Model for combining risk assessment, Lean method and Six Sigma method for achievement of sustainability in environmental management system

Ilia Tzenev\(^a\), Dimitar Bantutov\(^a\), Mariana Shirkova\(^b\), Georgi Popov\(^c\)

\(^a\)"Practice Q.A. Ltd. 23, www.praktika-ok.com, GSM: 0888-984798,
\(^b\)"QUALITY 21-st CENTURY” Foundation, www.kachestvo-21.com, GSM: 0888-989635,
\(^c\)University of Central Missouri – USA, http://www.ucmo.edu/ss/facstaff/popov.cfm

Abstract

In the last few years we observed a “boom” for implementation and certification of environmental management systems ISO 14001. The question is how not only to obtain certificate, but to maintain programs for sustainable development of the environment. Good international techniques are Lean and Six Sigma methods. The authors will present their experience for applying these techniques with ISO 14001.

Key words: environment, management system, sustainable development, risk, model

1. Introduction

ISO 14001 2004 is an environmental management standard. It defines a set of environmental management requirements for environmental management systems (EMS) (ISO 14001.2004). The standard is intended to assist variety of organizations to protect the environment, to implement pollution prevention strategies, and to improve their environmental performance. This paper

Резюме

През последните години се наблюдава един „бум“ за въндряване и сертификация по ISO 14001 за системи по управление на околната среда. Въпросът е внедрители не само да получат сертификат, но и да поддържат програми за устойчиво развитие на околната среда. Едни добри международни техники са методите „6 sigma“ и „оптимизация на процесите“ (LEAN). Авторите ще представят своя опит за прилагането на тези техники при ISO 14001.

Ключови думи: околна среда, система за управление, устойчиво развитие, риск, модел
presents value-added project for EMS implementation. The authors used generic ABC Environmental Company to avoid advertisement and conflict of interest. The environmental company has less than one hundred employees. Since the standard is so broad, the paper addressed risk assessment methods, Plan, Do, Check, Act (PDCA) cycle, significant aspects evaluation decision making tree, Lean Six Sigma (LSS) tools implementation, and residual risk reduction. (ASQ PDCA)

One of the difficulties with EMS is to establish proper procedures for environmental aspects determination and evaluation (ISO 14031.1999). This process presents difficulties due to significant variation of the environmental aspects. The main goal of the paper is to establish common procedures for aspects scores reduction. LSS principles are combined with risk assessment tools, variation reduction and sustainability methods.

The proposed EMS implementation addresses environmental, safety and health needs in the risk assessment processes to prevent or minimize the work-related hazards and risks associated with the use, storage, maintenance, and disposal of environmental aspects. One of the goals is to educate engineers, chemical and equipment manufacturers, environmental, health and safety (EHS) professionals, business leaders, and workers to understand and implement EMS methods and apply this knowledge and skills to reduce risk and prevent pollution.

One of the many challenges EHS professionals are facing is developing skills to convince the management to maximize the effectiveness of the EMS program and consequently increasing productivity. EHS professionals have to help the management transform EMS into an accepted business value for the organization. In order to be successful, the EHS students and professionals have to learn to use the EMS LSS principles and incorporate them into standard business practices. A major hurdle to the adoption of EMS is the perception that the EMS cost/benefit ratio is unfavorable. EHS professionals should recognize business cost drivers and justify EMS implementation expenditures in the early aspects adoption and product development stage. Therefore, the author developed EMS model that incorporates LSS, risk assessment, aspects scores variation reduction and residual risk reduction. To demonstrate the applicability of the model; the author selected a case study that was suitable for practical demonstration and educational module.

II. Problem Description

According to ISO 14001 procedures, every environmental aspect will have to be evaluated (ISO 14004.2004). This project defines the evaluation criteria used to determine the degree of significance of each aspect on the Environmental Aspects & Impacts List, upon the identification and inclusion of a new aspect to this list. The following ENVIRONMENTAL ASPECT SIGNIFICANCE DETERMINATION SYSTEM was developed.

1.0 PURPOSE

The key to a successful registration for conformance with ISO 14001 is to precisely determine the organization's Environmental Aspects and Impacts. EMS team should evaluate which aspects are the most significant and therefore require the most attention. Two definitions should be introduced before the initial evaluation takes place.

"3.3 -- Environmental Aspect: Element of an organization's activities, products or services that can interact with the environment.

# A significant environmental aspect is an environmental aspect that has or can have a significant environmental impact."

"3.4 -- Environmental Impact
Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services." (ISO 14001)

There are three distinct requirements contained within section 3 of ISO 14001.

a. The organization shall identify the environmental aspects of its activities, products and/or services. In other words the organization must understand how it interacts with the environment.

b. The organization shall identify the specific environmental aspects that can be controlled, and over which it can be expected to have influence.

c. Arrive at a list of significant environmental aspects based upon the individual environmental impact of each environmental aspect. The importance of this third step cannot be underestimated. The final list of significant environmental aspects will provide the basis for the Environmental Policy statement, and the Environmental Objective(s) and Targets. In other words the list of significant environmental aspects drives the entire content and scope of the operational portion of the EMS.

An example of Significant Environmental Aspects (SEA) decision making tree is presented below.

Fig. 1. SEA decision making tree model

This procedure defines the evaluation criteria used to determine the degree of significance of each aspect on the Environmental Aspects & Impacts List, upon the identification and inclusion of a new aspect to this list, or upon updating an existing aspect.

2.0 SCOPE
This procedure applies to all aspects on this list.

3.0 RESPONSIBILITIES
It is the responsibility of the Process Review Team Leader to modify this list according to the input received by the process review team.

4.0 PROCEDURE
Content Requirements of Environmental Aspects

• understand how it interacts with the environment
• control versus influence
• arrive at a list of significant environmental aspects based upon impacts
• develop a procedure to support the decision making process

Identify Environmental Aspects

All of the organization’s activities, products and/or services must be included within the environmental aspects review framework. The organization must assemble a listing of potential environmental aspects. The purpose of this activity is not to determine the importance of each aspect. The purpose is to create a complete listing of how the organization interacts with the environment. The organization must include the effect of non-routine situations in the listing such as emergency conditions, start-up and shutdown activities. The procedure that is developed to produce the list of environmental aspects must recognize the concept of continual improvement. The procedure and the list of aspects can be influenced by future actions such as new legislation, changes in operations, etc. The Management Review (4.6) section mandates continual improvement because the environmental management system must be reviewed on a periodic basis to insure that it is still effective based upon the organization’s activities, products and/or services. (ISO 14001)

The process of arriving at a list of Significant Environmental Aspects must be a reasonable and understandable procedure. Therefore, the following scoring procedure was developed. The procedure is intended to help the EMS team streamline the scoring process and evaluate the risks.

There are 3 major sections that make up the Environmental Aspects & Impacts Scoring List:

• Significance Scores without Controls
• Significance Scores with Controls
• Overall Significance Rating Chart

Common to these 3 sections are the following:

• Location
• Department
• Index
• Aspect
• Impacts to Environmental Properties
• Polarity Adjustment
• Impact Subtotal
• Frequency

Location, Department, Index, Aspect

Location and Department columns have been provided as an option to further define the Aspect, if necessary. In some cases the aspect might be significant enough in more than one location and/or department to warrant an additional score of that aspect in more than one line item. In most cases the aspect will only require a single line item listing, but an indication of a more specific location and/or department might be necessary to track that aspect in the event it changes ownership or
location throughout its lifecycle at ABC. The absence of an indicator in either field indicates “not applicable” or “all of the above”. The Location and Department legends are shown below:

Locations
l Laboratory
w Warehouse Building
f Field (in general)
t T Building
a Abatement Building

Departments
a Abatement
r Remediation
k ABC Supply
it Information Technology/Securities
o General Overhead
ac Accounting
hr Human Resources

The Index column is a serialized alphanumeric designator to differentiate each line item as new aspects are added to the list. The letter designator is used to define in what process the aspect was discovered. It is possible that an aspect might be discovered in multiple processes, and requires more than one line item listing and index designator. The number designator will be incremented with respect to the last number assigned within each letter upon the addition of a new aspect to the list. This legend defines those letters and their processes:

f Field Process
a Administration Process

Impacts to Environmental Properties

Each of the 10 Impacts to Environmental Properties will be rated using:
+1, -1, or 0 rating. Where:

+1 Means that aspect has a positive impact on the environment for that property.
-1 Means that aspect has a negative impact on the environment for that property.
0 Is used when an aspect has no impact on the environment for that property, or when that property is not applicable for that aspect.

When rating the impacts in the Significance Scores without Controls section, consider the aspect’s impact on that property in an unregulated environment, in and of itself, and outside of any controls ABC might have on it in a worse-case scenario.
When rating the impacts in the Significance Scores with Controls section, consider the aspect’s impact on that property under ABC’s complete control within its current regulations and operational standards.

Impact Subtotal and Polarity Adjustment

These 10 impacts will then be summed together into an Impact Subtotal. That subtotal will then be used in the remaining Significance Score’s calculation. In the event the subtotal equals zero, a Polarity Adjustment value will be substituted as a replacement to the Impact Subtotal and instead be used in the remaining Significance Score’s calculation. Without this polarity adjustment, that calculation, which is a product of several factors, would use this unacceptable zero factor and generate a meaningless zero score.

In the Significance Scores without Controls section, the Polarity Adjustment will be a value of -1.
In the Significance Scores with Controls section, the Polarity Adjustment will be a value of +1.

An example of environmental aspects evaluation procedure is presented below.

Fig. 2. Environmental aspects evaluation procedure example

**Frequency**

Frequency is a rating that indicates the frequency of use of an aspect by ABC, or the frequency of that aspect’s presence on ABC’s property. It will be determined using as scale of 1 to 4:

1 Rarely
2 Infrequently
3 Frequently
4 Continuously

This value will be the same for both sections:

- Significance Scores without Controls
- Significance Scores with Controls
The following 3 ratings are to be used in the Significance Scores without Controls section only:

Impact Severity
Impact Severity is a rating that indicates how severe the aspect might impact the environment in the event of an uncontrolled full release. It will be determined using a scale of 1 to 3:
1 Low
2 Medium
3 High

Impact Probability
Impact Probability is a rating that indicates how probable the aspect might impact the environment in the event of an uncontrolled full release. It will be determined using a scale of 1 to 3:
1 Low
2 Medium
3 High

Legal Risks
Legal Risks is a rating that indicates the degree of risk and the probability of a law suit in the event of an uncontrolled full release of that aspect in the environment. It will be determined using a scale of 1 to 3:
1 Violates Environmental Industry-Specific Regulations
2 Violates General Regulations
3 No Known Risks

The following rating is to be used in the Significance Scores with Controls section only:

Current Controls
Current Controls is a rating that indicates the degree of control ABC currently has on that aspect. It will be determined using a scale of 1 to 3:
1 Acceptable
2 Needs Improvement
3 Unacceptable

Significance Score for Significance Scores without Controls Section
The Significance Score in this section is calculated using the following equation:
The sum of Impacts to Environmental Properties multiplied by, Impact Subtotal or Polarity Adjustment multiplied by, Frequency multiplied by, Impact Severity multiplied by, Impact Probability multiplied by, and Legal Risks.

An example of environmental aspects evaluation procedure that includes Frequency, Severity, Probability and Legal Risks is presented below.
Fig. 3. Environmental aspects Risk Assessment evaluation procedure example

Significance Score for Significance Scores with Controls Section
The Significance Score in this section is calculated using the following equation:
The sum of Impacts to Environmental Properties multiplied by, Impact Subtotal or Polarity Adjustment multiplied by, Frequency multiplied by, Current Controls.
Once the hierarchy of controls is established, significant scores could be evaluated again. An example of significance scores with controls is presented below.

Fig. 4. Environmental aspects evaluation procedure including controls example

Overall Significance Rating Chart
This last section calculates an overall significance rating called Score Spread for each aspect and provides a color-coded graphical representation to compare each aspect’s rating. Once all scores have been established and calculations made, the entire list can be sorted by Score Spread to reveal the most extreme ratings from highest to lowest.
This rating is calculated as follows:
The absolute value of the difference between, Significance Scores with Controls & Significance Scores without Controls.
Fig. 5. Environmental aspects evaluation of the difference between, Significance Scores with Controls & Significance Scores without Controls

The larger the value of the spread, the more extreme (higher) the rating, which generally translates into the following:

The more hazardous the aspect, typically the more controls ABC applies to that aspect. The evaluation team may decide to use color coding to visualize the risks and shade the more extreme ratings in a darker red region.

The graphical representation is calculated by finding the minimum and maximum values of all Score Spreads available.

After the initial Environmental Aspects evaluation, it became obvious that aspects without controls have enormous significance scores variation.

### III. Solution to the problem

In order to reduce variation, new control methods had to be proposed for each environmental aspect. The objective of the project is to reduce aspects significance scores and the target is to demonstrate statistically significant reduction of significance scores. New tools and statistical methods were developed to solve the problem. Lean Six Sigma tools were utilized. The new tool is based on PDCA approach described in the Lean Six Sigma: process Improvement Tools and Techniques textbook (Summers D. 2011). In addition, the risk assessment tool could be considered significantly expanded version of failure modes and effects analysis (FMEA) methodology. (ASQ)

First, a histogram was prepared to demonstrate the enormous variation in the environmental aspects scores. Please see figure 6. below.
Second, standard MS Excel tools were used to calculate and compare the mean, mode, median, range, standard deviation, variance, Kurtosis and skewness (StatSoft). Other tools, such as QI Macros are also available, but the author utilized standard MS Excel functions (LSS Tools).

Please see the table below.

Table 1. Significance scores.

<table>
<thead>
<tr>
<th></th>
<th>WITHOUT controls</th>
<th>WITH controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-10.5319</td>
<td>-0.21277</td>
</tr>
<tr>
<td>Standard Error</td>
<td>2.326167</td>
<td>0.487049</td>
</tr>
<tr>
<td>Median</td>
<td>-5.5</td>
<td>-2</td>
</tr>
<tr>
<td>Mode</td>
<td>-1</td>
<td>-2</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>22.55302</td>
<td>4.722111</td>
</tr>
<tr>
<td>Sample Variance</td>
<td>508.6388</td>
<td>22.29833</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>35.94634</td>
<td>1.519692</td>
</tr>
<tr>
<td>Skewness</td>
<td>-5.42011</td>
<td>1.049506</td>
</tr>
<tr>
<td>Range</td>
<td>185</td>
<td>26</td>
</tr>
<tr>
<td>Minimum</td>
<td>-180</td>
<td>-12</td>
</tr>
<tr>
<td>Maximum</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Sum</td>
<td>-990</td>
<td>-20</td>
</tr>
<tr>
<td>Count</td>
<td>94</td>
<td>94</td>
</tr>
</tbody>
</table>
It was determined that there was significant difference between the scores without controls and the
scores after the process control. After that, the author used $t$-test to determine if the difference was
statistically significant. (StatSoft $T$-test) $T$-test showed statistically significant difference. $T$ critical
was 1.66 and $t$-stat was – 4.21.

The objective was to reduce aspects significance scores. Our target was to demonstrate statistically
significant reduction of significance scores. The project should be considered successful. It reduced
standard deviation by nearly 79%. The mean and the median scores were also significantly
reduced.

The required resources for the project were not related to purchasing of new equipment and
software. However, significant investment in time and personnel is required. The development of
such system required approximately one hundred and fifty (150) hours of EMS sponsor’s time. In
addition EMS team meetings and individual interviews resulted in additional five hundred and fifty
(550) hours of various team members time. It will be difficult to justify such expense if the
organization is not fully committed to Environmental, Health and Safety excellence.

IV. Conclusions
Reduction of Aspects significance scores was achieved. The project demonstrated
statistically significant reduction of significance scores. The project was successful and
accepted by the management. It reduced standard deviation by nearly 79%. The mean and the
median scores were also significantly reduced.

EHS professionals have to develop management skills and diversify their knowledge to
overcome difficulties during such projects. After the initial analysis, it became clear that such
significant investment in EMS significance scores variation reduction projects can’t not be
easily justified based on risk assessment alone. Future leaders in the safety profession will
have to develop statistical skills and demonstrate knowledge in financial management. In
order to defend such projects, EHS professionals have to be familiar with variety of risk
management techniques, LEAN Six Sigma tools and financial management principles.
Being an expert in environmental compliance is not enough to complete successful
complex projects. Complex projects require multi-disciplinary knowledge and cross-
disciplines management skills. Safety leaders have to become familiar with different
organizational structures and variety of stakeholders interests to complete such projects. EHS
professionals have to be prepared to deal with various levels of the organizational
management and demonstrate competencies.
References:


