



# SURFACE VEHICLE RECOMMENDED PRACTICE

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## Design Review Based on Failure Modes (DRBFM)

### RATIONALE

Design Review Based on Failure Modes (DRBFM) has been adopted by both automotive and non-automotive companies. There is a growing demand for DRBFM information since these companies expect their global supply base to utilize the process as well. As with FMEA, companies tend to use slight variations of the process which can cause complexity for suppliers that support multiple companies. Development of a recommended practice (SAE J2886) has been supported by users of DRBFM from both manufactures and suppliers. SAE J2886 Design Review Based on Failure Modes (DRBFM) Recommended Practice will provide a common approach to the implementation of the methodology.

SAE J2886 has been reaffirmed to comply with the SAE Five-Year Review policy.

### FOREWORD

There are many approaches to Quality Improvement. Problem detection, root cause analysis, countermeasure development, and recurrence prevention are all necessary activities to quickly address product concerns in the market. However to achieve the highest levels of quality it is certainly best to avoid market concerns altogether.

Failure Mode and Effects Analysis (FMEA) is a well-established tool to avoid potential problems at the planning stages before the design, tooling, and manufacturing processes are finalized. In its earliest form SAE Aerospace published the Recommended Practice titled "Fault/Failure Analysis Procedure" in 1967 (ARP926). Eventually automobile manufacturers began to adopt similar methods which evolved into the SAE Surface Vehicle Standard J1739 Potential Failure Mode and Effects Analysis in Design (Design FMEA) and Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA). The FMEA is a comprehensive tool meant to identify pockets of risk prior to product release. It's only limitation is that it is effective for mitigating risks with single cause and effect relationships. The FMEA process attempts to identify these risks by reviewing the entire product prior to release. The DRBFM focuses on a few risks but to a great depth of detail

Design Review Based on Failure Modes (DRBFM) is a Quick Design Review tool meant to complement FMEA by applying some of the same principles. For efficiency, DRBFM focuses on engineering changes once a baseline design has been established. A cross-functional team looks at how the changes could potentially diminish the product's function. Follow up actions are identified to ensure the potential concerns are prevented (guilty until proven innocent).

The foundation of DRBFM can be found in the book (Toyota Style Mizenboushi (Preventative Measures) Method GD3, How to Prevent a Problem Before It Occurs, JUSE Press, 2002), the SAE white paper (JSAE 20037158 – SAE 2003-01-2877 Reliability Problem Prevention Method for Automotive Components – Development of GD3 Activity and DRBFM (Design Review Based on Failure Modes) and the SAE white paper QUICK DR Application on Puddle Light System. Additional information on DRBFM and DRBTR can be found in the SAE Ebook, Design Review Based on Failure Modes (DRBFM) and Design Review Based on Test Results (DRBTR) Process Guidebook.

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Documents

Document Sharing Hub

The essential elements of this DRBFM Recommended Practice are formed by information within the reference documents and industry usage and knowledge. DRBFM is a creative, collaborative, and interactive approach. To be successful an open, inquisitive, and challenging mindset is a prerequisite. In many cases implementation of this approach requires an organizational cultural change that can only happen with strong management buy-in and over sight.

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## 1. SCOPE

SAE J2886 Design Review Based on Failure Modes (DRBFM) Recommended Practice is intended for Automotive and Non-Automotive applications. It describes the basic principles and processes of DRBFM including planning, preparation, change point FMEA, design reviews, decisions based on actions completed, and feedback loops to other processes, such as design, validation and process guidelines (Appendix B - DRBFM Process Map).

The intent of each fundamental step of the DRBFM methodology is presented. It is intended for use by organizations whose product development processes currently (or intend to) use Failure Mode & Effects Analysis (FMEA) or DRBFM as a tool for assessing the potential risk and reliability of system elements (product or process) or as part of their product improvement processes.

DRBFM is not intended to replace FMEA however, companies interested in adopting DRBFM will benefit from the focus on specific change points and supporting engineering decisions based on detailed discussions. DRBFM is a change in company culture that requires management commitment to changing the mind set of employees to drill deep and continually ask the question "What Else". The DRBFM user is responsible for following this recommended practice as well as corporate policies. Alternative documentation formats are provided to meet the intent of the recommended practice.

### 1.1 Purpose

The purpose of SAE J2886 is to establish a basic understanding of the DRBFM process in order to promote the value of the DRBFM method and mind set. The DRBFM value is in the mind set of promoting good design, good discussion and good design review to find "deeper" risks. The reader should be aware that the DRBFM process should mature with usage, thus there is no one perfect process. The process description outlined below is a suggested starting point to be refined over time by the user and to be refined as the culture, creativity and knowledge of the user matures.

## 2. REFERENCES

### 2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

- 2.1.1 Oshima, Megumu, Nissan Motor Ltd Quick, DR Application on Puddle Light System.
- 2.1.2 Yoshimura, Tatsuhiko, Toyota Style Mizenboushi (Preventative Measures) Method GD<sup>3</sup>, How to Prevent a Problem Before It Occurs, JUSE Press, 2002
- 2.1.3 Haughey, Bill, Design Review Based on Failure Modes (DRBFM) and Design Review Based on Test Results (DRBTR) Process Guidebook, SAE International
- 2.1.4 JSAE 20037158 – SAE 2003-01-2877 Reliability Problem Prevention Method for Automotive Components - Development of GD<sup>3</sup> Activity and DRBFM (Design Review Based on Failure Modes) - Hirokazu Shimizu and Toshiyuki Imagawa (Toyota Motor Corporation) Hiroshi Noguchi (Kyushu University)
- 2.1.5 SAE J1739 Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA) Standard

## 2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

### 2.2.1 Wright, Don SAE 2011-01-1275 Application of Mizenboushi (GD<sup>3</sup>) Method of Problem Prevention to Vehicle, Component and Subsystem Validation

## 3. DEFINITIONS

### 3.1 FUNCTION

A description of the task or tasks which a system, subsystem, assembly or component is intended to perform over time. A well defined function would include limits and conditions. The limits will define the functional range of expected operation from minimum to maximum and the conditions define how many times it must function and in what environment it must operate within. Examples of typical functions could be, but are not limited to:

- Contains washer fluids (basic function)
- Conforms to noise level requirements at cold start (condition/requirement of a basic function unless the basic function's sole purpose is to make noise)
- Conforms to color harmony requirements (condition/requirement of a basic function)
- Meets vehicle requirements for electrostatic discharge (ESD) (condition/requirement of a basic function)
- Provides structural support (basic function)
- Seals to prevent external foreign material (basic function)

### 3.2 DESIGN REVIEW BASED ON FAILURE MODES (DRBFM)

DRBFM is a fusion of Failure Mode and Effects Analysis (FMEA) and Design Review. DRBFM is a tool used to guide and manage good discussion related to design changes (both intentional and incidental). DRBFM focuses on the impact of the change on design, evaluation procedures, and manufacturing systems (including suppliers) with the intent of anticipating and preventing risk related to changes.

### 3.3 INCIDENTAL CHANGE

An area that does not change in a new design but is influenced by a changed environment or interface. The incidental change results from an intentional change or change in operating conditions within the design, manufacturing, or supplier.

### 3.4 INTENTIONAL CHANGE

An area of a system, subsystem or part that must be changed. The intentional change is the subject of an engineering change request and when approved becomes an engineering change notice, engineering work order or engineering work instruction.

Change Point can be either intentional or incidental as defined in 3.3 and 3.4.

### 3.5 DESIGN REVIEW BASED ON TEST RESULTS (DRBTR)

DRBTR applies a creative thinking to the review of parts during and after testing to find “buds of problems.” The objective of finding “buds of problems” means that speculative observations are made on parts that meet requirements or pass testing. The DRBTR participant is asked to consider (based on an observation) what kinds of customer problems could occur. The DRBTR process requires mitigation of each speculative observation in one of three ways; document why the observation is not an issue, document the observation is an issue and will be addressed in a specified company format, or document an action to explore the observation further.

### 3.6 COUNTERMEASURES

A defensive action that is done in order to deal with a potential risk such as a defined cause of a failure mode or concern in DRBFM. A countermeasure is an action taken to prevent an undesirable outcome to the customer. The countermeasure explains why a design feature, material property, interface clearance, etc. will ensure the specific failure will not be experienced by the customer.

## 4. DRBFM PARTICIPATION

### 4.1 Management

Management is responsible for establishing a focus on continuous improvement, systems engineering, and promote an engineering mind set to establish a clear understanding of expected DRBFM proficiency. Management supports engineers by providing them guidance, support in the DRBFM process, and ensuring tasks are completed at the proper time. Management should establish DRBFM policies to create a culture of making decisions based on a foundation of “Engineering Knowledge”.

### 4.2 Engineers

Engineers are responsible to ensure the product and/or process design meets requirements (including specifications and performance limits) and customer expectations. DRBFM is a tool engineers can use in their daily activity to identify and resolve concerns for product or process changes early in the development process.

### 4.3 DRBFM Roles

In general, there are key roles designated to ensure the success of the “Good Discussion” using DRBFM.

- a. DRBFM Expert has knowledge and experience conducting and reviewing DRBFM reports. The DRBFM Expert interfaces with management to establish best practices in the company and has the ability to train DRBFM Professionals and coach individual teams as needed.
- b. DRBFM Professional is trained by a DRBFM Expert, who leads teams and promotes DRBFM discussion and methodology on the right products at the right time. The Professional should have at least a basic knowledge of the product or process. The Professional is responsible for the adequate and thorough completion of the DRBFM. DRBFM does not promote this role as an additional person within the process but the expectation each engineer (and manager) will gain the necessary DRBFM knowledge and proficiency to be considered a DRBFM Professional.
- c. DRBFM Participant, also known as a team member, contributes to the Design Review discussion as a cross-functional representative of various impacted disciplines, including but not limited to: service, manufacturing, supplier engineering and manufacturing, design engineering of interfacing sub-systems, peer engineers, and materials engineering.
- d. DRBFM “Reviewer” is the person (or change review board) who decides the direction (makes decisions and removes roadblocks) on the implementation of a change. The reviewer is responsible for the quality and reliability of the product. The reviewer utilizes the expertise of the team and ensures the team has considered and addressed all interfaces and interactions.

#### 4.4 When to do DRBFM:

A fundamental principle for reliability is to avoid changing the conditions of a Good Design (a field-proven design and field-proven operating environment); however design modifications occur from the actual development stage through product retirement. When these “change points” are defined, engineers need to discover problems resulting from the change points including those that are intentional (physical part changes) and incidental (changes to surrounding environment such as load, vibration, heat sources, etc. even if the part design does not change).

Determination of when DRBFM should be done (for a design, requirements or process change) is based on many factors (Appendix A - Change Point Awareness Sheet):

- Customer required
- Internal company criteria such as:
  - If the change could impact safety, government compliance or regulations, or impact of the functionality of the part.
  - If the change complexity impacts one or more of the following: design analysis, extensive testing needed, and/or impact to manufacturing, assembly or service.
  - If the consequences of the change could impact quality, reliability, performance, cost or customer expectations.
  - If there is limited organizational competency relative to the change including; design standards and guidelines, engineering experience (knowledge), or manufacturing technology.
  - New supplier

Companies that have a rigid change management system can include DRBFM as an analysis tool used to support or reject a proposed change as part of a technical change review process.

#### 5. DRBFM PROCESS

This DRBFM recommended practice identifies each of the DRBFM steps and provides formats and definitions. Each step is an essential building block of information to ensure a thorough analysis. Each of the following steps are defined in detail (Appendix B - DRBFM Process Map).

Step One: Preparation

Step Two: Change Point FMEA

Step Three: Design Review

Step Four: Actions Results and Feedback

##### 5.1 Step One: Preparation

Planning and preparation tools help the engineer understand the many influences of the product design and make a deliberate attempt to avoid missing information. Preparation can involve picking a baseline, comparing impact to the baseline and understanding what is different. In many companies some or all of these documents are completed during preparation phase.

The advanced preparation must be considered prior to starting DRBFM analysis. This preparation on the part of the engineer is required and eliminates the inefficient practice of beginning with a blank sheet. The preparation the engineer does ahead of time creates the necessary information for a “Good Discussion” with all necessary stakeholders.

### 5.1.1 Gather Engineering Knowledge

There are several organizational tools and documents to help the engineer begin the DRBFM process. Although the type and number of tools may vary by company or industry there are some that are common for engineers. The sequence might vary but the engineer would consider:

- defining a baseline design based on similarity, quality and cost (Appendix C: Risk Assessment / Planning).
- utilizing customer and plant quality data to help select the baseline design (Appendix C: Risk Assessment / Planning).
- pulling together the functions, requirements and interactions based on new design. Often previous DFMEA's (or existing product family DFMEA), P diagrams, design guidelines and best practices provide a starting point for requirements. (Appendix D - Definition of Functions, Change Points and Interfaces)
- design change impact to manufacturing and suppliers based on obtaining and reviewing existing Process Flow Diagrams (Appendix C: Risk Assessment / Planning).
- design change impact to validation plan and reliability targets based on obtaining and reviewing previous validation plans (Appendix E: ADVP&R Example).

Companies use different forms of documentation to compile this data and this recommended practice does not require a specific format.

### 5.1.2 Define Change Points

A change point is a description of a change. The change point is evaluated to assess the potential impact on the product functions. A change point may result in the addition of a product function, a change in attaching methods, a change to a part drawing or specification, a change in the products ability to meet governmental requirements, a change in use environment (temperature, humidity, vibration, etc.), material, shape, software, machining, assembly, production location, and so forth.

A specification change change point that is within normal design guidelines that has been previously validated may not warrant a DRBFM analysis (low impact change point). A clear company/departmental guideline is helpful to define the change point impact level, and when this corresponds to the need for a DRBFM analysis.

Recommended change point tools:

- a. Change Point/Function Matrix: correlates the change and function . (Appendix D - Definition of Functions, Change Points and Interfaces).
- b. Description of Novelty (newness or experience) - (Appendix F - Definition of Novelty)
- c. Change comparison table: Comparison of old and new design characteristics (Appendix D - Definition of Functions, Change Points and Interfaces).
- d. Change visualization (old vs new: block diagram, pictures, sketches, marked drawings).

### 5.1.3 Develop DRBFM Plan

A general planning tool is used by companies responsible for design development. The planning tool is based on the current understanding of a program and known program risks. It identifies a basic risk mitigation plan which may include development testing, process development, and parts where supplier collaboration is critical. It may include the following elements:

- Administrative information (Part description, responsible engineer, base design description)
- Quality - Risk assessment (Design drivers, traceability, and historical product performance)
- Quality - Reliability Tools (DFMEA, PFMEA, DRBFM, DRBTR, DFM/A and FTA)

A plan for each part should be constructed using engineering knowledge gathered and change point definition as input. This plan is used to determine what system, sub-system, or part requires a DRBFM, who must participate in the team discussion (Design Reviews), and timing requirements of DRBFM.

#### Summary

The method for determining design changes that require DRBFM will vary by company. It is recommended that a DRBFM planning methodology be integrated into a company's existing quality and reliability assessment activities. Examples of initial risk assessment and planning formats are provided in Appendix C that can be considered (recommended but not required or limited to) when completing the planning phase of DRBFM.

### 5.2 Step Two: Change Point FMEA

It is recommended the design engineer perform their analysis prior to meeting with additional experts (Section 5.3). The DRBFM process is a two step approach. The first step, sometimes called Forum One, includes change point detail and change point analysis followed by a management review and decision to proceed with multi-disciplinary team review or cancel design change.

#### 5.2.1 Document Change Point Detail and Functions

It is important to fully describe each change point and associated functions within the DRBFM worksheet (Appendix F DRBFM Format). Change points can be in design, supplier, usage environment, customer, or internal specification, and so forth. This review should not only look within the area of change, but also into interdependent areas that could be impacted by the change even though they may not be directly connected or interfaced with the problem area.

The first section of the DRBFM format (Change Point definition) must clearly define each change. The format typically indicates information in a "FROM the baseline design", "TO the proposed design" and "REASON for the proposed change."

- Bushing shape changing FROM round TO oval allowing for spool to float reducing valve hysteresis (REASON).
- Bushing changing FROM containing lead, TO lead-free bushing due to European law & customer requirement (REASON).
- Changing FROM broached valve body TO scooped valve body to use existing equipment capacity (REASON).

The intent is a clear change point definition of what the part or feature was and what it is going to be along with a reason why the change is being considered. It is recommended this section show or reference a series of images (before and after) to provide a better understanding of the change. It is recommended part numbers, product dimensions and specifications should be included.

Once the area of change is clearly defined an assessment is made to determine which functions are impacted by each change. Consider using one of the examples (Appendix D) to ensure functions are not overlooked.