

	SURFACE VEHICLE RECOMMENDED PRACTICE	SAE J2886 MAR2013
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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.

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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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 oversight.

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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 GD³, 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 GD³ 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 Mizzenboushi (GD³) 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.

5.2.2 Document Initial Change Point Analysis

Now that the specific areas of change and associated functions are identified, the DRBFM process is intended to follow the mindset of the engineer. Even though the details need to be documented, it is important not to stifle the creative thought process of the engineer by focusing on the DRBFM worksheet. The DRBFM process is meant to support the engineer in the design process to make sure the end result is a product that meets functional requirements and customer expectations.

The engineer should note their concerns as they define the design to meet the requirements. The concerns should not be just a surface reflexion of the problem but should “drill deep” into the problem by documentation of the engineers thoughts and questions. This is a normal step in the day-to-day activity of the engineer and at regular points concerns can be transferred to the DRBFM worksheet.

Criteria	Description of Concern	Example
Concerns regarding Change Point and Function	Written description of reduction in performance or malfunction no matter how large or small related to the functions impacted by the area of change (including interfaces and interactions). Concerns also need to consider when the concern could occur (under what circumstance: e.g., hot or cold temperatures, run or crank mode, electrical conditions). Concerns are not limited to design related concerns but should also consider impact on manufacturing, supplier, service, validation, cost and designing for customer usage and expectations. Make sure to consider indirect or hidden impact due to the physics of the system (Electo-magnetic discharge, resonance frequencies, etc.).	<p>The new manufacturing process could allow burrs which would create excess pressure under thrust plate</p> <p>The new material could cause the flex circuits to stick together during assembly</p> <p>The new location of the puddle light will not illuminate the required area</p> <p>The reduced material surface of the hinge will not withstand the loads of the locking mechanism.</p>

The progression of engineering thought should lead to the specific reason why the concern would occur. Asking the question “why” several times ensures the root cause mechanism has been exposed.

Criteria	Description of Causes	Example
Potential causes and circumstances of Concerns	For any concern identified there needs to be measurable criteria to identify an accurate cause (e.g., tensile strength or kilogram per area). Causes are explained in detail with specifications, requirements and in relation to a specific part location.	<p>Part mass increased from xx to yy</p> <p>The cross-sectional area of the hinge is reduced, the cover is stressed by the bell crank</p> <p>Door panel shape is blocking the required light pattern</p> <p>Cross talk between motor phase and algorithms</p> <p>Difficult routing in assembly due to wire length 10mm shorter.</p> <p>When the grip is operated, the impact force to light unit is increased</p>

It is important for the engineers to consider the influence of the concerns and causes on the design and the customer experience. The engineer should always consider what would happen to the infacing systems, sub-systems and component if a change is made to their design. A significant part of the DRBFM process is to consider the impact of change upstream and downstream.

Criteria	Description of Effects	Example
Influences on vehicle /consumers	The effects should address the impact on the part itself, surrounding parts or systems and the final customer. Consider what would happen if the failure occurred, symptoms witnessed by the customer.	<p>The necessary area is not lit</p> <p>The light does not work</p> <p>The door cannot be opened</p> <p>Increased effort to lift door handle</p> <p>Customer hears a rubbing noise</p> <p>The pedal feel is spongy</p> <p>Water inside passenger compartment</p>

The risk associated with the specific effect is recommended. The risk can be defined by Severity (with a severity table), Importance (High, Medium, Low), or prioritization (A, B, C). This step is optional if the maturity level of the DRBFM process within the company addresses all causes with the same detailed engineering discussion and closure.

The objective of the countermeasure section is to document what knowledge is already known.

Criteria	Description of Countermeasures	Example
Countermeasures (Design , Testing and Manufacturing steps taken to Avoid Concern / cause)	<p>A written description of the defensive actions already taken to deal with a potential risk such as a defined cause of a failure mode or concern in DRBFM. It should explain why the feature, material property, interface clearance, etc. will ensure the specific cause will not result in an effect (loss of function or dissatisfaction) experienced by the final customer.</p> <p>What the designer/engineer already did to assure that the concern does not occur (could include simulations, tests, try outs.)</p>	<p>Minimum rate of light transmission is set.</p> <p>Process certification for Diffusing agent is determined</p> <p>Similar design in production within the company</p> <p>Computer simulation verifies new material will withstand new high temperature of 140c within the current vibration profile.</p> <p>Added vision system to manufacturing process to verify slot width and depth meet requirements</p> <p>Supplier specification for adhesive shows it can withstand the expected thermal environment (range of 140c high and -20c low).</p>

The DRBFM process defines the action plan development as a team event and part of the Design Review (Forum Two). The intent is to leverage the combined knowledge of the cross-functional team. Once the engineer has completed their work through documentation of countermeasures, they are ready for a review with their manager (supervisor) and/or DRBFM coordinator or expert.

5.2.3 Management Review and Decision (Forum One)

The intent of this review between the engineer and their manager (supervisor) is to ensure the documentation of change and associated preparation is complete and provides a framework of knowledge for the Design Review (Forum Two). The expectation is the manager understands the DRBFM methodology and can provide feedback to the engineer to improve the details of the DRBFM. It also provides an early decision point of moving forward with the design change, make improvements to the current design change or cancel the design change.

5.3 Step Three: Design Review

A fundamental approach in reliability is to use a proven or conservative design to address the many factors affecting performance. However, design modifications will happen throughout the life of a product. The goal in the DRBFM methodology is to enable faster development cycles while ensuring a robust design that integrates design, evaluation, and the manufacturing (production) processes. DRBFM is a method of thoroughly discussing design changes to discover potential problems and formulating countermeasures and actions to solve those problems.

It is recommended a multi-disciplinary team review the proposed design. The design review, sometimes called Forum Two, includes the results of the engineer's DRBFM analysis followed by a decision to proceed with testing, make appropriate design changes, or cancel design change. In preparation of the team event organize real parts to support good discussion and or 3D models where applicable (Genba, Genchi, Genbutsu).

5.3.1 Discuss Initial Change Point Analysis

The completed information is organized and forwarded to the identified cross-functional team members for review prior to the design review. Any person having questions regarding something missed in change point definition or functions and requirements could contact the engineer prior to the meeting with any questions or concerns.

The design review meeting is kicked off with the engineer clearly explaining the change and reason for the change by showing their design (drawings or software). Once an understanding of the change is complete, the engineer opens the discussion of change points to ensure definition was clear and if anyone thought some interface or interaction might have been missed during the preparation phase of the process. The change point definition leads to an agreement of the functions and requirements impacted by the defined change points.

A typical agenda for Forum Two might look like:

- Discuss reason for change
- Discuss change points by review of drawing (use hardware / real parts where available)
- Discuss functions impacted by change points
- Discuss concerns due to change
- Discuss detailed causes and effects of concerns
- Discuss importance level of identified effects
- Discuss defined countermeasures (what work has been done to address concerns) and reason why design should work
- Define actions for design, evaluation and manufacturing (including suppliers)

A typical session for Forum Two might look like:

- Drawings hanging on the walls, on the table or projected
- Could have previous parts, models, rapid prototype parts or 3D graphics in the room
- People are standing and reviewing their area of responsibility and expertise
- Suppliers and customers are included in the discussion
- Ideas are captured on sticky notes, story boards, flip charts or computer
- Discussions are technical and engineering focused
- Sketches and calculations are made
- Information is transferred to reporting format (DRBFM worksheets) as a separate activity

5.3.2 Discuss and Document Additional Concerns and Actions

The intent of the design review is for the team to add additional concerns from their area of expertise and any concerns that might fail to meet customer satisfaction.

Criteria	Description of Additional Concerns and Causes	Example
Additional concerns/causes	Additional concerns and/or causes cited during the design review. These are intended to be technical descriptions but can be worded in the form of a question or statement.	<p>Particulates may be introduced in the manufacturing process causing contamination</p> <p>Abrasion to component due to use of carry over shipping dunnage</p> <p>Cable will not withstand stress of routing during assembly due to reduced width (from xxmm to yymm) in middle of cable</p> <p>Will the new fastener withstand the current torque defined for the operation?</p> <p>Will the required torque of the new fastener create complexity at the supplier operation?</p> <p>Will the proposed change introduce new noise factors (EMI, tones, squeaks)?</p> <p>How does the concern impact service (cost of repair, proliferation of part numbers, aftermarket parts, training)?</p>

The format can vary from additional concerns documented into the same column or in separate columns (see appendix). The intent of the separate columns is to see the value added from the team meetings to determine if the initial analysis was complete or if additional training and coaching is required to uncover all detailed concerns and causes. There is also an expectation for all team participants to engage in active engineering discussion to uncover all concerns.

After identification of current actions or countermeasures already taken to address problems, new actions need to be identified. New recommended actions are intentionally shown in three categories to encourage the design review team to consider actions that address the potential problems found during the design review. Design actions are usually the responsibility of the design-responsible engineer such as tolerance stacks, material changes and design changes. Evaluation actions are usually the responsibility of the validation engineer such as testing, teardown after testing and ride evaluations. Manufacturing actions are usually the responsibility of the process-responsible engineer such as tooling specifications, machine run-off and process control planning. All three categories have their own responsible person and target date for completion that should be feasible according to the product and process development timing.

Criteria	Description of Actions	Examples
Recommended Actions (Results of DRBFM)	Action statements should be written detailed enough so responsible people in design, test and manufacturing can start working immediately.	The information written in the recommended action needs to be specific and not vague (e.g., increase overall length from 28mm to 32mm, test min/max specification to failure, add automatic bar code reader to machine, etc.)
Design Actions	Design actions might include conducting a parallel assessment of alternative design solutions. What confirmation analyses (engineering calculations) should we perform that ensures the concern is not a problem?	<p>Conduct human factors study to determine impact of design change</p> <p>Change the length of the fuel filler tube not to soak the neck of filler tube (from 35mm to 54mm)</p> <p>Change the size of the weep hole in the fuel filler neck to prevent clogging</p> <p>Change the direction of the mud cover to prevent build-up of splashed mud</p> <p>Perform tolerance and stack analysis to determine if design falls within the defined min/max limits</p> <p>Consider alternative design shape and size to meet required manufacturing cycle time restrictions</p> <p>Change cam profile in pump ring to operate quieter with aerated oil</p>
Validation/Test Actions	Validation actions might include a test with specific loads under different environmental conditions. How will we test to prove the concern won't happen or how will we test that the new design or process is better than the old? What operation conditions should the test be performed at and what degradation level (if any) should the part be at prior to evaluation?	<p>Add a requirement to run part with max temperature of 140c for 200 hours prior to conducting seizure test.</p> <p>Run A-B vibration test comparison of current and proposed materials (steel to plastic)</p> <p>Look for evidence of abrasion post test</p> <p>Test part to failure to confirm safety margin</p>

Criteria	Description of Actions	Examples
Manufacturing Actions	Manufacturing actions might include error proofing to ensure the parts can be manufactured with given tolerances of each feature. Manufacturing actions might also include error proofing ideas to ensure the correct part can be assembled in the correct orientation. What should we do in the processing/process flow to reduce or eliminate the concern? How does the change impact the supply base (including all tier suppliers) and will it increase or decrease the cost of the part?	<p>Do 24 piece low flow study on product test stand.</p> <p>Off line trial of 30 assemblies to be performed to confirm nut head will not deform within torque limits</p> <p>Take photos and videos of solder process to be reviewed by all team members</p> <p>Develop a manufacturing plan to change the process from an automated operation to manual operation.</p> <p>Evaluate the impact of the new assembly to ensure there is not an impact on cycle time</p>

As potential new problems are found during DRBFM Forum One and Forum Two it is necessary to address each cause factor. Every cause factor will have either a past design action (countermeasure) or new action identified to avoid problems and close any open loops that could lead to production or field failures. Action plan categories can be left blank when no action for that category is necessary.

5.3.3 Team Review and Decision (Forum Two)

The intent of this review is for a cross functional group (experts in their field) provide feedback in the form of additional specific concerns and actions. The expectation is for the team to agree on results of the design review and respective owners agree on assignments and ownership of actions to validate the potential concern is avoided. It also provides the decision point of moving forward with the design change, making physical parts for testing and spending the resources and money to conduct validation activity or cancel the design change.

5.4 Step Four: Action Results and Feedback

The action taken to solve each cause will benefit the design team. The DRBFM worksheet is evidence of due care for changes that impact product functionality especially safety-related functions. When saved as part of the design records the DRBFM serves as technical memory for others to read and gain a better understanding of what changed, why it changed, and what was done to prevent problems implementing the change.

5.4.1 Document Action Results: Design, Validation, Manufacturing

Action closure should include drawing revisions, engineering change numbers, test report numbers, control plan numbers, etc. as a pointer to other documents that are used as a normal part of product and process development and production. The DRBFM process requires the engineer to address any action results that fail to meet functional requirements back to management for review and decision on how to proceed.

5.4.2 Update Design, Process, Validation Guides

A company's design standards, test standards and manufacturing process standards should be updated, as needed, to reflect the lessons learned as a result of the DRBFM.

6. DRBFM CONSISTENCY

DRBFM is not intended to be rigid in details on performing the methodology but the deliverable should be consistent. It is recommended companies adopt a format that best meets their culture while delivering intended results to their company or customer.

As with any new methodology, variation in application of the DRBFM process can create confusion and lead engineers to lose site of the real value and deliverables. It is recommended that companies adopt some form of certification within the organization to provide information to people seeking guidance and feedback. The number of certification levels can vary however it is recommended that people understand who is considered proficient versus just getting started.

6.1 DRBFM Review and Audit

In order for an organization to understand the proficiency level of people within the organization there needs to be some level of auditing. It is recommended that management play an active role in the audit process. The audit should be conducted by a person who is proficient in the understanding of the methodology. The intent of the audit is to provide feedback on the content of the DRBFM as well as the method getting there. The goal is to create a culture of understanding why DRBFM is important (what value does it add to the practitioners and the company). The audit is also intended to identify required coaching along with management understanding of organizational proficiency.

It is recommended companies develop and maintain an on-going DRBFM Review and Audit process. The intent of the reviews and audits are to understand the proficiency of the organization and determine if additional (specific) training is required. The audits also provide an opportunity to gage the engineering knowledge of the product and process and determine if additional actions are required to address risk areas.

7. NOTES

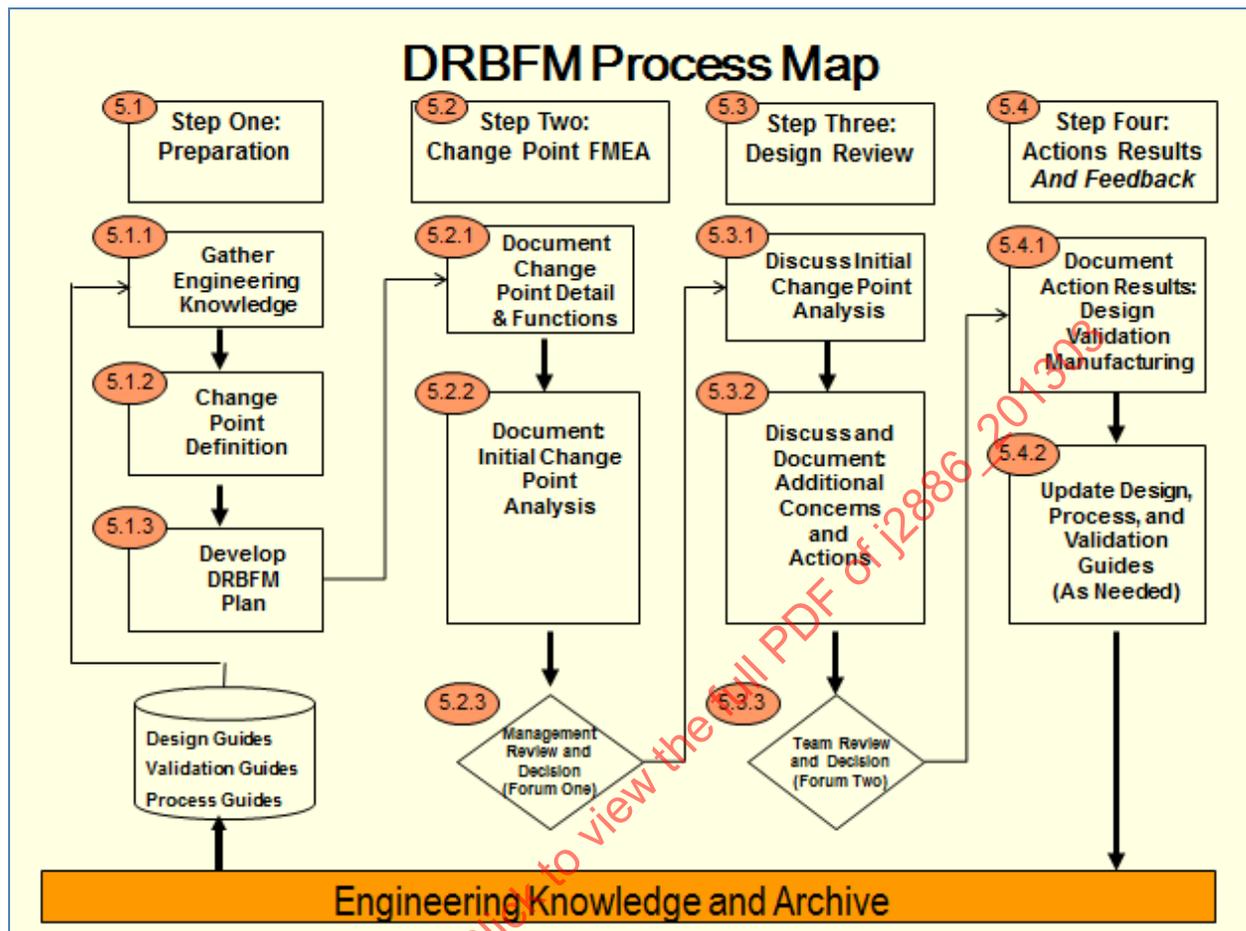
7.1 Marginal Indicia

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

APPENDIX A – CHANGE POINT AWARENESS WORKSHEET

Awareness Sheet				
	Target keyword (starting view point)	Keyword for identifying intentional and incidental changes		Comments:
		Intentional Changes	Incidental Changes	
1	Specification			
2	Function			
3	Performance			
4	Usage Environment	Load		
		High temp.		
		Low temp.		
		Humidity		
		Vibration		
		Power supply		
		Noise		
		Radio Wave		
		Light		
		Sound		
		Water		
		5	System (mating parts)	
6	Structure			
7	Shape			
8	Circuit			
9	Software / Algorithm			
10	Component			
11	Material			
12	Processing			
13	Assembly			
14	Equipment			
15	Supplier			
16	Material supply			
17	Manuf. location			
18	Mass			
19	Refrigerant			
20	Oil			
21	Oil			
22	Leakage Requirements			
23	Manufacturing	Process Flow Diagram		
		(Product Characteristics)		
		(Process Characteristics)		
		PFMEA		
		Process Control Plan		
	Work Instructions			

APPENDIX B – DRBFM PROCESS MAP



APPENDIX D – DEFINITION OF FUNCTIONS, CHANGE POINTS AND INTERFACES (EXAMPLES)

Optional Example 1: Item/Function Matrix

ITEM / FUNCTION MATRIX						
Design →		Counterweights & Crank arms	Interface main journals & fillets 1-5 (to bearing shells /	Interface trust face main journal 3 (to bearing shell / block)	Rear flange to flexplate interface.	Interface pin journal 1 - 4 (to bearing shells / conrod)
Functions ↓	Design Change Points → Requirement / Environment Change Points ↓	-	-	-	New bolt pattern, 5 M10 bolts at 25Nm instead of 4	-
Balance firing & inertia / reciprocating to crankshaft torque and rpm	-	X				
Transmit radial forces / torque and rpm	New turbocharged application increased torque from 255Nm to 283Nm, same RPM	X	X		X	X
Provide concentric flange face and threads for bolts	-				X	
Center and position flexplate					X	
Provide bearing surface to crank shells / block	-		X			
Carry axial load from clutch, position crankshaft in block	-			X		
Provide bearing surface to connecting rod	-					X
Supply bearings with oil	-	X	X			X

Optional Example 2: DRBFM Change Point/Function Matrix

DRBFM CHANGE POINT/FUNCTION MATRIX						
Sample data for training purposes only.						
System, Assembly, Part Name	FUNCTIONS (Refer to DFMEA)	Affected by Change - Pump rotor changing from 8 slots to 10 Y or N	Affected by Change - Different cam profile in pump ring Y or N	Affected by Change - Adding 2 vanes Y or N	Affected by Change - Changing from automatic to manual assembly of vanes Y or N	Affected by Change - Removed hole on cam ring Y or N
Pump Asm	Pump assembly provides regulated pressure and variable oil flow	Y	Y	Y	Y	N
Rotor, Pump	Pump rotor locates, guides, and drives the vanes	N	N	N	N	N
	Pump rotor provides the outboard thrust surface for the shaft retaining ring	N	N	N	N	N
Ring, Pump	Pump ring guides and provides radial thrust surface for vanes	N	N	N	N	N
	Pump ring maintains a metal to metal face seal with the thrust plate and pressure plate	N	Y	N	N	Y
Vane, Pump	Pump vane rides in and driven by rotor slots	N	N	N	N	N
	Pump vane follows ring cam contour and seals to it	N	Y	N	N	N
	Pump vane seals off intake and discharge porting	Y	Y	Y	N	N

APPENDIX E – ADVP&R EXAMPLE

ANALYSIS / DEVELOPMENT / VALIDATION PLAN & REPORT (ADVP&R)								SECTION II - PLAN AND REPORT DATA								
								PLAN #			PLAN DATE			AUTHORS NAME		
SECTION I -- DESIGN EVALUATED								REPORT APPROVAL			CUSTOMER APPROVAL					
PART NAME		PART #		UFC #		REVISION DATE/LEVEL		REPORTING ENGINEER NAME								
MODEL YEAR		PLATFORM		MODEL #		SUPPLIER NAME		PHONE #			REPORT DATE					
SECTION VI -- DFMEA APPROVAL				SECTION V -- VALIDATION RESULTS APPROVAL												
APPROVED: _____ NOT APPROVED: _____				APPROVED: _____ NOT APPROVED: _____												
VALIDATION ENGINEER SIGNATURE: _____ DATE: _____				Delphi VALIDATION ENGINEER SIGNATURE: _____ DATE: _____												
SECTION III -- ADV PLAN SUMMARY								SEC IV -- ADV REPORT								
ITEM #	PROCEDURE #	PROCEDURE TITLE	REQMNT #	REQMNT TITLE	REQMNT VALUE	RESPON SIBILITY	EVALUATION PHASE	SAMPLE		TIMING		SAMPLES TESTED			RESULTS	NOTES
								QTY	TYPE	START	COMPL	QTY	TYPE	STAGE		
3	UL 1995, CTS 16454400	UL Recognition: Strength Test	Section 61, 3.3.2	Burst	1950 psig		DV	3	C	4-Jan-11	11-Feb-11				Passed UL testing	
4	UL 1995, CTS 16454400	UL Recognition: Fatigue Test	Section 62, 3.3.1	Pressure cycle	250k cycles		DV	3	C	4-Jan-11	11-Feb-11				Passed UL testing	

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