Another Tool in the Kit
or
Examples the FMEA Model Applied to both Problem Solving and Environmental Risk Analysis

Risk Assessment – a Prioritization Tool
Many of us, especially those in the automotive industry are familiar with both the Design Failure Mode and Effects Analysis (DFMEA) and the Process Failure Mode and Effects Analysis (PFMEA) tools typically used for risk assessment. We also know we can use them to identify and prioritize improvement opportunities.

By looking at the FMEA method / model through a different set of lenses, I have learned and applied FMEA methodology in a variety of situations that go beyond the initial intent.

Two of these instances will be explored in this paper:
- ✍ Problem Solving – another tool to aid a structured approach
- ✍ Environmental Program (Aspect and Impact) Risk Analysis / Mitigation

A little history and back to basics
Failure mode and effects analysis has been around for a long time. Its genesis was in the US military in the 1940's. It has evolved and is now used in a variety of industries such as aerospace, automotive, semiconductor manufacturing, health care and food service and others. The intent was to provide a systematic approach to identifying potential failures and the subsequent effects of these failures on the "product system," especially with regard to effects felt by the ultimate user/customer.

The following section is not intended to be an in depth "how to" for using the FMEA, Both the American Society for Quality (ASQ) and the Automotive Industry Action Group (AIAG) are sources for additional information.

So, the basics …

The following format illustrates the analysis section of the typical automotive Potential FMEA (this example is an oversimplification and is meant only to depict the approach to Potential Failure Mode and Effects Analysis).

Item / Function	Potential Failure Mode	Potential effect(s) of failure	Sev	Class	Potential cause(s) of failure	Current Design Controls Prevention	Occ	Current Design Controls Detection	Det	RPN
Gas Gage	Does Not Indicate Fuel Level	Run Out of Gas	10	C	No signal to fuel indicator	(1) Life cycle testing at extreme environmental conditions; (2) Fuel indicator defaults to empty with no signal	5	Test data; prototype and pre-production testing	4	200

Some definitions:

Sev Severity rating – team assesses severity of the potential failure mode from a customer perspective on a scale of 1 to 10 – 10 indicates a very severe effect – in this example, the vehicle could run out of gas and the driver stranded.

Class How critical is the effect of the potential failure – in this cas e a "C" was entered to identify it as a critical type concern

Occ Occurrence rating – an estimate on how frequent the potential failure could happen – a scale of 1 to 10 is used with 1 being the lowest estimate of frequency.

Det An estimation of ease of detection – a range of 1 to 10 is used by the team with 10 meaning very difficult to detect and 1 indicating almost sure detection (prior to potential failure in this example).

RPN Risk Priority Number – the product of Sev X Occ X Det – in this example, RPN = 200. Typically, the team will use the RPN number to prioritize follow on actions for risk mitigation.

A little history and back to basics (continued)

RPN	Recommended Action	Responsibility & Target completion date	Action results				
			Actions Taken & Effective Date	Sev	Occ	Det	RPN
200	redesign electrical connection from sensor to gage	Mr Wizard 4/1/2020	redesign complete and retested 3/31/2010	10	2	4	80

A continuation of the columns on the right side of the form show entries for follow on actions, responsibilities, target complete date, actual date complete and RPN re-assessment by the team. In this example, there was an electrical design enhancement and the new RPN estimated at 80.

This preceding example illustrates the systematic approach to risk identification and mitigation in an automotive environment. Now, let's expand the universe …

Problem Solving:

An adaptation of the FMEA to Cause, Effect, and Influence – or - Facilitating a Systematic Root Cause Analysis and Investigation

Let's modify (simplify) the FMEA form just a little and use only the following ranking scale 0, 1, 5, and 10. By using only those rankings, the team can quickly assess the influences with almost no debate needed with regard to ranking. A zero would indicate no influence, 1 a low influence, 5 mid range influence and 10 a most significant influence.

I have applied this tool with:

- only one influence column - the severity of contribution to the problem, or
- 2 influences - (1) the severity of contribution to the problem and (2) probability of occurrence or,
- a 3rd – how easy is it to detect that the potential cause evident.

Adapt it to the situation – remember, there is a premium on time and one of the advantages of this process is that will enable quick identification of the most probable causes – especially if the team facilitator/leader has done some homework and can pre-fill some of the potential causes.

In this example, the process is making bread - the problem is stated as "the dough didn't rise as expected." Please note that the rightmost columns of the form are not yet shown – these are used to summarize actions and results – 2 influences are depicted, contribution ranking and probability of occurrence.

Problem Statement	Potential cause(s) of failure	Current Control Methods	Contributio Ranking	Probability Ranking	Ranking
Dough did not rise as expected	salt not added	check sheet and inventory posting	10	5	50
	old yeast	fifo	10	10	100
	oven temp incorrect	thermocouple calibration and closed loop control	0	N/A	0
	potential cause		1	1	1

Problem Solving (continued):

At this point, the team has estimated the cause contribution to the problem (contribution ranking) and the probability of this cause happening (probability ranking). Remember that to expedite the brainstorming session for causes, the team has opted for a ranking scale of 0, 1, 5, or 10 and chose to use only 2 influences on the ranking (contribution and probability). The product of these 2 is shown in the "Ranking" column – the higher the ranking number, the more probable the cause. These should be investigated first with remedial action taken as appropriate. In this example, "old yeast" most probably should be looked at first. As in any investigation, if there are notable gaps in process control that could lead to a future concern, they should be addressed as a preventative and potential process improvement action – even if there was no direct link to the problem under investigation.

Ranking	Recommended Analysis / Action	Responsibility & Target Completion Date	Actual Complete Date	Comments / Action results
50	check run records and inventory balance	John 3/15/09	3/12/2009	run records indicate the proper amount was added
100		Mary 3/12/09		yeast has 2005 expiration date
0	none	N/A	N/A	N/A
1	none at this time			

The rightmost columns form an abbreviated action (what, who, and when) as well a summary of findings. In this very simplified example, old yeast was the most probable cause of the dough not rising and further, fifo inventory practice was not enough to ensure that the yeast was still active. Remedial action needs to be taken.

To summarize the "1, 5, 10" approach to root cause analysis, it is another tool in the kit (not the only one), it is systematic, it enables quick team analysis, and it provides a summary picture of the activities surrounding the cause analysis process.

Now, on to an example using the FMEA model to assist in the Environmental Management Program.

Environmental Program (aspects and impact) - Risk Analysis / Mitigation

For those involved in managing the Environmental program, the FMEA model lends itself very readily to categorizing, assessing and providing a mitigation plan for environmental risks. ISO 14001 requires such a plan.

So, as in the previous examples, the same basic approach and format is followed. Select a rating scale that makes sense to the organization. In my experiences, the same ranking scale as in the automotive scheme is used but a fourth category “contain,” the ability to contain the environmental risk is added to the form matrix and is a component of the RPN calculation. The scale and contents then becomes 1 through 10 for each of the categories (Sev, Occ, Det, and Contain).

As in the problem solving example, a team approach works best. Again, pre-planning by the facilitator / team leader will certainly speed up the process – pre-identification and listing on the form of the risks is a terrific starting point as preparation for the 1st team meeting. The following is an example of one format that has been successfully used in an ISO 14001 facility.

The leftmost columns of the form are used to identify risks associated with the “current situation”. In this following example, the plant has a centralized pump room for multiple hydraulic systems in the building. The pump oil tank can hold up to 500 gallons of fluid. The risk is that there will be a catastrophic tank failure that will result in all the fluid spilled to the pump room floor and ultimately, to the environment.

Current Situation						
Environmental Risk	**Current Risk Mitigation**	**Sev**	**Occ**	**Det**	**Contain**	**RPN**
Hydraulic pump room - 500 gallon hydraulic oil spill to environment	600 gallon continment dyke in pump room with reinforced containmet bladder and spill alarm	8	5	2	1	80
Risk 2						
Risk 3						
Risk n						

Based on current mitigation, the team has assessed an overall RPN of 80 (maximum score could be 10,000) and because containment is assured, no further action or analysis is required at this time – as summarized in the rightmost columns “Mitigation Planning”:

Mitigation Planning								
Further Action Planned	**Responsibility & Target Completion Date**	**Actual Complete Date**	**Sev**	**Occ**	**Det**	**Contain**	**RPN**	**Comments / Action results**
None needed at this time	N/A	N/A	8	5	2	1	80	Environmental plan includes RCA for oil spill and re-visit Risk Analysis

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Summary

The FMEA model provides a systematic method for approaching a variety of situations beyond to the initial intent of design and process potential "failure mode and effects analysis." The examples illustrate application relative to ***problem solving*** and to ***environmental risk management (aspects and impact)***. By not being constrained by initial intent, the practitioner can find other places to use this approach. Remember, however, that there are other tools in the kit – use each as appropriate to the situation.

Another couple of observations …

It is most apparent to me, the PDCA cycle, of which these two prior examples illustrate, is a core element of success and sustainability.

Additionally, a few years ago I came across a poem by Rudyard Kipling from his investigative reporter days. Rudyard as you may recall, was the author of Gunga Din among other works. One of the works was a poem reminding me some problem solving basics:

"I keep six honest serving-men
(They taught me all I knew);
Their names are What and Why and When
And How and Where and Who."

From the poem - "I Keep Six Honest Serving Men ..."
By Rudyard Kipling (1865-1936)

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