THE FINE AND KNNEY METHOD APPLIED TO A FMEA STUDY

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Abstract

At the end of some FMEA, there can be around fifty or more actions, which have a real impact on the studied failure. However, the only calculation of a difference of RPN between two actions is not enough to lead the choice to one or other. Statistically, there is no difference and we have to choose both of them.

For example: a preventive action like installation of a safety valve can resolve a hazard of overpressure on the outlet side of a blowtorch, decreasing the RPN index from 125 to 85. For the same mode of failure, another solution may be a diverter of circuit, with a final RPN index of 90. At a first side, we cannot declare that a RPN index of 85 is indeed more effective than a 90 one!

The purpose of this article is to give a tool for making this choice less subjective.

Theorical aspects

Fine and Kinney [1976] give a coefficient of effectiveness of an action that decreases a risk $K_{eff}$:

$$K_{eff} = \frac{M}{D} \times R$$

(1)

Were:

$$D = \sqrt[3]{\frac{C}{100}}$$

(2)

With:

$C$ = total Costs (€ or $)

$R$ = Index of initial risk

$M$ = Reduction of the risk (in %)

Let us apply this formula to method FMEA

$$K_{eff} = \frac{M}{D} \times RPN_0$$

(3)

Were:

$$RPN_0 = O_0 \times S_0 \times D_0$$

(4)

$O_0, S_0, D_0$ are respectively the factors of occurrence, of severity and risk of not-detection, before the action was taken.

We imagine by brainstorming the new factors of occurrence, of severity and risk of not-detection, after the action will be taken. One $RPN_1$ then is obtained

$$RPN_1 = O_1 \times S_1 \times D_1$$

(5)

Which must be lower than $RPN_0$

Then
\[ M = \frac{RPN_0 - RPN_1}{RPN_0} \]  

\[ D \] is in the same way calculated that in (2), we can then, for each action calculate a \( K_{\text{eff}} \) and start with the action with the higher index.

**Visual representation:**

Each action is represented on a graph with 2 dimensions where the X-coordinate represents the cost and the ordinate represents the efficiency of the action.

We also delimit zones of intervention.:

![Diagram - Efficiency – Cost](image)

**FIGURE 1: Diagram - Efficiency – Cost**

The chart is divided into four equal quadrants to define the following zones, optional we can colorize them. The actions represented by the couple located in green zone (first quadrant) will be the first to be initiate.

To estimate the cost of the project as well as possible Sharma [2005] suggests calculating the cost by evaluating time necessary to the realization of the action and multiplying it by the time cost.

Then we give an example with 7 modes of failures of a ballpoint pen

This method is useful for quantifying in a precise way the effectiveness and for leading the choice of the actions to carry out first.

We will not describe here the FMEA method; many works there refer and describe in an exhaustive way its practical execution. We will limit ourselves here to deliver a tool of decision-making aid when the actions decided and approved by the group at the end of the analysis must be firstly selected.

**Context**

At the end of some FMEA, there can be around fifty or more actions, which have a real impact on the studied failure. However, the only calculation of a difference of RPN between two actions is not enough to lead the choice to one or other. Statistically, there is no difference and we have to choose both of them.

For example: a preventive action like installation of a safety valve can resolve a hazard of overpressure on the outlet side of a blowtorch, decreasing the RPN index from 125 to 85. For the same mode of failure, an other solution may be a diverter of circuit, with a final RPN index of 90. At a first side, we can not declare that a RPN index of 85 is indeed more effective than a 90 one!
By the way, for a manager, we can imagine that the favourite project will be the less expensive one. The purpose of this article is to help the manager in his choice.

**Theoretical Aspects**

Fine and Kinney [1976] give a coefficient of effectiveness of an action that decreases a risk $K_{eff}$:

$$K_{eff} = \frac{M}{D} \times R$$

Were:

$$D = \sqrt[3]{\frac{C}{100}}$$

With:

- $C$ = total Costs (€ or $)
- $R$ = Index of initial risk
- $M$ = Reduction of the risk (in %)

More is $K_{eff}$ raised; more the action is effective.

Let us apply this formula to method FMEA

$$K_{eff} = \frac{M}{D} \times RPN_0$$

Were:

$$RPN_0 = O_0 \times S_0 \times D_0$$

$O_0, S_0, D_0$ are respectively the factors of occurrence, of severity and risk of not-detection, before the action was taken. We imagine by brainstorming the new factors of occurrence, of severity and risk of not-detection, after the action will be taken. One $RPN_1$ then is obtained

$$RPN_1 = O_1 \times S_1 \times D_1$$

Which must be lower than $RPN_0$. Then

$$M = \frac{RPN_0 - RPN_1}{RPN_0}$$

$D$ is in the same way calculated that in (2), we can then, for each action calculate a $K_{eff}$ and start with the action with the higher index.

**Visual Management:**
A visual representation can be helpful for the FMEA team members less accustomed to equation. We advice to use an Excel worksheet, for example, and by encoding the formulas (6), (2) and (3) we are able to leave a chart; as schematized on figure 1. Each action is represented on a graph with 2 dimensions where the X-coordinate represents the cost and the ordinate represents the efficiency of the action. That gives advantage of positioning the actions the ones compared to the others. More, we can delimit zones of intervention.

The chart is then divided into four equal quadrants to define the following zones, optional we can colorize them (table 1):

<table>
<thead>
<tr>
<th>Efficience</th>
<th>Reduction effectiveness in risk</th>
<th>Cost</th>
<th>Zone</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Top Left (I)</td>
<td>Green</td>
</tr>
<tr>
<td>Average</td>
<td>High</td>
<td>High</td>
<td>Top Right (II)</td>
<td>Orange</td>
</tr>
<tr>
<td>Average</td>
<td>Low</td>
<td>Low</td>
<td>Bottom Left (III)</td>
<td>Orange</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Bottom Right (IV)</td>
<td>Red</td>
</tr>
</tbody>
</table>

TABLE 1: Quadrant of the effectiveness of action

The actions represented by the couple located in green zone (first quadrant) will be the first to be initiate.

How to estimate the cost of the project as well as possible?
Sharma [2005] suggests calculating the cost by evaluating time necessary to the realization of the action and multiplying it by the time cost.

**Example:**

For example: 7 modes of failures of a ballpoint pen.

<table>
<thead>
<tr>
<th>Potential Effect(s) of Failure</th>
<th>A/E</th>
<th>OCCUR</th>
<th>DET</th>
<th>RP/N0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ink runs</td>
<td>2</td>
<td>8</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Loss of cap</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Ink wrong color</td>
<td>5</td>
<td>3</td>
<td>6</td>
<td>90</td>
</tr>
<tr>
<td>Ink dries</td>
<td>7</td>
<td>3</td>
<td>6</td>
<td>126</td>
</tr>
</tbody>
</table>
TABLE 2: Modes of failure of a ball point pen

<table>
<thead>
<tr>
<th>Action(s)</th>
<th>SEV</th>
<th>OCC</th>
<th>DET</th>
<th>RPN</th>
<th>Decrease of the risk %</th>
<th>Considered working hours</th>
<th>Cost time (€)</th>
<th>Cost €</th>
<th>Coefficient of effectiveness (Keff)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to find a formula of more viscous ink</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>8</td>
<td>50,00</td>
<td>150</td>
<td>50,00</td>
<td>7.500,00</td>
<td>2</td>
</tr>
<tr>
<td>2 mechanism of entering point</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>80,00</td>
<td>500</td>
<td>50,00</td>
<td>25.000,00</td>
<td>3</td>
</tr>
<tr>
<td>3 locating pin with the assembly</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>15</td>
<td>83,33</td>
<td>50</td>
<td>50,00</td>
<td>2.500,00</td>
<td>26</td>
</tr>
<tr>
<td>4 anaerobic tank</td>
<td>7</td>
<td>1</td>
<td>6</td>
<td>42</td>
<td>66,67</td>
<td>250</td>
<td>50,00</td>
<td>12.500,00</td>
<td>17</td>
</tr>
<tr>
<td>5 to reinforce structure</td>
<td>8</td>
<td>1</td>
<td>6</td>
<td>48</td>
<td>50,00</td>
<td>200</td>
<td>50,00</td>
<td>10.000,00</td>
<td>10</td>
</tr>
<tr>
<td>6 to change plastic type</td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>40</td>
<td>50,00</td>
<td>50</td>
<td>50,00</td>
<td>2.500,00</td>
<td>14</td>
</tr>
<tr>
<td>7 stopper sticks to the corp pen</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>50,00</td>
<td>15</td>
<td>50,00</td>
<td>750,00</td>
<td>3</td>
</tr>
</tbody>
</table>

TABLE 3: Actions to solve the modes of failure of a ballpoint pen, estimate of the cost and calculation of its effectiveness

Table 4 gives us the classification of the actions by order ascending of effectiveness:

<table>
<thead>
<tr>
<th>N°action</th>
<th>Action</th>
<th>Decrease of risk (%)</th>
<th>Cost €</th>
<th>Keff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>To find a formula of more viscous ink</td>
<td>50,00</td>
<td>7.500,00</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Mechanism of entering point</td>
<td>80,00</td>
<td>25.000,00</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Stopper sticks to the corp pen</td>
<td>50,00</td>
<td>750,00</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>To reinforce structure</td>
<td>50,00</td>
<td>10.000,00</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>To change plastic type</td>
<td>50,00</td>
<td>2.500,00</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>Anaerobic tank</td>
<td>66,67</td>
<td>12.500,00</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>Locating pin with the assembly</td>
<td>83,33</td>
<td>2.500,00</td>
<td>26</td>
</tr>
</tbody>
</table>

TABLE 4: Actions to solve the modes of failure of a ball point pen: classification according to their effectiveness
A locating pin which is less expensive and which has a greater impact on the failure, will be focused first, rather than finding an ink more viscous, for example. Graphically, this result is represented on figure 2, what enables us to see that if we must choose between actions, it would be necessary to take those located in the green zone, namely the actions n°3 and 4.

\[ 
\begin{array}{c}
\text{Efficiency (Keff)} \\
30 \\
25 \\
20 \\
15 \\
10 \\
5 \\
0 \\
\end{array} \\
\begin{array}{c}
\text{Cost (€)} \\
0 \\
10000 \\
20000 \\
30000 \\
\end{array} \\
\]

FIGURE 2: Graphics reduction in the risk-cost of the solution to the failures of a ball point pen

**Conclusion**

This method is useful for quantifying in a precise way the effectiveness and for leading the choice of the actions to carry out first, if there are no needs of exhaustive actions.

The main advantage is that it is easy to use – eventually after a creation of a template in a spreadsheet and visual.

By the way, this is only a tool of decision-making help. If the company has the possibility of carrying out the actions in the orange zone in the same time, of course, they have to do!

**References**


PANKAJ SHARMA Calculating COPQ Using Weighted Risk of Potential Failures LLC 2006