tate-Body Engr BX 09 30	Based on test results (Test No. 1481) upper edge spec raised 123mm	7 2 2 28
4		Insufficient wax thickness specified		Insufficient wax thickness specified	Vehicle general durability testing as above	7	196	Add laboratory accelerated corrosion testing	Combine w/ test for wax upper edge verification	Test results (Test No. 1481) show specified thickness is adequate. DOE shows 25% variation in specified thickness is acceptable.	7 2 2 28
2		Inappropriate wax formulation specified		Inappropriate wax formulation specified	Physical and Chem Lab test Report No. 1265	2	28	None	Conduct Design of Experiments (DOE) on wax thickness		
5		Entrapped air prevents wax from entering corner/edge access		Entrapped air prevents wax from entering corner/edge access	Design aid investigation with non-functioning spray head	8	280	Add team evaluation using production spray equipment and specified wax	Body Engr & Assy Ops BX 11 15		7 1 3 21
3		Wax application plugs door drain holes		Wax application plugs door drain holes	Laboratory test using worst case wax application and hole size	1	21	None		Based on test, 3 additional vent holes provided in affected areas	
4		Insufficient room between panels for spray head access		Insufficient room between panels for spray head access	Drawing evaluation of spray head access	4	112	Add team evaluation using design aid buck and spray head	Body Engr & Assy Ops	Evaluation showed adequate access	7 1 1 7

SAMPLE



DESIGN FMEA

DEVELOPMENT OF A DESIGN FMEA (Continued)

- Has the component application changed?
- What are the environmental changes?
- 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.

15) Occurrence (O)

Suggested Evaluation Criteria:

(The team should agree on an evaluation criteria and ranking system, which is consistent, even if modified for individual product analysis.)

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 2,000	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

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 reviews, prototype tests, fleet testing) are those that have been or are being used with the same or similar designs.

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.



DESIGN FMEA

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (DESIGN FMEA)

FMEA Number 1234

Page 1 of 1

Prepared By A. Tate - X6412 - Body Eng

FMEA Date (Orig.) 8X_03_22 (Rev.) 8X_07_14

System
Component 01.03/Body Closures

Model Year(s)/Vehicle(s) 199X/Lion_4dr/Wagon

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

Design Responsibility Body Engineering

Key Date 8X_03_01_ER

Item	Function	Potential Failure Mode	Potential Effect(s) of Failure	S I S V	C A S	O C C U R	D I G N O S I S	R. P. N.	Recommended Action(s)	Responsibility & Target Completion Date	Action Results	
											Actions Taken	S O C I E T Y
9	Front Door L.H. HBHX-0000-A	Corroded interior lower door panels	Deteriorated life of door leading to: <ul style="list-style-type: none"> Unsatisfactory appearance due to rust through paint over time Impaired function of interior door hardware 	7	13	6	17	284	Add laboratory accelerated corrosion testing	A Tate-Body Eng 8X 09 30	7 2 2 28	22
								196	Add laboratory accelerated corrosion testing	Combine w/test for wax upper edge verification	7 2 2 28	
									Conduct Design of Experiments (DOE) on wax thickness	A Tate Body Eng 9X 01 15		
								28	None			
									Add team evaluation using production spray equipment and specified wax	Body Eng & Assy Ops 8X 11 15	7 1 3 21	
								21	None			
									Add team evaluation using design aid buck and spray head	Body Eng & Assy Ops	7 1 1 7	

SAMPLE



DESIGN FMEA

DEVELOPMENT OF DESIGN FMEA (Continued)

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 upon the type (2) or type (3) current controls, provided the prototypes and models being used are representative of design intent.

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. In order to achieve a lower ranking, generally the planned design control (e.g., preventative, validation, and/or verification activities) has to be improved.

Suggested Evaluation Criteria:

(The team should agree on an evaluation criteria and ranking system, which is consistent, even if modified for individual product analysis.)

Detection	Criteria: Likelihood of Detection by Design Control	Ranking
Absolute Uncertainty	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 a 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



DESIGN FMEA

FMEA Number 1234 (1)
 Page 1 of 1
 Prepared By A. Tate - X6412-Body Eng. (4)
 FMEA Date (Orig.) 8X 03 22 (Rev.) 8X 07 14 (7)

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (DESIGN FMEA)

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

System X
 Subsystem 01.03/Body Closures (2)
 Component 199X1.0n_4dr/Wagon (5)
 Model Year(s)/Vehicle(s) 199X1.0n_4dr/Wagon

Core Team I.Fender, Cat. Product Dev., Chassis Manufacturing, J.Ford, Assy Ops, Dalton, Frasag, Henley, Assembly Plants (8)

Item	Function	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	Current Cause(s)/Mechanism(s) of Failure (13)	Current Design Controls (17)	Recommended Actions (18)	Responsibility & Target Completion Date (20)	Actions Taken (21)	Action Results (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	Upper edge of protective wax application specified for inner door panels is too low Insufficient wax thickness specified	Vehicle general durability T-118 T-109 T-301 Vehicle general durability testing- as above	Add laboratory accelerated corrosion testing Add laboratory accelerated corrosion testing Conduct Design of Experiments (DOE) on wax thickness	A Tate-Body Engg 8X 09 30 Combine wrist edge verification A Tate Body Engg 9X 01 15	Based on test results (Test No. 481) upper edge specified raised 125mm Test results (Test No. 481) show specified thickness is adequate. DOE shows 25% variation in specified thickness is acceptable.	7 2 2 2E 7 2 2 2B
		Inappropriate wax formulation specified			Physical and Chem Lab test- Report No. 1265	None			
		Entrapped air prevents wax from entering corner/edge access			Design aid investigation with non-functioning spray head	Avi team evaluation using production spray equipment and specified wax	Body Engg & Assy Ops 8X 11 15		7 1 3 21
		Wax application plugs door drain holes			Laboratory test using "worst case" wax application and hole size	None			Based on test, 3 additional vent holes provided in affected areas
		Insufficient room between panels for spray head access			Drawing evaluation of spray head access	Avi team evaluation using design aid buck and spray head	Body Engg & Assy Ops	Evaluation showed adequate access	7 1 1 7

SAMPLE



DESIGN FMEA

DEVELOPMENT OF A DESIGN FMEA (Continued)

18) Risk Priority Number (RPN)

The Risk Priority Number is the product of the Severity (S), Occurrence (O), and Detection (D) ranking

$$RPN = (S) \times (O) \times (D)$$

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 "1,000". For higher 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.

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:

- Design of Experiments (particularly when multiple or interactive causes are present).
- Revised Test Plan.
- Revised Design.
- Revised Material Specification.

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

20) Responsibility (for the Recommended Action)

Enter the Organization and individual responsible for the recommended action and the target completion date.

21) Actions Taken

After an action has been implemented, enter a brief description of the actual action and effective date.

22) Resulting RPN

After the corrective action have 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.

All Resulting RPN(s) should be reviewed and if further action is considered necessary, repeat steps 19 through 22.



DESIGN FMEA



DESIGN FMEA

DEVELOPMENT OF A DESIGN FMEA (Continued)

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:

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



Ford



DESIGN FMEA



PROCESS FMEA

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



PROCESS FMEA



PROCESS FMEA

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:

- Identifies potential product related process failure modes.
- Assesses the potential customer effects of the failures.
- 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.
- Develops a ranked list of potential failure modes, thus establishing a priority system for corrective action considerations.
- Documents the results of the manufacturing or assembly process.

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.

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 functions effected 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 failures 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.



PROCESS FMEA

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

FMEA Number: 1450
 Page 1 of 1
 Prepared By: J. Ford - X6521 - ASSY.Ops
 FMEA Date (Orig.) 9X_05_17 (Rev.) 9X_11_06

Item: Front Door L.H. (1844X000A)
 Model Year(s): Vehicle(s): 199X Lion... 407/408/409
 Process Responsibility: Body Engng./Assembly Operators
 Key Date: 9X_03_01 - ER
 9X_08_25 - Jpb + J

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

Process Function Requirements (9)	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	Current Process Controls (16)	D.R.P.N. (17)	Recommended Action(s) (18)	Responsibility & Target Completion Date (20)	Action Results (22)	
							Actions Taken (21)	S.O.D.R. (S.O.D.R. = S e v e r i t y x O c c u r r e n c e x D e t e c t i o n)
Manual application of wax inside door	Insufficient wax coverage over specified surface	Deteriorated life of door leading to: <ul style="list-style-type: none"> Unsatisfactory appearance due to rust through paint over time Impaired function of interior door hardware 	Visual check each hour-1/shift for film thickness (depth meter) and coverage	5 280	Add positive depth stop to sprayer Automate spraying	MFG Engrg 9X 10 15 Mfg Engrg 9X 12 15	7 2 5 70	Stop added, sprayer checked on line Rejected due to complexity of different doors on same line
To cover inner door, lower surfaces at minimum wax thickness to retard corrosion			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	7 1 3 21	Temp and press limits were determined and limit controls have been installed - control charts show process is in control Cpk=1.85
			Preventative maintenance programs to maintain head	2 28	None			
			Operator instructions and lot sampling (10 doors / shift) to check for coverage of critical areas	7 392	Install spray timer	Maintenance 9X 09 15	7 1 7 49	Automatic spray timer installed - operator starts spray, timer controls shut-off control charts show process is in control Cpk=2.05
SAMPLE								



PROCESS FMEA

INTRODUCTION (Continued)

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.

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.

Application of the form is described below, points are numbered according to the numbers encircled on the form shown on the facing page. An example of a completed form is contained in Appendix D.

- 1) **FMEA Number** Enter the FMEA document number, which may be used for tracking.
- 2) **Item** Enter the name and number of the system, subsystem or component, for which the process is being analyzed.
- 3) **Process Responsibility** Enter the OEM, department and group. Also include the supplier name if known.
- 4) **Prepared By** Enter the name, telephone number and company of the engineer responsible for preparing the FMEA.
- 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).
- 6) **Key Date** Enter the initial FMEA due date, which should not exceed the scheduled start of production date.



PROCESS FMEA

FMEA Number 1450
 Page 1 of 1
 Prepared By J. Ford - X6521 - Assy.Ops
 FMEA Date (Orig) 9X.05.17 (Rev) 9X.11.06

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

Item Front Door L.H./RH BX-000-A
 Model Yeans(s)/Vehicle(s) - 199X/Len - 4dr/Wagon
 Core Team A. Tate Body Engrg., J. Smith-DC, R. James-Production, J. Jones-Maintenance
 Process Responsibility Body Engrg./Assembly Operations
 Key Date 9X.03.01.ER 9X.08.26 Job #1

Process Function (9)	Requirements	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	Cause(s) / Mechanism(s) of Failure (13)	O C C U R (15)	Current Process Controls (16)	D e t e c (17)	D e t e c (18)	Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22)		
											Actions Taken (21)	S O D R. S e v e r i t y	
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	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 Automate spraying	MFG Engrg 9X 10 15	7 2 5 70	70	
				Spray heads 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	7 1 3 21	21	
				Spray head deformed due to impact	2	Preventative maintenance programs to maintain head	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	7 1 7 49	49	Automatic spray timer installed - operator starts spray, timer controls shut-off control charts show process is in control Cpk=2.05

SAMPLE



PROCESS FMEA

DEVELOPMENT OF A PROCESS FMEA (Continued)

7) FMEA Date Enter the date the original FMEA was compiled, and the latest revision date.

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.)

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.

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 non-conformance 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.

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:

- "How can the process/part fail to meet specifications?"
- "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	Cracked	Grounded
Binding	Deformed	Open Circuited
Burred	Dirty	Short Circuited
Handling Damage	Improper Set-up	Tool Worn



PROCESS FMEA

FMEA Number 1450

Page 1 of 1

Prepared By J. Esrd - X6521 - Assy_Ops

FMEA Date (Orig) 9X_05_17_ (Rev.) 9X_11_06

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

Item Front Door L.H./R.H.X-000-A

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

Process Responsibility Body Engrg./Assembly Operations

Key Date 9X_03_01_ER 9X_08_26 Job #1

1 4 7

3 6 8

2 5

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

Process Function (9)	Requirements	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	Severity (12)	Cause(s) (13)	Occurrence (14)	Current Process Controls (15)	Detection (16)	D.P.N. (17)	Recommended Action(s) (18)	Responsibility & Target Completion Date (19)	Action Results (20)		O.D.P.N. (21)	
												Actions Taken (21)	Severity (22)		
Manual application of wax inside door		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 Spray heads clogged - Viscosity too high - Temperature too low - Pressure too low	8	Visual check each hour- 1/shift for film thickness (depth meter) and coverage	5	280	Add positive depth stop to sprayer Automate spraying	MFG Engrg 9X_10_15 Mfg Engrg 9X_12_15	7	2	5	70
To cover inner door, lower surfaces at minimum wax thickness to retard corrosion					Use Design of Experiments (DOE) on viscosity vs. temperature vs. pressure	5	Test spray pattern at start-up and after idle periods, and preventative maintenance program to clean heads	3	105	None	Mfg Engrg 9X_10_01	7	1	3	21
					Preventative maintenance programs to maintain head	2		2	28	None					
					Spray head deformed due to impact	2									
					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	7	1	7	49
										Automatic spray timer installed - operator starts spray, timer controls shut-off control charts show process is in control Cpk=2.05					

SAMPLE



PROCESS FMEA

DEVELOPMENT OF A PROCESS FMEA (Continued)

**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.

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 | |

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.



PROCESS FMEA

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)

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

Item Front Door L.H./R.H.HX.000-A (2) Process Responsibility Body Engng./Assembly Operations (3)
 Model Year(s)/Vehicle(s) 199X/Icon_4dr/Wagon (5) Key Date 9X_03_01_ER (6) 9X_08_26_Job #1 (8)
 Core Team A. Tate Body Engng., J. Smith-OC, R. James-Production, J. Jones-Maintenance

Process Function Requirements (9)	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	Cause(s)/Mechanism(s) of Failure (13)	O.C.U.R. (15)	Current Process Controls (16)	D.T.P.N. (17)	Recommended Action(s) (18)	Responsibility & Target Completion Date (20)	Action Results (22)	
									Actions Taken (21)	S.O.D.P.V.C.T.N.
Manual application of wax inside door	Insufficient wax coverage over specified surface	Deteriorated life of door leading to: <ul style="list-style-type: none"> Unsatisfactory appearance due to rust through paint over time Impaired function of interior door hardware 	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 Automate spraying	MFG Engng 9X 10 15 Mfg Engng 9X 12 15	7 2 5 70	Stop added, sprayer checked on line Rejected due to complexity of different doors on same line
To cover inner door, lower surfaces at minimum wax thickness to retard corrosion			Spray heads clogged <ul style="list-style-type: none"> 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 Engng 9X 10 01	7 1 3 21	Temp and press limits were determined and limit controls have been installed - control charts show process is in control Cpk=1.85
			Spray head deformed due to impact	2	Preventative maintenance programs to maintain head	2 25	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	7 1 7 49	Automatic spray timer installed - operator starts controls shut-off control charts show process is in control Cpk=2.05

SAMPLE



PROCESS FMEA

DEVELOPMENT OF A PROCESS FMEA (Continued)

12) Severity (S) (Continued)

Suggested Evaluation Criteria:

(The team should agree on an evaluation criteria and ranking system, which is consistent, even if modified for individual process analysis.)

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. Customers 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 item 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.	1

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.



PROCESS FMEA

FMEA Number 1450

Page 1 of 1

Prepared By J. Ford - X6521 - Assy_Qds

FMEA Date (Orig) 9X_05_17 (Rev.) 9X_11_06

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

Process Responsibility Body Engrg/Assembly Operations

Key Date 9X_08_26 Job #1

Item Front Door L.H./R.H.X-000-A

Model Year(s)/Vehicle(s) 199X/Lion_4dr/Wagon

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

Process Function Requirements (9)	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	Severity (12)	SIAS (13)	Potential Cause(s)/Mechanism(s) of Failure (14)	Current Process Controls (15)	D.P.N. (17)	Recommended Action(s) (18)	Responsibility & Target Completion Date (20)	Action Results (22)	
										Actions Taken (21)	S.O.D.P.C.T.N. (22)
Manual application of wax inside door	Insufficient wax coverage over specified surface	Deteriorated life of door leading to: <ul style="list-style-type: none"> Unsatisfactory appearance due to rust through paint over time Impaired function of interior door hardware 	7	7	Manually inserted spray head not inserted far enough	Visual check each hour-1/shift for film thickness (depth meter) and coverage	5 280	Add positive depth stop to sprayer Automate spraying	MFG Engrg. 9X 10 15 Mfg Engrg 9X 12 15	Stop added, sprayer checked on line Rejected due to complexity of different doors on same line	7 2 5 70
To cover inner door, lower surfaces at minimum wax thickness to retard corrosion					Spray heads clogged - Viscosity too high - Temperature too low - Pressure too low	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	Preventative maintenance programs to maintain head	2 28	None			
					Spray time insufficient	Operator instructions and lot sampling (10 doors / shift) to check for coverage of critical areas	7 392	Instal 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



PROCESS FMEA

DEVELOPMENT OF A PROCESS FMEA (Continued)

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.

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
- Improper weld - current, time, pressure
- Inaccurate gauging
- Improper heat treat - time, temperature
- Inadequate gating/venting
- Inadequate or no lubrication
- Part missing or mislocated

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.

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.

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. For a detailed description of capability/performance analysis, refer to publications such as the ASQC/AIAG Fundamental SPC Reference Manual.



PROCESS FMEA

FMEA Number 1450 (1)
 Page 1 of 1 (4)
 Prepared By J.Ford - X8521 - Assy_Obs (7)
 FMEA Date (Orig) 9X_05_17 (Rev.) 9X_11_08

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

Item Front Door L.H./R.H.X-000-A (2)
 Process Responsibility Body Engg./Assembly Operations (3)
 Key Date 9X_03_01_ER (5)
 Key Job #1 9X_08_26_Job #1 (6)
 Core Team A. Tate Body Engg., J. Smith-OC, R. James-Production, J. Jones-Maintenance (8)

Process Function Requirements (9)	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	Cause(s) of Failure (13)	Potential Cause(s)/ Mechanism(s) of Failure (14)	Current Process Controls (15)	Detection (17)	Recommended Action(s) (18)	Responsibility & Target Completion Date (20)	Actions Taken (21)	Action Results (22)
Manual application of wax inside door	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	B Visual check each hour / shift for film thickness (depth meter) and coverage	5	280 Add positive depth stop to sprayer Automate spraying	MFG Engg 9X 10 15 Mfg Engg 9X 12 15	Stop added, sprayer checked on line Rejected due to complexity of different doors on same line	7 2 5 70
To cover inner door, lower surfaces at minimum wax thickness to retard corrosion			3	Spray heads 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 Engg 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	Spray head deformed due to impact	2 Preventative maintenance programs to maintain head	2	28 None			
			8	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										



PROCESS FMEA

DEVELOPMENT OF A PROCESS FMEA (Continued)

15) Occurrence (O) (Continued)

Suggested Evaluation Criteria:

(The team should agree on an evaluation criteria and ranking system, which is consistent, even if modified for individual process analysis.)

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 2,000	≥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

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. 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



PROCESS FMEA

DEVELOPMENT OF A PROCESS FMEA (Continued)

16) Current Process Controls (continued)

type (1) controls provided they are intergrated 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.

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.

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.

Suggested Evaluation Criteria:

(The team should agree on an evaluation criteria and ranking system which is consistent, even if modified for individual process analysis.)

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



PROCESS FMEA

FMEA Number 1450

Page 1 of 1

Prepared By J. Ford - X6521 - Assy_Ops

FMEA Date (Orig.) 9X_05_17_(Rev.) 9X_11_06

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

Process Responsibility Body_Engng./Assemble Operations

Key Date 9X_03_01_ER 9X_08_26_Job.#1

Item Front Door L.H./HBHX-000-A

Model Year(s)/Vehicle(s) 199X/Lon_4dr/Wagon

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

Process Function Requirements (9)	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	Severity (12)	SIAS (13)	Potential Cause(s)/ Mechanism(s) of Failure (14)	OCCUR (15)	Current Process Controls (16)	Detectability (17)	DFPNI (18)	Recommended Actions (19)	Responsibility & Target Completion Date (20)	Action Results (22)	
												Actions Taken (21)	Score (22)
Manual application of wax inside door	Insufficient wax coverage over specified surface	Deteriorated life of door leading to: <ul style="list-style-type: none"> 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	250	Add positive depth stop to sprayer	MFG Engng 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 heads clogged <ul style="list-style-type: none"> Viscosity too high Temperature too low Pressure too low 	3	195	Spray heads clogged <ul style="list-style-type: none"> 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	195	Use Design of Experiments (DOE) on viscosity vs. temperature vs. pressure	Mfg Engng 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	28	Spray head deformed due to impact	2	Preventative maintenance programs to maintain head	2	28	None			
		Spray time insufficient	8	392	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													



PROCESS FMEA

DEVELOPMENT OF A PROCESS FMEA (Continued)

18) Risk Priority Number (RPN)

The Risk Priority Number is the product of Severity (S), Occurrence (O), and Detection (D) rankings.

$$RPN = (S) \times (O) \times (D)$$

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 "1,000". For higher RPN's 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.

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.

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:

- 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.
- Only a design and/or process revision can bring about a reduction in the severity ranking.
- 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



PROCESS FMEA

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)

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

Process Responsibility Body Engrg./Assembly Operations (3)
 Key Date 9X_03_01 ER (6)
9X_08_28 Job #1 (8)

Item Front Door L.H./HBHX-000-A (2)
 Model Year(s)/Vehicle(s) 199X/Lion_4dr/Wagon (5)
 Core Team A. Tate Body Engrg., J. Smith-OC, R. James-Production, J. Jones-Maintenance

Process Function Requirements (9)	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	Severity (12)	Causes (13)	Occurrence (14)	Current Process Controls (15)	Detectability (16)	R.P.N. (17)	Recommended Action(s) (18)	Responsibility & Target Completion Date (20)	Action(s) Taken (21)	Action Results (22)
Manual application of wax inside door	Insufficient wax coverage over specified surface	Deteriorated life of door leading to: <ul style="list-style-type: none"> 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/shift for film thickness (depth meter) and coverage	5	280	Add positive depth stop to sprayer	MFG Engrg 9X_10_15	Sprayer checked on line	7 2 5 70
To cover inner door, lower surfaces at minimum wax thickness to retard corrosion				Spray heads clogged <ul style="list-style-type: none"> 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	Rejected due to complexity of different doors on same line	7 1 3 2
				Spray head deformed due to impact	2	Preventative maintenance programs to maintain head	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 controls operate, show process is in control	7 1 7 49

SAMPLE



APPENDIX B Design FMEA Example

FMEA Number 1234 1
 Page 1 of 1
 Prepared By A. Tate - X6412- Body Eng 4
 FMEA Date (Orig.) BX_03_22 (Rev.) 8X_07_14 7

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (DESIGN FMEA)

Design Responsibility Body Engineering 3
 Key Date 8X_03_01_ER 6

System X
 Subsystem 01.03/Body Closures 2
 Component 199X/Lon_4dr/Wagon 5
 Model Years(s)/Vehicle(s) 199X/Lon_4dr/Wagon

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

Item	Function	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Occurrence	Current Design Controls	DIPN	Recommended Action(s)	Responsibility & Target Completion Date	Action Results		
										Actions Taken	SOV	DR
9	Front Door L.H. HBHX-0000-A	Corroded interior lower door panels	Deteriorated life of door leading to: <ul style="list-style-type: none"> Unsatisfactory appearance due to rust through paint over time Impaired function of interior door hardware 	7	6	Vehicle general durability test vch. T-118 T-109 T-301	7 294	Add laboratory accelerated corrosion testing	A Tate-Body Engg BX 09 30	7 2 2	28	28
	<ul style="list-style-type: none"> 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 											
						Vehicle general durability testing- as above	7 196	Add laboratory accelerated corrosion testing	Combine w/test for wax upper edge verification	7 2 2	28	28
						Physical and Chem Lab test- Report No. 1265	2 28	None	A Tate Body Engg BX 01 15			
						Design aid investigation with non-functioning spray head	8 280	Add team evaluation using production spray equipment and specified wax	Body Engg & Assy Ops BX 11 15	7 1 3	21	21
						Laboratory test using "worst case" wax application and hole size	1 21	None				
						Drawing evaluation of spray head access	4 112	Add team evaluation using design aid buck and spray head	Body Engg & Assy Ops	7 1 1	7	7
						SAMPLE						





APPENDIX C

Process FMEA Flow Chart/Risk Assessment Example

(Application of Wax to Inside of Door)

<u>Process Step</u>	<u>Risk Assessment</u>
1) Get wax applicator wand from holder	Low risk
2) Open vehicle door	Low risk
* 3) Insert wand and pull trigger for 12 seconds while making three passes	High risk
4) Release trigger wait 3 seconds	Medium risk
5) Remove wand	Medium risk
6) Close vehicle door	Low risk
7) Replace applicator wand in holder	Low risk

* FMEA Required (high risk)





APPENDIX D

Process FMEA Example

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)

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

Process Responsibility Body Engg./Assembly Operations (3)

Key Date 9X_03_01_ER (6) 9X_08_26 Job #1

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

Item Front Door L.H./RH X-900-A (2)

Model Year(s)/Vehicle(s) 199X/1 ton 4dr/Wagon (5)

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

Process Function Requirements (9)	Potential Failure Mode (10)	Potential Effect(s) of Failure (11)	Severity (12)	Cause(s) (13)	Potential Cause(s)/Mechanism(s) of Failure (14)	Occurrence (15)	Current Process Controls (16)	Detection (17)	D.R.P.N. (18)	Recommended Action(s) (19)	Responsibility & Target Completion Date (20)	Action Results (22)	
												Actions Taken (21)	S.O.D.R. (22)
Manual application of wax inside door	Insufficient wax coverage over specified surface	Deteriorated life of door leading to: <ul style="list-style-type: none"> 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	19	MFG Engg 9X 10 15 Mfg Engg 9X 12 15	7 2 5 70	Stop added, sprayer checked on line Rejected due to complexity of different doors on same line	7 2 5 70
To cover inner door, lower surfaces at minimum wax thickness to retard corrosion				Spray heads clogged <ul style="list-style-type: none"> Viscosity too high Temperature too low Pressure too low 	6	Test spray pattern at start-up and after idle periods, and preventative maintenance program to clean heads	3	105	105	Use Design of Experiments (DOE) on viscosity vs. temperature vs. pressure	Mfg Engg 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 programs to maintain head	2	28	28	None			
				Spray time insufficient	8	Operator instructions and lot sampling (10 doors / shift) to check for coverage of critical areas	7	1392	1392	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





APPENDIX E

Glossary

Control Plans	Written description of the system used for controlling the manufacturing/assembly process.
Design Intent	What a given component/subsystem/system is expected to do or not to do.
Design Life	The time period for which the design is intended to perform its requirements.
Design Validation/ Verification (DV)	A program intended to assure that the design meets its requirements.
Design of Experiments (DOE)	An efficient method of experimentation which identifies factors that affect the mean and variation with minimum testing.
Feature	A product characteristic (e.g., radius, hardness) or a process characteristic (e.g., insertion force, temperature).
Pareto	A simple tool for problem solving that involves ranking all potential problem areas.
Process	The combination of people, machines and equipment, raw materials, methods and environment that produces a given product or service.
Process Change	A change in processing concept which could alter the capability of the process to meet the design requirements or durability of the product.
Quality Function Deployment (QFD)	A structured method in which customer requirements are translated into appropriate technical requirements for each stage of product development and production.
Special Product Characteristic	A special product characteristic (e.g., critical, key, major, significant) is a product characteristic for which reasonably anticipated variation could significantly affect a product's safety or compliance with governmental standards or regulations, or is likely to significantly affect customer satisfaction with a product.





APPENDIX E

Glossary

**Special Process
Charateristic**

A special process characteristic (e.g., critical, key, major, significant) is a process characteristic for which variation must be controlled to some target value to ensure that variation in a special product characteristic is maintained to its target value during manufacturing and assembly.

Vehicle Campaigns

Recall of vehicles for rework or safety inspection.



Ford





APPENDIX F

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (DESIGN FMEA)

FMEA Number _____

Page _____ of _____

Prepared By _____

FMEA Date (Orig.) _____ (Rev.) _____

System _____
Subsystem _____
Component _____

Design Responsibility _____

Key Date _____

Model Year(s)/Vehicle(s) _____

Core Team _____

Item	Function	Potential Failure Mode	Potential Effect(s) of Failure	S I S S e v e r i t y	C I S C a u s e s	O C C U R P o t e n t i a l C a u s e (s) / M e c h a n i s m (s) o f F a i l u r e	C u r r e n t D e s i g n C o n t r o l s	D e t e c t R. P. N.	R e c o m m e n d e d A c t i o n (s)	R e s p o n s i b i l i t y & T a r g e t C o m p l e t i o n D a t e	A c t i o n R e s u l t s			
											A c t i o n s T a k e n	S e l e c t	R. P. N.	



Ford







